Invasive plants in Mediterranean type regions of the world

Plantes envahissantes dans les régions méditerranéennes du monde

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Preface / *Préface*

La prolifération des plantes exotiques envahissantes est un problème important, encore peu connu, pour la préservation des habitats naturels. Ces espèces présentent des risques pour les écosystèmes, pour l'économie et pour la santé. La nature ne connaît pas de frontières et il est nécessaire d'aborder cette question à partir d'une optique internationale afin de pouvoir proposer des mesures efficaces de prévention et de contrôle.

Le Conservatoire Botanique National Méditerranéen de Porquerolles, l'Organisation Européenne et Méditerranéenne pour la Protection des Plantes, le Conseil de l'Europe, l'Union mondiale pour la Nature et ont allié leurs efforts pour co-organiser ce premier « Atelier de Travail International sur les Plantes Envahissantes dans les régions méditerranéennes du monde ». Nos organisations sont toutes impliquées de façon complémentaire dans la prise en compte de ce problème et agissent en partenariat avec les Ministères de l'Agriculture et de l'Environnement et la communauté scientifique de nombreuse pays concernés afin d'élaborer des recommandations.

Plus de 110 experts de 27 pays des 5 régions méditerranéennes du monde (Bassin Méditerranéen, Australie, Californie, Afrique du Sud et Chili) se sont réunis à Mèze, ville méditerranéenne qui s'implique tout particulièrement pour la protection de l'environnement.

Pourquoi les régions méditerranéennes ? Il s'agit de zones biogéographiques ayant des climats similaires où l'on retrouve souvent les mêmes plantes envahissantes et les mêmes enjeux écologiques (habitats littoraux, présence d'îles, problèmes d'érosion des sols…).

L'Europe, et plus particulièrement les pays méditerranéens, sont est très en retard dans le domaine des plantes envahissantes. De nombreuses unités de recherche scientifique travaillent sur le sujet mais les professionnels de l'horticulture, les techniciens « espaces verts » des collectivités et, plus largement, le grand public, n'ont que très rarement été informés ou impliqués sur le problème. Ces derniers sont pourtant étroitement mêlés au processus d'introduction et de diffusion.Chercheurs en biologie et en sciences humaines, gestionnaires d'espaces, horticulteurs et pépiniéristes, unis par un même défi, ont échangé lors de cet atelier leurs connaissances afin de faire émerger des recommandations concrètes pour une véritable stratégie de lutte et de prévention contre les plantes envahissantes.

Ces Actes présentent la « Déclaration de Mèze », élaborée par l'ensemble des participants au cours de cet atelier de travail. Les communications et posters sont ici restitués et apportent un état actuel de la situation dans les régions méditerranéennes du monde sur les thèmes variés et complémentaires de l'élaboration de listes de plantes envahissantes, la prévention d'espèces introduites volontairement pour l'horticulture, la communication et les actions de gestion. Nous souhaitons que cette première rencontre marque le début d'une durable et fructueuse coopération entre les acteurs des régions méditerranéennes du monde.

François Boillot (Conservatoire Botanique National Méditerranéen de Porquerolles)
Ian M. Smith (OEPP/EPPO)
Eladio Fernández Galiano (Conseil de l'Europe)
Jamie Skinner (UICN – Centre pour la Coopération Méditerranéenne)

Mèze Declaration/

Déclaration de Mèze

Preamble

From 25 to 27 May 2005, 110 plant scientists, conservationists and other experts from 24 countries met in Mèze (France) to discuss the threats to biodiversity, the environment and the economy posed by invasive alien species (IAS) (definitions according to the COP meeting of 26 March 2002: UNEP/CBD/COP/6/18/Add.1/Rev.1) of plants in the world's five Mediterranean type climate regions – southern Australia, California, Chile, the Cape region of South Africa and the Mediterranean basin – and to search for possible ways to address these threats.

Although the Mediterranean climate regions cover less than 5% of the Earth's land surface, they are home to about 20% of the world's vascular plants, including a high number of endemic species and many taxa of considerable economic importance, and the Workshop Participants noted with concern that this plant diversity is increasingly threatened by invasive alien species, often exacerbated by global change and in particular its climatic components.

Recognising the importance and relevance of existing organizations, programmes and initiatives that address the issue of IAS in the framework of several international fora, such as the Convention of Biological Diversity (Guiding Principles for the Prevention, introduction and mitigation of impacts on alien species that threaten ecosystems, habitats or species, The Hague, April 2002), the Council of Europe (Bern Convention European Strategy on IAS, Strasbourg December 2003) the International Plant Protection Convention (IPPC), the European and Mediterranean Plant Protection Organization (EPPO), the Paris Declaration (Conference Biodiversity Science and Governance, January 2005), The Global Invasive Species Programme (GISP) and the Baltimore Declaration (Technical Workshop on the Implementation of a Global Invasive Species Information Network (GISIN) Baltimore, USA, April 2004), and recognising the great importance attached to regional co-operation;

Recognising the environmental, economic, health, and other social risks posed by plant IAS;

Préambule

Du 25 au 27 mai 2005, plus de 110 experts, défenseurs de l'environnement et autres, venus de 24 pays se sont réunis à Mèze (France) pour discuter des menaces que les plantes exotiques envahissantes (EEE) (selon la définition retenue par la Conférence des parties contractantes du 26 mars 2002 ; version anglaise : UNEP/CBD/COP/6/18/Add.1/Rev.1) dans les écosystèmes de type méditerranéens (ETM) font courir à la biodiversité, à l'environnement et à l'économie dans les cinq régions à climat méditerranéen du monde – Australie du Sud, Californie, Chili, région sud-africaine du Cap et bassin méditerranéen – et rechercher des moyens éventuels pour faire face à ces menaces.

Bien que les régions à climat méditerranéen couvrent moins de 5% de la surface de la Terre, elles comptent environ 20% de la flore vasculaire connue, y compris un nombre élevé d'espèces endémiques et de taxons qui ont une importance économique considérable ; les participants de l'Atelier ont noté avec préoccupation que cette diversité florale est de plus en plus menacée par des espèces exotiques envahissantes, cette menace étant souvent aggravée par les changements à l'échelle du globe, notamment l'évolution des climats.

Reconnaissant l'importance et la pertinence des organisations, programmes et initiatives concernant les espèces exotiques envahissantes au titre de plusieurs documents et institutions internationaux comme la Convention sur la diversité biologique (Principes directeurs sur la prévention, l'introduction et l'atténuation des effets des espèces exotiques qui menacent des écosystèmes, des habitats ou des espèces, La Haye, 2002), le Conseil de l'Europe (Stratégie européenne de la Convention de Berne sur les espèces exotiques envahissantes, Strasbourg, décembre 2003), la Convention internationale pour la protection des végétaux (CIPV), l'Organisation européenne et méditerranéenne pour la protection des plantes (OEPP), la Déclaration de Paris (Conférence internationale sur le thème "Biodiversité : sciences et gouvernance", janvier 2005), le Programme mondial sur les espèces envahissantes (GISP) et la Déclaration de Baltimore (Atelier sur la mise en œuvre d'un Réseau mondial d'information sur les espèces envahissantes (GISIN), Baltimore (Etats-Unis), avril 2004) et reconnaissant l'importance capitale de la coopération régionale;

Reconnaissant les risques écologiques, économiques, de santé et autres risques sociaux posés par les plantes exotiques envahissantes;

Aware of the international commitments of the World Summit on Sustainable Development, Johannesburg 2002 and the Ministerial Conference 'Environment for Europe', held in Kiev in 2003, which both recommend the management of IAS and the prevention of their introduction so as to help the global Millennium goal of halting the loss of biological diversity by 2010;

Realising the importance of information and experience sharing among the countries in the Mediterranean climate regions for the effective management of plant IAS;

Noting the lack of inventory of plant IAS in some Mediterranean type climate regions and basic information about the threats they pose;

Confronting the lack of education, awareness and communication about the impacts of plant IAS on the environment and the livelihoods of people;

Recognising the substantially different impacts of plant IAS in the different Mediterranean type climate regions;

Recognising the different social and economic realities in the different countries of the Mediterranean type climate regions and the different priorities given to plant IAS;

Recognising that methods of tackling plant IAS and their impacts often exist, including environmentally sound approaches which are overlooked,

The participants of the workshop

1. Urge governments, scientific institutions, NGOs and all other stakeholders, as part of their continuing efforts to conserve biological diversity, to apply the best known practices for the prevention, eradication, and control of plant IAS, building on existing knowledge and control and prevention systems where these exist;

Conscients des engagements internationaux pris lors du Sommet mondial sur le développement durable (Johannesburg, 2002) et de la Conférence ministérielle "Un environnement pour l'Europe", tenue en 2003 à Kiev, où étaient recommandées la gestion des espèces exotiques envahissantes et la prévention de leur introduction pour contribuer à l'objectif mondial du Millénaire d'inverser la tendance actuelle à la déperdition de la diversité biologique d'ici 2010;

Réalisant l'importance de l'échange d'informations et d'expériences entre les pays dans les régions à climat méditerranéen pour une gestion efficace des espèces exotiques envahissantes;

Notant l'absence d'inventaire de plantes exotiques envahissantes dans certaines régions de type méditerranéen et d'informations de base sur les risques qu'elles présentent;

Confrontés au manque de communication, de prise de conscience et de formation concernant les risques de plantes exotiques envahissantes sur l'environnement et les vies des personnes;

Reconnaissant les effets très variés de plantes exotiques envahissantes dans les diverses régions à climat méditerranéen;

Reconnaissant les différentes réalités sociales et économiques dans les pays à écosystèmes de type méditerranéen et les différentes priorités données aux plantes exotiques envahissantes;

Reconnaissant qu'il existe souvent des méthodes pour faire face aux plantes exotiques envahissantes et à leurs effets, y compris des approches respectueuses de l'environnement qui sont négligées ;

Les participants de l'atelier

1. Pressent les gouvernements, institutions de recherche, ONG et autres parties prenantes, de mettre en œuvre, dans le cadre de leur action continue pour préserver la biodiversité, les meilleures pratiques pour la prévention, l'éradication et le contrôle de plantes exotiques envahissantes sur la base des connaissances et des systèmes de prévention et de lutte existants,

2. Call upon governments to ensure that national legislation and regulations effectively address the management and control of plant IAS and limit the spread and further introductions of such plants and of those that are potentially invasive because of their known impacts elsewhere;

3. Encourage plant IAS practitioners and experts in the countries concerned to share experiences, skills, technologies and data on the inventory, monitoring, management, control and eradication of such plants;

4. Recommend the preparation of 'Codes of Conduct' for stakeholder groups, including both the public and the private sector, that take into account, adapt, and build on existing guidelines where these exist;

5. Urge governments and donor agencies to increase funding to facilitate the development of prevention, management and monitoring programmes, essential research, and economic analysis on invasive alien plants;

6. Encourage the development of national inventories of invasive alien plants in the Mediterranean type climate countries, using appropriate information technology; suggest the Global Invasive Alien Database as a clearing house mechanism; further the development of spatial tools to assist in the management of plant IAS; and encourage governments to support the exchange of information, methodologies and staff in biological control programmes;

7. Call upon the countries to cooperate in the development and distribution of materials for public awareness and education.

2. Invitent les gouvernements à s'assurer que leur législation et leur réglementation prennent effectivement en compte la gestion et le contrôle de plantes exotiques envahissantes et limitent la dispersion et l'introduction de ces espèces et de celles qui peuvent être envahissantes en raison d'effets qui ont pu être constatés ailleurs,

3. Encouragent les gestionnaires et les experts de plantes exotiques envahissantes dans les pays intéressés à partager expériences, compétences, technologies et données en matière d'inventaire, de suivi, de contrôle et d'éradication de ces espèces,

4. Recommandent la préparation de codes de conduite pour les groupes d'acteurs, qu'ils soient du secteur public ou du secteur privé, en prenant en compte, en adaptant et en développant le cas échéant, les directives existantes,

5. Pressent les gouvernements et les autres institutions donatrices d'augmenter les financements pour permettre le développement de programmes de prévention, de gestion et de suivi, les recherches nécessaires et les études économiques sur les plantes exotiques envahissantes,

6. Encouragent l'élaboration d'inventaires nationaux dans les pays à écosystèmes de type méditerranéen en faisant appel aux moyens informatiques appropriés ; proposent la *Global Invasive Database* comme outil de collecte d'informations ; soutiennent l'élaboration d'outils d'aménagement du territoire pour gérer les plantes exotiques envahissantes ; et encouragent les gouvernements à soutenir l'échange d'informations, de méthodologies et de personnels dans le cadre de programmes de contrôle biologique,

7. Appellent les pays à coopérer pour l'élaboration et la distribution de matériels destinés à la sensibilisation et à la formation du grand public.

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/
Articles

Lists of invasive plants and criteria: state of the art

/

Elaboration de listes de plantes envahissantes : état des lieux

Setting priorities for invasive alien plant management in South Africa

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South Africa

Abstract

South Africa has a major problem with invasive alien plants. Hundreds of species already have wide distributions in the country, and many others show signs of starting to invade. The country has a very ambitious national programme ("Working for Water") that is tackling invasive plant species in all natural and semi-natural ecosystems. Despite encouraging progress over the past decade, the problem is immense, and much work remains to be done to ensure the best use of resources. This paper reviews several research projects undertaken recently to guide medium- and long-term planning of control operations.

Research was done to provide objective lists of the most widespread and abundant invasive alien species ("major invaders") and those species that have only recently shown invasive tendencies ("emerging invaders"). The main lists, and groupings within them, provide a useful means for prioritising species for a range of interventions. These lists, however, provide a static picture of the current situation with regard to plant invasions.

There is, however, no protocol for assessing the likely future spread patterns needed to inform medium- to long-term planning. A detailed assessment was made of the environmental correlates of distribution of the 71 most widespread and abundant species, and implications were explored for invasions in different vegetation types in the region over the next few decades. Most species are currently confined to 10% or less of the region, but could potentially invade up to 40%. Over a third of the modelled species have limited potential to substantially expand their distribution. About 20% of the vegetation types have low invasion potential where fewer than five species can invade, and about 10% have high invasion potential, being potentially suitable for more than 25 of the plant invaders. These results suggest that management of

the invasive plant species that are currently most widespread should focus on reducing densities, for example through biological control programmes, rather than on controlling range expansions. Areas that require additional management focus in the future were identified.

Emerging invaders provide a special problem for long-term planning. A climate-matching procedure was used to define areas of southern Africa that could be invaded by 28 plant species classified as emerging invaders. There was no relationship between the extent of the climatically suitable area of the different species and an expert ranking of their invasion potential, emphasising the uncertainties inherent in making assessments based on very little information. The results also highlight the importance of early warning systems and risk assessment of newly introduced alien plants in South Africa, and emphasise the importance of dealing with alien plant invaders in the early stages of invasion.

The studies discussed above relate to actual and potential distributions of invasive plant species, but make no assessment of actual and potential impact. A study was made of the potential impacts of 71 major and 28 emerging plant invaders on biodiversity, water resources, and natural rangelands in southern Africa. Impact scores, derived from the literature and expert inputs, included the per capita impact estimated using attributes such as size and growth form, multiplied by the natural ability of species to form dense stands as an index of population-level impact. Such information provides a useful input to long-term planning and scenario development.

Introduction

South Africa has a major problem with invasive alien plants (Richardson *et al.* 1997). Hundreds of species already have wide distributions in the country, and many others are starting to invade. The country has a very ambitious national programme ("Working for Water") that is co-ordinating the integrated management of invasive plant species in all natural and semi-natural ecosystems (van Wilgen *et al.* 1998). Initiatives underway include large-scale mechanical clearing of invaders followed by restoration of degraded sites, a major investment in biological control (Moran *et al.* 2005), and many projects aimed at reducing the use of invasive species in spheres such as horticulture. Despite encouraging progress over the past decade, the problem is immense, and much work remains to be done to ensure the best use of scarce resources. This paper reviews several recent and ongoing projects undertaken to guide medium- and long-term planning of control operations. The initiatives involve the objective listing and further categorization of “major” and “emerging” invaders, predicting the potential ranges of the major current invaders, gaining better knowledge of the geographical distribution of areas most affected by plant invasions, and predicting the invasive potential of emerging invaders.

Objectively defined lists of major and emerging invaders

The problem of alien plant invasions in South Africa is so severe that not all invasive species can receive the same level of management, or indeed any management. Some species require multi-facetted efforts that must be sustained over large areas over decades. Other species call for more focussed interventions, for example where eradication is potentially an option, or where the species are commercially important and hence desirable in parts of the landscape. Yet others, including many with short residence times in the country, require only careful surveillance or perhaps pro-active biological control. Interventions need to be prioritised on the basis of objective criteria. South Africa has several “lists” of invasive alien plant species, and several attempts have been made to categorise or prioritise species for various purposes (e.g. Robertson *et al.* 2003). None of these lists provides the level of detail, especially relating to spatial dimensions of the problem, for planning interventions at the national scale in the medium to long term. What follows is a brief summary of a recently completed classification of invasive alien plant species in South Africa for the purpose of prioritizing species and areas for management action (Nel *et al*. 2004).

For information on species distributions, the exercise drew mainly on data in the South African Plant Invader Atlas (SAPIA) which contains records for over 500 species in South Africa, Lesotho and Swaziland. Data in SAPIA were collected mainly during a series of extensive roadside surveys undertaken by L. Henderson (1979–1993) and during a national atlassing exercise (1994–1998), with additional data collected on an *ad hoc* basis after 1999 (Henderson 1998). Most data in SAPIA were collected at the scale of quarter-degree cells (15' latitude x 15' longitude, hereafter sixteenth degree cells). SAPIA also contains information on habitat and abundance. These data provided the required spatial dimensions for the compilation of the required list.

Various filtering approaches were applied to define lists of “major invaders” (species already well established in the country, with potentially severe impacts) and “emerging invaders’ (species at an early stage of invasion – either only recently introduced, or only recently entered a phase of rapid population growth). Criteria that were considered included the number of records in the SAPIA database and considerations of habitat and range/abundance. The lists consider only invaders of natural and semi-natural habitats and excludes species that invade mainly agricultural or otherwise transformed land. For non-riparian species, only species that are known to invade natural vegetation were included. Preliminary lists were prepared for consideration by experts, both through communication of lists via e-mail and numerous personal contacts, and through focussed consideration of species for which less information was available at a workshop. 571 species were considered in this process. Initial screening protocols divided these into preliminary lists of major (82 species) and emerging invaders (454 species). Final deliberation and fine-tuning of the lists at the workshop of experts focussed on the extent to which species could invade and impact on natural and semi-natural ecosystems and (for emerging species) the extent to which the combination of their current range, potentially invisible habitat in South Africa, and/or the size of the current and likely future propagule bank affected the risk of invasion. The final lists comprised 117 “major invaders” and 84 “emerging invaders” (Table 1).

The classification of species within the categories of “major invaders” and “emerging invaders” (Table 1) provides the means for prioritisation of management actions. For instance, among the major invaders, species at the top left-hand corner of Table 1(a) are those that demand major multi-level and multi-faceted programmes. Species in other boxes within the shaded area call for a variety of approaches, the features of which depend on the species concerned. Similarly, for the emerging invaders, the position of species within the framework reveals a range of potential intervention strategies. The objective listing of species in categories as described above also provides a sound basis for national-scale monitoring, probably most meaningfully at the decadal scale, to determine broad-scale trends of emerging species and the level of success achieved in various interventions.

(a)

Range	"Abundance"			Total
	Abundance	Common	Scarce	
Very Widespread	3	8	0	11(11)
Widespread	22	46	2	70 (70)
Localised	36	60	81	177(36)
Total	61(61)	114(54)	83(2)	258 (117)

(b)

Propagule pool size	Range				
	Large	Moderate	Riparian	Small	Total
Large	4	22	7	3	36(36)
Moderate	7	29	9	11	56(45)
Small	3	8	4	8	23(3)
Total	14(14)	59(51)	20(16)	22(3)	115(84)

Table 1. Numbers of species in each sub-category of "major invaders" (a) and "emerging invaders" (b) in South Africa (see text; from Nel et al. 2004). Highlighted cells indicate the sub-categories finally included in "major" and "emerging" categories.

Predicting future spread – an essential requirement for informing long-term management strategy at the national scale

The lists derived from the procedures described above are very useful for assigning priority, but they reflect a static snapshot of the current situation. Recently, an attempt was made to define the potential ranges of the suite of most important current invaders (Rouget *et al.* 2004). The rationale was that these species are sure to continue to constitute the bulk of the problem well into the future and that knowing the potential for further spread of these species is important for designing intervention strategies. Seventy-one of the "major invaders" as defined by Nel *et al.* (2004) were selected for study - those for which 50 or more distribution records were available in SAPIA (preliminary analyses revealed that modelling generally yielded dubious results for species with fewer records). A variant of climate-envelope modelling (Farber and Kadmon 2003) was used to produce climate-suitability surfaces for each species. Invasion potential was considered for the nine major terrestrial biomes of southern Africa, and for the 441 vegetation types recognized in a recent national-scale vegetation mapping exercise (Mucina and Rutherford 2004).

Results showed that most species are currently confined to 10% or less of the region, but that some could potentially invade up to 40%. However, about a third of the modelled species have limited potential to substantially expand their distribution. About 20% of the vegetation types have low invasion potential where fewer than five species can invade, and about 10% have high invasion potential, being potentially suitable for more than 25 of the plant invaders. Areas that require additional management focus in the future were identified. Results suggest that management of most invasive plant species that are currently most widespread should focus on reducing densities, for example through biological control programmes, rather than on controlling range expansions.

Focus on emerging invaders

Emerging invaders are a special problem for long-term planning in the management of biological invasions. It is often difficult to justify intervention for species that have yet to invade large areas or have obvious impacts, even where such species are known to be highly invasive elsewhere in the world. Yet, it is well known that intervention at the early stage of invasion is most cost-effective (Rejmánek & Pitcairn 2002). Objective means are required to identify those emerging invaders that warrant priority attention.

A climate-matching procedure was used to define areas of southern Africa that could be invaded by 28 plant species classified as emerging invaders. The 28 species were selected from the list of “emerging invaders” defined by Nel et al. (2004; see above), taking only those species identified as most important (using several objective criteria), but ensuring that at least one species was present from each main sub-category of emerging invaders (Table 1, lower section). Clearly, distribution data from South Africa are inadequate for modelling the potential range of such species, so climatic profiles were collated for the selected species from those parts of the world with generally similar climates and where good species distribution data were available. The procedure used data from Australia and the USA together with the South African data. The CLIMATE model, which uses 16 climate variables based on temperature and rainfall data, was used to construct preliminary climatic profiles for each species. These were then converted to "climatic-envelope surfaces" at a resolution of 1'x1' grid cells. Surfaces for all 28 species were added together to create a final combined surface – theoretically providing an objective estimate of areas most likely to be invaded by a representative sample of emerging invaders (Figure 2).

A clear positive relationship existed between the current range of species and their potential range in South Africa. Importantly, there was no relationship between the extent of the climatically suitable area for the different species and an expert ranking of their invasion potential, emphasising the uncertainties inherent in making assessments based on little information. Emerging invaders are not predicted to invade substantial "new areas" – i.e. they are invading similar areas to major weeds.

These results provide useful inputs for the prioritisation of efforts on emerging species, for instance when deciding which species should be flagged for investment in biological control (Olckers 2004).

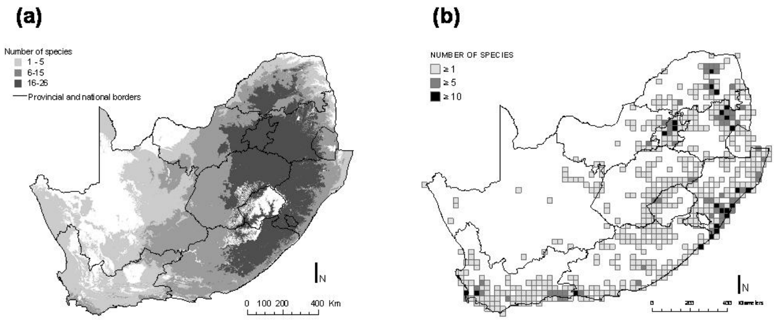

Figure 2. Potential (a) and current (b) distribution of 28 emerging plant invaders (see text). Data on current distributions is from Nel *et al.* (2004) and the SAPIA database (Henderson 1998).

Assessing potential impacts of major and emerging plant invaders

The studies discussed above relate to actual and potential *distributions* of invasive plant species, but make no assessment of actual and potential impact. A preliminary study was made of the potential impacts of 71 major and 28 emerging plant invaders on biodiversity, water resources, and natural rangelands in southern Africa. Impact scores, derived from the literature and expert inputs, included the per capita impact estimated using attributes such as size and growth form, multiplied by the ability of species to form dense stands as an index of population-level impact.

The population impact scores of individual species on water resources were generally similar to previous assessments. Some previously underrated species achieved high impact scores on biodiversity and rangelands because they can transform natural communities or are toxic to livestock. The total impact scores for species were markedly affected by the extent of the climatically suitable area. Some *Opuntia* species achieved high scores because they can invade most of the arid and semi-arid interior as well as higher rainfall areas. *Prosopis glandulosa*, which invades the arid interior, also achieved a high score. Riparian invaders such as *Arundo donax*, and species of *Acacia* and *Populus* can invade a large proportion of the river systems in the region. The geographic distribution of the population impacts of the major species on biodiversity and water resources differed substantially from those on rangelands, but rangeland impacts differed little from those based on the number of species alone. This was not the case for the emerging species, where the predicted impacts on rangelands, biodiversity and water resources differed little from those based on species number. The number of species invading an area was not a good indicator of the potential impact. Species numbers alone can only be used to estimate the potential impacts when most of the predicted distributions or impact scores, or both, are similar. Such information provides a useful input to long-term planning and scenario development.

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Development of a ranked inventory of invasive plants that threaten wildlands in the western United States

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Abstract

One of the primary tasks of the California Invasive Plant Council is to develop a ranked inventory of invasive plants of greatest ecological concern in California. Previous lists were developed through expert consensus and not through a repeatable ecologically-based decision making process. As a result, we created a risk assessment criteria that provide a uniform methodology for evaluating and ranking invasive non-native plants that threaten wildlands. The ranking and listing system for each species is based on several questions associated with three key factors including the severity of ecological impact, biological potential for invasion, and the extent of distribution. The overall goal is to create a ranked inventory of invasive weeds that is scientifically defensible, contains extensive information useful to land managers, and provides transparent ranking criteria that are accessible to the user. It is expected to be widely used to educate policy makers and support land management decisions. The list will also serve to identify important information gaps in our understanding of the impacts and invasive potential of existing non-native plants. The current evaluation process will consider 350 invasive plant species. The evaluations resulting from the systematic application of these criteria will group invasive non-native plant species into three categories based directly on the overall scores derived from the criteria-based evaluations. Species categorised as High, Moderate, and Low, including Alerts, will be included in final publications of the ranked inventory, with another set of species that were evaluated but not listed.

Most states within the U.S. have established “noxious weed lists.” Similarly the United States Department of Agriculture has developed a federal noxious weed list. These lists typically focus on species that threaten agricultural production (crops and rangeland) and other economic interests, but rarely include invasive plants that damage native ecosystems.

Historical perspective

In 1994, the California Invasive Plant Council (Cal-IPC, formerly known as the California Exotic Pest Plant Council, or CalEPPC) initially produced a list of invasive non-native plant species for California based on the professional opinions of weed scientists and land managers statewide. The compilation, entitled *The CalEPPC List: Exotic Pest Plants of Greatest Ecological Concern in California* (1994), was envisioned as a quick-reference educational resource about non-native species that were problems in wildlands. A Cal-IPC committee subsequently revised the list in 1996 and again in 1999 based on substantial new information about certain species, including some that had not been listed previously. These lists were widely distributed in print form and on the Cal-IPC website (http://groups.ucanr.org/ceppc/1999_Cal-IPC_list/).

The 1999 version of the list contained 146 species categorised under the following groups:

- List A: Most invasive wildland pest plants; A-1 widespread (20 species) and A-2 regional (19 species);
- List B: Wildland pest plants of lesser invasiveness (34 species);
- Red alert: Species with potential to spread explosively but currently restricted in distribution (16 species);
- Need more information (49 species).

The original list and its 1999 revision were produced by a small committee of experts, which limited the number of plants that were evaluated. Because the original list rankings were made based on the collective personal experience of a small group of weed professionals across the state, objective criteria and ranking mechanics were not developed, and the ranking process was neither fully transparent nor documented.

From its inception, the list generated considerable interest and usage among land managers, agency administrators, landscape designers, botanists, and volunteer restoration groups, and has become the authoritative reference on wildland weeds in the state. As a planning tool, the list helps users base their land management strategies on priorities derived from an assessment of risks from ranked weeds. However, in recent years some state and local agencies have used the list to guide management priorities and to restrict plantings on public or private lands. The list is now frequently cited as an authoritative document for planning and management purposes. Thus, the inventory is increasingly applied in a quasi-regulatory role to support recommendations for natural resource management.

As the list's usage and visibility grew, so did the need to make it more transparent, more scientifically (and therefore, legally) defensible, and more comprehensive. As a result, Cal-IPC undertook an extensive revision process to address these issues.

Goals and criteria of new list

Because the increasingly authoritative status of the list grew beyond the original intent of the ranking, Cal-IPC embarked on an effort to develop the "Criteria for Categorizing Invasive Non-Native Plants that Threaten Wildlands" in 2000. Prior to the development of these criteria, a list committee was formed to review the existing criteria-based, invasive species ranking systems from the United States and other areas around the world.

Similar projects have been undertaken in Florida (Fox *et al.* 2000), New England (Mehrhoff 2000), and over a decade ago at the United States National Park Service (Hiebert and Stebbendieck 1993). The Nature Conservancy has recently developed a set of criteria for ranking invasive species (Morse *et al.* 2004). Australia (AQIS 2000; Weiss and McLaren 1999) and New Zealand (Timmins and Williams 1987) have been at the forefront of developing novel approaches to weed ranking. Others have looked at ranking bird and mammal pests (Smallwood and Salmon 1992), as well as fish (Kolar and Lodge 2004). Based on the regional goals identified by the committee, including the development of criteria focused on ecological impacts, the committee chose to adapt, as a template, the format and content of protocols developed by NatureServe and The Nature Conservancy (Randall *et al.* 2003).

After establishing a committee, the first step in the process was to define invasive plants that threaten wildlands as plants that are not native to, yet can spread into, the wildland ecosystems under consideration and either displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

By 2003, the committee completed a new set of risk assessment criteria to provide a transparent, repeatable, and credible basis to identify invasive plants that threaten wildlands (Warner *et al.* 2003). The new criteria, entitled "Criteria for Categorising Invasive Non-native Plants that Threaten Wildlands," distinguish between those non-native species that pose a significant threat to wildlands and those that pose a lesser threat or little threat. It provides a uniform methodology for evaluating and ranking invasive non-native plants that threaten wildlands. The overall goal of this project was to create a ranked inventory of the state's invasive weeds that will

- be scientifically defensible,
- contain (and connect to) extensive information useful to land managers, and
- provide transparent ranking criteria that are accessible to the user.

There are several important benefits to developing a scientifically defensible inventory for invasive plants. While previous lists lacked supporting documentation, the documentation required to substantiate each ranking in this new process will facilitate a specific and thorough response to any challenges to the validity of a particular ranking. In light of the quasi-regulatory uses of the list, the ability to address a set of specific criteria will increase the overall credibility of the ranking process itself and the resulting lists. The justification and documentation for the ranking of each species will be readily available through the Cal-IPC website, further increasing accessibility to list users. Finally, transparent criteria will enable inventory users to participate more directly in the process of ranking California's invasive weeds. It will encourage objectivity, promote ongoing discussion and evaluation, and foster increased use of scientifically derived evidence and documentation. It will also provide an objective mechanism for revising the inventory rankings.

In addition to scientists and land managers from California, the criteria were developed in cooperation with weed experts from Arizona and Nevada as a tri-state effort. Participation by the three states also offered the opportunity to develop consistent regional criteria for ranking invasive plants.

Criteria format

The criteria for evaluating invasive plants are divided into three major categories, ecological impacts, invasive potential, and ecological amplitude and distribution. Each of the categories addresses specific issues in more detailed questions (Table 1).

A scored is tallied in each of these categories based on the answers provided. Scores from the first three sections are combined to yield an overall ranking. A species can be ranked into one of six possible categories, High, Medium, Low, High Alert, Medium Alert, and evaluated but not listed. The first five of these will be used to generate statewide lists of invasive plant species. Associated with each question is a ranking of the reliability of the documentation cited in the evaluation process. The full evaluations, including score sheets, available references, and results for all species evaluated are available on the Cal-IPC website (cal-ipc.org) and a copy of the cited references are retained at the society headquarters in Berkeley, California.

Category	Question area
Ecological Impact	Impact on abiotic ecosystem processes
	Impact on plant community composition, structure, and interactions
	Impacts on higher trophic levels
	Impact on genetic integrity
Invasive Potential (Species' ability to invade natural communities)	Role of anthropogenic and natural disturbance in establishment
	Local rate of spread with no management
	Recent trend in total area infested within state
	Innate reproductive potential
	Potential for human-caused dispersal
	Potential for natural long-distance dispersal
	Other regions invaded outside of state or country
Ecological amplitude and distribution (Species current occurrence across different ecological types; based on Holland 1986, and the extent of invasion within infested ecosystems)	Ecological amplitude
	Distribution

Table 1. Categories and questions areas used in the evaluation criteria and ranking process.

The final ranking categories are defined as follows:

– **High**: These species have severe ecological impacts on ecosystems, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. These species are usually widely distributed ecologically, both among and within ecosystems.

– **Medium**: These species have substantial, but generally not severe, ecological impacts on ecosystems, plant and animal communities, and vegetation structure. Their reproductive biology is conducive to moderate to high rates of dispersal, though establishment is generally dependent on ecological disturbance. Ecological amplitude and distribution may be limited to widespread.

– **Low**: The ecological impacts of these species are minor (though potentially significant in specific cases). Their reproductive biology and other invasiveness attributes result in low to moderate rates of invasion. Ecological amplitude and distribution are generally limited, although these species may be locally persistent and problematic.
– **Alert**: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. The designation alerts managers to species capable of rapidly invading unexploited ecosystems, based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.
– **Evaluated but not listed**: In general, this designation is for species for which information is currently inadequate to respond with certainty to the minimum number of criteria questions, or for which the sum effects of ecological impacts, invasiveness, and ecological amplitude and distribution fall below the threshold for listing (i.e., the overall rank falls below Low). Many such species are widespread but are not known to have substantial ecological impacts (though such evidence may appear in the future).

Evaluation process

With the completion of the criteria in 2003, Cal-IPC set as a goal the evaluation and ranking of approximately 300 invasive plant species using the risk assessment process. These species were chosen based on existing records and data, such as previously published lists of invasive species or recommendations from observers, managers, scientists and others.

To complete the statewide ranked inventory, an expert committee consisting of eight individuals was formed comprising people with experience in invasive species biology, plant ecology and taxonomy, and land management. This team provides final review of each actual plant assessment for completeness, accuracy and consistency, and is the final arbiter of each plant’s evaluation.

After determining the species to be evaluated and developing the list committee, Cal-IPC staff and student employees were hired to obtain documentation and information for each of the thirteen criteria (questions) that were assessed. This not only required extensive literature searches to find published material but also surveys of California land managers to request unpublished observational data. All copies of the literature were provided to the Cal-IPC office.

Experts in individual species from around the state were identified and ask to serve as reviewers. This process of soliciting input from the broadest spectrum of expertise ensures that the system has widespread support and usefulness. These reviewers were provided with a copy of the available literature for the species which they provided expertise and were asked to complete a Plant Assessment Form (PAF) for that species. These reviewers conducted the preliminary assessment using the criteria previously discussed.

The list committee met on several occasions to review the draft PAFs sent in by the reviewers. The committee considered the evaluation and supporting documentation in order to render a consensus group decision on ranking or categorising the each species. To date, nearly 200 plant evaluations have been completed, with a complete date estimated to be October 2005. The completed PAFs are posted on the Cal-IPC website (cal-ipc.org) for comment by the membership.

Deliverables

Once all species have been evaluated, a final list of ranked invasive plants will be made available on the Cal-IPC website and published in print form for dispersed at a variety of meetings throughout the state, as well as through extensive Cal-IPC mailings. Although the adopted rankings will be statewide, the criteria can be adapted to develop regional lists for specific regions (i.e., Weed Management Areas, individual counties, or watershed areas). Furthermore, other states can use information available from the California literature databases to more effectively and economically develop their specific lists. Researchers can also utilise the completed PAFs to identify important gaps in our understanding of the biology and impact of invasive plants on abiotic and biotic processes.

Although management considerations are not a component of the criteria, linking the inventory to management information about specific invasive plants will make the inventory a more powerful tool for land managers. Several resources have come on-line that will be linked to the inventory, including the compiled management information provided in sources like *Invasive Plants of California's Wildlands* (Bossard *et al.* 2000). This resource was published by Cal-IPC and is available in its entirety on its website.

It is important to note that the evaluation and ranking of invasive plants is an ongoing, iterative process. When substantial and substantiated new information becomes available, the committee will re-evaluate, especially if the new data would potentially influence the ranking outcome.

Finally, this comprehensive, up-to-date inventory and prioritisation of the suite of invasive plant species in California will provide the important pre-cursor to future efforts to develop more effective pre-screening criteria for new non-native plant introductions. This initial set of criteria can be tested and applied to potentially threatening species not yet present in California. However, development of predictive weed risk assessment models requires this first step of applying rigorous criteria to plants with known behaviors and characters before moving forward to the next crucial steps of prediction and prevention.

To see the full document, the existing 1999 list of invasive plants, the new Plant Assessment Forms (PAF), as well as completed species PAFs, see the California Invasive Plant Council website at www.cal-ipc.org.

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A method of selection and hierarchisation of the invasive and potentially invasive plants in continental Mediterranean France

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Abstract

Which among the exotic plants in the French Mediterranean area are considered invasive ?

Managers and politicians need to know clearly which of the species present in their country are invasive in order to efficiently allocate resources to the monitoring and management actions.

We propose a simple, reproducible method based on on-field knowledge to determine which of the exotic species present in the French Mediterranean area are major or emerging invaders, which ones are potential invaders to monitor, and which one do not present a risk.

It is based on 3 criteria :

– Status of the exotic species in Mediterranean France

We focused on naturalised and casual plants as 2 different groups, xcluding protected species and the ones having a close geographic origin. Their dynamism was included in the process too.

– Impacts of the species on natural and semi-natural ecosystems

We selected the species having more than 50 % of their population in natural or semi-natural ecosystems, with a particular interest on the density of their populations and potential genetic impact.

– Comparison with other regions of the world

The behaviour of the species in other parts of the world is a good indicator of their invasiveness.We compared species developing in landscape habitats with lists of invasive plants in mediterranean countries and species developing in riparian habitats with the Global Compendium of Weeds.

Then, the frequency for each naturalised species passing these criteria made the distinction between major and emerging invaders.

This work leads to a list of major and emerging invasive plants to manage in priority, a list of potential invaders to monitor and allows conclusions on the characteristics of these species.

Introduction

According to the most currently used definition, invasive plants are defined as "alien plants spreading naturally (without the assistance of people) in natural or semi-natural habitats, to produce a significant change in terms of composition, structure or ecosystem processes" (Cronk & Fuller, 1995).

This definition refers to the damaging impact of the species on environment, i.e. ecological notions corresponding to the phenomenon of biological invasion.

In order to clarify the concepts and the definitions used in the biological invasion vocabulary, Richardson *et al.* (2000) and Nel *et al.* (2004) suggest basing the definition of « invasive » on the spreading speed of the plant, without any relation to its damaging ability.

The notion of environmental impact reappears as the "transformer" concept (Richardson *et al.*, 2000; Pysek *et al.*, 2004): "transformers are a category of invasive species (therefore xenophytes only) which are able to change the characteristics of ecosystems over large areas".

Therefore, an « invasive plant » according to Cronk & Fuller (1996) is a « transformer » according to Richardson *et al.* (2000).

At present, one of the most current expressions on invasive plants is: "Invasive alien species are considered to be the most important threat to biological diversity loss after habitat destruction" (UNEP 2001).

In order to facilitate the understanding in the biological invasion field, we have to rely on notions admitted and shared by everybody. Considering the amount and the urgency of remaining work, species with small impacts on ecosystems cannot be considered as "invasive". In the method we propose, "invasive plant" means "transformer". This definition, however, agrees with those of "major invader" and "emerging invader" (Nel *et al.*, 2004):

- “major invaders” are those invasive alien species that are well-established, and which already have a substantial impact on natural and semi-natural ecosystems
- “emerging invaders” currently have less impact, but have attributes and potentially suitable habitats that could result in increased range and impact in the next few decades.

The present method aims at selecting and prioritising xenophytes which represent an established or potential threat to natural or semi-natural French Mediterranean ecosystems and, are thus good candidates for eradication and management action. Only species established and recorded in the area are taken into account. Non-introduced potentially dangerous species need to be studied using other methods (Pest Risk Analysis et Weed Risk Assessment); to deal with such a problem requires different tools (literature, climatic predictions: Kriticos & Randall, ...).

Our method is based on field information and easily accessible data from other countries. The criteria used are simple and reproducible:

- The initial list includes all the non-indigenous species of the study area, i.e. those being naturalised and casual introductions. From this list, we remove species that are protected, declining, and those of geographically close origin.
- Naturalised species are included in the analysis. Their environmental impact in the study area is assessed, and then compared with their impact in other world regions with similar climatic conditions. Some special cases are studied. The frequency of these species allows us to define 2 categories: major invaders and emerging invaders.
- Casual species are studied only through bibliographic data concerning their invasive potentialities in other world regions with similar climatic conditions.

The method is applied to the French Mediterranean area (as defined by Quezel, 1985, and Quezel & Medail, 2003), which belongs to the Mediterranean Basin biogeographical zone. Other world regions with similar climatic conditions (South Africa, Chile, south-western Australia, California) are designated as “other Mediterranean regions”.

Initial list of non-indigenous species in the French Mediterranean area

Naturalised and casual species

The terms "naturalised" and "casual" are used according to the definition by Pysek *et al*. (2004). We exclude the archeophytes, doubtfully indigenous species (for example *Anagyris foetida* L., *Stachys germanica* L., *Tanacetum vulgare* L.), cultural relics which cannot spread outside of their plantation places (for example *Crocus* spp., *Narcissus* spp., *Perovskia* spp., *Phlox* spp., *Tilia* spp), and most of the infraspecific taxa, except some that are well-characterised (*Pinus nigra* Arnold subsp. *Nigra*).

Among the 1253 introduced species known at present in the French Mediterranean area (project "Flore méditerranéenne, CBNMP"), the following have been retained:

– 351 naturalised or naturalising species (6 of which have not been observed since at least 20 years)
– 902 casual introductions (586 of which have not been observed since at least 20 years).

Protected species

Species that receive legal protection are eliminated from the selection of those that are invasive: these by definition are rare and/or vulnerable; in addition, their legal protection prevents eradication action. This category includes 12 naturalized and 8 casual species. The selection is then continued with 339 naturalized and 894 casual species.

Dynamism

Only species that are spreading geographically can be considered as invasive. Since there is little available data prior to 1970 in the French Mediterranean area, apparent progressions may be overestimations, and, at the same time, apparent declines may be due to underestimated figures. Thus we assume that species suffering a sharp decline since 1970 are unlikely to become dynamic in the future.

As this reasoning requires long term observation, it cannot be applied to casual species.

Among the 339 naturalised (and non-protected) French Mediterranean species, 27 have disappeared or have clearly declined since their discovery. The selection in then continued with 312 naturalised and 894 casual species.

Geographical origin

A third restriction concerns species of close geographical origin: the southern half of France, the northern half of Italy, Corsica, Sardegna and the north-eastern half of the Iberian Peninsula. Because it is difficult to consider such species as real xenophytes (Pysek *et al.*, 2004; Jauzein, 1997), they are removed from the list of potential invaders. This decision, however, may be reconsidered if one of these species appears to be truly invasive.

Thirty-one naturalised and 203 casual species are concerned. Three additional naturalised species remain under study: *Cytisus striatus* (Hill) Rothm., *Periploca graeca* L. and *Pinus nigra* Arnold subsp. *nigra*; these species are indigenous in neighbouring countries, but they have been deliberately introduced in France, and are densely spreading in natural biotopes. The selection is then continued with 281 naturalized and 691 casual species.

The next stage in this method is the impact study, which requires a good knowledge of the on-field behaviour of each species in the French Mediterranean area. This behaviour is considered as known and roughly predictable for the naturalised species, but not for the casual species which lack a sufficient quantity of observations. Consequently, naturalised and casual species are studied separately from this point on.

Study of naturalised species

Impact

Target biotopes

The present method concerns only species well-established in natural or semi-natural biotopes: by definition, invasive species represent a threat to biodiversity, the same as weeds and ruderal species represent respectively agronomical and urban threats.

According to Nel *et al.* (2004), species having less than 50% of stations in natural or semi-natural biotopes are usually considered to be risk-free. Most of these species are nitrophilous and not competitive; however great their vigour in secondary biotopes, they are poorly equipped to deal with native biodiversity, and hardly show any dynamism in open places lacking nitrates (ex.: *Amaranthus* spp., *Erigeron* spp., *Euphorbia* subgen. *Chamaesyce*, etc.).

Recently introduced species do not fit completely this rule, because a phase of enforcement and multiplication in secondary biotopes usually occurs before the invasion of natural biotopes (Kornas, 1990; Richardson *et al.*, 2000; Pysek *et al.*, 2004). Consequently, we did not apply the 50% rule to strongly dynamic species introduced in the last 20 years. This peculiarity concerns a single species, *Bothriochloa barbinodis* (Lag.) Herter (= *Dichanthium saccharoides* auct. gall.), which will be discussed together with the 3 previously quoted special cases.

Among the 281 selected naturalized species, 184 are considered as not well-established in natural or semi-natural biotopes. The selection is then continued with 97 naturalised species, including 4 special cases.

Overcrowding of the biotope

The species selected by this method are known as “transformers”: a transformer is able not only to establish itself in natural or semi-natural biotopes, but also to reduce biotope biodiversity. The overcrowding criterion is accepted if at least one 80% covering population of the species is known in a natural biotope in the study area. This behaviour is usually regular: the first evidence can be retained as unquestionable proof, and, very often, occurs as early as the first establishment in a primary biotope. Some species are able to change the nature of the substrate (allelopathy, salt or plant fragment accumulation); such effects are not taken into account, firstly due to the lack of information, secondly because they are proved only for strongly overcrowding species (*Carpobrotus*).

A few atypical cases are known: overcrowding without loss of biodiversity (*Ailanthus altissima* (Miller) Swingle and *Oxalis pes-caprae* L. in the Mediterranean islands: VILA *et al.*, 2004), or, on the contrary, apparent competition with an indigenous species without overcrowding (*Bidens frondosa* L. vs. *B. tripartita* L.). However, the information we have on these cases is not accurate enough to take them into account.

Successful integration is characterised by a moderate covering in natural and semi-natural biotopes (32 species). The selection in then continued with 65 naturalized species, including the 4 special cases.

Genetic impact

The risk of « genetic pollution » of indigenous taxa by those introduced and taxonomically close taxa is kept as selection criterion in some countries (Pheloung, 1995). However, no such impact has been proven in the French Mediterranean area. Only two introduced pine trees, *Pinus halepensis* Miller subsp. *brutia* (Tenore) E. Murray and *Pinus nigra* Arnold subsp. *nigra*, may cause introgressive hybridisation of their indigenous homologues, *P. halepensis* subsp. *halepensis* and *P. nigra* subsp. *salzmannii* (Dunal) Franco, but this fact has not been demonstrated.

The 217 naturalised species which are not retained through the impact criterion (184 in secondary biotopes only, 33 in primary biotopes but not overcrowding) may be interpreted as dynamic plants which up to date have not had any opportunity to become really invasive. Most of them are probably unable to establish themselves in natural biotopes, but some may still be in a multiplication phase ("lag phase"). The lag phase is usually short (a few decades: Kornas, 1990), but some exceptions are known: for example *Ambrosia artemisiifolia* L., a strictly ruderal species during the last century, which begun to invade riverbanks a few years ago.

Following these data, these species are to be placed under surveillance: this means that some of them may become invasive in the future. We propose to respect their present populations, and to locally eradicate them if abnormal proliferations occur.

At this stage, 65 naturalised species remain potentially invasive. It is time to study their behaviour in other regions of the world.

Comparison with other regions

The comparison of invasiveness behaviour in other regions, at least in those having similar climatic conditions, is used as investigation method since the demonstration of REICHARD (2001). However, in our opinion, this criterion is not very suitable: it depends on many poorly known elements linked to history, human activities, local climatic peculiarities, microflora, etc. Therefore, it can be retained only if it agrees with the ground data.

Moreover, southern continental France stays in northern marginal position with respect to the Mediterranean area *sensu stricto*, which sometimes leads to strongly atypical impacts: some species currently known as invasive in Mediterranean climate are not invasive in southern France (*Eupatorium adenophorum* Sprengel, *Arundo donax* L.) or very locally invasive (*Oxalis pes-caprae* L., *Acacia dealbata* Link); on the contrary, some usually non-thermophilous species show threatening behaviour in alluvial forests (*Parthenocissus inserta* (A. Kerner) Fritsch).

According to these elements, invasive capacities known in other Mediterranean regions of the world (southern and eastern Mediterranean basin, South Africa, California, Chile, south-western Australia) cannot be systematically extrapolated to the French Mediterranean area.

Wet biotopes, according to the definition of Nel *et al*. (2004), are more vulnerable to invasions than dry biotopes in the Mediterranean region (Quezel *et al*., 1990). Hence, two cases may occur:

– If the species colonises only dry biotopes, it is regarded as dangerous if it is declared as invasive in at least one other Mediterranean country in the world (Brunel & Tison, 2005). However, exceptions are possible: an invasive species may be unrecognized due to a taxonomic confusion (ex: *Senecio angulatus* L.f.) or because it was never introduced elsewhere (ex: *Bothriochloa barbinodis* (Lag.) Herter).
– If the species colonises wet biotopes (with or without dry biotopes), it is regarded as dangerous independently of its behaviour in other Mediterranean regions of the world. In this case, specific databases are lacking; the best reference is the *Global Compendium of Weeds* (Randall, 2002), which however possibly overestimates invasiveness potential as it takes into account all climates. The species absent from the *Global*

Compendium of Weeds are therefore considered to be at low risk and are only placed under surveillance.

Dry biotope species: comparison with other Mediterranean regions

Among the dry biotope species selected through the previous stages, only three are not recognised as invasive in other Mediterranean regions in the world: *Aeonium haworthii* Webb & Berth., *Aristolochia altissima* Desf. (= *A. sempervirens* auct.) and *Jarava ambigua* (Speg.) Penail (= *Stipa brachychaeta* auct. gall.); they form dense populations in primary biotopes, but remain very localized and appear to be non-spreading. They are placed under surveillance. This category also includes 2 of the remaining "special cases": *Bothriochloa barbinodis* (Lag.) Herter and *Pinus nigra* Arnold subsp. *nigra*.

Wet biotope species: comparison with The Global Compendium of Weeds

All the selected wet biotope species are declared invasive by the *Global Compendium of Weeds*, and therefore all are retained according to our method. However 13 of them are missing from the invasive species databases of Mediterranean countries. This fact confirms that dry and wet biotope species must necessarily be distinguished: these 13 species are dangerous transformers, and several of them are common in the study area (*Parthenocissus inserta* (A. Kerner) Fritsch, *Elodea nuttallii* (Planchon) St John, *Lemna minuta* Kunth...).

Finally, the comparison with other regions of the world, though confirming the previous results, has an extremely weak influence upon the selection of invasive plants: only 3 naturalised species are placed under surveillance.

Sixty-two species are thus retained, 58 being considered transformers and 4 being singled out for study. These 4 cases have to be dealt with at this stage, before distinguishing major and emerging invaders.

Special cases

Bothriochloa barbinodis (Lag.) Herter (= *Dichanthium saccharoides* auct. gall.)

This species, only recently discovered in France (Hérault: Kerguelen, 1979), has shown an extraordinarily rapid spreading. The low number of now invaded natural lawns could be attributed to the lag phase phenomenon if we take into account the species antecedents. *B. barbinodis* is quoted in the *Global Compendium of Weeds*, and its absence in other Mediterranean databases can be explained only by absence of introduction elsewhere.

Proposed status: invasive species.

Cytisus striatus (Hill) Rothm.

This Iberian species has been spotted for its swift implantation in siliceous natural biotopes. However, its behaviour in France does not seem different from its natural one. Eighty percent covering has not been proved in primary biotopes (though common in secondary biotopes; this behaviour remains acceptable for a species of close geographical origin.

Proposed status: species under surveillance.

Periploca graeca L.

This is a north-eastern Mediterranean species, native westwards to Toscana and known as vulnerable in its natural area. Its very fast spreading in France during the last decades looks paradoxical because it shows all the characteristics of an invasive plant. This behaviour difference is likely due to a horticultural origin of the French populations, which therefore do not have a direct link with the close indigenous populations and have no patrimonial value.

Proposed status: invasive species.

Pinus nigra Arnold subsp. *nigra*

The black pine has been pointed out to be very invasive in southern France. However, its regional behaviour does not significantly differ from the one of indigenous pines, nor from its own one in its natural area: the pinewoods gain 30 to 100 m per century on the surrounding lawns (this spread is inferior to the limit of invasiveness: Richardson *et al*., 2000; Pysek *et al*., 2004). Moreover, the recent dynamism of the species is due to the disappearance of its natural predators (cattle) and not to its intrinsic behaviour.

Proposed status: species under surveillance, with special attention paid to some populations.

Sixty species remain selected as invasive.

Distinction between major and emerging invaders

The retained species are classified according to their frequency on the territory. The number of stations of each of them is estimated through the chorological data of the Conservatoire Botanique National Méditerranéen de Porquerolles, added by varied observators' notes.

The 40 transformers present in 10 stations or more of the study area are declared as **major invaders**. They are: *Acacia dealbata* Link, *Acer negundo* L., *Agave americana* L., *Ailanthus altissima* (Mill.) Swingle, *Ambrosia artemisiifolia* L., *Amorpha fruticosa* L., *Araujia sericifera* Brot., *Artemisia verlotiorum* Lamotte, *Azolla filiculoides* Lam., *Baccharis halimifolia* L., *Buddleja davidii* Franchet, *Carpobrotus edulis* (L.) N.E. Br., *Cortaderia selloana* (Schultes & Schultes fil.) Ascherson, *Elaeagnus angustifolia* L., *Elide asparagoides* (L.) Kerguélen, *Elodea canadensis* Michaux, *Helianthus tuberosus* L., *Helianthus* x-*laetiflorus* Persoon, *Impatiens glandulifera* Royle, *Lemna minuta* Kunth, *Lonicera japonica* Thunberg, *Ludwigia grandiflora* (Michaux) Greuter & Burdet, *Ludwigia peploides* (Kunth) P. H. Raven, *Morus alba* L., *Opuntia stricta* (Haworth) Haworth, *Oxalis pes-caprae* L., *Parthenocissus inserta* (A. Kerner) Fritsch, *Paspalum distichum* L., *Periploca graeca* L., *Phyla filiformis* (Schreider) Meikle, *Reynoutria japonica* Houtt., *Reynoutria* x-*bohemica* Chrtek & Chrtekova, *Robinia pseudoacacia* L., *Rumex cristatus* DC., *Senecio angulatus* L. f., *Senecio inaequidens* DC., *Solidago gigantea* Aiton, *Symphyotrichum* x-*salignum* (Willd.) G.L. Nesom, *Tradescantia fluminensis* Velloso, *Vitis riparia* Michaux.

The 20 transformers present in less than 10 stations of the study area are declared **emerging invaders**. They are therefore considered as future major invaders: the "transformer behaviour" appears as early as the first establishment in primary biotopes and the further spreading of the species is then predictable. Management actions against these species will be the most efficient a priori. They are: *Arctotheca calendula* (L.) Levyns, *Bothriochloa barbinodis* (Lag.) Herter, *Carpobrotus acinaciformis* (L.) L. Bolus, *Chrysanthemoides monilifera* (L.) Nordlindh, *Diospyros lotus* L., *Elodea nuttallii* (Planchon) St John, *Eragrostis curvula* (Schrader) Nees, *Hakea sericea* Schrader & Wendland, *Heracleum mantegazzianum* Sommier & Levier, *Humulus japonicus* Siebold & Zuccarini, *Impatiens parviflora* DC., *Lagarosiphon major* (Ridley) Moss, *Ligustrum lucidum* Aiton f., *Myriophyllum aquaticum* (Velloso) Verdcourt, *Pittosporum tobira* (Thunb.)

Aiton f., *Reynoutria sachalinensis* (Schmidt) Nakai, *Saccharum spontaneum* L., *Sagittaria latifolia* Willd., *Senecio deltoideus* Lessing, *Solanum eleagnifolium* Cav.

Study of casual species

By definition, casual species have never been self-sufficient in the study area. However, some of them may appear again and/or find better growing conditions, and then become invasive. The previous notions of "decline", "impact" and "number of stations" are meaningless for such species. The 691 previously selected casual species are directly submitted to the comparison with other regions of the world, which is the only possible information about their invasive capacities.

Comparison with other regions

This criterion can be used according to the same modalities as for naturalised species: if a species is hygrophilous (or not) in its natural area, so it will probably be in France too.

– As for previous stages, the dry biotope species are declared as potentially invasive only if they are known to be invasive in other Mediterranean regions in the world, except if they are not registered in the *Global Compendium of Weeds*; this case is hardly probable since this database takes all regional publications into account.
– Species able to colonise wet biotopes are considered as potentially invasive in all cases if they are at least registered in the *Global Compendium of Weeds*.

The final status is obviously inferior to that of naturalized species: according to our method, a casual species cannot be invasive at present, at the most it may become invasive in the future. Therefore, the species retained as potentially invasive are placed under surveillance, the others are eliminated from the selection.

This selection concerns 629 casual species limited to dry biotopes. Among them, 52 are pointed out as invasive in at least one Mediterranean foreign country, and are cited too by the *Global Compendium of Weeds*; these species are therefore placed under surveillance.

62 casual species are able to establish in wet biotopes. Among them, 5 are not cited by the *Global Compendium of Weeds*: *Aristolochia macrophylla* Lam., *Morus kagayamae* Koidzumi, *Rosa banksiana* Abel, *Rotala filiformis* (Bellardi) Hiern et *Trifolium angulatum* Waldst. & Kit. In fact, 4 of them certainly do not present any risk. Only *Morus kagayamae* may be an underestimated invasive species, because it was grown only recently out of Far East; its behaviour in France let us suspect a strong propagation ability and justifies a surveillance status.

The casual wet biotope species include therefore 58 potentially invasive species which are placed under surveillance.

It is interesting to note that, among the 110 casual species under surveillance, only 18 are ancient which went extinct in France long ago.

Conclusion

The present method gives the following results:

- The 351 species naturalised in southern continental France include 40 major invaders, 20 emerging invaders, 221 species under surveillance (potentially invasive) and 70 species considered as non-invasive. The proportion of species considered as invasive or potentially invasive is 80,06%. The proportion of species considered as invasive sensu stricto is 17,09%.
- The 902 casual species in southern continental France include 110 species under surveillance (potentially invasive) and 792 species considered as non-invasive. The proportion of species considered as potentially invasive is 12,20%. The proportion of long-ago extinct species is 64,97% with respect to casual species, but only 16,36% with respect to those casual being potentially invasive.

  This result shows a positive correlation between the survival potential and the invasive potential: the disappearance of a casual species is more probably linked to its intrinsic weakness than to unfavourable in-situ conditions.
- The “10-rule” of Williamson (1996) does not seem to apply here: 28,01% (and not c. 10%) of the introduced species are well-established; among them, 17,09% (and not c. 10%) appear invasive in natural ecosystems,

although our definition of “invasive” is very restrictive. However, the first percentage may be distorted by an underestimation of the ancient (“historical”) casuals, and by the lack of statistics of ornamental species strictly confined to gardens, which never have been listed comprehensively.

Among the 60 invasive species listed, 14 (13 in wet biotopes and 1 in dry biotopes) have not been recorded as invasive elsewhere, which represent 23.33% of species not having an invasiveness story elsewhere. This remark asks for another one: among the 60 invasive species, at least 44 species (73,33%) have been deliberately introduced for cultivation.

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A review on geomatic tools for assessing, inventorying and mapping alien plant invasions in the Mediterranean basin

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Abstract

Geomatic tools, i.e. informatics' tools and methods applied to geography, such as GIS, tGIS (temporal GIS) and web-GIS, GPSs, data-bases and remote sensing, are becoming widespreadly used for basic research on IAS, for assessing, inventorying and mapping allodiversity from genes to species, for data transfer, sharing and comparison, for landscape-scale or geostatistical studies, retrospective analyses and management purposes.

The reducing costs, the increasing know-how inside the scientific community, public administration, stakeholders, the pressing need to exchange data in quantity and time between different parts of the world, to address global change processes, are fuelling the spread of the use of geomatics in the research and management sector. The resulting increasingly use of these tools, from one hand, have given new insights into phytogeography and plant invasions processes, but from the other fuelled the need for international standard for metadata definitions, data quality and for comparing, updating, exchanging and retrieving data, maps and experimental results. The problem of comparing studies on single species or whole exotic floras between countries has been, so far, mainly addressed toward its main focal point, that is taxonomic and terminological coherence, yet many other topics need to be addressed, especially when data are provided by mean of geomatic tools or presented in digital format and maps. This presentation addresses some of the main available geomatic tools for the study of IAS, main pro and cons of the different methods, applicability in the Mediterranean basin, and finally remarks the needs for international standards in metadata definitions.

Introduction

Does biological invasions science progress primarely by the acquisition of new tools, by evidence of new invasions or by the emergence of new concepts? The study of plant invasions has used so far two basic approaches: manipulative experiments and natural experiments (*sensu* Richardson *et al.,* 2004). The growing trend to study plant invasions at larger spatial and temporal scales, where manipulative experiments are not feasible, has made natural experiments one of the most appealing approach to find generalities in invasion ecology (Richardson *et al*., 2004; Pauchard et 2004). In this concern and debate, geomatic tools (Gomarasca, 2005), i.e. informatics' tools and methods applied to geography, such as e.g. GIS, temporal GIS (tGIS) and web-GIS, GPSs, Decision Support Systems, data-bases and remote sensing are becoming widespreadly used for basic research on invasive alien plants (IAS), for assessing, inventorying and mapping allodiversity from genes to species, for data transfer, sharing and comparison, for landscape-scale studies, spatial analysis and geostatistics, retrospective analyses or early detection and for management purposes. The reducing costs, the increasing know-how inside the scientific community, public administration, stakeholders, the pressing need to exchange data in quantity and time between different parts of the world, to address the global vegetation change processes (Davis *et al.,* 2005), are fuelling the spread of the use of geomatics in the research and management sector. The resulting increasingly use of these tools, from one hand, have given new insights into phytogeography and plant invasions processes, reviving scientific fields that are often reach in theoretical concepts, but from the other fuelled the need for international standard for metadata definitions, infrastructures for spatial information, data quality and for comparing, updating, exchanging and retrieving data, maps and georefered experimental results. The problem of comparing studies on single species or whole exotic floras between countries has been, so far, mainly addressed toward its main focal point, that is taxonomic and terminological coherence, yet many other topics need to be addresses, especially when data are provided by mean of geomatic tools or presented in digital format and maps.

This short review addresses some of the main available geomatic tools for the study of IAS, main pro and cons of the different methods, applicability in the Mediterranean basin, and finally remarks the needs for international standards in metadata definitions and suggests possible directions for future research and international collaboration.

Geomatic tools

The main methods and tools that are part of this pool of techniques are often discussed, indagated and defined separately, but, in fact, they are normally inter-operating and synergic. In fact, the term tool is reductive and Wright *et al*. (1997) have solved the ambiguity of GIS as a tools or as a science. Their considerations fully apply to geomatics as a whole. Furthermore, as remarked by Huber & Schneider (1999), this field has so far so widely devellopped that there are hardly any experts who have a broad view of the whole field of GIS and geomatics and who can provide a clear framework for project implementation. Team work is a clear prerequisite for a frutiful application of this integrated techniques at a profitable level. A great diversity of products on the market call themselves GIS, and there is no single operational definition to help distinguish between them (Huber & Schneider, 1999), e.g. in terms of availability of tools or prices, nevertheless current users of GIS certainly have an idea on what a GIS can or cannot be used for. Geomatics overlaps the term "Biodiversity Informatics"a new synthetic discipline that integrates biological research, computational science, and software engineering to investigate complex evolutionary and ecological phenomena (Baker *et al*., 1998; Fischman, 1996; Grace, 1997; Krishtalka and Humphrey, 2000).

Assessing, inventorying and mapping (invasive) alien plants

One valuable application of geomatics concerns assessing and mapping plant invasions. Digital mapping offers a great platform of data for ecological studies and provides a knowledge baseline from which to measure the success of future control programmes. It is also helpful to educate the public and increase public awareness, inform decision makers, solicit support and document the process. Various stakeholders benefit from knowing the current condition of an invasive alien on the landscape and ecosystems. Mapping can provide data which, if appropriately analysed and interpreted, can help in understanding the invasion process, assess trouble spots, test models and therefore improve efforts to conserve species, regulate introductions, enforce quarantines and provide a legislation framework. Mapping is also very useful for studing the biological invasions at the gene level, for dealing with molecular patterns of data with spatial interest (Petit, 2004). The use of geomatic technologies provides a mechanism to view the invasion geographically, easily update the databases, provides additional tools for ecological studies and help to determine where to focus resources to obtain the broadest management result (Brundu *et al.,* 2003). One significant contribution in this sector was given by the European project EPIDEMIE concerning a set of Mediterranean island (i.e. Crete, Corsica, Balearics, Lesvos, Port Cros, Porquerolles, Rhodes, Sardinia; see Brundu et al., 2004) and fourty IAS. In the Sixth Framework Programme of the European Union the projects DAISIE and ALARM are expected to deal with inventorying, data-basing and mapping at Community level (Settele *et al.,* 2005). Outside Europe there is a much broader literature and practical results on alien and weed mapping projects and many examples of (geographical) databases. Some projects are oriented to one or a few species of greater invasiveness or impact, e.g. *Arundo donax* L., (Finn and Minnesang 1990; Frandsen 1997; Di Pietro 2002) mapped and surveyed by the Team Arundo del Norte, *Miconia calvescens* DC (Conant *et al.* 1997). Other projects have more general purposes, e.g. Hawaiian Ecosystems at Risk - H.E.A.R. Project; South African Working for Water Programme (Le Maitre & Versfeld, 1994; La Maitre *et al.*, 2000; D.W.A.F., 1997); Southern African Plant Invaders Atlas, i.e. SAPIA (Henderson, 1998; 2001a, 2001b); Montana Noxious Weed Survey and Mapping System (Cooksey & Sheley, 1997, 2002); U.S. Geological Survey – Southwest Exotic Plant Mapping Programme (U.S.G.S. and S.E.P.M.P. 2002; Hiebert 1997; Hiebert and Stubbendiek 1993), Department of Primary Industries, Water and Environment – Tasmanian Weed Mapping Network (D.P.I.W.E. 2002; Bishop, 1996; Pitt, 1997), Australian Weeds of National Significance (Parsons & Cuthbertson, 1992; W.O.N.S., 2002), Australian Department of Agriculture, Fisheries anf Forestry Weed Information and Mapping System (Thackway *et al.,* 2003). One common denominator of these different projects, is that they all share and exploit, at different levels, geomatics.

Mapping the species distribution of an alien flora at a local, regional or national level (i.e. at different scales) poses some methodological problems to be solved, both concerning invasive and non-invasive plant species. Some of these problems (e.g. sampling methodology, data-base implementation) are similar to those involved in the mapping of native floras and therefore widely discussed in the literature (e.g. Kuchler and Zonneveld, 1988; Uotila, 1999), while others are peculiar of the alien plants, of their ecology, invasion dynamics and distribution patterns e.g. along roads (e.g. Bastow Wilson et al. 2000; Milton & dean, 1998; Pauchard & Alabach, 2004; Parendes and Jones 2000; Gelbard & Belnap, 2003) and riparian networks (e.g. Planty-Tabacchi *et al*. 2001), in soil types (Firbank *et al.,* 1998), in fragmented habitats (With 2002) and as consequence of land-use changes (e.g. Vilà *et al*. 2003).

Geomatic techniques applied to mapping may have some inherent problems, due to differences in type and scale of information acquired in comparison to traditional field methods (Joshi *et al*., 2004), but integrated approaches may help in solve these problems. Alien plant communities should to be converted in terms of GIS primitives (Brundu *et al*., 2003) for standardise data collection and management.

Digital mapping is normally the first step toward the application of Geostatistics, a term commonly used to describe a set of techniques that model spatial variation in data and use these models to estimate or classify other data based on these models. Geostatistics developed out of empirical approaches developed by South African mining engineers in the 1950s and 1960s and were given theoretical validity by the development of random function theory in the 1960s (Amstrong, 1998). Another "natural" development of digital mapping is spatial analysis (e.g. Fortin & Dale, 2005; Cliff and Ord, 1981). Finally, mapping is one essential prerequisite for monitoring which constitutes a very first priority, as the importance of long-term studies is always remarked on in the literature (e.g. Blossey 1999). Monitoring provides data that lead to better understanding of long-term changes, which in turn contributes to more effective management regimes of biological invasions.

Comparisons of maps

The lack of common standards lead to a profusion of different maps that rarely facilitate comparisons; depending on the quantity and quality of data and the methodology used in the analysis, a given map may be useful or misleading (Hulme, 2003; Rytkönen, 2004). Identification of categorical differences between maps is the basis of much land and vegetation change studies (Power *et al*., 2001). Map comparison procedures are used to numerically express the similarity between two maps. The results of a map comparison can be an overall value for similarity (e.g. a value between 0 and 1) or a map in its own which means that the results of a comparison is a third map which indicates per location how strong the similarity is (Hagen, 2002; Pontius, 2000). When comparing maps the human observer considers many aspects intuively, local and global similarities, logical coherence, patterns. Map comparison performed by software can evaluate some criteria of similarity, but lack for others, futhermore they generally lack the flexibility to switch form one criterion to another when the data requires so. Despite these disadvantages, there are several reasons to perform automated map comparisons. Two importanat properties are of automated methods are repeatability and objectivity. Most of the available softwares perform map comparisons of raster data containing nominal data, but some methods may be applicable also to vector data.

The most commonly used methods are cell-by-cell comparisons, Kappa statistics (Carletta, 1996; Maclure & Willet, 1987; Monserud & Leemans, 1992) and its variations (Pontius, 2000) for expressing similarity both in quantity and location, hierachical fuzzy pattern matching (Power et al., 2001) also called fuzzy inference system approach and fuzzy set approach (Hagen, 2002), use of neutral models (Gardner *et al.,* 1987). Between the available softwares, RIVM and RULE are worth to be mentioned.

Vector vs. raster encoding method

The raster (or grid) encoding method is the most common system for the digital mapping of floristic data in Europe as it is used by the Atlas Florae Europaeae Project (Stott 1981; Suominen 1999), and usually applied also to alien floras (e.g. in Germany, see Deutschewitz *et al.,* 2003, or in Catalonia, Spain, see Pino et al., 2005). Any raster model may produce artefacts (Burrough 1984; De Mers 2002; Tomlin 1990), mainly around the borders of the study area, especially in case of islands and small islets and archipelagos and along the coast. Also species on cliffs and riversides or along road and riparian networks are problematic in this respect (Kurtto and Lampinen 1999). Other local reasons for distortion are the presence of areas that have been more accurately studied by botanists in comparison to others. The only method to correct these artefacts is the use of a smaller grid network, or differential sampling near the distribution limits in comparison to the inner parts of the range. An intermediated solution may be the use of a mixed vector-raster encoding approach (Brundu *et al.,* 2003), i.e. recording coordinate features of species location and leaving to GIS software the possibility of raster conversion and frequency estimates or other biodiversity measures (e.g. Humpries et al. 1999, Skov 2000) according to a grid of cells of a given size.

Remote sensing: direct detection of alien plants

From a theoretical point of view, remote sensing *s.l.* offers significant opportunities for providing timely and synoptic information on invasions of alien species into native habitats (e.g., Madden, 2004; Underwood *et al*., 2003; Joshi *et al.,* 2004). Traditional field methods of mapping, provide plenty of possibilities to describe flora and vegetation in a large detail but are time and labour intensive, might be biased by the subjectivity of the interpreter (Congalton, 1991; Müllerová. 2004) and therefore not always easy to replicate compare and update. In contrast to field-based surveys, imagery can be acquired for a lot of different habitats, over a much larger area, and in a short period of time. Consequently, researchers have sought to exploit unique phenological, spectral, or structural caracteristics of the alien species in the image to distinguish them from the mosaic of species around them. (Underwood *et al.,* 2003). Remote sensing provides a wide range of sensor systems including aerial photographs, airborne multi-spectral scanners, satellite imagery, low and high spatial, spectral, temporal resolution and ground based spectrometer measurements (Joshi *et al.,* 2004). The "native" digital data of most of the remotely sensed data it's a significant opportunity for a prompt integration with geomatic software and data.

Nevertheless, especially in the Mediterranean region, spatial heterogeneity, mosaic-like patterns of frequent land-cover changes (e.g. provocated by wild fires), complicates the study of seasonal and long-term trends. Concerning the applicability of remote sensing tools in the field of biological invasions, we must distinguish between the possibility to detect single alien species or communities and the possibility to detect "predictors" (or impacts) and predictors' changes. The former is more riskfull, the latter gives the very best results. In thematic literature, aerial photograph interpretation is regarded as a useful tool in different Mediterranean-type environments for studying alien plants distribution, e.g. in South Africa (Rowlinson et al. 1999; Stow et al. 2000) and Australia (Miller 1996), but also in different eco-regions (e.g. Frazier and Moore 1993; Everitt *et al*. 1995; Mast *et al*. 1997; McCormick 1999). Species recognition by remote sensing is normally quite difficult and doubtful, also for native plants, especially in the highly heterogeneous and patchy Mediterranean environment (De Jong and Burrough 1995), generally, mainly indirect techniques can be used (pattern analysis, habitat/land use classification, land-use change detection, supervised classification on multi-temporal data, rule based extraction algorithm, neural networks etc.) that may require quite a dense network of natural feature ground control points, field campaigns with portable spectroradiometers, image digital processing and enhancement. The recent availability of more defined data in term of geometric, temporal and radiometric resolution and new commercial satellite sources may give some aid, but costs are still high even when compared to intensive field surveys and many constraints still remains (Joshi *et al*., 2004).

Remote sensing: indirect detection of alien plants and integration with GIS

Remote sensing *s.l.* is of major interest for obtaining ecological information (land use, land-use changes, fragmentation, fire extension, irrigation and riparian network etc.) that are of great importance for GIS analysis and for monitoring environmental change, land use changes and disturbance that are known to be important drivers of the plant invasion processes and of the resulting distribution pattern. For example, for regional monitoring applications relying on temporal data sets, Landsat has several advantages. First, with more than 30 years of Earth imaging, it offers the longest-running time series of systematically collected remote sensing data (Cohen and Goward, 2004; Röeder et al., 2005). Second, the spatial resolution facilitates characterization of land cover and cover change associated with the grain of land management (Cohen and Goward, 2004). A very larg set of measures for landscape strucuture analysis (landscape indices) has been developped during the past two decades (e.g. Foreman & Godron, 1986; O'Neil *et al*., 1988; Baker & Cai, 1992; McGarigal & Marks, 1995; Frohn, 1998) with available software for data analysis, and their response to the spatial structure and scale of the landscape has been descibed and quantified (e.g. Rescia *et al.,* 1997; Hargis *et al.,* 1998). The relation between these landscape indices on the one side and plant diversity in general, and allodiversity more in specific, on the other side, has started to receive attention (Roy *et al*., 1999; Collingham et al., 2000; Honnay *et al.,* 2003; With 2002). This is very likely due to the fact that the use of GIS techniques and landscapes data sources, such as satellite imagery have facilitated large scale pattern analysis, but the availability of systematically recorded biological data at the landscape level as ground-control-truth remains a serious bottleneck (Honnay *et al*., 2003).

Modeling and predicting invasions

The spatial prediction of (invasive) species distributions from survey data has been recognised as a significant component of conservation planning (Austin, 1998, 2002a, 2002b; Elith & Burgman, 2002; Franklin, 1995; Guisan & Zimmermann, 2000; Higgins and Richardson, 1996; Higgins *et al.,* 2001; Korniss and Caraco, 2005; Rejmánek, 2000; Scott *et al.,* 2002). A wide variety of statistical and machine-learning methods have been introduced, often in conjunction with GIS and remote-sensing. Bioclimatic models are being used to predict the distribution of plant and animal species at large spatial scales

(Guisan & Zimmermann, 2000). However, bioclimatic models may produce inaccurate predictions when important local or regional factors are missing from input data in the models (Iverson *et al.,* 1999; Thuiller *et al*., 2003) In Europe, land use changes, in particular agricultural intensification, have led to widespread changes in the distribution and abundance of many different taxa (Benton *et al*., 2003; Thuiller *et al*., 2004). This problem seems to be particularly severe for alien plants in the Mediteranean where a positive relationship between alien occurrence and human population density or anthropisation *s.l.* exists (e.g. Araújo, 2003). A possibility to compensate for such human-induced factors is to include within species distribution models additional variables expected to summarise factors affecting local distributions of species. The inclusion of these variables should be expected to improve the accuracy of bioclimatic models (Loehle & LeBlanc, 1996; Midgley *et al*., 2003), and as matter of fact the inclusion of land cover increased the expanatory power of bioclimatic models for 2294 European plant species (Thuiller *et al.,* 2004), although the spatial, temporal and thematic resoltuion of the land cover map are a clear constrain, being spatial variation of land cover highly correlated with spatial variation of bioclimatic variables. The Corine Land Cover digital map is available on the web (EEA Data Center) for authorised download, but should be refinied and locally tested before being used for modeling; in fact it contains useful implict information such as landscape indices and land-use change. Frequency and intensity of perturbation, road network, riparian disturbance, agricultural intensification, irrigation, grazing, fire history, tourism settlements, accurate digital terrain model, could be more relevant to improve the predictive ability of bioclimatic models for some IAS. If the regional abundance of a single alien species might be mainly explained by climate, the local presence-absence pattern of the given alien might be mainly explained by human-related predictors.

Analysing and georeferencing data from Herbaria or other historical sources

European herbaria, botanical gardens and historical collections represent the most estensive collection of specimens worldwide (Berendsohn *et al*., 1997). Databasing biological information is a highky complex task and any attempt to provide an easiliy comprehensible model are bound to fail, at least when attempts are made to interconnect systems. The vast majority of locality descriptions associated with biological specimens (or maps on printed media) housed in natural history museums lack the geographic coordinates required for computer-based spatial analyses (Schölzel *et al.*, 2002). Assigning such coordinates to existing specimen records is a process called retrospective georeferencing. The georeferencing of biological collections makes those collections more valuable by allowing them to be used in spatially explicit biodiversity analyses. Plant specimens are usually well preserved, so any identification error can be corrected to account for recent progress in taxonomy. The spread of alien plant species can, in some cases, be reconstructed using herbarium specimens, or other historical data, even when the phenomenon is rapid, but the reconstruction is certainly more accurate when the invasion occurred during an active sampling period. Accounting for sampling biases associated with herbarium specimens is important in order to objectively delineate periods of invasiveness for exotic species. The highly variable sampling effort for herbarium specimens strongly cautions against using herbarium data without correction procedures (Pyšek *et al.*, 1995; Murphey *et al.*, 2004; Schölzel *et al.*, 2002; Delisle *et al.*, 2003; Stansbury & Scott, 1999).

Awareness raising, dissemination of information, stakeholders' issues

The role of humans in promoting and accelarating biological invasion is worldwide recognised, thus awaraness raising, education, dissemination of information are focal points. As highlighet by Ricciardi et al. (2000), retrieving critical information about the taxonomic identification, spread, impact, and control has always been difficult because much of this information is buried in disciplinary journals from many different fields or in obscure government documents and technical reports, and other grey literature, that are not widely accesible, especially in the newly invaded range. An increasing amount of information is also being stored in electronic repositories and on the web. Numerose electronic databeses have been developped recently to disseminate information on alien plants and are available on the internet, e.g. the Global Invasive Species Database developed by the IUCN/SSC Invasive Species Specialist Group (ISSG) as part of the global initiative on invasive species led by the Global Invasive Species Programme (GISP), the Global Invasive Species Information Network, or GISIN. Nevetheless, generally speaking, the information available worldwide is very variable in scope and quality, limiting the availability to managers to combact invasions. (Ricciardi *et al.*, 2000).

Infrastructures for spatial information and metadata definitions

At European Community level, the INfrastructure for SPatial InfoRmation in Europe initiative (INSPIRE) aims at making available relevant, harmonised and quality geographic information for the purpose of formulation, implementation, monitoring and evaluation of Community policy-making. (RDM, 2002). The effects of this initiative on the environmental, research sector and on geomatics are therefore of great concern. It intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. The target users of INSPIRE include policy-makers, planners and managers at European, national and local level and the citizens and their organisations (RDM, 2002). The spatial information infrastructure addresses both technical and non-technical issues, ranging from technical standards and protocols, organisational issues, data policy issues including data access policy and the creation and maintenance of geographical information for a wide range of themes, starting with the environmental sector. The INSPIRE initiative recognises the fact that most of the quality spatial information is available at local and regional level, but that this information is difficult to exploit in a broader context for a variety of reasons. The situation on spatial information in Europe is one of fragmentation, gaps in availability of geographical information (for example, only a few pan-European geographical information layers exist, often designed for specific purposes that limit the possibilities of their wider use e.g. CORINE Land Cover and the SABE dataset, i.e. Seamless Administrative Boundaries of Europe, from EuroGeographics), duplication of information collection and problems of identifying, accessing or using data that is available. As a result of these problems, effective Union policy actions suffer because of lack of monitoring and assessment capabilities that take into account the spatial dimension.

Metadata are the information and documentation, which makes data understandable and shareable for users over time. Metadata can be thus defined as "information on information resources", i.e. the documentation necessary for a user to discover whether an information resource exists, who has it, where it is located, what are the conditions for accessing it, data accuracy, resolution, precision and whether it is fit for the purpose that the user intends (ETeMII 2001; Munro 1998). Any mapping project, information system, (geographical) data-base about IAS should aim to provide as much as possible accurate metadata. Furthermore, metadata allow quality of geospatial data to be maintained, transfer data between users and different GIS and database softwares. There are important European metadata network projects in progress (e.g. C.E.N. 2002; E.S.M.I. 2002; EUROSTAT 2001; INSPIRE 2002-2005) and one of the main reference standards worldwide is the Content Standard for Digital Geospatial Metadata produced by the Federal Geographic Data Committee (F.G.D.C. 1998). In order to ensure international compatibility of the collected data, it is necessary to define also standards taxonomic units and general descriptors, to be harmonised with the existing international ones (e.g. Berendsohn 1999; Euro+Med PlantBase 2001; Greuter et al. 2000; T.D.W.G. 2005; C.D.E.F.D., 2005). Standards and comparability are required for physiognomic vegetation classification, habitats, land uses, soil types, geographical terminology etc. (e.g. Hollis and Brummitt, 1992; Holmgren *et al*., 1990; E.C., 1991, 1994; EUNIS, 2005; Kanellopoulos, 2005).

Furthermore, a great diversity of products on the market call themselves geographical information systems (GIS), and there is no single definition to help distinguish between them. With the rapid expansion of the GIS market over the last years, it became appearent that the diversity of terms, notions and functionality in the different GIS has a negative impact on the productive use of GIS: users spends a lot of the project's time learning the particular concepts of a software, development language, and implementation specific details have to be fully understood to assure the quality of results. But even more dangerous for the future of GIS technology, there are hardly any experts who have a broad view of the whole filed of GIS and who can provide a clear framework for project implementation (Huber & Schneider, 1999). Quite often there is a strong dependency of an organisation on the persons who established the GIS database. Quite recently GIS software companies accepted the need for standardisation of at least the data part of GIS. Other groups, like the OpenGIS Consortium or the ISO Technical Committee 211, want to go evenfurther by standardasing GIS functions in order to be able to develop interoperable systems (Huber & Schneider, 1999). A pan-European network, the NATURE-GIS Network, will link all the different organisations and stakeholders who have an interest in the application of Geographic Information and Geographic Information Systems (GI-GIS) to protected areas

(Kanellopoulos, 2005), that's a focal point considering that invasions into natural vegetation have always been of special importance (e.g. Pyšek *et al*., 2002).

Temptative conclusions and ideas for future research

The problem of managing biological invasions under globalisation and global change is a complex issues, and requires an integrative approach between many different sectors and a plethora of specialists, including economists and trade experts (Perrings et al., 2005). Global biodiversity scenarios for 2010 highlight dramatic future increases in biological invasions in Mediterranean ecosystems, proportionally more so than in any other ecosystems (Hulme, 2004; Sala *et al*., 2000). Traditional approaches are often inadequate to deal with the global onslaught of alien plants (Ricciardi *et al*., 2000). In this framework, geomatics, in its broader sense, plays a fondemantal role in the research and management sector and provides tremendous opportunities in mapping and modelling the distribution of alien plants and in managing geographical information pertinent to biological invasions and nature conservation.

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Alien plants in Mediterranean-type ecosystems of the Americas: comparing floras at a regional and local scale

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Abstract

Plant invasions are increasingly homogeneizing native ecosystems at local and global scales, thus reducing plant biodiversity. A basic knowledge about the magnitude and extent of plant invasions is necessary to prevent this process in the long term. We show patterns of plant invasions in mediterranean Chile. We documented alien species richness and their taxonomic distribution across administrative regions of Chile. We explored latitudinal gradients, in terms of plant diversity and floristic similarities. We also compared the diversity of alien plants between protected and non-protected areas. Finally, we compared alien floras of California and Central Chile. The 15% of the total flora of Chile (690 spp.) corresponds to alien plants, being the 57% of them located in mediterranean ecosystems. Alien plants are poorly represented in protected areas, being concentrated around human-disturbed sites. Species richness was higher in California than in Chile, probably due to a higher propagule pressure, a higher international trade and more intense human activities. However, in both regions, we detected a latitudinal response of alien plant composition, strongly correlated with the amount of precipitations.

This study will contribute to the knowledge of the exotic flora as a first step to explore underlying mechanisms that determine patterns of invasions and as a base to orient future plans for monitoring and preventing alien plant invasions in Central Chile and other Mediterranean ecosystems of the world.

Introduction

Alien plant invasions are increasingly homogeneising native ecosystems (Olden *et al.*2004, McKinney 2004), thus reducing plant biodiversity (Heywood, 1989). Basic knowledge about the magnitude and extent of plant invasions as well as the underlying causes that determine this process is needed to prevent its negative consequences in the long term (Weber 2001). This knowledge is critical as economic globalisation will increase the magnitude of alien plant invasion worldwide (Pimentel *et al.* 2001). One way to increase our knowledge about plant invasions is to compare taxonomic patterns of alien floras that occur at different regions. Comparisons among biogeographical homoclimatic regions is one of the most promising approaches (Pauchard *et al.* 2004). This approach examines if regions that share similar climates share similar alien floras as well. If it is not the case, then local factors such as propagule pressure, disturbance regime and native biota may be invoked to explain differences between the alien floras (Lonsdale 1999).

In this manuscript, we present preliminary results for two approaches used to study invasive species in central Chile. First, we analysed alien floras that occur in two mediterranean-type ecosystems: Central Chile (Lat.29º– 44 º S y Long. 72 º) and California (USA) (Lat. 35º – 42º N y Long.125º W). These two regions share similar temperature and precipitation gradients (Mooney *et al*. 1970, di Castri 1991; Lewis & Ferguson, 1993), but differ significantly in human land use, disturbances regimes and native biota (Sax 2002; Arroyo *et al*. 1995). Second, we conducted an analysis of alien flora of Central Chile at a local scale, comparing plants near vs. away from roads, and inside vs. outside protected areas. The rational behind this comparative approach is that roads are corridors and sources for exotic plants, allowing them to spread across landscapes, thus invading even the less disturbed ecosystems of protected areas (Pauchard & Alaback 2004)

Methods

We analysed herbarium data comparing floras from species to family level. For Chile, we used the Herbarium of the University of Concepción and for California Calflora data base (www.calflora.org). In Chile, we considered eight administrative regions (IV to X Region) and for California, 50 counties. Due to area differences between regions and counties, for California we grouped counties into latitudinal zones (Figure 1). We determined the similarity of alien floras between the two regions along precipitation gradients. Additionally, we conducted comparisons of the species, genus and family diversity between these two mediterranean ecosystems. We explored the existence of latitudinal gradients of plant composition between these two regions. For the local scale, we studied seven protected areas (PA) of Central Chile (Table 1). At each PA, we disposed 2 x 50 m transects near (roadside) and away from roads (50 m into vegetation interior), inside and outside PA. We identified and registered all vascular plants (exotic and natives) found. In this way, we sampled a total of 100 transects.

PROTECTED AREA	CODE	NUMBER OF TRAN-SECTOS	LATITUDE	LONGI-TUDE	Area (Ha)
R.N. RADAL 7 TAZAS	1	16	35º25' S	71º00' O	5.026
P.N. NAHUELBUTA	2	16	37º44' S	72º55' O	6.832
R.N. LOS RUILES	3	8	35º37' S	72º21' O	45
R.N. LOS QUEULES	4	12	35º58' S	72º42' O	147
P.N. LAGUNA DEL LAJA	5	16	37º23' S	71º24' O	11.880
R.N. RALCO	6	16	37º55' S	71º25' O	12.492
P.N VILLARRICA	7	16	39º21' S	71º27' O	63.000

Table 1.– List of protected areas of Central Chile sampled with the 2 by 50 m transects in this study.

Results

Alien species richness was notably higher in California (1190 species) than in Central Chile (599 species); 400 alien species were shared between the two regions (Fig. 2). Moreover, the distribution of Families that contained alien species was remarkably similar between Chile and California (Fig. 3). Cluster analysis detected a low similarity between regions, indicating that both regions have a differentiated alien flora (Fig. 4). However, inside the two regions, species groups were ordered following a similar latitudinal gradient (Fig. 4). At Family level, a clear response to latitudinal gradient was observed. For example, in Boraginaceae, the species richness increased with latitude; while in the Mimosaceae, this figure decreased with latitude (Fig. 5).

In the seven Protected Areas (PA) studied, we detected a total of 507 species, being 96 aliens and 411 natives. Species richness varied significantly among PA, being R.N. Siete Tazas that which contained the highest values (Fig. 6). Species richness was significantly higher near than away from roads (Fig. 7) and outside than inside protected areas (Fig. 7).

Conclusions

a. Central Chile and California differ in the taxonomic composition of alien plant species. California has a higher number of alien species, suggesting that the differeNces in histories of introductions, propagule pressures and disturbance regimes between the two regions are very important.

b. Irrespective of the low similarity between Central Chile and California, both flora responded in similar way to the latitudinal gradient, which suggest an ecological convergence to precipitation gradients.

c. In Central Chile, alien species richness was higher at the protected areas (Siete Tazas) located at the northern part of the latitudinal gradient where anthropogenic disturbance and human populations are higher.

d. The species richness was higher near the roads and also outside protected areas. This results reinforce the assertion that roads serve as corridors and propagules sources for alien species and that native vegetation protected inside protected areas may “resist” invasive process of alien plant species.

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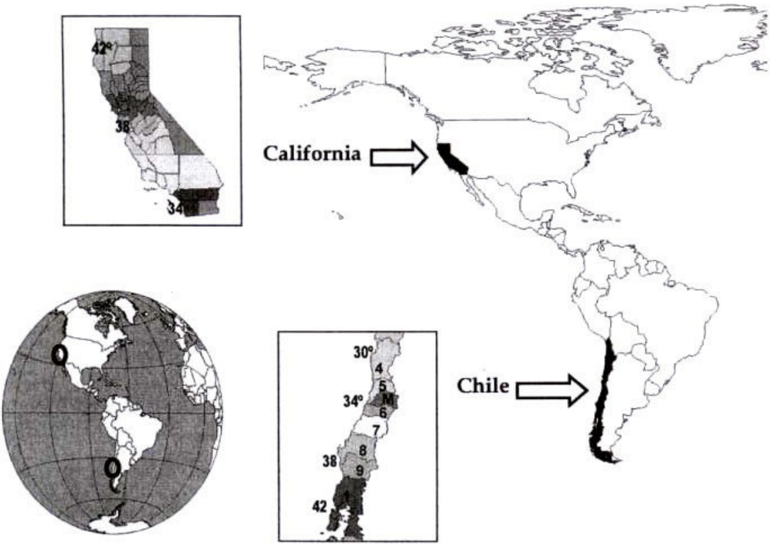
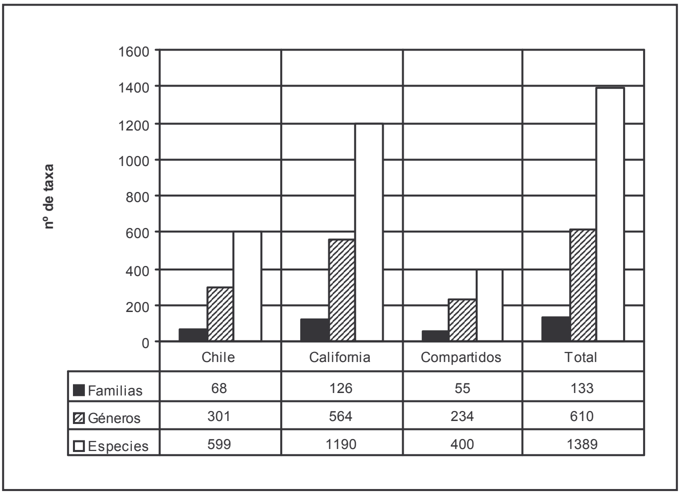


Figure 1. – Geographic location of the two biogeographic regions involved in this study: Central Chile and California.



	Chile	California	Compartidos	Total
Familias	68	126	55	133
Géneros	301	564	234	610
Especies	599	1190	400	1389

Figure 2. Taxonomic diversity of exotic flora of Central Chile and California, at Family, Genus and species level.

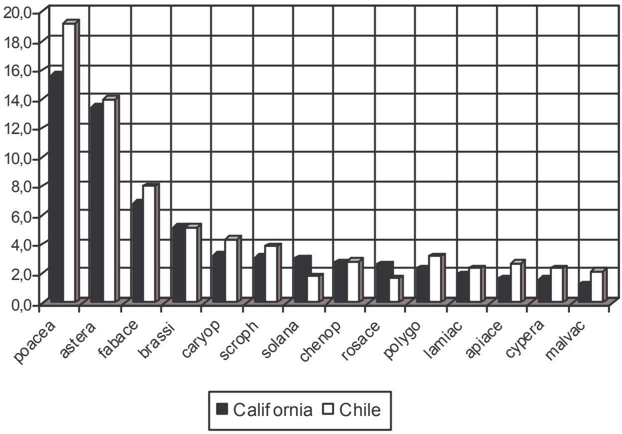


Figure 3. Percentage ratio of number of the alien species in a family and total number of alien species in the region. Families shown are the most diverse in Chile and California.

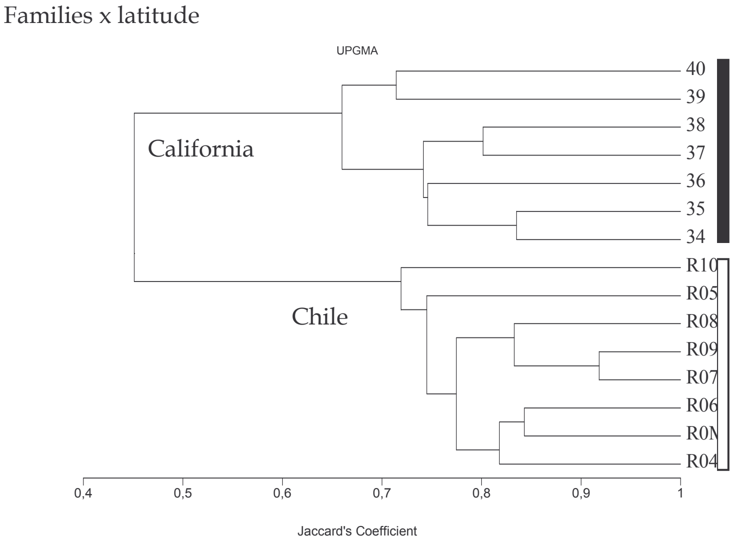


Figure 4. Cladogram of the similarity of exotic families by latitude. Black column shows California. White column shows administrative regions of Chile.

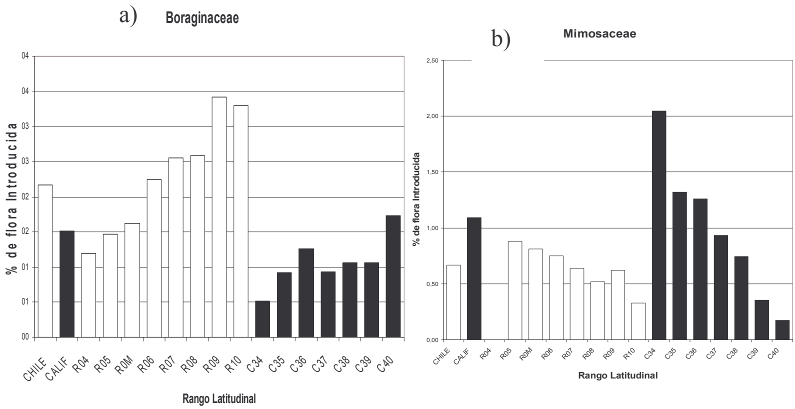


Figure 5 – Latitudinal pattern of species belonging to a) Boraginaceae and b) Mimosaceae.

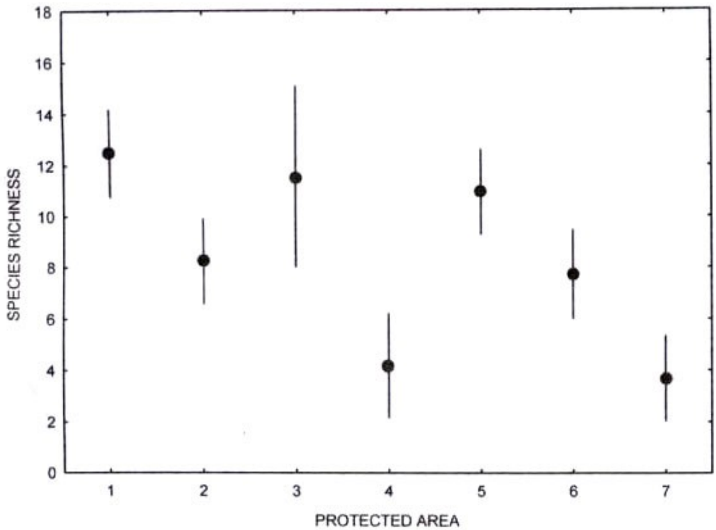


Figure. 6.- Mean alien species richness observed at the 2 by 5 m transects at the seven protected areas selected for this study (numbers indicate the protected area, Table 1). Lines represent Standard Error.

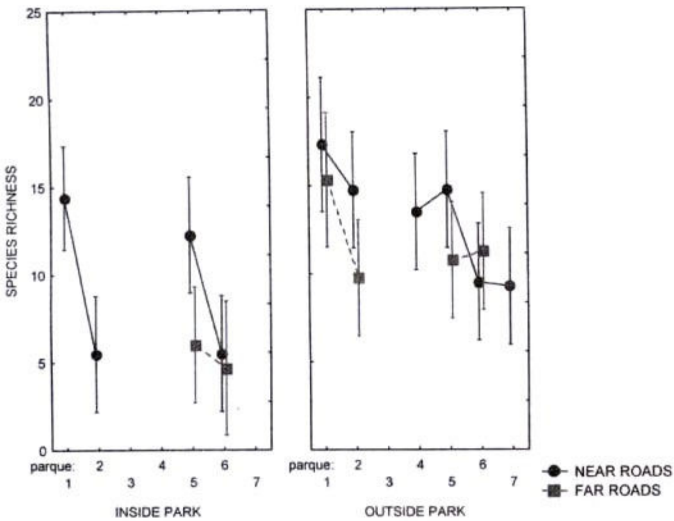


Figure 7.- Mean alien species richness observed near and far of roads, inside and outside protected areas, Central Chile.

Etat actuel de nos connaissances sur les plantes envahissantes au Maroc

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Abstract

La flore du Maroc compte près de 4500 espèces et sous espèces (Jahandiez & Maire, 1931-1934) ce qui se traduit par une richesse floristique diversifiée et originale. Comparé aux autres pays de la méditerranée, le Maroc occupe une place privilégiée et constitue un réservoir phytogénétique.

Plus de 65% de la flore est d’origine méditerranéenne, mais des influences étrangères peuvent exister. Ainsi, des éléments holarctiques arrivant du nord ou des éléments sahariens venus du sud ou sud-est trouvent des conditions particulières à leur maintien, des espèces macaronésiennes qui présentent beaucoup d’affinités avec celles des îles Canaries et Madère, des espèces tropicales caractéristiques des périodes humides et chaudes, des espèces saharo-indiennes caractéristiques des périodes chaudes et sèches. L’originalité de la flore du Maroc réside dans le nombre élevé d’espèces endémiques, environ 900 espèces et sous-espèces (19% de la flore totale).

Au fil des ans, la flore adventice au Maroc s’enrichit par l’introduction de nouvelles espèces qui sont reconnues mondialement comme plantes envahissantes. Ces espèces posent de sérieux problèmes de concurrence dans les cultures et dégradent la biodiversité par leur action colonisatrice du milieu et par conséquent, causent la disparition de plusieurs espèces intéressantes (endémiques par exemple). Ces espèces ont d’autant plus de chances d’acquérir une aire de distribution étendue surtout si leur capacité de propagation est importante. Cette faculté dépend essentiellement de leur pouvoir de reproduction et de dissémination.

Il est à souligner que le Maroc ne dispose jusqu'à présent d'aucune liste officielle des plantes dites envahissantes ou nuisibles. Toutefois, une étude sur la biodiversité fait ressortir un inventaire officieux des espèces menacées de

disparition (Rattal, 1999) par leur surexploitation sans faire allusion à l'action des espèces envahissantes.

Un premier index synonymique des taxa présents dans les milieux cultivés ou artificialisés a permis de faire la liste de 838 espèces et sous espèces (Boulet *et al.*, 1989). Ensuite, nos observations et nos prospections sur le terrain depuis 1980 nous ont conduits à recenser en premier lieu 12 espèces récemment introduites et absentes de la flore du Maroc et considérées dans beaucoup de pays comme plantes nuisibles. Ces résultats ont été publiés dans Weed Research en 1997 (Tanji & Taleb, 1997). Cette liste s'est vue enrichie par l'introduction d'une nouvelle espèce, Verbesina encelioides (Cav.) Benth. et Hook. ex Gray (El Mfadli, 2002).

Dans cet article de synthèse, nous dressons la situation des plantes introduites ou naturalisées depuis des décennies au Maroc (Jahandiez & Maire, 1931-1934) en mettant l'accent sur celles qui ont fait l'objet de travaux de recherche.

Nouvelles espèces introduites

Dix sept espèces adventices appartenant à 9 familles botaniques sont considérées nouvellement introduites au Maroc (Tableau 1). Cette introduction est caractérisée par la dominance de deux familles, *Solanaceae* et *Poaceae* (soit 50% de l'effectif). De même, les 2/3 des espèces recensées ont été introduites entre 1970 et 1997 (Tableau 1).

Nom scientifique	Famille botanique	Code Bayer	Année probable d'intro-duction
Nicotiana glauca L.*	*Solanaceae*	NICGL	Avant 1931*
Ricinus communis L.*	*Euphorbiaceae*	RICCO	Avant 1931*
Oxalis pes-caprae*	*Oxalidaceae*	OXACE	Avant 1931*
Kochia scoparia (L.) Scrad.	*Chenopodiaceae*	KCHSC	1948
Salpichroa origanifolia (Lam.)	*Solanaceae*	SALOR	1949
Baillon	*Solanaceae*	SOLEL	1949
Solanum elaeagnifolium Cav	*Malvaceae*	ABUTH	1980
Abutilon theophrasti Medik.	*Lythraceae*	AMMCO	1980
Ammania coccinea Griseb.	*Poaceae*	ECHPH	1980
Echinochloa phyllopogon (Stapf)	*Poaceae*	CYPDI	1980
Koss	*Poaceae*	DTTAE	1980
Cyperus difformis L.	*Euphorbiaceae*	EPHHL	1980

Nom scientifique	Famille botanique	Code Bayer	Année probable d'intro-duction
Dactyloctenium aegyptiacum (L.) Richt. *Euphorbia heterophylla* L. *Solanum cornutum* Lam. *Brachiaria eruciformis (Smith) Griseb.* *Corchorus olitorius* L. *Panicum capilare* L. ***Verbesina encelioides*** (Cav.) Benth. et Hook. ex Gray	*Solanaceae* *Poaceae* *Tiliaceae* *Poaceae* *Asteraceae*	SOLCU BRAER CRGOL PANCA VEREN	1986 1970 1990 1990 1997

*signalées dans le catalogue des plantes du Maroc (Jahandiez & Maire, 1931-1934)

Tableau 1. Liste des espèces introduites au Maroc

Uniquement 3 espèces parmi les 17 ont fait l'objet de recherches depuis 1984 très avancées aboutissant à des stratégies de contrôle. C'est le cas de *Solanum elaeagnifolium* Cav. (Morelle jaune), *Oxalis pes-caprea* L. (Oxalide) pour un début de recheche sur leur biologie, écologie et comportement et de *Verbesina enceloides* (Cav.) Benth. et Hook. ex Gray.

Solanum elaeagnifolium Cav.

Espèce originaire d'Amérique subtropicale, cette *Solanaceae* est très connue dans plusieurs pays (USA, Argentine Chili, Brésil, Inde, Grèce, Yougoslavie, Italie, etc.) pour la mauvaise réputation qu'elle a dans le domaine agropastoral (Taleb, 1996a).

Malgré les multiples essais de lutte mécanique, culturale et chimique, son éradication ou seulement son contrôle sont souvent très difficiles.
Au Maroc, elle fait partie des 115 espèces particulièrement gênantes depuis des décennies (Taleb, 1996b). Elle a été signalée pour la première fois par Gattefosi (Contr. 459) en 1949 (Catalogue annoté des Plantes du Maroc) dans la région d'El Borouj – Province de Settat qui constitue la limite nord du Tadla- et à Casablanca (El Aânk). Elle fait son apparition au Tadla (Centre de Mise en valeur 506) aux environs de 1950, date coïncidant avec l'introduction de la culture du coton dans la région. De là, elle s'est propagée dans les deux rives de l'Oum Rabia (Beni Amir et Beni Moussa) à une vitesse spectaculaire. Depuis, elle ne cesse d'envahir les régions limitrophes (El Kelâa des Sraghna, le Haouz, la Chaouia) et des zones lointaines (Souss, Saïss, la Basse Moulouya, Nador)

(Taleb & Bouhache, 1994, Qorchi & Taleb, 1997). Devant ce constat, elle a été déclarée comme étant la mauvaise herbe la plus nuisible au Maroc tant au niveau des cultures qu'hors cultures (parcours, bord des routes).

Nous résumons les principales actions menées pour contrecarrer la propagation de la morelle, sachant que c'est l'espèce la plus étudiée (biologie, écologie, lutte) et qui a mobilisé un nombre important de chercheurs et d'institutions:

- le grand effectif des chercheurs qui se sont intéressés à cette espèce et qui représentent différents établissements notamment l'Institut Agronomique et Vétérinaire Hassan II (IAV- Hassan II), l'Institut National de la Recherche Agronomique (INRA), la Direction de Protection des Végétaux, le Contrôle Technique et Répression des Fraudes(DPVCTRF), les Facultés des Sciences des zones infestées ;
- le nombre important de mémoires et de thèses ;
- les nombreuses publications nationales et internationales ;
- trois grands projets de recherches réalisé: entre l'IAV Hassan II et la Compagnie Marocaine de Commercialisation des Produits Agricoles (COMAPRA), entre l'IAV- Hassan II et la Direction de l'Enseignement Agricole (DERD), entre l'INRA et la Direction de la Production Végétale du Ministère de l'Agriculture (DPV) ;
- plusieurs fiches techniques sont émises par différents établissements : DPVCTRF, INRA, Offices Régionaux de Mise en Valeur Agricole (ORMVA) des régions touchées ;
- trois journées nationales de sensibilisation (1993, 1994 et 1997) et de nombreuses journées régionales et locales ;
- au moins trois questions se sont posées au parlement ;
- les multiples publications par la presse nationale et régionale ;
- la création d'un comité national de lutte contre la morelle jaune en 1992 ;
- la création d'une Association de lutte contre la morelle jaune en 1995 ;
- publication de deux arrêtés gobernatoriaux.

Oxalis pes-caprae **L. (=** ***O. cernua*** **Thurb.)**

C'est une adventice vivace dicotylédone, appartenant à la famille des *Oxalidaceae.* Au Maroc, elle est qualifiée de mauvaise herbe la plus nuisible aux cultures et à la biodiversité. Elle a des caractères biologiques et morphologiques qui lui permettent d'exercer une nuisibilité directe. Elle possède un système raçinaire très développé rhizomateux avec de nombreux bulbilles pouvant exploiter les couches arables d'une façon préoccupante. Elle est aussi capable de se développer en population très dense avec un feuillage étouffant et interceptant le maximum de lumière. Son effet allélopathique sur céréales a été aussi démontré: il réduit la germination des semences des céréales jusqu'à 63% (Bouhache et Gharmate, 2002).

Outre son caractère rudéral (le long des routes, les forêts humides, les clôtures, la proximité des habitations) elle est dernièrement inféodée aux milieux de cultures (vergers, vignobles, céréales et cultures légumières)

Dans le nord du Maroc, une forme stérile multi pétales (surnuméraires) (*Oxalis cernua* Thunb. var. *pleniflora* Lowe, Fl. Mad. P. 100, 1868) a été signalée (Jahandiez et Maire, 1931-1934 ; Ater, 2002).

Les différents travaux se résument ainsi :

- Etude de la biologie et de l'écologie de l'espèce avec sa répartition au Maroc et son importance,
- Essais de désherbage dans les différents biotopes où elle existe (Tanji, 1988; Rssaissi & Bouhache, 1994),
- Etude de son effet allélopathique sur les céréales d'automne (Bouhache & Ghammarte, 2002).

Verbesina encelioides (Cav.) Benth. et Hook. ex Gray (= *Ximenesia encelioides* Cav.)

L'aire d'origine de *V. encelioides* est le continent américain en général. Selon les auteurs, elle est native de l'Amérique (cité par Grichar et Sestak, 1998), l'Amérique du nord (cité par Lopez et *al*., 1996), l'Amérique tropicale (cité par Kaul et Mangal, 1987), ou de l'Amérique du sud et le Mexique (Tuvia, 1998). *V. encelioides* est répartie dans plusieurs pays du monde. Elle est largement distribuée en Argentine et en Australie (Taleb et *al*., 2002). Egalement, elle est naturalisée en Afrique du Sud (Wells et *al*., 1986), en Europe, dans les Iles britanniques (Clement and Foster, 1994), en Inde, au Sud Ouest d'Israël (Tuvia, 1998), au Botsawana, en Namibie, en Arabie Saoudite (Al-Farraj et *al*., 1988). Au nord de l'Inde, elle est la mauvaise herbe la plus abondante. Elle se comporte comme une mauvaise herbe hivernale qui germe après les moussons et occupe les champs de maïs, orge, riz, arachide, millet (Kaul et Mangal, 1987).

Elle a éte récemment introduite au Maroc et spécialement dans la région de Souss (Sud du pays) depuis 1997. En général, elle envahit les espaces vides, les bordures de routes et des habitations, et commence à pénétrer dans les champs cultivés (Tuvia, 1998; El Mafdli, 2002) ;

C'est une Asteraceae. Elle est reconnue sous plusieurs noms scientifiques : (Bayer (1992):

- *Verbesina encelioides* (Cav.) Benth. et Hook. f. ex Gray ssp. *exauriculata* (Robins. et Greenm.) J. R. Goleman.
- *Verbesina exauriculata* (Robins. et Greenm.) Cockerell.
- *Verbesina encelioides* ssp *encelioides*.
- *Verbesina encelioides* ssp *exauriculata*
- *Verbesina scabra* Phil. (1840)
- *Verbesina microptera* (DC.) Herter (1836)
- *Verbesina aurita* Phil. (1891)
- *Ximenesia encelioides* Cav. var. *exauriculata* (Robins. et Greenm.) F. C. Gate.
- *Ximenesia encelioides* Cav. var. Cana-DC. (1836)
- *Ximenesia encelioides* Cav. (1794)
- *Ximenesia encelioides* Cav. var. *pachyptera* DC.
- *Ximenesia encelioides* Cav. var. *oblongifolia* DC.
- *Ximenesia encelioides* Cav. var. cana DC. (1836)
- *Ximenesia encelioides* Cav. var. hortensis DC. (1836)
- *Ximenesia exauriculata* (Robins. et Greenm.) Rydb.
- *Ximenesia microptera* DC. (1836)
- *Ximenesia australis* Benth. et Arn. Ex DC. (1838)
- *Pallasia Serratifolia* Sm. (1813)
- *Encelia albescens* A. Gray. (1873)

Elle est dotée d'une large amplitude écologique (Kaul et Mangal, 1987). Elle s'accommode avec sa nouvelle aire d'introduction et se propage naturellement (El Mfadli, 2002). La première phase de son invasion est agressive et rapide grâce à sa capacité à fleurir et à produire des semences durant toute l'année (Tuvia, 1998). Elle commence par l'occupation des terrains incultes et les bordures de routes et s'étend ensuite aux terrains cultivés, toutes cultures confondues (Kaul et Mangal, 1987 ; Tuvia, 1998).

Au Maroc, une seule étude a été menée en 2002 et a touché les aspects suivants de l'espèce:

– la répartition,
– la germination,
– la croissance et développement.

Comparativement avec d'autres populations du monde, étudiées par d'autres auteurs, celle du Maroc apparaît plus plastique. Elle est capable de germer dans une large gamme thermique allant de 8°C à 35°C, avec une indifférence vis-à-vis de la présence ou l'absence de lumière et une tolérance remarquable au stress hydrique. Sa capacité d'émergence a été prouvée jusqu'à 3,5 cm de profondeur d'enfouissement.

Toutes ces caractéristiques lui confèrent une grande capacité colonisatrice. C'est une mauvaise herbe jugée très redoutable à cause de sa toxicité vis-à-vis du bétail, son habilité à héberger des maladies et des insectes nuisibles. A l'échelle nationale, elle constitue un véritable danger à court et à long terme, à cause du phénomène de compétition favorisé par une croissance luxuriante et vigoureuse, et son aptitude à attirer *Bemisia tabaci* et *Trialeurodes vaporariorum*, les principaux vecteurs du virus de la maladie des feuilles jaunes en cuillères de la tomate (TYLCV).

Conclusion

En guise de conclusion, nous signalons que les espèces introduites sont connues à l'échelle internationale par leur statut de mauvaises herbes redoutables. Parmi elles celles qui sont inféodées directement aux milieux cultivés où elles exercent une forte concurrence vis à vis des différentes cultures pratiquées, d'autres constituent une menace pour la biodiversité.

Mis à part la morelle jaune, la recherche concernant les autres espèces identifiées en est à ses débuts ou est absente. Ainsi, nous recommandons les actions suivantes:
– à l'instar de beaucoup de pays, le Maroc doit avoir une liste officielle des espèces envahissantes afin de limiter leur extension en élaborant des stratégies adaptées à chaque cas,
– renforcer le système national de contrôle et de quarantaine pour empêcher ou limiter l'introduction,
– consolider l'échange d'informations par le biais de réseaux sur les plantes envahissantes,

– encourager la recherche dans ce domaine en prêtant une attention particulière à l'invasion des milieux naturels.

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The Global Invasive Species Database (GISD) and the international exchange of invasive species information: using global expertise to help in the fight against invasive alien species

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Abstract

Many countries do not fully appreciate the problems associated with invasive alien species (IAS) and have been slow to react. Sharing information and expertise internationally on the ecology, impacts and practical management of IAS is a priority for raising awareness, preventing unwanted introductions and successfully managing IAS. Information about the invasiveness of a species elsewhere is a key component in assessments of risk of invasiveness and hence critical for prevention and/or early response. International mechanisms for the exchange of IAS information and expertise are described, including;

- the Global Invasive Species Database;
- the planned development a global register of invasive species;
- aliens-L and other listservers and;
- the planned development of a Global Invasive Species Information Network.

Discussion includes the role of a centralised database like the Global Invasive Species Database in the context of a distributed network, the importance of standards for data and information exchange, and recent thinking on the “Conservation Commons”, which promotes free and open access to data, information and knowledge for conservation purposes.

Introduction

The magnitude and frequency of species introductions beyond their native range has increased dramatically with the expansion of global trade and passenger movements. Whether intentional and unintentional, the introduction of some invasive alien species (IAS) have resulted in the degradation and destruction of natural ecosystems and economic collapses – we are only just beginning to understand the extent of their damage. We need to disseminate information widely about the causes and consequences of biological invasions to raise awareness about the threat of IAS and about prevention and management strategies. It is necessary to discover, and improve access to, IAS information from all over the world in order to develop a better understanding of the scale and impacts of the problem. The Invasive Species Specialist Group (ISSG) is involved in several "vehicles" for such information exchange, including

- the Global Invasive Species Database;
- the planned development of a Global Register of IAS and a Management Project Register;
- the listserver Aliens-L; and
- the Global Invasive Species Information Network (GISIN). Some other examples of international IAS information exchange are also described.

The Global Invasive Species Database (GISD)

The Global Invasive Species Database is a free, online source of authoritative information about IAS that negatively impact biodiversity. The GISD was developed as part of Phase I of the Global Invasive Species Programme (GISP). It is managed, maintained and under continuous development by ISSG with support from partners such as the World Conservation Union (IUCN), the National Biological Information Infrastructure (NBII) of the US Geological Survey, the University of Auckland and Landcare Research-Manaaki Whenua. It contains comprehensive profiles of all kinds of invasive species from plants, mammals, invertebrates, birds, reptiles, fish and amphibians, to macro-fungi and micro-organisms. Users of the GISD can search for IAS information by scientific, common name or synonym, country or location, life form, habitat type or by any combination of these. A taxonomic search is also available.

Extensive consultation and user analysis suggested that the GISD should be primarily a management and awareness-raising/educational tool delivering summary information, rather than a source of primary data for researchers. In consideration of the fact that a large proportion of the potential audience of the GISD does not have English as a first language and may not have scientific training, information is presented in plain English in a standard format as simply as possible.

Many potential users of the GISD have very unreliable access to the Internet or none at all (e.g. the South Pacific and parts of Africa), so alternative methods of disseminating IAS information must be provided. ISSG is hopeful of making IAS information available across the “digital divide” through hardcopy and CD-ROM, but financial resources for this are currently lacking.

Profiles of invasive species in the GISD cover the biology, ecology, native and alien range of invasive species and include references, contacts and images. Each profile contains links to local, national and regional resources where more detailed and locally specific information can be found. Information in the GISD is either created or reviewed by acknowledged international invasive species experts and is updated on an ongoing basis. With almost 300 profiles completed and reviewed by experts, the GISD currently receives an average of more than 40,000 hits per day (~900 unique visitors/day).

A search in the GISD for invasive species in France for example, currently produces the names and profiles of 40 invasive alien species, plus 26 more that are native to France and invasive elsewhere. We estimate there are hundreds of IAS with known biodiversity impacts in France so there is much work still to do. A number of European initiatives are collecting IAS information for the region and sharing their information with the GISD. We would welcome any further assistance to improve the European component of the GISD. The GISD can be found at www.issg.org/database and is mirrored by NBII at www.invasivespecies.net/database.

A global register of invasive species

Knowledge of the past invasiveness of an organism is particularly important in assessing potential risks from new introductions given that

> Only one factor has consistently high correlation with invasiveness: whether or not the species is invasive elsewhere. (Wittenberg and Cock 2001).

National and regional biosecurity organisations need to be able to access information on species whose introduction anywhere in the world has resulted in negative environmental and social impacts. Many of these organisations already use information from sources such as the Global Compendium of Weeds (GCW) for risk assessments. A global register of invasive species will build on this work to identify IAS in all taxa. ISSG is planning to develop such a register if sufficient financial resources can be obtained. We will need to collect and standardise information about IAS from the literature, national and regional collection and observation databanks, practitioners in the field, IAS information exchange networks and information that ISSG has been collecting since it began in 1994. A large proportion of this information is currently unavailable on the Internet and initially, many lists of pests and weeds, for example, will need to be digitised.

Along with digitisation, standardisation of terminology used by contributing sources is a major challenge. There is a great deal of variation in the definitions used in lists, for example, and in the criteria used to place organisms on those lists. Many lists only refer to ‘exotic species’ and are described as 'preliminary’, reflecting the fact that often very little is known about the situation being assessed. Terminologies and definitions already in use internationally (e.g. GISD, GCW, Nordic-Baltic Network on Invasive Species, etc) will be integrated and universal standards proposed. Translation and interpretation of information from contributing sources will sometimes require correspondence with those sources.

At its simplest, the global register of invasive species can provide an alert that an alien species has been considered to have had biodiversity impacts somewhere in the world along with a link to the source that made that statement. That source will contain implicit distribution information through its geographical context and possibly other information of interest to users such as introduction date, pathway or vector, origin, habitat, impact and management information.

Listservers and other information exchange activities

A helpful contribution to information exchange on biodiversity impacts of IAS can be achieved through the use of Listservers. For example, a message posted on the well-established Aliens-L listserver along the lines of "there is some deliberation about plans to use alien species ‘X’ for purpose ‘Y’ in our country or region will usually "flush out" several responses if the species in question has been problematic elsewhere. Another listserver with Asian-Pacific regional range and more of an agricultural pest and weed emphasis is PestNet. It offers a rapid species identification service using expert taxonomists to identify pest and weed species from users' images.

Listservers may lack some aspects of consistency, standardisation, and quality control compared to a global database or a distributed network, but they offer an important contribution to empowerment and horizontal information transfer (e.g. practitioners helping each other and others) because of their great flexibility and their ability to deal quickly with ad-hoc, time-critical issues.

ISSG staff also use our information and expertise networks and our files to respond directly to regular requests for IAS information. For example, ISSG staff recently provided information showing the potential invasiveness of 15 tropical aquarium fish destined for import (another source had described them as either harmless or lacking impact information). In another case, we supplied potential impact information for a report raising concerns about a proposed crayfish aquaculture introduction. ISSG's networks can also be tapped for technical advice and information on education and awareness raising, human dimensions, early warning systems, economic consequences, policy, legal and institutional frameworks, risk assessment and best management practices, pathways and vectors, IAS informatics, and training and capacity building.

The Global Invasive Species Information Network (GISIN)

The development of a Global Invasive Species Information Network (GISIN) was proposed at the sixth meeting of the Conference of the Parties to the Convention on Biological Diversity held at The Hague in April, 2002. The GISIN will provide a platform through which IAS information from many participating databases and web sites can be accessed. The GISIN will use a web services architecture consisting of:

- IAS data standards,
- standardised data elements,
- IAS terminology – thesauri – closed vocabularies for data elements,
- aggregation of data and information in standardised "Invasive Species Profiles",
- service discovery mechanisms,
- search and presentation tools.

It will enable the sharing of species profiles or fact sheets, expertise lists, observation and bibliographic information as well as information about research and management projects. The databases and web sites providing information could be local, national or regional in scope or they may have a thematic focus, such as aquatic IAS or rodent eradications, for example.

Since the majority of countries lack resources and capacity in information management with regard to biological invasions issues, the GISIN will disseminate tools and experience to other countries. The tools being developed by GISIN include a ‘capacity building’ database that will be offered at no cost to users. Its use will promote the adoption of a common system for collecting, storing and sharing information on invasive species.

ISSG contributions to the development of the GISIN include sharing our extensive experience in locating, evaluating and presenting IAS information from many diverse sources for use by a broad international audience. In addition, we are developing a Species Profile Schema for GISIN and we have been participating in workshops to develop standards for data types such as species lists, fact sheets, distribution records, maps, observations and specimens, bibliographies, diagnostic and identification information, images, projects, and experts. While people will always do things in their own unique manner and standards cannot be imposed, prior knowledge of the existence of standards will result in a more uniform approach that will facilitate data sharing.

The role of the GISD within GISIN

GISIN will link major sources of online IAS information, but in many parts of the world IAS information is widely dispersed and difficult to access. Much of it has not been published and/or digitised, especially information about IAS in the developing world. Much of this information would not be available on the Internet if it were not for the activities of the GISD and national or regional initiatives such as the Conservatoire Botanique National Méditerranéen de Porquerolles that have maintained a focus on creating content of relevance to their region.

In addition, different user groups have different IAS information requirements. Quarantine officers, land managers, environmental and biodiversity specialists, extension agents and other individuals and organisations concerned with the environment need quick access to a user-friendly source of relevant,

summarised information. The GISD meets these information needs as directly as possible by locating, synthesising and checking relevant material for accuracy using expert reviewers, before presenting the results on the Internet. This work compliments that of the GISIN, which provides access to IAS data and information sources, but leaves it up to a relatively experienced user to interpret the data and to manage issues such as variation in terminology and data quality.

We suggest that our experience and information networks, and our digitising and data discovery activities, make the ISSG a vital contributor of content to the GISIN. In turn the ISSG can use the GISIN to help build the global register of invasive species, the management project register and other strategic products that require a familiarity with the data and an understanding of users' needs.

Information sharing and the conservation commons

All of the information exchange efforts described depend on the free exchange of IAS data information and knowledge. The Conservation Commons promotes free and open access to data, information and knowledge for conservation purposes (see http://conservationcommons.org). At its simplest, it encourages organisations and individuals alike to place documents, data and other information resources related to conservation in the public domain. The Conservation Commons is characterised by an underlying set of principles:

– **Principle 1. Open Access** The Conservation Commons promotes free and open access to data, information and knowledge for conservation purposes.
– **Principle 2. Mutual Benefit** The Conservation Commons welcomes and encourages participants to both use resources and to contribute data, information and knowledge.
– **Principle 3. Rights and Responsibilities** Contributors to the Conservation Commons have full right to attribution for any uses of their data, information or knowledge and the right to ensure that the original integrity of their contribution to the Commons is preserved. Users of the Conservation Commons are expected to comply, in good faith, with terms of uses specified by contributors and in accordance with these Principles.

Conclusion

IAS are a global scourge, driven by human activities and increasing exponentially. We need to facilitate effective responses by drawing conclusions and making recommendations based on our understanding of the problem, and bring about change by sharing our knowledge widely to empower individuals and communities. To do this we need IAS data, information and knowledge from all parts of the world. We need to facilitate access to that data, information and knowledge and to break down barriers that impede collaboration and the free flow of information.

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Prevention dealing with introductions and spread of invasive plants (through horticulture, agriculture, forestry and landscape management) / *Prévention contre l'introduction et la dispersion volontaires de plantes envahissantes (par l'horticulture, l'agriculture, la foresterie et l'aménagement paysager)*

Changing attitudes to plant introduction and invasives

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Abstract

Plant introduction has a long history since the first recorded expedition of 1493 B.C. sent by Queen Hatshepsut of Egypt to the Land of Punt. Most civilisations engaged in a two-way traffic of plant introduction and export and the acquisition of new plant resources for trade and agriculture was a characteristic of the colonisation process by the European powers since the 15th century.

There have also been several major waves of ornamental plant introductions. Perceptions of the natural world and attitudes to the exploitation of plant diversity have changed over the centuries. Until the coming into force of the Convention on Biological Diversity, plant resources were regarded as the 'common heritage of mankind' with little regard to the interests of the communities from whose land the resources were obtained. In effect, access to plant resources was on a free for all basis, thus putting countries in the developed world at a considerable advantage over those in the developing world. Botanic gardens played a major role in plant introduction, especially in the 18th and 19th centuries. In contrast, the CBD reaffirms nations' sovereign rights over their natural biological resources and agreements to ensure and regulate this have been introduced.

An unsuspected consequence of the introduction of many thousands of plant species into cultivation was the escape of considerable numbers of them from agricultural fields and botanic gardens into disturbed habitats and some of these in turn became naturalised and a threat to natural plant communities. Such alien and invasive plants are now seen as a major threat to biodiversity conservation causing a rethink in our attitudes to introducing new germplasm and the need to adopt safeguards to try and limit or prevent possible undesirable consequences.

Introduction

The introduction of plants (and animals) has a long and complex history. The earliest recorded plant introductions were those of the expedition of 1493 B.C. sent by Queen Hatshepsut of Egypt to the Land of Punt; subsequently most civilizations have engaged in the deliberate introduction of plants from around the world for a variety of scientific, economic and cultural purposes such as science, agriculture and horticulture. An unsuspected consequence of the introduction of many thousands of plant species into cultivation was the escape of considerable numbers of them from agricultural fields, private and botanic gardens into disturbed habitats and some of these in turn became naturalised and a threat to natural plant communities. This did not begin to be appreciated until the 20th century and today such alien and invasive plants are now seen as a major threat to biodiversity conservation as well as having serious social and economic consquences.

The ever-increasing extent of trade and travel is leading to the spread of more and more invasive plants, animals and diseases and today it is reckoned that the dangers of bioinvasion constitute an environmental threat that may be second only to habitat loss in its potential to cause irreparable damage to our planet with serious economic consequences (Bright 1998). Other papers at this Workshop will detail the loss of biodiversity, destruction of ecosystems, disruption of traditional agricultural and fishing communities and threats to public health caused by these bioinvasions. This paper is concerned with the ways in which attitudes to plant introduction, by both scientists, economists, sociologists and the general public, have changed over the centuries.

The quest for plant diversity

The reasons for introducing plants are many, the most notable being:

Scientific curiosity

Many plant intrductions were made as part of the desire by scientists to explore, describe and understand better the natural world. The 18th century was characterised by a major series of efforts through voyages of exploration and trade, organised by the European powers, notably Britain, France, the Netherlands, Spain and Portugal, to extend knowledge of the physical and natural world. Many of these voyages led to large numbers of plant (and animal) specimens and propagules being brought back for scientific study and many were brought into cultivation in botanic gardens and private gardens and nurseries. For example, the voyage of the Endeavour (1768–1771) under the command of Captain James Cook was one of the most significant and influential voyages of discovery in history. The naturalists Joseph Banks and Carl Solander, who sailed with Cook, collected and examined specimens from more than 100 new plant families with 800 to 1,000 new species.

In the 18^{th} and 19^{th} centuries, the predominant approach to botany was a descriptive one, not only in Europe but elsewhere in the world, and it was dominated by taxonomy. Many of the plants brought back as specimens or cultivated in botanic gardens and nurseries were described as new species, genera and families, a process that continues to the present day. This laid the foundation for our understanding of the natural world and the development of evolutionary biology. The cultivation of native and exotic plants also allowed experiments to be undertaken in genetics, plant breeding and plant physiology and the rise of modern experimental biology.

Biophilia

Humans have an almost unsatiable interest in plant and animal diversity, natural history and gardening, a phenomenon which Wilson (1984) called biophilia – the love of life but more than that, 'the innate, hereditary tendency to affiliate with life, to be attracted to it, to like its variety, to enjoy and prefer certain qualities of it'. As an illustration of this, the Royal Society for the Protection of Birds (RSPB) was founded in 1889 and since then has grown into Europe's largest wildlife conservation charity with more than a million members while the Royal Horticultural Society in the UK, for example, has over 350 000 members. Not surprisingly then, the introduction of more and more diversity of plant species was welcomed and encouraged so that they could be enjoyed and admired in private and public gardens and written about in countless publications.

Collectionism

A consequence of the influx of new plant species and the prospect of discovering many more to intrdouce was the development of interest by wealthy patrons in building up collections of plants or of particular groups of plants. A remarkable example of such collectionism was the great so-called tulipomania of 1636–37 in the Netherlands when tulips which began as an imported luxury from Turkey in the 16th century appreciated by connoisseurs and scholars were developed by growers to produce a huge number of varieties with an unlimited array of hues, petals shapes and sizes which could be bought by thousands of small buyers, leading to a mass of speculation and eventually regulation (Schama 1987).

A more recent example in the 19th and 20th century was the passion for introduction into the United Kingdom of Rhododendrons following the publication of Hooker's Rhododendrons of Sikkim-Himalaya in 1849–51. Initially the craze was confined to gentlemen collectors – wealthy landowners with space to grow these beautiful and colourful plants at great expense – but later they became popular in small domestic gardens. Curiously, the Rhododendron which became a serious invasive was the fairly ordinary Rhododendron ponticum. This evergreen shrub was introduced to Britain from southern Spain, at the end of the 18th century and later from Turkey, as an ornamental and was widely planted and used as cover for game in large estates. Subsequently it escaped and became naturalized and often invasive, replacing native woodlands in the British Isles and Ireland. Recent research indicates that it is at least partly, possibly largely, a hybrid, formed in Britain between Spanish *R. ponticum*, American *R. catawbiense* and other species (Milne & Abbott 2000).

Collectionism has not been confined to wealthy patrons or the nouveau riche. Botanic gardens also have, over the years, vied with each other in amassing large collections of samples of species, although generally without any scientific or conservation ethic in mind. "Serendipitous collectionism" has been the rule in most botanic gardens until recently (Heywood 1996). The introduction and cultivation of exotica from warm climates led to the development of specialised structures to maintain these plants over the winter, such as orangeries, limonaia, stoves, greenhouses and the spectacular palm houses and conservatories that characterise many botanic gardens today.

Medicine

One of the first major uses of plants was for medicine and a major focus of plant introductions was, and continues to the present day, plants of actual or potential sources of new drugs.

In Europe, the majority of today's botanic gardens have developed from the western tradition of medicinal gardens – the Gardens of Simples (Horti Simplicium) or Physic Gardens – that were founded from the 16th century onwards in Italy and other countries. The role of these early botanic gardens was to provide demonstration material for the use of local doctors and herbalists, for teaching medical students and for the actual supply of medicinal plants for use in therapies. The plants grown in these medicinal gardens were largely European or Mediterranean in origin but in due course with the rapidly increasing exploration of different parts of the world, the diversity of plants that became available for introduction was very much greater and the medicinal gardens began a process that continues to the present day – the study of the diversity of the world's flora (Heywood 1987). Today the introduction of medicinal plants is often the subject of bioprospecting agreements (Reid *et al*. 1993)

Trade

The development of the spice trade was one of the main motivations of much of the plant introduction process, especially during the early European colonial period. The introductions were often from one colonial teritory to another, often via botanic gardens, so that a ready supply of the spices could be grown for import to Europe and elsewhere. Many other commodities such as palm oil, jute and rubber were similarly introduced for trading.

Agriculture

The agricultural crops grown in most country are dependent on germplasm which has been introduced from other countries. Initially, colonisers tended to ignore native species in many countries such as Australia and introduced other crops for agriculture and horticulture

The basis of the agricultural economy of southeast Asia was largely the result of plant introductions aranged through botanic garden networks – tea, coffee, rubber, oil palm and various spices being examples.

Forestry

Throughout the world, forestry has utilised alien and exotic species for a variety of purposes, especially in reafforestation and plantations. In South

Africa alien trees such as *Pinus pinaster* were planted on Table Mountain so as to increase the water supply in the mountain catchment areas, on the recommendation of the Colonial Botanist in the 1860s and foresters (Huntley 1996), only to become a serious invasive weed as are *P. radiata* and *P. patula* and *P. halepensis* (Moran *et al*. 2000).

Community benefit and social uses

Many exotic plants have been introduced for the benefits they confer upon communities, directly or indirectly, such as the introduction of crops to suppport the local economy. An example is *Opuntia ficus-indica* into the Canary Islands in the early 19th century for the red dye Cochineal produced by a scale insect that feeds on prickly pears. Cochineal production became the leading export from between the 1820s and the 1850s, especially in Lanzarote but now the crop is a relict one and the species has become a serious invasive.

Spices, stimulants and intoxicants such as saffron crocus, tobacco, cannabis and opium poppy are examples of species introduced for social uses.

Plant introductions and the colonisation process: the role of botanic gardens

The acquisition of new plant resources for trade and agriculture was a characteristic of the colonisation process by the European powers since the 15th century. As Calestous Juma has written in *The Gene Hunters* (1989), 'the acquisition of colonies was not enough unless linked with the availability of labour and plant genetic resources'. This involved the movement of stocks of economically useful plants from one part of the world to another on a massive scale in the furtherance of colonial agriculture. Botanic gardens played an important and often key role in this enterprise. The combined networks of colonial botanic gardens of the European powers such as France, the Netherlands and particularly the United Kingdom served as a very effective mechanism for the transfer of germplasm around the world, long before the modern genetic resources movement was developed. Indeed, most of the tropical colonial botanic gardens that were established from the 18th century onwards by these countries as part of the exploration and colonisation process were to play a major role in economic development, agriculture, commerce and trade.

The earliest tropical botanic garden was that of Pamplemousses on the island of Mauritius (Île de France), founded in 1745 by the governor Labourdonnais who bought a vegetable garden called Mon Plaisir. While its initial aim was to provide fresh fruit and vegetables for the town of St Louis and for the ships that called in at the port, later many spice plants were introduced such as nutmeg (*Myristica fragrans*) and clove (*Syzygium aromaticum*), and amongst the food plants, was cassava which was grown to feed the slaves. The Garden has subsequently been instrumental in introducing many other economically important species into cultivation and making them available to other Gardens and set the pattern that others were to follow.

Botanic gardens have been major centres of plant introduction since the 15th century and today it is estimated that 80 000 or more species are in cultivation in the world's 2000 plus botanic gardens and arboreta. The formal large scale exchange of plants apparently began with the agreement between the Chelsea Physic Garden and Leiden University in 1683. In addition, a particularly important mechanism for plant introduction was the *Index Seminum* whereby seed of a wide array of species was made available free of charge to other botanic gardens, the first one being that issued by Oxford University Botanic Garden in the 18th century.

On the negative side, nurseries, private and botanic gardens have been a major source of invasives in some countries and botanic gardens in particular have been implicated. For example, *Miconia calvescens* which was introduced to Hawaii and Tahiti is now considered to be one of the greatest threats to the fragile ecosystems of the islands. In Tahiti, it was first planted as an ornamental at a private botanical garden in 1937; it can now be found on approximately 70% of the island. Horticultural activity (botanic gardens, arboreta, gardeners) is probably responsible for about 60% of invasive plant introductions in the United States.

Acclimatisation and acclimatisation societies

A curious feature of the introduction process was the establishment of acclimatisation gardens and societies such as those in France, Great Britain, Australia and New Zealand. Acclimatisation gardens were created in Spain, for example, so as to permit the introduction, protection and acclimatisation of plants from their American colonies and from Asia to allow them to be transferred to the Madrid botanic garden and to the royal gardens of Aranjuez.

The most celebrated of these acclimatisation gardens was that of La Orotava on the island of Tenerife, Canary Islands founded in 1788 by the Marques de Villanueva and still surviving today as a botanic garden. No surprisingly, many of the species successfully cultivated in La Orotava did not survive their subsequent shipment to the mainland or could only be grown under some form of protection such as orangeries.

According to Sainte-Hillaire, at what was apparently the world's first acclimatisation meeting in Paris in 1854,

> The prospect was nothing less than to people our fields, our forests, and our rivers with new guests; to increase and vary our food resources, and to create other economical or additional products. [quoted in Low 2002].

Although countries undoubtedly benefited, they also suffered severe adverse consequences as many of the introduced acclimatised plants escaped from cultivation and invaded native ecosystems causing major loss of biodiversity. Acclimatisation has been described by Low (2002) as 'one of the most foolish and dangerous ideas ever to infect the thinking of nineteenth-century men'.

The backlash against introductions

Not everyone was happy with the growing introduction of exotic species. Over time attitudes to plants invaders have changed considerably, ranging from almost unqualified support for exotic imports to suspicion and then downright antagonism. In the 19th century, the merits of growing foreign plant species, especially those from the tropics was much debated. William Morris, the designer and socialist and founder of the Arts and Crafts movement believed that the proper place for exotic species was in botanic gardens, not domestic gardens and this was echoed in the English natural garden movement (Preston 2002). There developed a form of horticultural nationalism in which the new model English garden had to be protected from invasion by alien exotics which were even castigated for their unnaturalness, even their sexuality and scent! More recently, such approaches to limit or control introduced species have been criticised as being nativist, racist or xenophobic (Simberloff 2003) but this is seldom justified as in most cases the motivation for this action is soundly based on documented assessment of the likely economic or ecological impacts that bioinvasions will cause. To help avoid such ideological confusion, Colautti and MacIsaac (2004) have proposed a neutral terminology for 'invasive' species.

We are now in a situation where many people recognise both the risks and benefits of plant introductions and the challenge is to develop and implement a strategy that allows the social, economic and environmental costs to be minimised without foregoing the benefits that derive from the introduction process. Thus Bright (1998) outlines a counter-invasion strategy that stretches from international legal reform to on-the-ground control techniques. And, recognising that the principal challenge may not be so much technical as cultural, Bright calls for a higher degree of ecological literacy — an appreciation of the value of native plants and animals, and an ability to 'read' landscapes well enough to see the invaders within them.

The biotechnology dilemma

If ever a demonstration was needed of the multidisciplinary background to the plant introduction process and the key role of the general public, one need only look at the highly divergent attitudes to agricultural biotechnology and the introduction of transgenic organisms. The issue is complicated by ethical, moral, socio-economic, political, philosophical and scientific issues and each side presents its opposing views somewhat stridently.

A final observation: if climate change proceeds at the rapid rate which many scientists now believe it will, the need for large-scale introduction of exotic species adapted to the new habitats and conditions will provoke a rethink of the whole of the introduction process and attitudes may change again.

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Invasive alien plants in Europe – how can they be regulated?

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Abstract

Invasive alien plants can be injurious to other plants – this provides the chance to regulate them as “plant pests” within the framework of plant health. Pest risk analysis (PRA) is a tool used in plant health to assess risks of organisms harmful to plants and to identify options for their management. Standards of the International Plant Protection Convention (IPPC) and the European and Mediterranean Plant Protection Organisation (EPPO) are available to facilitate the procedure of PRA. These standards are also applicable to alien plants, but some specialities have to be considered. In contrast to the “traditional plant pests”, which are introduced unintentionally, alien plants are usually introduced intentionally. This requires a different approach in the framework of plant health. In many cases, the identification of (potential) invasiveness is very difficult. For selection of management options a differenciated approach is necessary as well, including the prohibition of introduction of significantly risky plants and the obligation for specified requirements to restrict their spread. EPPO can give recommendations to its 47 member countries on how to manage invasive alien plants. The EU Council Directive 2000/29/EC (plant quarantine directive) provides the legal base to regulate the introduction of invasive plants in accordance with the IPPC. Its implementation is now in preparation. This article provides a background to the possible regulation of invasive alien plants based on PRA in the framework of plant health in Europe.

Introduction

Alien plants can pose serious threats to cultivated and wild plants. In the majority of cases, these threats are the consequences of indirect effects: competition for space and resources, change of habitats, e.g. by altering soil chemistry or water regime. The fact, that invasive alien plants can be injurious to other plants provides the chance to regulate them as "plant pests" within the framework of plant quarantine, or plant health, which aim is to prevent introduction and spread of organisms harmful to plants and to promote appropriate measures for their control. Furthermore, habitats and ecosystems can be protected from the consequences that the introduction of an invasive alien plant may have, as they are essential for the survival of plants. Plant health is implemented in Europe by a long established and well developed system. Traditionally, only direct pests of plants (viruses, fungi, insects etc.) are regulated by this system, but the regulation of indirect pests – in particular invasive alien plants – is now under discussion. In the framework of plant health, pest risk analysis (PRA) is the essential tool to assess whether an organism has a negative impact on plants and whether it should be regulated. The risk of introduction and spread of this pest is assessed and – if appropriate – options for measures are evaluated and proposed. Standards by the International Plant Protection Convention (IPPC) and the European and Mediterranean Plant Protection Organisation (EPPO) are available to facilitate this procedure. These standards are also applicable to alien plants (for a background, see Schrader and Unger, 2003), but there are some significant differences in comparison to the "traditional plant pests".

Risk assessment of alien plants

From a traditional plant pest, it is usually known before that it can be harmful to plants, at least somewhere and under certain conditions. For alien plants, the potential to cause damage is more the exception than the rule, and is often much more difficult to evaluate and to quantify. But in plant quarantine, it is only possible to regulate an organism, if it is of potential economic (including environmental) importance to the area endangered thereby (IPPC, 1997). Invasive plants have effects on the environment, threat to biodiversity is part of their definition. Their impacts are generally described in qualitative rather than in economic terms.

In particular for alien plants for planting, it is not necessary to assess if they could enter a country – it is intended that they do so, because they are traded and introduced intentionally. Instead, it is important to look at the pathway from the intended to the unintended habitat and the probability of establishment in the unintended habitat – with other words: can the plant escape from where it has been seeded or planted? This assessment involves the consideration of climatic and other abiotic factors, the reproductive strategy of the plant species, possible prevention of establishment by natural enemies or by competition from species present in the PRA area, likelihood of eradication or control of the species after introduction etc.

Even the escape from an intended habitat is not causing any harm in probably most cases. One of the challenges to assess the risks of alien plants is the identification of the plant's potential for invasiveness. For plants affecting wild plants, it is necessary to evaluate damage or threat to biodiversity. In this context, it is important to define or estimate thresholds – from which point is a plant invasive? From which point on is biodiversity threatened? How is damage to be defined?

It is necessary to find out if the assessed organism has intrinsic attributes indicating that it could cause significant harm to plants or plant communities. Attributes of plants which could be relevant for invasiveness are broad ecological amplitude and high adaptability, ability to build up a persistent seed bank and to produce many seeds or vegetative propagules, and high competitive strength. Important questions are if the species is invasive in its native range or elsewhere, if the chances for rapid natural spread are high, if the propagules are highly mobile or if the plant does benefit from cultivation or browsing pressure, and if there is a likelihood of building up monospecific stands etc. An indication for invasiveness may also be the experience that the plant is invasive in other areas. According to Williamson (1999) this is the the only consistent predictor. An invasion is often triggered by planting large volumes of a plant species, and by repeated and secondary introductions (see e.g. Kowarik, 2003). The success of a plant in invading a certain area will also depend on the invasibility of the related habitat, so this will have also to be assessed. The prediction of invasiveness of an assessed plant will probably in most cases be the major difficulty in the whole PRA. Several publications deal with the prediction of invasiveness and the related difficulties (e.g. Kolar and Lodge 2001, Williamson 2001, Heger and Trepl 2003). Trials (experimental plantings) could be an option to get more information on invasiveness, but the time-lag effect is difficult to be assessed. For first time introduction of plant species, a screening would be useful, with simple criteria, followed by an in-depth Risk Analysis, if there is some indication for invasiveness.

Consequences of establishment and spread

The assessment of effects or consequences from establishment and spread of a pest in the considered area is an important step to find out if a species should be regulated. At first, direct effects or primary consequences have to be evaluated. For environmental risks, important consequences would be for example the reduction of the abundance of keystone plant species, of plant species that are major components of ecosystems or of endangered native plant species. Furthermore, protection of other plant species against significant reduction, displacement or elimination is provided, though endangered species receive more attention than just “normal" species because of their status. Keystone plant species are "responsible" for the existence of an ecosystem of a certain type or are the main drivers for the development of or succession within an ecosystem. Species that are major components of ecosystems are of particular relevance, because reduction of their abundance will certainly change the habitat or ecosystem that is dependent on them, or even cause the ecosystem to degrade or even collapse.

Examples for indirect pest effects or secondary consequences relate to significant effects on plant communities, significant effects on designated environmentally sensitive or protected areas, significant changes in ecological processes and of the structure, stability or dynamics of an ecosystem (including further effects on plant species, erosion, water table changes, increased fire hazard, nutrient cycling, etc.), effects on human use (e.g. water quality, recreational uses, tourism, animal grazing, hunting, fishing), or costs of environmental restoration. If for example *Robinia pseudoacacia* is invading certain habitats it may have a significant effect on the whole plant community, because ecological processes may be affected by an accumulation of nutrients due to a nitrogen enrichment in the soil caused by this tree species. This has a significant negative impact on nutrient-poor soils, which often are habitats for endangered plant species. Another kind of example is the damage which could be caused by the aquatic plant *Crassula helmsii* (New Zealand pygmyweed). Its vegetative growth leads to dense mats which can block ponds and drainage ditches, and may even outcompete native flora. It impoverishes the ecosystem for invertebrates and fish. The vegetation mats can be dangerous to pets, livestock and children who mistake them for dry land.

Other negative impacts of introduced invasive alien plants can be allelopathic effects or hybridization. *Ailanthus altissima* for example, has allelopathic effects on many other tree species and may consequently inhibit succession (Heisey, 1990, 1996). Alien species can hybridise with closely-related natives, which may lead to a loss of genetic and species diversity. An example is the American grass species *Spartina alternifolia* which was accidentally introduced and hybridised with *S. maritima* in Britain, producing *S. x townsendii*. The hybrid led to a tetraploid species, *S. anglica*, which outcompeted the parent species and is invading successfully British wetlands (Gray *et al.* 1991, Thompson, 1991). Alien plant species may also hybridize with other non-natives, possibly leading to the evolution of a stronger, more vigorous hybrid, as is the case with *Reynoutria x bohemica*, hybrid of *R. japonica* and *R. sachalinensis* (Pysek *et al.* 2003).

Risk management of alien plants

If risk assessment reveals an unacceptable risk to plants, management options have to be identified to reduce or exclude these risks. The situation with invasive alien plants that are introduced unintentionally (as for example propagules or hitch hikers with other plants) is comparable with other plant pests – measures may be determined, which block or reduce entry and spread via the identified pathway(s). But with intentionally introduced plants, management options are quite different. The management part of ISPM No. 11 does not give detailed guidance on how to proceed with invasive or potentially invasive plants. In the framework of EPPO, it is therefore currently discussed to develop a standard for the import of alien plants. Important points to consider are: the surveillance after planting, the preparation of control or emergency plans if a plant is found outside its intended habitat and spreads to an unacceptable degree, the restriction on import, sale, holding, and on planting (including authorisation of intended habitats, prohibition of planting in unintended habitats, required growing conditions for plants), the notification before import, restrictions on movement (e.g. prevention of movement to specified areas), the obligation to report findings. In any case, the intended use of the plant is influencing the choice of management measures. A differentiation between the intended use of species, e.g. for gardening (within urban areas) or for landscaping (planted in large amounts/many different locations, in the countryside) can also influence the selection of possible measures.

For plants new to a territory, it is difficult to predict how they will behave. If an invasive behaviour has never been observed before, but some characteristics or attributes of the plants and their potential habitats raise suspicion for invasiveness, an option could be to monitor plants after import and planting. This could be combined with an emergency plan to be used when the plant is found outside its intended habitats in undesirable numbers.

Because the measures for ornamental plants may be difficult to understand for the public, raising of publicity is an important point in this context. Measures may easier be accepted for clear-cut cases than for plants for which only a risk potential has been identified.

Regulatory framework

With EU-Council Directive 2000/29/EC (EC, 2000) protective measures against the introduction of organisms harmful to plants or plant products into the EU-Member States from other EU-Member States or from third countries are possible, as well as protective measures against the spread of harmful organisms within the Community by means related to movements of plants, plant products, and other related objects within a Member State.

One of the most important measures in this Directive is the listing of harmful organisms whose introduction into the community must be prohibited. In addition, implementing provisions may be adopted to lay down conditions for the introduction into the Member States and the spread within the Member States of organisms which are suspected of being harmful to plants or plant products but are not listed.

Currently, it is under discussion, if this regulatory framework will also be used for invasive alien plants. Though theoretically possible, implementation has still to be developed.

Some EPPO Member Countries that are not EU-Member States have partly some regulations on specific plants, but these are focused on unintentional introductions.

Conclusions

For invasive alien plants that threaten other plants or plant products directly or indirectly, the revised IPPC and EPPO standards on PRA provide the necessary elements for a substantial risk analysis. The experience for their application and the implementation of their results in this regard has yet to be increased. Results of the PRAs can be used for recommendations by EPPO to its Member Countries, including proposals for management options. PRAs and EPPO management options could provide the basis for the EU Commission and accordingly for separate EPPO Member Countries that are not EU Member States to regulate specified invasive alien plants, including prohibition of import or conditions for introduction or use.

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The IPPC-Standards are available at the IPPC website (International Phytosanitary Portal): www.ippc.int, the EPPO-Standards at the EPPO homepage (www.eppo.org). For the latter an update is in preparation.

Importation d'organismes exotiques à des fins scientifiques – Droit communautaire et dispositions législatives et réglementaires françaises

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Abstract

Introduction of exotic organisms into a territory must be controlled to prevent serious economic losses, drastic health problems, and associated environmental problems.

Certain harmful organisms, plants, plant products and other objects, may be introduced into the European Union, for trial or scientific purposes, but only under specified conditions.

International conventions such as the International Convention on Plant Protection (ICPP), the Convention on Biological Diversity (CBD), Sanitary and Phytosanitary Standards (SPS) under the World Trade Organisation (WTO), European Union provisions, French legislative provisions, French regulation provisions and French administrative provisions provide obligations and govern the movement and the confinement of certain harmful organisms, plants, plant products and other objects in France.

Research Institutes could import live organisms, macro and micro organisms and plants into the French territory, if these species are imported according to the legislation and regulations in use at International level (ICPP, CBD, SPS, CITES), by the European Union (Directive 95/44/CE, Directive 2000/29/CE), and by France (Decree 2003-768, Ordinance of June 10, 1998, Ordinance of November 22, 2002).

Quarantine activity needs to be approved and regulated organisms may be imported after being declared to the official plant protection authorities (French Regional Service of Plant Protection), and with a Letter of Authority.

L’introduction d’organismes exotiques dans un territoire doit être contrôlée, pour prévenir de sérieux problèmes économiques, de santé publique, et environnementaux. Dans un contexte international où le volume des marchandises échangées est en constante augmentation, la majorité des introductions d'organismes exotiques sont liées aux activités commerciales et concernent à la fois des introductions volontaires et des introductions fortuites liés aux matériels faisant l'objet des échanges. Certains organismes nuisibles, plantes, produits végétaux et autres objets peuvent être introduits dans l’Union Européenne à des fins scientifiques, ou pour des travaux de recherche variétale, seulement sous certaines conditions. Les conventions internationales, le droit communautaire, les dispositions législatives et réglementaires françaises portent obligations à l’occasion de toute importation et détention de certains de ces organismes nuisibles normalement prohibés à des fins de recherche. Ces organismes vivants, macro et micro organismes, et des plantes peuvent être importés sur le territoire français, si les activités sont agréées et si le matériel vivant est accompagné des documents officiels requis à l’occasion de toute importation, détention ou mise en circulation. Les installations d’accueil doivent assurer la protection des utilisateurs et de l’environnement.

Dispositions internationales

L’objet de la Convention Internationale pour la Protection des Végétaux (CIPV), est la prévention de la dissémination et de l’introduction d’organismes nuisibles. Par organisme nuisible est entendu

> toute espèce, souche ou biotype de végétal, d’animal ou d’agent pathogène nuisible pour les végétaux ou produits végétaux (art.2.1.)

tel que défini à l’occasion de la dernière révision de la Convention adoptée à l’occasion de la Conférence de l’Organisation des Nations Unies pour l’Alimentation et l’Agriculture (FAO 1997). Chaque partie contractante à la présente Convention assure la promotion et adopte des mesures de lutte contre les organismes nuisibles et met en place les mesures législatives, techniques et réglementaires appropriées. Ces dispositions concernent les végétaux, produits végétaux, lieux de stockage, emballages, conteneurs, terre, objets et matériels susceptibles de porter ou disséminer des organismes nuisibles. Chaque partie s’engage à mettre en place une organisation officielle de la protection des végétaux, cette dernière délivre des certificats phytosanitaires conformes, dresse une liste des organismes nuisibles réglementés sur son territoire et met en place les mesures particulières si nécessaire concernant l'importation d'organismes nuisibles, de végétaux et produits végétaux et autres articles réglementés, aux fins de recherche scientifique, à des fins éducatives ou à des usages spécifiques sous réserve de garanties appropriées. Les parties participent aux instances internationales, aux organisations régionales, et à l'élaboration de normes internationales. L'organisation régionale responsable pour la coopération internationale en protection des végétaux dans la région européenne et méditerranéenne est l'Organisation Européenne et Méditerranéenne pour la Protection des Plantes (OEPP).

L'Accord sur l'application des mesures sanitaires et phytosanitaires (SPS) de l'Organisation Mondiale du Commerce (OMC – GATT 1994) s'applique aux mesures sanitaires et phytosanitaires qui peuvent directement ou indirectement affecter le commerce international. Il offre la possibilité de prendre les mesures sanitaires et phytosanitaires nécessaires à la protection de la santé et de la vie des personnes et des animaux ou à la préservation des végétaux, sous conditions. Ces mesures ne peuvent être prises que si elles sont fondées sur des principes scientifiques, elles ne doivent en aucun cas établir une discrimination arbitraire ou injustifiée entre les membres, et se doivent d'être conformes au présent accord.

Depuis 2003, il est à noter un rapprochement entre la CIPV et la Convention sur la Diversité Biologique (CDB), par la mise en place d'un programme de collaboration et la signature d'un protocole d'accord. Un des objectifs affichés de la CDB est clairement énoncé dans son texte initial

> empêche d'introduire, contrôle ou éradique les espèces exotiques qui menacent des écosystèmes, des habitats ou des espèces. (art.8 h).

Toute importation d'organismes vivants à titre scientifique ou à des fins commerciales ne peut être envisagée qu'eu égard aux dispositions de la Convention internationale des espèces de faune et de flore sauvages menacées d'extinction (CITES). Cette dernière réglemente le commerce international des spécimens de flore et de faune sauvages, concerne l'exportation, la réexpédition et l'importation de plantes et d'animaux vivants ou morts ou de leurs parties et produits. Sur la base d'un système de permis et de certificats qui peuvent être délivrés si certaines conditions sont remplies. Chaque partie désigne un organe de gestion, chargé de délivrer ces permis et certificats. Les espèces animales et végétales, soumises à réglementation sont inscrites aux annexes de la Convention.

Droit communautaire

Les mesures de protection contre l'introduction, dans les Etats membres de l'Union Européenne, d'organismes nuisibles aux végétaux ou aux produits végétaux, en provenance d'autres Etats membres ou de pays tiers, y compris les départements d'outre-mer français et les îles Canaries ont été publiées en 1977 (Directive 77/93/CEE). Ce dernier texte a été codifié en 2000 par la publication de la Directive 2000/29/CE. Chaque Etat membre de l'Union crée ou désigne une autorité responsable. En annexes figurent la liste des organismes nuisibles dont l'introduction et la dissémination doivent être interdites, les organismes dont l'introduction et la dissémination doivent être interdites s'ils se trouvent sur certains végétaux ou produits végétaux, la liste des végétaux, produits végétaux et autres produits dont l'introduction doit être interdite, les exigences particulières que tous les Etats doivent imposer pour l'introduction et la circulation de végétaux, de produits végétaux et d'autres produits, la liste de ces derniers devant être soumis à une inspection phyto-sanitaire, la liste des végétaux et produits végétaux qui peuvent être soumis à un régime particulier, ainsi que les informations relatives au certificat et passeport phytosanitaires. Il est à noter qu'à compter du 1er janvier 2005 (art.2 e) le terme « organismes nuisibles » est défini comme énoncé par la CIPV.

Les conditions dans lesquelles certains organismes nuisibles, végétaux, produits végétaux et autres objets énumérés aux annexes I à V de la Directive 2000/29/CE du Conseil peuvent être introduits ou circuler dans la Communauté ou dans certaines zones protégées de la Communauté pour des travaux à des fins d'essai ou à des fins scientifiques ou pour des travaux sur les sélections variétales, sont énoncées dans la Directive 95/44/CE. Pour les activités susnommées nécessitant l'utilisation de matériel visé aux annexes de la Directive 2000/29/CE, les Etats membres veillent à ce qu'une demande soit adressée aux organismes officiels avant l'introduction ou la circulation de ce matériel, que ce dernier circule accompagné d'une lettre officielle d'autorisation, que les activités et les installations d'accueil aient fait l'objet d'un agrément. Sont précisés dans la directive, les conditions générales applicables, les conditions de détention en quarantaine, le modèle de lettre officielle d'autorisation, les mesures de quarantaine, y compris les tests concernant les végétaux, produits végétaux et autres objets destinés à être mis en circulation après quarantaine.

Dispositions législatives françaises

Toute marchandise peut être soumise à un contrôle douanier, lorsque l'importation ou l'exportation n'est permise que sur présentation d'une autorisation, licence, certificat, la marchandise est prohibée si elle n'est pas accompagnée d'un titre régulier (art.38 du Code des douanes).

L'introduction, la possession et le transport d'organismes nuisibles réglementés sont interdits sauf exceptions autorisées. La présence de tout nouvel organisme nuisible doit être obligatoirement déclarée aux autorités compétentes. La liste des végétaux, produits végétaux et autres objets soumis au contrôle phytosanitaire est déterminée par arrêté du ministre chargé de l'agriculture. L'inspection et les contrôles sont effectués par les agents du Service régional de la protection des végétaux ou les agents délégués du ministère. Le contrôle documentaire est effectué par les agents des douanes, de la concurrence, de la consommation et de la répression des fraudes. Les agents habilités ont accès aux locaux, aux installations, aux véhicules de transport. Ces agents peuvent prélever des échantillons et les mettre en quarantaine et peuvent dresser procès-verbal. Peut être puni de deux ans d'emprisonnement et de 75 000 € le fait d'introduire, détenir ou de transporter sur le territoire des organismes nuisibles, le fait de faire circuler des végétaux, produits végétaux et autres objets sans respecter les conditions fixées par les arrêtés du ministre chargé de l'agriculture, le fait de ne pas accompagner de passeport phytosanitaire les végétaux, produits végétaux, et autres objets, lorsque ce dernier est obligatoire. Peuvent être punis d'emprisonnement ou d'amendes les personnes physiques ou personnes morales qui n'auraient pas respecté la réglementation en vigueur. (art.L.251-4, 251-6, 251-12, 251-18, 251-20 du Code rural).

L'introduction dans le milieu naturel, volontaire, par négligence ou par imprudence : de tout spécimen d'une espèce animale à la fois non indigène au territoire d'introduction et non domestique, de tout spécimen d'une espèce végétale à la fois non indigène au territoire d'introduction et non cultivée, de tout spécimen de l'une des espèces animales ou végétales désignées par l'autorité administrative, est interdite. Toutefois, l'introduction dans le milieu naturel de spécimens de telles espèces peut être autorisée à des fins agricoles ou forestières par l'autorité administrative. Un décret en Conseil d'Etat précise les conditions d'application du présent article (art.L. 411-3 du code de l'environnement), décret non encore publié à ce jour.

Dispositions réglementaires

Les services déconcentrés du ministre chargé de l'agriculture comportent les directions régionales et départementales (décret n°84-1191). Dans le cadre de la protection des végétaux, le directeur de la direction régionale de l'agriculture et de la forêt (DRAF) met en œuvre les mesures réglementaires de surveillance et de protection phytosanitaire, et assure la diffusion des connaissances (décret n°84-1192). Les dispositions réglementaires relatives à la protection des végétaux constituant la partie réglementaire du code rural ont été publiées en 2003 (décret 2003-768). Les conditions à remplir pour l'introduction ou la circulation de certains organismes nuisibles, végétaux, produits végétaux, et autres objets pour des travaux à des fins scientifiques sont définies par l'arrêté du 10 juin 1998. Les activités sont soumises à agrément et le matériel est accompagné d'une lettre officielle d'autorisation. Les demandes d'agrément et de lettre officielle d'autorisation sont effectuées auprès du responsable des activités à la DRAF, Service régional de la protection des végétaux (SRPV). Les exigences sanitaires, les mesures de protection contre les organismes nuisibles, la liste des organismes nuisibles pour tous les Etats membres et certaines zones protégées ont été arrêtées en 2002 (arrêté du 22 novembre 2002) et modifiées par l'arrêté du 18 mai 2004.

Dispositions administratives françaises

Publié en 2002 le document « Procédures d'agrément des installations en vue de l'introduction ou de la circulation de certains organismes nuisibles, végétaux, produits végétaux et autres objets pour des travaux à des fins d'essai ou à des fins scientifiques ou pour des travaux sur les sélections variétales concernés par les dispositions de la directive 95/44/CE modifiée » décrit d'une façon précise l'ensemble des procédures relatives à la demande d'agrément des installations. Sont précisées les exigences selon les niveaux de confinement, la détermination du niveau de confinement en fonction des matériels réglementés : arthropodes, bactéries, champignons, nématodes, virus. Une deuxième note de ce document présente l'ensemble des textes en vigueur en 2002.

Conclusions

Sur le plan international, afin de prévenir la dissémination d'organismes nuisibles, il nous semble important que certains pays membres de l'Organisation Mondiale du Commerce adhèrent aux Conventions susnommées. Que ces pays ne tardent pas à mettre en œuvre les outils et mesures assurant la non dissémination d'organismes nuisibles. Au sein de l'Union Européenne, les décisions doivent être prises plus rapidement à l'occasion d'évènements avérés scientifiquement importants. L'ensemble du dispositif réglementaire et administratif français fixant les exigences en vue de l'importation d'organismes vivants à titre scientifique et la mise en œuvre de l'agrément des activités peut être une des bases de l'élaboration d'un standard international pour les pays d'Europe et de la Méditerranée. Bien que tous les textes cités soient disponibles via de nombreuses sources d'information, force est de reconnaître qu'à ce jour l'ensemble du dispositif présenté est peu connu de l'ensemble de la communauté scientifique sur le territoire de l'Union Européenne et en France. Un effort de communication de la part des différentes instances internationales, de l'Union Européenne et nationales, nous semble être toujours d'actualité.

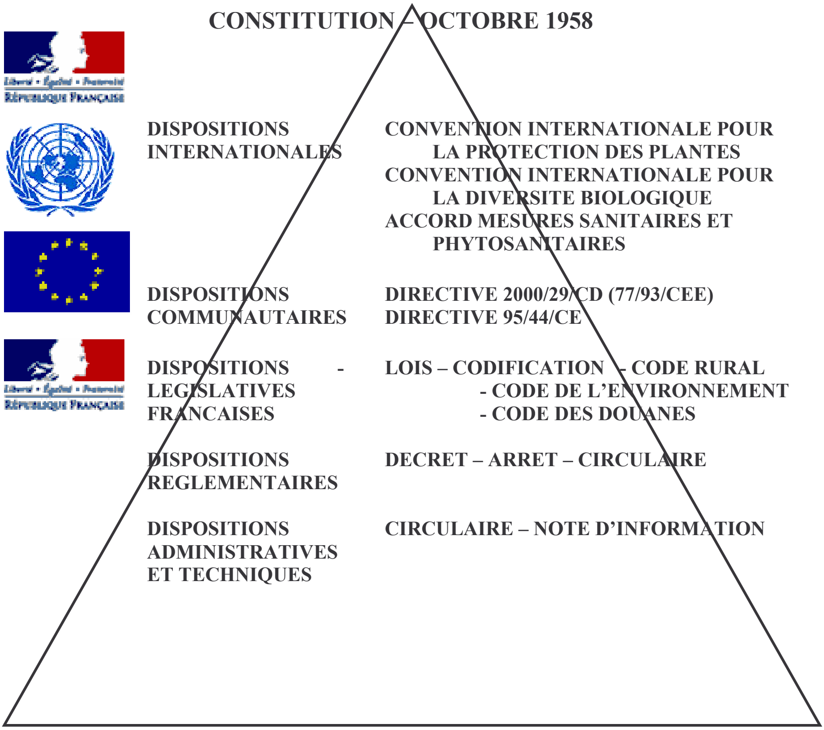

Figure 1. Hiérarchie des normes

Texte	Objet	Principales implications
Convention Internationale pour la Protection des Végétaux (C.I.P.V.), Rome 1951, révisée en 1997	Prévention de la dissémination et l'introduction d'organismes nuisibles	Organisation officielle de la protection des végétaux Certification phytosanitaire Liste des organismes nuisibles réglementés Mesures pour l'importation des ON à des fins de recherche Collaboration internationale, normes internatio-nales
Accord sur l'application des mesures sanitaires et phytosanitaires (SPS) de l'Organisation Mondiale du Commerce (OMC-GATT) 1994	Mesures sanitaires et phytosanitaires qui peuvent, directement ou indirectement affecter le commerce international	Mesures sanitaires et phytosanitaires Fondées sur des principes scientifiques Aucune discrimination arbitraire ou injustifiée
Convention sur la Diversité Biologique (CDB) Rio de Janeiro, 1992	Conservation de la diversité biologique	Empêcher l'introduction, contrôler ou éradiquer les espèces exotiques
Convention Internationale des Espèces de Faune et de Flore Sauvages menacées d'Extinction (CITES), Washington, 1973, amendée en 1979	Réglementation du commerce international des spécimens de faune et de flore	Désignation d'un ou plusieurs organes de gestion Délivrance de permis et de certificats Espèces animales et végétales soumises à réglementation
Directive 2000/29/CE du Conseil du 8 mai 2000	Mesures de protection contre l'introduction dans la Communauté d'organismes nuisibles aux végétaux ou aux produits végétaux et contre leur propagation à l'intérieur de la Communauté	Désignation d'une autorité unique Liste des organismes nuisibles prohibés Liste des végétaux, produits végétaux et autres objets soumis à contrôle ou prohibés
Directive 95-44/CE de la Commission du 26 juillet 1995 (la directive 77/93 /CEE est abrogée)	Conditions dans lesquelles certains organismes nuisibles, végétaux, produits végétaux et autres objets peuvent être introduits ou circuler dans la Communauté ou dans certaines zones protégées à des fins scientifiques	Agrément des activités et des installations d'accueil Lettre officielle d'autorisation
Code des douanes	Art. 38	Infractions à la réglementation pour importation de marchandises prohibées
Code rural	L. 251-4 L. 251-6 L. 251-12 L. 251-18 à L. 251-20	Interdiction d'introduction, de détention et de transfert de ON Déclaration obligatoire de la présence nouvelle d'ON Liste des végétaux, produits végétaux et autres objets

Texte	Objet	Principales implications
		soumis à contrôle Inspection et contrôle, agents habilités, dispositions pénales
Code de l'environnement	L. 411-3	Interdiction d'introduction dans le milieu naturel
Décret n° 84-1191	Organisation des services déconcentrés du ministère de l'agriculture	Directions régionales et Directions départementales
Décret n° 84-1192	Organisation et attributions des directions régionales	Protection des végétaux : mise en œuvre de mesures réglementaires de surveillance et de protection phytosanitaire, diffusion des connais-sances
Décret 2003-768	Partie réglementaire du livre II du Code rural	Protection des végétaux
Arrêté du 10 juin 1998	Modalités relatives à l'introduction et à la circulation à titre scientifique d'organismes nuisibles, de végétaux, produits végétaux et autres objets	Le matériel à des fins scientifiques peut être introduit ou circuler sur le territoire ou dans les zones protégées si ces activitéssont agréées et si ce matériel est accompagné d'une « Lettre officielle d'autorisation »
Arrêté du 22 novembre 2002	Exigences sanitaires des végétaux, produits végétaux et autres objets	Liste des organismes nuisibles prohibés, liste des végétaux, produits végétaux et autres objets soumis à contrôle ou à prohiber
Dispositions administratives françaises	Procédures d'agrément des installations	Procédures administratives à mettre en place pour l'agrément des activités

Figure 2. Les principaux textes

Invasive plant species in Portugal: an overview

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Abstract

The invasion by exotic plants is threatening the Portuguese native flora becoming a serious environmental problem. In the last two centuries, and especially in recent decades, the number of introduced plant species increased extensively with aliens representing nowadays more than 15 % of a total of ca. 3200 taxa of the Portuguese vascular flora. Their presence has increased probably more than 1000 % during the last two centuries, reaching nowadays the worrying figure of about 500 species. Almost 40 % of the listed species are actually or potentially invasive, including agricultural weeds and invaders of natural habitats, and ca. 7% are considered dangerous invaders. Leguminosae and Asteraceae provide the largest numbers of problematic species. Australia seems to supply the most dangerous and aggressive invaders in Portugal, including several Acacia and Hakea species. From different origins and taxonomies *Ailanthus altissima* and *Cortaderia selloana* also worth special attention due to the current drastic increase in their distribution.

Recently, Portuguese legislation has recognised this problem (dec.- *lei* 565/99), creating a list of the exotic species introduced, identifying the invasive ones, and forbidding the introduction of new species unless proven not harmful. Although this list does not include all the species introduced and despite the fact that there are exceptions for forestry and agricultural purposes, it is a good starting point. The legislative process is still being implemented and will apply penalties to the use of listed invasive species. As next steps, the list needs updating and it is essential to implement the regulations in the field with inspections to horticulturist, landscape architectures, gardeners, boarders and others. Technician‘s training is still needed to assure the correct application of the legislation.

Introduction

The invasion by exotic plants is threatening the Portuguese native flora and becoming a serious environmental problem (Almeida & Freitas 2001, Campelo 2001, Marchante 2001; Almeida & Freitas, *in press*). In the last two centuries, and especially in recent decades, the number of introduced plant species increased extensively with aliens representing nowadays more than 15 % of a total of ca. 3200 *taxa* of the Portuguese vascular flora (Almeida 1999). Their presence has increased probably more than 1000 % during the last two centuries, from 33 known sub-spontaneous species in 1800 reaching in 2005 the worrying figure of about 550 species (Almeida & Freitas, *in press*) and still increasing (Figure 1). This data should be seen as conservative with new introductions in ornamental sector being frequent and often difficult to track. Almost 40 % of the listed species are actually or potentially invasive, including agricultural weeds and invaders of natural habitats, and ca. 7% are considered dangerous invaders. Fabaceae and Asteraceae provide the largest numbers of problematic species. Australia seems to supply the most dangerous and aggressive invaders in Portugal, including several Acacia and Hakea species.

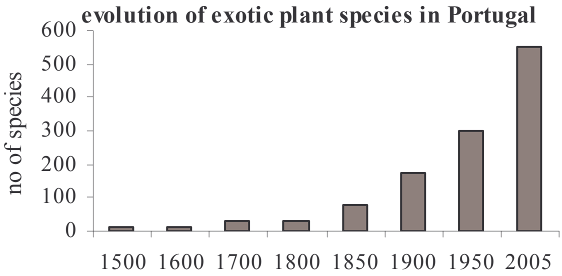

Figure1. Increase of exotic plant species introduced in Portugal since 1500 (based on Almeida 1999; Almeida & Freitas, *in press*).

Some of the worst examples of species responsible for threatening the Portuguese native flora (Table I) are given by species of the genus *Acacia* (Marchante *et al.* 2003), *Hakea* and *Carpobrotus* (Pinto da Silva *et al.* 1989, Campelo 2001); *Ailanthus altissima* (Miller) and *Cortaderia selloana* (Schultes & Schultes fil.) Ascherson & Graebner also worth special attention due to the current drastic increase in their distribution. The big spread of some of these species, namely the ones with tree habit, has already displaced large areas of native vegetation, including several areas with conservation interest which preservation is nowadays seriously threatened.

Family	**Species (origin)**	**Introd. purpose**	**Habitats invaded**
Aizoaceae	*Carpobrotus edulis* (L.) N.E. Br. (South Africa)	Ornamental and to fix sand dunes and slopes	Coastal sand dunes, capes and next to slopes where it was planted
Apiaceae *(Umbelliferae)*	*Eryngium pandanifolium* Cham & Schlecht (South America)	Ornamental	Near waterlines in the low Mondego Basin
Commelinaceae	*Tradescantia fluminensis* Velloso (South America)	Ornamental	Shadow and humid areas; managed woods understory
Convolvulaceae	*Ipomoea acuminata* (Vahl) Roem.& Sch. (Tropical regions)	Ornamental	Large carpets in disturbed habitats and slopes
Haloragaceae	*Myriophyllum aquaticum* (Vel.) Verdc. (South America)	Accidental introduction	Aquatic habitats
Fabaceae	*Acacia dealbata* Link (SE Australia and Tasmania)	Slopes stability and ornamental	Mountain areas, roads and river margins;
(Leguminosae)	*Acacia melanoxylon* R. Br. (SE Australia and Tasmania)	Ornamental; forestry, shadow	Along roads, and mountain areas adjacent to where it was planted
	Acacia longifolia (Andrews) Willd. (Australia)	Curb sand erosion; ornamental	Coastal areas (sand dunes and capes); along rivers; …

Family	Species (origin)	Introd. purpose	Habitats invaded
	Robinia pseudoacacia L. (eastern North America)	Forestry, ornamental and soil stabilisation	Near rivers and roads; pinewoods and disturbed lands
Pittosporaceae	*Pittosporum undulatum* Vent. Australia)	Ornamental and shelter	Managed areas where it was planted as ornamental
Poaceae *(Gramineae)*	*Cortaderia selloana* (Schultes & Schultes fil.) Ascherson & Graebner (South America)	Ornamental	Spreading in some dune systems and along roads/ highways/ rails or other
Pontederiaceae	*Eichhornia crassipes* (C.F.P. Mart.) Solms-Laub. (Tropical South America)	Ornamental	Water-courses and lagoons
Proteaceae	*Hakea sericea* Schrad. (Eastern Australia)	Ornamental and quickset hedges	Pinewoods and disturbed lands; isolated individuals in relatively pristine places
	Hakea salicifolia (Vent.) B.L. Burtt (SE Australia and Tasmania)	Ornamental; wind break especially near the coast	Coastal areas (sand dunes), Mountain areas where it was planted and disturbed lands
Simaroubaceae	*Ailanthus altissima* (Miller) Swingle (China)	Ornamental	Spread mainly in urban areas and in road sides

Table I. Some of the worst and more aggressive invasive plant species present in Portugal

Portuguese legislation

Early in 1974, a first law (decreto-lei 165/74 de 22 Abril) recognised water-hyacinth (*Eichhornia crassipes*) as an invasive species, forbidding its importation, culture, selling, transport or possession. In 1999, the Portuguese law has recognised in a more wide-range the problem of invasive species (decreto-lei 565/99 de 21 de Dezembro), creating a list of the exotic species introduced, identifying the invasive ones, and forbidding the introduction of new species unless proven not harmful. This regulation was the result of the international commitment assumed when Portugal approved, for ratification, the Bern Convention (decreto-lei n.º 95/81, de 23 de Julho), the Bone Convention (decreto-lei n.º 103/80, de 11 de Outubro) and the Convention of Biodiversity (decreto-lei n.º 21/93, de 21 de Junho), all suggesting the adoption of measures limiting the deliberate introduction and preventing the accidental introduction of invasive species, as well as the control or eradication of the invasive species already introduced. A previous law from 1987 (Lei de Bases do Ambiente: decreto-lei n.º 11/87, de 7 de Abril) on article 15, no. 6, demanded the elaboration of adequate legislation to regulate the introduction of exotic plant species, and on article 16, no. 3 the adoption of measures of effective control of the introduction of any wild animal species both aquatic and terrestrial. The recent legislation was drawn to operate as a clean list approach, meaning that every exotic species currently in the country should be listed in the law and to introduce any other species an authorization should be asked.

The legislation was prepared by ICN (Institute of Nature Conservation, Ministry of Environment) and DGF (Forestry National Services), with the collaboration of the scientific community, namely to set up the species list.

The list of invasive plants

The law includes 3 separated lists of species each presented as an annex: **annex I**, lists the non indigenous plant and animal species introduced in Portugal, and identifies those considered invasive; the non invasive species are called indigenous in what concerns the application of this law! **annex II**, lists non indigenous species that are considered of interest for gardening and forestry; these species are also considered indigenous in terms of the application of this law! **annex III**, list the non indigenous species that already have ecological risk elsewhere but are not yet invasive in Portugal.

Calling "indigenous" to all the species that are not listed as invasive or do not hold ecological risk could lead to some misinterpretation; particularly in the frequents occasions along the text when the non indigenous species are referred, not becoming obvious which species are in fact included or not.

The content of the law

The law limits the intentional introduction of exotic species in nature even if the aim is not to release it. Nevertheless, due to economical reasons, exceptions are considered to species used in agriculture (agriculture, horticulture and zootechnic). In practice, and particularly considering both invasive (annex I. pointed as invasive) and species with ecological risk (annex III), it specifically prohibits:

– its cultivation, growth, maintenance in confined place, utilisation as ornamental plant or pet; and
– to give, to buy, to sell, and to transport specimens of those species except when they are dead and do not hold any viable propagule. Exceptions are considered to scientific and educational purposes, as long as legally authorised by ICN.

Other exceptions are considered when proposing the introduction of a new species:

– when it is proved to have unequivocal advantages to men of natural biocenosis;
– when there is no native species that fit to the same purpose;
– when the introduction is preceded by a rigorous study of impacts whose results will be relevant to the authorisation.

This study, additionally to biological and ecological characterization, can include controlled experiments under confinement which should be controlled by an administrative entity. The authoriqation or rejection of introduction depends on the final evaluation of this entity.

Exceptions are not to be allowed if the area where the species is meant to be introduced includes a protected area, a zone of special protection, a Natura 2000 site, an island without human population or natural lagoons. In these particular cases, it will only be allowed if the species is the only viable option to nature conservation or if human health or safety depends on it.

Field impacts of the application of the law

Entities such as botanical gardens, nurseries, greenhouses, plant shops, pet shops, zoological parks, circus, game parks, etc. need to request a license to ICN to detain non indigenous species specifying the list of the species already detained. Other legislation (ex. CITES) should also be respected. If the license is conceded, regular visits from environmental bureau (including ICN) or other people with specific competences (governmental institutions particularly responsible by agriculture, forestry, veterinary, fishing and aquaculture, and police force entities), should be forecasted to check the safety conditions of the places that detain the species, and to check updating of the species list.

Places that commercialise exotic plant and/or animals should expose to the public a synopsis of this law (published as annex 4).

When a new species (theoretically all the species not included in annex I, II or III) is to be introduced an authorisation should be requested to ICN. When the species to introduce is destined to be used as forestry or synergetic the authorisation has to be asked to DGF, consulting the ICN. To prevent accidental introductions the species should be submitted to quarantine following rules imposed in ICN or DGF proposals.

Other technical-scientific and administrative tasks contemplated in this legislation should be assured by ICN, sometimes with collaboration from DGF.

Penalties are considered from 150€ to 45000€ to be paid for faults that could include the detention of an invasive species or the nonexistence of the license to detain the non indigenous species, and it varies if being a private person or collective entity. The penalties could also include interdiction of the permit to keep the profession or activity; or closing a commercial establishment.

How is the law seen by people that deal with exotic species

It is not! In a recent preliminary query to horticulturists, pet shops and gardening centers, simple questions were asked about their knowledge regarding this legislation and its implications. Most of the answers revealed the lack of information about it!

Theoretically, the places that detain exotic species should have asked for a license and sent a list of the non indigenous species detained to ICN from edition of the law to 6 months after… we believe it never happened…

Next steps and suggestions

Some species were missing in all 3 annex right from the beginning, and now, 6 years after, the lists are far from being complete (figure 2) and need to be updated; new introductions, mainly due to ornamental purpose, species shifting category, namely species becoming new invaders, and some synonym inaccuracy are already numerous and should be altered.

It is essential to implement the regulations in the field with a strong effort on informing citizens directly involved and implementing inspections to horticul-turist, pet shops, garden centers, boarders and others. Technician's training is still needed to assure the correct application of the legislation, namely in differentiating all the species listed.

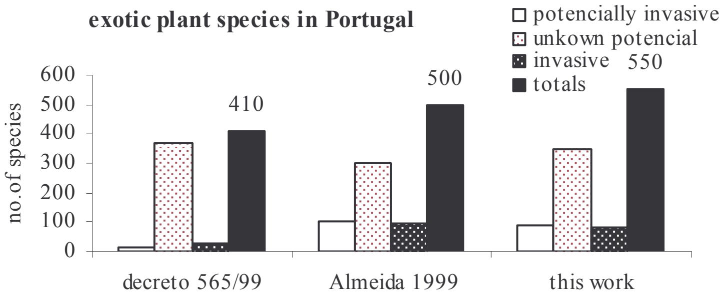

Figure 2. Exotic plants species categorised according to its invasiveness in Portugal, following different bibliographic sources: the legislation (dec.565/99), Almeida (1999), and a brief update prepared to this work.

To facilitate the evaluation, when someone asks for authorisation to introduce a new species, this legislation could consider a quicker way to first assess its weedy potential. For instance, a numerical score (like Australian legislation) including plant's prior history of weediness, climate preferences, biological, reproductive and dispersal traits. Each new species to be introduced would be scored by expertise's and according to the result it would have a "yes" or "no" quick answer, or could demand some tests.

Acknowledgement

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Engaging the horticulture industry in the process of reducing invasions by exotic plants in wildlands

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Abstract

Wildland weeds and their impacts on biodiversity are currently active topics of discussion. These weedy invaders are now being included in governmental Noxious Weed programs that restrict and regulate importations in an attempt to minimise unintentional introductions. In spite of the regulations, accidental introductions of invasive exotic plants are still coming from gardens and landscapes. In order to help reduce these introductions, the horticulture industry is teaming up with environmentalists to follow a voluntary set of industry-created rules known as the Voluntary Codes of Conduct.

Native Plant societies, public land managers (parks, wildland sanctuaries, etc.), land conservancies, and environmental organisations (Audubon, etc.) have contributed information that has led to the recognition of invasive plants as a major threat to natural areas. At times, the waves of invasive plants seem overwhelming, especially on small sites surrounded by disturbed, developed areas. Scientists working in these areas have come to realise that many of the invaders were originating from plants introduced in local development, not from the accidental release of a contaminant from seed.

In Hawaii, it is estimated that 70% of the invasive plant species originally escaped from gardens and landscaping. As technologies improve in the development of horticultural plants, the risk of releasing potentially problematic species also improves. The public demands plants that are hardy, take little care, and will grow rapidly to fill in areas within the landscaping. These are also the characteristics of plants that are good invaders. The producers and sellers for these plants are caught in a dilemma.

In December 2001, a conference was held at the Missouri Botanical Garden inviting members from many different agencies, businesses, and organisations who are involved with exotic plants. At the end of the three day session, a set

of principles were agreed upon by all and Voluntary Codes of Conduct were drafted by each of the five groups. This was a major step in bringing all parties together and working towards common goals.

The next goal is to have a working set of Codes of Conduct that would be ready for a wide distribution. To achieve this, a variety of industry businesses from different regions of the country will be invited to participate in adopting and refining the Codes of Conduct. Cost expenditures and/or cost savings will be recorded along with customer/clientele reaction to the program.

Ultimately, the long term goal is to see a reduction in the number of invasive species entering into wildlands from gardens. In the regions where these surveys will be conducted, careful attention will be paid to monitoring local natural areas and identifying the rate of invasion. Another positive outcome would be to have a successful self-regulating process that will be recognised by governmental regulatory bodies.

Introduction

In recent times, invasive species, plant, animal and pathogens, have been recognised as a serious threat to biodiversity, human health, and the economy. In the United States, invasive species are second only to direct habitat destruction for the loss of biodiversity (Wilson 1997). However, on protected lands invasive species are the number one threat. The estimated cost from invasive species total $137 billion annually in losses to agriculture, forestry, fisheries and in the maintenance of open waterways. It is estimated that only 79 species caused the bulk of cost at $97 billion dollars (OTA.1993)

Impacts to biodiversity are devastating. Invasive species have contributed to the decline of nearly half of the listed imperiled or endangered species in the U.S. (Pimentel *et al* 2000). Non-indigenous weeds are invading at a rate of approximately 700,000 ha/yr (Babbitt 1998). Initially, recognised invasive species were correlated with agriculture and whose introduction was typically unintentional. But now with the increased movement of plant materials and more rapid breeding technology, new garden plants are being introduced at a much greater rate.

We know that many of the species that invade wildland areas come from intentional plantings (Reichard 2004). Government agencies, for example, spread invasive exotic plants through revegetation programs that are intended to help control flooding or erosion. A less direct, yet still considered intentional release, comes from horticultural plants used in landscaping and gardens. Hawaii, for example, has documented that 70% of the invasive plant species are known to have come from gardens (Hawaii Dept of Natural Resources).

In order to address this pathway for invasion, more focus has been applied to the nursery industry. In 2001 the Missouri Botanical Garden hosted a workshop and invited people from a variety of plant related businesses, organisations, and interests to discuss possible solutions for this problem. As a result, Voluntary Codes of Conduct were developed by each of the interest groups. These Codes are guidelines for each interest group to self-regulate on a voluntary basis. The Nature Conservancy's Invasive Species Initiative is also supporting this project by providing staff to implement the codes over a larger region.

Working groups to combat invasive plants

There are a growing number of working groups collaborating on solutions to the invasive plant problem. These groups are know as Invasive Plant Councils, Networks, or Exotic Pest Plant Councils and are made up of a variety of entities. The constituency of the groups vary based on the local interests, but usually contain government agencies, public and private landowners, and, more recently horticulture businesses. These councils have proven to be an effective way to proactively work on issues in an informal, relaxed environment.

Today, representatives from the horticulture industry participate in many of the invasive plant working groups. The focus of discussion is developing a scientifically derived list of locally problematic plants that at least for now would not have a huge impact on the economy of the businesses. More cooperation will be needed to address all of the invasive species in a way that can be handled by the industry.

The time now has come for action to follow-up on the great evolution of ideas. An implementation plan that would address the needs of the business while effectively putting to practice the concepts of reducing new plant introductions was looming. And through a meeting of the minds, several involved parties put together the idea for a workshop to produce Codes of Conduct.

A direct approach

The Missouri Botanical Garden in St. Louis, Missouri, hosted a workshop inviting participants from various interest groups to develop Voluntary Codes of Conduct. These codes address the threats of invasive plants in this region, the personal responsibility of each interest group, and the actions these groups will voluntarily take to prevent invasions. This is a voluntary step being taken as a measure of self-policing in conjunction with existing regulatory laws. Since the industry is involved in the development of these guidelines, it can incorporate its own best practices which will improve the implementation in the long run.

The major groups represented at the 2001 Workshop included government agencies and municipalities, botanical gardens, horticulture industry, and the gardening pubic. To the results from this conference link to: http://www.centerforplantconservation.org/invasives/codesN.html.

A set of "Findings" were established as a starting point of agreement:

- People are major dispersers of plants.
- The magnitude of this dispersal is unprecedented and has allowed dispersal of species that manifest aggressive traits in new areas.
- Plant introduction and improvement are the foundation of modern agriculture and horticulture, yielding diversity to our supply of plants used for food, forestry, landscapes and gardens, medicinal and other purposes.
- A small proportion of introduced plant species become invasive and cause unwanted impacts to natural systems and biological diversity as well as economies, recreation, and health.
- Plant species can be invasive in some regions, but not in others.
- The impacts of invasive plant species can occur at times and places far removed from the site of introduction.

Now, the hard part! The participants were asked to develop a set of principles that all could agree as the framework for developing their own interest groups strategies. After much debate, six principles were established. These prince-ples, also called the St. Louis Six, are true statements agreed upon by all that attended the meeting.

- Plant introduction should attempt to minimise unintended harm.

- Efforts should be implemented consistent with national standards, while considering regional differences to the fullest extent possible.
- Prevention and early detection are the most cost effective techniques that can be used against invasive plants.
- Research, public education and professional training are essential to a successful program.
- Individuals from many fields undertake a broad-based and collaborative effort to address this challenge.
- A successful invasive plant species strategy will make use of all available tools. Codes of conduct are an essential first step in that they encourage voluntary initiative, foster information exchange, and minimise the expense of regulation.

These basic principles helped to form the framework for each of the Codes of Conduct developed by the interest groups. It was important to the horticulture industries represented to keep a local, regional perspective in that most invasive plants are not invasive everywhere. Information is key to success and the input should come from a variety of applicable sources. Collaboration is also critical to the success of this type of program.

The voluntary codes of conduct

Using the elements from the "Principles", each of the interest groups developed their own codes of conduct. These codes are guidelines for business practices. The nursery professionals and landscape architects each developed their own codes appropriate for their business. The nursery professionals codes are paraphrased as follows:

- Ensure that invasive potential is assessed by qualified experts using appropriate methods prior to marketing plant species new to North America.
- Work with experts and stakeholders to determine which species in your region are currently invasive or will become invasive. Identify suitable alternatives.
- Develop and promote alternative plant material through selection and breeding.
- Where agreement has been reached phase out those specific existing stock.
- Follow all laws on importation and quarantine of plant materials.

– Encourage customers and garden writers to use and promote non-invasive plants.

Also paraphrased here are the Landscape Architects professional codes:

– Seek out education and information on invasive species issues.
– Determine what species are highly invasive or may present a threat.
– Identify all solutions to problems caused by harmful invasive plants.
– Take advantage of education opportunities related to invasive species.
– Identify and specify non-invasive species that are suitable alternatives.
– Eliminate specification of species that are invasive in your region.
– Be aware of potential environmental impacts beyond the managed area.
– Encourage suppliers to provide non-invasive plants.
– Collaborate in the revision of landscape ordinances to include invasive species issues.

In both cases, the codes written reflect the need for collaboration and information sharing. Businesses are participating in existing invasive plant networks and councils. They are still a relatively new kid on the block and are having all the difficulties of catching up. There is much skepticism by the industry as to the impact of their role in this voluntary program. More work needs to be done to reach out to businesses and incorporate their needs into these invasive plant prevention strategies.

The next step

The Nature Conservancy and the Missouri Botanical Garden have established a position, the Horticulture and Landscape Professions Liaison, who will focus on exporting the nursery and landscape architects codes of conduct to new businesses. The goal is to engage varying types and sizes of businesses throughout the country. These businesses will be chosen from a set of criteria and grouped into regions. To suit the needs of these businesses, the codes will be “tailored” within reason allowing more comfort to experiment with this new set of policies.

The criteria used as guidelines for the selection of regions includes the following:

– Regions with good quality natural areas that have a high threat from development.
– Regions where the industry is participating at some level with partners working on invasive species issues.

These regions within the US are scattered around the 4 “corners” and in the middle of the country. To date, Florida, Hawaii, Oregon, California, the Midwest, and the Northeast all have the criteria listed above. There are willing participants, or existing participants that would like increase their implementation.

In many cases the businesses themselves will offer suggestions as to who might participate in the codes implementation. Typically, these suggestions are other businesses related to their own. For instance they may be members of a supply chain, businesses from the growers to retail nursery to landscape architect to the landscape installation firm. Knowing that there are other businesses participating in the region, especially ones that work together, may help provide incentive and/or reduce the perception of risk.

Implementation

There are many factors to consider when enlisting these businesses to participate in adopting the Voluntary Codes of Conduct. The codes may be revised to reflect the unique situation of the individual business, yet they need to remain effective. Choosing plants to take off the shelves will be the next issue at hand. Long term objectives, benchmarks, phase-out timelines and 3rd party oversight will all be a part of the implementation process.

The Codes of Conduct may need to be amended for the unique circumstance experienced at a particular business. One example of this has been from the botanical gardens codes. Here the codes were amended with additional guidelines that fit for the several satellite facilities associated with this garden. The changes do not diminish the invasive plant goals, but rather work better within the constraints of the individual facilities work parameters.

Part of the process of adopting the codes will include developing an implementation strategy. This strategy will clearly define the plants to be removed from sale. It may be that different businesses, even if they located with the same ecoregion and therefore share the same invasive species problems, may not choose to adopt the same plant list for retiring. Ultimately, as many of the plants on regional invasive plant lists should be addressed. Plants that are big sellers may be put off until later for removal.

The idea of writing out a long-term plan for implementation will help greatly by clearly stating the time frame in which all of the problematic species agreed upon will be dealt with. There has been concern by the industry that all of the plants on a given list will need to be removed from shelves at once. Some businesses are quite willing to removal all invasive off their shelves right away. It may be that they did not carry the more problematic ones, or that they were not big sellers originally. There may be some plants that businesses are not willing to negotiate at any time interval.

Once the strategies are in place, timelines with benchmark goals are agreed upon, and the business has started its implementation, there needs to be a way to check on the progress and make sure the business is living up to there agreement. This gets to the issue of policing. It could very well be that a simple yearly check of inventory by local garden clubs, plant societies or plant councils could provide the information needed. Everyone involved needs to feel secure that the tenets of the codes are being upheld without undo pressure from collaborative partners.

In the continuing effort to refine the Codes of Conduct process, a survey will be submitted to each business participating with the request to complete on a regular basis for a minimum of one year. This survey will provide information on how the business perceives the clienteles attitudes toward the removal of certain plant species. It will also help identify other implementation factors that were not addressed originally.

Support materials will need to be developed by partners to help businesses communicate with their cliental the changes in their selling practices. Brochures and signage are some of the tools that may be requested. Lists of alternative plants, both native and non-invasive horticultural stock, will be developed with the help of garden clubs, native plant societies and the industry themselves. Educating the gardening public is critical to long term change and the reduction of demand for invasive plants.

Finally, a survey will be developed to use as a tool to identify how the implementation of the Voluntary Codes of Conduct worked for that individual business. The survey will provide insight to the perception by the participating businesses on the reaction of their cliental as well as losses or gains by the business in relation to the removal of invasive plant stock. The results of this survey will allow for a further refining of the codes to meet the needs of each business type and take into account the regional setting.

Issues to address

There are several concerns brought up by the industry that will be taken into consideration, especially for long-term success of this program. The issues include:

– accurately identifying the perpetrator (species? cultivar?);
– scientifically assessing the invasiveness (how widespread);
– developing phase-out strategies for newly discovered invasive plants (3-7 year time frame, or shorter time frame with government buy out);
– involving the industry in the decision making for which taxa to remove;
– developing strategies for existing problem invasives (triage);
– adding a Code of Conduct for ecologists;
– determining who will oversee the implementation at the business site to make sure the business is enacting the codes as agreed upon;
– having recognition for this voluntary program from the regulatory agencies.

These issues will need to be addressed by the larger community of scientists and other participants in various working groups. Scientists are currently working on mapping and early detection protocols which will help to make identifying wildland invasive more accurate. It’s important to be able to back up a suggested invasive plant with science and not emotion. Resolution of these issues will help determine whether the horticulture industry will lead the way in this voluntary program or will be resistant and change only to the level of regulation.

Conclusion

Invasive plants will always be a part of our landscape. They do not, however, need to be as destructive as they are today. With good detection and response programs in place, plants not identified as invasive and “go bad” can be treated quite efficiently. More importantly, preventing invasive plants from entering the landscape will reduce the cost burden to the economy.

To do this successfully, there needs to be good communication between all entities that are responsible for their introduction and control. Invasive plant councils are a good step towards bringing these groups together and initiating dialog. Implementation of these new concepts can take two paths, voluntary or regulatory. The latter has a great cost to the taxpayer and may be less effective overall.

The Voluntary Codes of Conduct have already been proven to be adoptable by various business and entities. Botanic gardens (Missouri, North Carolina, Chicago, and now Denver) have started applying these codes to their horticultural practices. As more entities adopt these codes, more refinement can be directed towards individual business types. Having this level of communication between all participating entities will only increase the long term success of voluntary programs such as this.

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“Don’t plant a pest” initiative

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Abstract

Of the 125 most invasive species in California, 55% were introduced through the nursery or ornamental industry. Not all of these invasive ornamentals are still available via the nursery trade, however a number continue to be distributed as landscape ornamentals. Through a collaborative effort led by the California Invasive Plant Council, experts from the University of California Cooperative Extension, commercial and retail nurseries, growers, botanical gardens, gardeners, state and local agencies, non-profit organisations, and land managers developed the first brochure on horticultural alternatives to invasive plants. The brochure is designed to be a tool for Cal-IPC members and others to use in approaching their local nurseries, an educational tool for gardeners and consumers, and a template for other organisations that wish to produce similar materials. It includes general information on the invasiveness of 13 perennials, ground covers, and shrubs and briefly describes several native and non-native alternatives. These alternative species represent ornamentals that have the same form or function, but are not invasive in wildland areas. Since its publication in 2004, three separate printings and over 60,000 brochures have been distributed through requests. A second brochure will be published in 2005 that will include invasive trees in California, and again a listing of non-invasive alternatives.

Most of California has a mild Mediterranean climate that in conducive to the establishment and growth of many different ornamental species from around the world, including plants with temperate and sub-tropical origin. As a result, California is the largest retail nursery plant state in the United States, with 21% of the total market adding up to over $13 billion (USD) in production and revenue sales a year. In addition, catalogue sales of nursery plants in the United States exceed $3 billion per year. These can include purchases by mail or internet sales.

Although most of these introduced plants behave as they should and remain in the garden, a small fraction of them have spread to become invasive in natural areas, including rangelands and wildlands. These invasive plants can become serious wildland weeds that threaten California's biodiversity and economy. Of the 125 most invasive plants in California, 55% were introduced through the nursery or ornamental industry. Plant characteristics generally considered desirable in the garden are often the same characteristics that successful invasive species possess (Table 1). For example, plants that grow rapidly, establish under a variety of environmental conditions, produce prolific numbers of flowers, and are tolerant to both abiotic and biotic stresses are ideal for the garden. However, these same characteristics are generally found in invasive plant species. With nearly 3,000 nursery producers in California alone the opportunity for invasives to escape is very high.

Garden Plants	Invasive Plants
Easy to propagate	Broad germination
Establish rapidly	Coloniser
Mature early	Mature early
Abundant flowers	Prolific seeds
Pest/disease tolerant	Few natural predators

Table 1. Comparison of characteristics of garden and invasive plants.

In a survey conducted by the California Invasive Plant Council (Cal-IPC), they found that most nurseries sold some invasive plants. Twenty-two of the 25 nurseries surveyed carried at least one very invasive plant species. The average number of invasive plant species sold at a nursery was 5.5, including varieties of invasive species. In one nursery, 14 invasive species were being sold. Of the 52 plants targeted as being invasive ornamentals, 20 were not sold in any of the 25 nurseries included in the survey. Of the remaining 32 species available for sale, each was sold in about 10% of the nurseries.

Of the invasive plants surveyed for in southern California (San Diego) nurseries, the most commonly sold included *Hedera helix* (English Ivy) in 100% of nurseries, *Pennisetum setaceum* (crimson fountaingrass) and *Vinca major* (big periwinkle) in 91%, and *Helichrysum petiolare* (licorice plant) in 74%. In northern California (San Francisco Bay Area) nurseries, the most commonly sold invasive species were *Pennisetum setaceum* (crimson fountaingrass) in 48% of the nurseries, *Hedera helix* (English ivy) 36%, *Cortaderia selloana* (pampasgrass) and *Vinca major* (big periwinkle) in 28%, and *Schinus molle* (Peruvian peppertree) and *Cotoneaster lacteus* (Parney's cotoneaster) in 20%.

Gardeners and landscapers do not intentionally plant invasive species. Fortunately, most of the plants used in landscapes and gardens do not become invasive. Thus, by choosing suitable replacements for the few problem plants, much of the potential problems and expenses associated with invasive plant species can be avoided.

With this end in mind, the California Invasive Plant Council coordinated a project to develop a landscapes alternative brochure for wide distribution among the general public, landscapers and landscape professionals, and the nursery industry. This required a collaborative effort among weed and ornamental plant experts at the University of California Cooperative Extension, commercial and retail nurseries, growers, botanical gardens, gardeners, state and local agencies, non-profit organizations, and land managers. The brochure is designed to be a tool for Cal-IPC members and others to use in approaching their local nurseries, an educational tool for gardeners and consumers, and a template for other organizations that wish to produce similar materials.

With its publication in 2004, the brochure includes general information on the invasiveness of 13 perennials, ground covers, and shrubs and briefly describes several native and non-native alternatives. These alternative species represent ornamentals that are not invasive in wildland areas (Table 2). Many of the alternatives were selected based on similar appearance. Others were selected because of their functional role, such as a groundcovers that grow well in a shady place, or a border plant that likes full sun. The alternatives list thrive in the same environments as problem plants while offering added benefits such as attracting wildlife. In addition, the alternatives included are readily available and considered to be reasonably similar in cost.

Invasive plant	Alternative	Native or non-native
	Groundcovers & Perennials	
Carpobrotus edulis (Hottentot fig or iceplant)	*Delosperma cooperi* (hardy iceplant) *Osteospermum fruticosum*and hybrids (freeway daisy) *Teucrium chamaedrys*, or *T.* × *lucidrys* (wall germander) *Drosanthemum floribundum* (showy dewflower)	Non-native Non-native Non-native Non-native
Vinca major (big periwinkle) *Hedera helix* (English ivy) *Hedera canariensis* (Algerian ivy)	*Pachysandra terminalis* (pachysandra) *Campanula poscharskyana* (Serbian bellflower) *Trachelospermum asiaticum* (ivory star jasmine or asian jasmine) *Rubus pentalobus* (Taiwan raspberry) *Heuchera maxima* and hybrids (giant alumroot) *Asarum caudatum* (wild ginger) *Helleborus foetidus* (bear's foot hellebore) *Bergenia cordifolia* and hybrids (winter saxifrage)	Non-native Non-native Non-native Non-native Non-native Native Non-native Non-native
Helichrysum petiolare (lico-rice plant)	*Salvia leucophylla* (coast purple sage) *Teucrium fruticans* and cultivars (bush german-der) *Phlomis fruticosa* (Jerusalem sage) *Artemisia* sp. 'Powis Castle' *Eriogonum giganteum* (St. Catherine's lace)	Native Non-native Non-native Non-native Native
Cortaderia selloana	*Chondropetalum tectorum* (Cape thatching reed)	Non-native

Invasive plant	Alternative	Native or non-native
(pampasgrass)	*Muhlenbergia lindheimeri* (Lindheimer's muhly grass) *Carex spissa* (San Diego sedge) *Nolina bigelovii* (Bigelow's bear grass)	Non-native Native Native
	Shrubs	
Cytisus scoparius (Scotch broom) *Cytisus striatus* (Portuguese broom) *Genista monspessulana* (French broom) *Spartium junceum* (Spanish broom)	*Forsythia × intermedia* (forsythia) *Jasminum nudiflorum* (winter jasmine) *Cornus mas* (cornelian-cherry dogwood) *Kerria japonica* (Japanese kerria) *Ribes aureum* (golden currant) *Phlomis fruticosa* (Jerusalem sage) *Hypericum* 'Rowallane'shrub hypericum	Non-native Non-native Non-native Non-native Native Non-native Non-native
Cotoneaster lacteus (Parney's cottoneaster) *Cotoneaster pannosus* (silverleaf cotoneaster**)**	*Heteromeles arbutifolia* and cultivars (toyon) *Feijoa sellowiana* (pineapple guava) *Arbutus unedo* (strawberry tree) *Viburnum suspensum* (sandankwa viburnum) *Citrus mitis* or × *Citrofortunella microcarpa* (calamondin orange)	Native Non-native Non-native Non-native Non-native

Table 2. List of invasive plants and there alternatives included in the "Don't Plant a Pest" brochure.

The goal of the brochure is not only to assist in purchasing new plants for the garden, but also in replacing these known garden invaders, especially when the homeowner lives near wildland habitat.

Since its publication in 2004, three separate printings and over 60,000 brochures have been distributed through requests. A second brochure is nearly completed and will be published in 2005. It focuses on invasive trees of California, again suggesting multiple safe alternatives. The invasive species included in this brochure include:

- *Acacia melanoxylon* (black acacia),
- *Elaeagnus angustifolia* (Russian-olive),
- *Eucalyptus globulus* (Tasmanian blue gum),
- *Myoporum laetum* (myoporum),
- *Robinia pseudoacacia* (black locust),
- *Sapium sebiferum* (Chinese tallowtree),
- *Schinus molle* (Peruvian peppertree, sometimes erroneously called California peppertree),
- *Schinus terebinthifolius* (Brazilian peppertree),
- *Sesbania punicea* (rattlebush or scarlet wisteria).

Thus far, both brochures have suggested alternatives for garden plants known to be invasive in the greater San Francisco Bay area. Additional brochures suggesting alternatives for the central California coast, southern California, and invasive trees are in production and will be published in the next couple of years. To see the brochure, purchase copies, or learn more about invasive species see the California Invasive Plant Council website at www.cal-ipc.org.

Travail avec les professionnels de l'horticulture et du paysage dans la région méditerranéenne française – L'opinion et l'expérience d'un horticulteur –

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[Presentation in English but proceedings in French, i.e abstract for English speaking readers]

Abstract

The Conservatoire Botanique National Méditerranéen de Porquerolles has been running the first programme that takes invasive plants into account in a global manner since 2001. It concerns the French Mediterranean area, this is to say the regions of Languedoc-Roussillon, Provence-Alpes-Côte d'Azur and Corsica.

The particularity of the programme has been to develop a partnership with horticulture and landscape professionals. Many plants judged as invasive are traded. Professionals producing, selling and planting these species have to be aware of the problem and to be associated in order to find appropriate solutions. We elaborated the document « Invasive plants in the French Mediterranean area » with these professionals and the project is in course to propose alternative species to replace invasive plants in trade.

Olivier Filippi is a horticulturist specialised in Mediterranean plants whose fascinating mission is to introduce and acclimate new species. He participates to the programme and is concerned of the invasive plant question since many years.

He has taken the problem into account not selling anymore invasives and being aware of not introducing potentially invasive species. He will present the introduction and research activity of his structure and his interrogations about invasive plants.

Introduction

Le Conservatoire Botanique National Méditerranéen de Porquerolles anime depuis octobre 2001 le programme « Plantes envahissantes dans la région méditerranéenne ». Ce programme a pour objectif de prendre en compte le problème des invasions végétales dans sa globalité et a l'originalité de travailler en partenariat avec les professionnels de l'horticulture et du paysage.

Ces professionnels importent, produisent, vendent, plantent des végétaux pour le bien être et le confort de tous. Sans le savoir, ils participent parfois à l'introduction et à la dissémination de plantes jugées envahissantes. En effet, parmi les 60 espèces considérées envahissantes en région méditerranéenne française, au moins 44 (73.33%) ont été introduites pour l'agriculture ou l'horticulture. Inutile donc de mettre en place de coûteuses mesures de gestions dans les espaces naturels si les plantes envahissantes sont continuellement réintroduites par d'autres utilisateurs.

Le partenariat avec les professionnels de l'horticulture et du paysage

Associer les professionnels de l'horticulture et du paysage à la démarche apparaissait indispensable (Reichard, 2001) pour traiter le problème des plantes envahissantes à une échelle interrégionale (régions Languedoc-Roussillon et Provence Alpes Cote d'Azur). Après une étude pour comprendre la façon dont cette complexe filière s'articule en France, un comité de pilotage a été constitué. Les catégories professionnelles représentées étaient les suivantes.

Producteurs, vendeurs
- pépiniéristes collectionneurs,
- pépiniéristes représentant la fédération nationale,
- jardineries et commerce horticole.

Planteurs, utilisateurs
- paysagistes représentant la fédération régionale,
- collectivités, services des espaces verts (qui dans les collectivités de grande taille produisent leurs végétaux),

- planteurs en grand: Autoroutes du Sud de la France, Services Nationaux des Chemins de Fer,
- conservateurs de Jardin Botanique.

Tous ces acteurs entretiennent d'étroites relations entre eux.

Ces représentants ont été invités, lors d'une première réunion, à prendre connaissance du programme « Plantes envahissantes dans la région méditerranéenne » et à donner leur avis de professionnel sur le sujet. L'objectif n'était absolument pas de les contraindre ou de leur imposer des pratiques, mais de leur apporter des informations et de les accompagner dans la prise en compte du problème des plantes envahissantes dans leur activité.

Le dialogue et l'échange

L'état d'esprit lors de l'échange a toujours été:

- de présenter des éléments réalistes, en insistant bien sur la différence entre plantes exotiques et plantes envahissantes (on s'intéresse seulement aux plantes qui posent problème, pas à toutes les exotiques) et en admettant que certains phénomènes ne sont pas encore expliqués par la recherche scientifique (prédire si une espèce va devenir envahissante par exemple) ;
- de donner des éléments de connaissance pour que les professionnels puissent étayer leur réflexion et se faire leur propre idée (données de terrain où des cas d'invasion sont connus, données bibliographiques), et faire comprendre que ces plantes pénètrent dans les milieux naturels ;
- de faire appel à leurs connaissances concernant le marché, la biologie des plantes, etc, et les associer en amont des actions ;
- d'être à l'écoute de leurs idées, besoins et exigences autant que possible (exemple: proposer des plantes de substitution, ne pas avoir de discours alarmiste pour ne pas nuire à la profession, …) ;
- de promouvoir les initiatives positives (retrait de plantes envahissantes du catalogue, actions de contrôle dans des collectivités, …).

Le message transmis concerne ainsi beaucoup plus l'identité des professionnels plutôt que leur comportement (Reiser, 2001) et leur permet de s'impliquer selon leur propre volonté.

Le dialogue avec un professionnel

Le dialogue avec Olivier Filippi, pépiniériste collectionneur passionné par son métier est restitué ci-dessous.

Olivier Filippi, pouvez-vous s'il vous plait nous parler de votre activité ?

Je suis un pépiniériste collectionneur spécialisé dans les végétaux de jardins secs adaptés au climat méditerranéen, j'ai également des collections de sauge et de cistes. J'étudie, j'introduis, j'acclimate, je multiplie et je commercialise ces plantes qui nécessitent peu d'eau et d'engrais sous nos climats. Ma démarche s'inscrit dans une vaste réflexion écologique.

Y a t-il eu une évolution dans votre démarche d'introduction ?

Oui, je me suis intéressé aux plantes envahissantes il y a environ 10 ans, et je me suis depuis énormément documenté sur le sujet. J'ai alors réalisé que je ne souhaiterais pas être, dans quelques décennies, celui qui aurait introduit une plante qui perturberait nos milieux naturels.

La prise en compte du problème dans mon activité d'introduction s'est effectuée en deux étapes.

- Tout d'abord, j'ai décidé de ne plus introduire d'espèces originaires d'autres zones méditerranéennes du monde (Californie, Chili, Australie, Afrique du Sud). Je n'introduis maintenant plus que des végétaux du bassin méditerranéen, principalement d'Espagne, du Maroc et de Turquie. Les écosystèmes étant similaires, le risque d'introduire une plante à risque me semble fortement réduit.
- Depuis 2 ans, je filtre également les plantes agressives qui peuvent représenter un risque. Je m'appuie pour cela sur leur comportement dans leur milieu naturel ainsi que sur la bibliographie scientifique internationale.

Quelle est votre réaction par rapport aux plantes envahissantes couramment cultivées en France ?

Je suis sur une niche commerciale assez particulière puisque je me suis spécialisé dans les végétaux de jardins secs. J'ai donc toujours eu, en stock, très peu de plantes traditionnellement jugées envahissantes (Ailante, Robinier, Arbre aux papillons). Ces plantes représentent d'ailleurs maintenant une part de marché très réduite. Ne pas vendre de plantes envahissantes peut devenir selon moi très porteur du point de vue commercial et représenter aux yeux des acheteurs une réelle valeur ajoutée professionnelle.

Ma démarche par rapport à ces espèces a consisté, il y a six ans, à les retirer de ma pépinière, mais à laisser le nom de la plante dans mon catalogue en signifiant que l'espèce est envahissante et en proposant des plantes de substitution. J'ai ainsi un rôle pédagogique auprès de mes clients. Par exemple, pour l'espèce envahissante *Cortaderia selloana*, l'Herbe de la Pampa, j'ai indiqué

> Nous ne cultivons plus cette plante qui peut s'avérer envahissante par endroits et risque de concurrencer la flore spontanée. En remplacement je conseille l'utilisation de *Stipa gigantea*.

Quelle est votre position quant à une possible législation sur le sujet des plantes envahissantes?

La législation sur les espèces rares et protégées part du noble principe de protéger les espèces endémiques ou en voie de disparition dans notre région. Cette législation est cependant très peu connue des professionnels et mal appliquée.

Beaucoup de plantes jugées envahissantes pourraient parfaitement être substituées par des espèces faisant l'objet d'un statut de protection. Les professionnels désireux de faire consciencieusement leur métier et d'avoir un rôle actif dans la conservation d'espèces rares (culture de ces espèces rares selon un cahier des charges) se heurtent à la difficulté d'obtenir des informations et des documents officiels.

A mon avis, une législation sur les plantes envahissantes ferait de même: augmenter les difficultés pour les professionnels qui souhaitent exercer leur activité honnêtement, pousser certains à trouver des alternatives pour contourner la loi.

Je pense qu'il serait beaucoup plus pertinent d'informer et de responsabiliser les horticulteurs et les paysagistes sur le sujet, plutôt que de légiférer. Il faudrait pour cela une vaste campagne de communication sur les plantes envahissantes dans laquelle les producteurs constitueraient un important relais de l'information.

La stratégie d'action

> Des changements dans les mesures et les lois s'opèrent quand une masse critique de personnes détermine qu'un problème ou un dommage existe et demande des solutions (Reichard, 2001).

Or, nombre de particuliers ignorent le problème et en rient lorsqu'il est abordé (Claeys-Mekdade, ce volume).

Comment faire connaître le sujet ? Quelle est la stratégie à mettre en place ? Faut-il d'abord sensibiliser les professionnels qui éduqueront le grand public, ou informer le grand public qui aura une influence sur le marché ?

Faut-il que les gros producteurs (jardineries) soient les premiers à prendre en compte le problème, ou faut-il convaincre les petits producteurs en premier lieu ?

Les stratégies mises en oeuvre dans le cadre du programme ont été choisies de façon empirique:

- En matière de communication, le comité de pilotage a été interrogé quant à la mise en place d'actions médiatiques. Il a donné son accord sous réserve que le message transmis ne soit pas alarmiste. Ainsi, pour chaque action entreprise par le programme ou ses partenaires (gestion d'une réserve naturelle, travaux entrepris par une collectivité,…), une information à la presse a été assurée par l'Agence Méditerranéenne de l'Environnement.
- La demande d'information sur le sujet par le grand public étant réelle, il était nécessaire d'occuper le terrain médiatique et de délivrer un message clair et adapté. Un site Internet a été créé (www.ame-lr.org/plantes-envahissantes), de nombreuses actions de presse ont été menées (6 reportages télévisuels régionaux et nationaux, plus de 100 articles dans la presse spécialisée, régionale, nationale, …). Le thème des plantes envahissantes a recueilli énormément de succès auprès du grand public qui y trouve l'occasion s'intéresser non seulement à la flore en général mais également aux espèces protégées et à la notion d'espèces indigènes et exotiques (notion inconnue pour un public européen).

- Le travail avec les professionnels s'appuie sur un échange d'informations et des actions incitatives et la valorisation de ces initiatives (au travers d'actions de communication citées précédemment).
- En ce qui concerne les acteurs de la filière à impliquer, nous nous sommes appuyés sur les forces vives du groupe et leur mobilisation pour agir. L'objectif était que ces volontés aient un effet « boule de neige » sur les autres professionnels au niveau régional puis national.

Les premiers aboutissements du programme « Plantes envahissantes dans la région méditerranéenne »

La collaboration avec ces professionnels s'est avérée très fructueuse et a débouché sur la publication du document « Plantes envahissantes de la région méditerranéenne ».

Les professionnels de l'horticulture et du paysage ont été associés à toutes les étapes de la conception du document: choix des espèces, information donnée, relecture des textes, élaboration du plan de diffusion et communication auprès du public.

Ce document présente ainsi les 15 espèces jugées les plus envahissantes en région méditerranéenne française en fournissant des exemples probants et simples sur le sujet (ex: le cas de l'Ailante, arbre que tout le monde connaît). La biologie, le comportement agressif de l'espèce en milieu naturel mais aussi les qualités de l'espèce sont décrites dans un vocabulaire accessible. L'originalité du document était de proposer, à la demande des professionnels, des plantes de substitution indigènes ou exotiques.

Cette brochure, tirée à 9000 exemplaires a été diffusée aux professionnels de l'horticulture et du paysage, aux gestionnaires d'espaces naturels, aux associations naturalistes, aux collectivités, aux administrations et à toute personne en faisant la demande.

Elle a été mise en ligne, toujours à la demande des professionnels, elle est consultée par environ 5000 internautes par mois. La sortie de ce document a également été accompagnée de nombreuses actions de presse.

De plus, petit à petit, quelques pépiniéristes (certains y étaient déjà sensibles) retirent les plantes jugées envahissantes de leur catalogue et proposent des plantes de substitution.

Certaines collectivités sensibles au sujet sont conscientes de leur rôle de « vitrine » pour le grand public et ont mené des actions sur le sujet (les services « Espaces Verts » de collectivités nous ont en effet rapporté que de nombreux particuliers leurs demandent le noms des espèces plantées dans les espaces publics pour les utiliser chez eux). C'est le cas de la Ville de Sète qui lors de travaux de restauration de sa corniche, en a profité pour éliminer les plantes envahissantes (*Carpobrotus acinaciformis, Ailanthus altissima*). La ville de Lattes a élaboré une cartographie à l'échelle de la commune et a formé ses agents à reconnaître et gérer la jussie (*Ludwigia grandiflora*).

Enfin, le jardin botanique de la Villa Thuret (INRA d'Antibes) a souhaité faire l'inventaire dans ses collections des plantes qui pouvaient être jugées envahissantes et est très vigilant aux introductions de nouvelles espèces. Un travail sur la promotion d'espèces exotiques non envahissantes a été effectué. Ce jardin sert en quelque sorte de test pour le comportement d'espèces nouvellement introduites. Dans bien des cas cependant, les conditions de jardins botaniques sont très différentes de milieux naturels et les résultats de ce genre de tests apparaissent difficilement extrapolables.

Les projets à venir

Un rapport de confiance s'est établi avec les membres du comité de pilotage, ce sont maintenant les professionnels qui nous sollicitent pour des travaux sur le sujet.

Souhaitant aller plus loin dans la démarche de plantes de substitutions, une étude a été menée pour proposer d'autres espèces. Cette étude réalisée à l'été 2004 a consisté à s'entretenir individuellement avec les membres du comité de pilotage pour recueillir leurs avis sur des plantes de substitution, mais également sur le document paru et les actions à mettre en place.

Concernant les plantes de substitution proposées, les professionnels souhaitent vivement que soit utilisé le patrimoine floristique de la région. Pour chaque plante envahissante sont proposées des espèces de substitution aussi bien pour les grands aménagements que pour les particuliers, afin de répondre à la réalité du marché.

Les projets à venir concernant ce travail sont les suivants:

– publication des résultats sur les plantes de substitution à destination des professionnels et du grand public avec:
  - un récapitulatif sur la plante envahissante (biologie, impact) et une carte des risques dans la région méditerranéenne,
  - un descriptif des plantes de substitution (biologie, mise en culture) pour les grands aménagements et les particuliers ;
– une mise sur le marché des végétaux proposés et un engagement des planteurs en grand (collectivités, SNCF, ASF, ...) à les utiliser afin d'avoir un nombre suffisant de commandes et de promouvoir les plantes auprès du grand public (effet vitrine) ;
– des journées promotionnelles pour faire connaître la démarche et les végétaux proposées organisées par les organisations interprofessionnelles.

De façon plus large, il pourrait être mis en place:

- un partenariat et une procédure officielle avec des horticulteurs et pépiniéristes intéressés pour s'impliquer dans la conservation de plantes rares selon un cahier des charges pour la cueillette, la production et la vente de ces espèces ;
- un partenariat plus étroit avec les institutions et manifestations existantes, comme par exemple le Concours des Villes et Villages Fleuris pour que le projet soit pris en compte à une échelle nationale ;
- un centre de ressources et d'information afin de centraliser toutes les actions réalisées sur le thème des plantes envahissantes et de substitution et apporter notamment un appui aux collectivités.

Cette expérience nous montre que la coopération entre scientifiques et gestionnaires d'une part et introducteurs, producteurs et planteurs d'autre part est tout à fait possible, sous réserve que les deux partis soient disposés à des évolutions dans leurs pratiques respectives. Le travail accompli jusqu'à présent avec les professionnels de l'horticulture et du paysage est pilote en France. Il reste cependant restreint à un nombre réduit de professionnels et mérite d'être poursuivi et élargi.

Cette approche incitative qui se base sur un accompagnement de la filière pourrait ainsi aboutir à des Codes de Bonnes Conduites tels qu'ils ont été formulés par le Missouri Botanical Garden aux Etats-Unis (Linking Ecology and Horticulture to Prevent Plant invasions – Codes of Conduct).

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Communication, education and awareness on invasive plants

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Les plantes envahissantes : communication, éducation et sensibilisation

The human dimensions of invasive alien species

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Abstract

Most of the work that has been done on invasive alien species focuses on their biology and the pathways by which they invade. Far less attention has been given to the human dimensions of the problem, ranging from the desire for the exotic to economic drivers. Virtually all of our planet's ecosystems have a strong and increasing anthropogenic component that is being fed by increasing globalisation of the economy; many Mediterranean-type ecosystems are especially subject to such invasions. Second, people are designing the kinds of ecosystems they provide productive or congenial, incorporating species from all parts of the world. Third, growing travel and trade, coupled with weakening customs and quarantine controls, mean that people are both intentionally and inadvertently introducing alien species that may become invasive. And fourth, the issue has important philosophical dimensions, requiring people to examine fundamental ideas, such as "native" and "natural". The great increase in the introduction of alien species that people are importing for economic, aesthetic, accidental, or even psychological reasons is leading to more species invading native ecosystems, with disastrous results on both ecosystems and economies.

This presentation will include historical, economic, cultural, linguistic, health, psychological, sociological, legal, military, philosophical, ethical and political dimensions of the problem of invasive alien species.

Introduction

Invasive alien species–non-native species that become established in a new environment, then proliferate and spread in ways that damage human interests–are now recognised as one of the greatest biological threats to our planet's environmental and economic well-being[1]. Most nations are already grappling with complex and costly invasive-species problems: Zebra mussels (*Dreissena polymorpha*) from the Caspian and Black Sea region affect fisheries, mollusk diversity, and electric-power generation in Canada and the United States; water hyacinth (*Eichornia crassipes*) from the Amazon chokes African and Asian waterways; rats carried originally by the first Polynesians exterminate native birds on Pacific islands; and deadly new disease organisms such as the viruses causing SARS, HIV/AIDS, and West Nile fever, attack human, animal, and plant populations in both temperate and tropical countries. For all animal extinctions where the cause is known, invasive alien species are the leading culprit, contributing to the demise of 39 percent of species that have become extinct since 1600 AD[2]. The 2000 IUCN Red List of Threatened Species reported that invasive alien species harmed 30 percent of threatened birds and 15 percent of threatened plants[3]. Addressing the problem of these invasive alien species is urgent because the threat is growing daily, and the economic and environ-mental impacts are severe.

A key question is whether the global reach of modern human society can be matched by an appropriate sense of responsibility. One critical element of this question is the definition of "native," a concept with challenging spatial and temporal dimensions. While every species is native to a particular geographic area, this is just a snapshot in time, because species are constantly expanding and contracting their ranges, sometimes with human help. For example, Britain has nearly 40 more species of birds today than were recorded 200 years ago. About a third of these are deliberate introductions, such as the Little Owl (*Athene noctua*), while the others are natural colonisations that may be taking advantage of climate change[4].

According to one view, local biological 'enrichment' by non-native species always harms native species at some level, so any introduction should be regarded, at least in principle, as undesirable. An opposing view is that because species are constantly expanding or contracting their range, new species – especially those such as crops, ornamental plants, and pets, that are beneficial

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[1] H. A. Mooney, J. A. McNeely, L. E. Neville, P. J. Schei, and J. K. Waage, eds., Invasive Alien Species: Searching for Solutions (Washington, DC: Island Press, 2004).

[2] B. Groombridge, ed., Global Bioodiversity: Status of the Earth's Living Resources (Cambridge, UK: World Conservation Monitoring Centre, 1992).

[3] C. Hilton-Taylor, IUCN Red List of Threatened Species (Gland, Switzerland: IUCN, 2000).

[4] R. May, «British Birds by Number» Nature, 6 April 2000, 559–60.

to people – should be welcomed as "increasing biodiversity" unless they are clearly harmful. According to this view, in the case of British birds noted above, only those introduced by people and that are causing ecological or economic damage, such as pigeons, are considered invasive.

All continental areas have suffered from invasions of alien species, losing biological diversity as a result, but the problem is especially acute on islands in general, and for small islands in particular. The physical isolation of islands over millions of years has favoured the evolution of unique species and ecosystems, so islands often have a high proportion of endemic species. The evolutionary processes associated with isolation have also meant that island species are especially vulnerable to predators, pathogens, and parasites from other areas. More than 90 percent of the 115 birds known to have become extinct over the past 400 years were endemic to islands[1]. Most of these evolved in the absence of mammalian predators, so the arrival of rats and cats carried by people has had a devastating impact. Island plants are also affected. For example, the tree *Miconia calvescens* replaced the forest canopy on more than 70 percent of the island of Tahiti over a 50-year time span, starting with a few trees in two botanical gardens. Some 40–50 of the 107 plant species endemic to the island of Tahiti are believed to be on the verge of extinction primarily due to this invasion[2]. And introduced animals can affect plants. For example, goats introduced on St. Clemente Island, California, have caused the extinction of eight endemic species of plants and the endangerment of eight others[3].

An alien invasive species is not a "bad" species, but rather one "behaving badly" in a particular context, usually due to inappropriate human agency or intervention. A species may be so threatened in its natural range that it is given legal protection, yet may generate massive ecological and other damage elsewhere.

The degradation of natural habitats, ecosystems, and agricultural lands (through loss of vegetation and soil, and pollution of land and waterways) that has occurred throughout the world has made it easier for non-native species to become invasive, opening up new possibilities for them. For all of these

[1] Ibid., and Groombridge, note 2 above.

[2] J.-Y. Meyer, "Tahiti's Native Flora Endangered by the Invasion of *Miconia calve-scens*," Journal of Geography 23 (1997): 775–81.

[3] D. Pimentel, L. Lach, R. Zuniga, and D. Morrison, "Environmental and Economic Costs of Non-indigenous Species in the United States," BioScience 50 (2000): 53–65.

reasons, and others that will become apparent below, the issue of invasive alien species is receiving growing international attention.

The vectors: how species move around the world

The natural barriers of oceans, mountains, rivers, and deserts have provided the isolation that has enabled unique species and ecosystems to evolve. But in just a few hundred years these barriers have been overcome by technological changes that helped people move species vast distances to new habitats, where some of them became invasive. The growth in the volume of international trade, from US$192 billion in 1960 to over $7 trillion in 2003, provides more opportunities than ever before for species to be spread either accidentally or deliberately.

Some movement seems accidental, or at least incidental in that transporting the species was not the intention of the transporter. For example, ballast water is now regarded as the most important vector for transoceanic movements of shallow-water coastal organisms, dispersing fish, crabs, worms, molluscs, and microorganisms from one ocean to another. Enclosed water bodies like San Francisco Bay are especially vulnerable. The bay already has at least 234 invasive alien species, causing significant economic damage. California has one of the toughest ballast water laws in the nation, requiring ships from foreign ports to exchange their ballast water 200 miles from the California coastline, but enforcement remains spotty at best.

Ballast water may also be important in the epidemiology of waterborne diseases affecting plants and animals. One study measured the concentration of the bacteria *Vibrio cholerae* – which cause human epidemic cholera – in the ballast water of vessels arriving to Chesapeake Bay from foreign ports and found the bacteria in plankton samples from all ships[1].

Other invasives are hitchhikers on global trade. For example, the Asian long-horned beetle (*Anoplophora glabripennis*) is one of the newest and most harmful invasive species in the United States. Originating in northeastern Asia, it finds its way to the United States through packing crates made of low-quality timber (in other words, that which is too infested for other uses). The number of insects found in materials imported from China increased from 1 percent of all

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[1] G. M. Ruiz *et al.*, "Global Spread of Micro-organisms by Ships," Nature, 2 November 2000, 49–50.

interceptions in 1987 to 20 percent in 1996. Outbreaks were reported in and around Chicago as early as 1992, in Brooklyn in August 1996, and in California in 1997. The beetle finds a congenial home among native maples, elders, elms, horse chestnuts, and others. The US Department of Agriculture predicted that if the beetle becomes established, it could denude Main Street USA of shade trees, affect lumber and maple sugar production, threaten tourism in infested areas, and reduce biological diversity in forests (USDA, 2004).

Another dangerous trade-related species for North America is the Asian gypsy moth, *Lymantria dispar*, which was first reported in the United States in 1991, entering as egg masses attached to ships or cargo from eastern Siberia. The caterpillars of this species are known to feed on more than 600 species of trees, and as moths, the females can disperse themselves over long distances. Scientists fear that this species could cause vastly more damage than the European gypsy moth, which already defoliates 1.5 million hectares of forest per year in North America.

With almost 700 million people crossing international borders as tourists each year, the opportunities for them to carry potential invasive species, either knowingly or unknowingly, are profound and increasing. Many tourists return with living plants that may become invasive, or carry exotic fruits that may be infested with invasive insects that can plague agriculture back home. They may also carry diseases between countries, as apparently happened with the SARS virus. Tourism is considered an especially efficient pathway for invasive alien species on sub-Antarctic islands such as South Georgia. Tourism to the island reached 15,000 in 1999. Part of the problem is that many tourists are visiting similar islands on the same trip, increasing the chances of a seed, fruit or insect being carried more than would be expected from a single landing of a few people who spend an extended time on one island. Expert opinion considers that tourism poses considerable threats to the endemic biota of these islands because it increases the likelihood of invasive species arriving and becoming established[1].

Many species are introduced on purpose, but have unintended consequences. One example of purposeful introduction gone wrong is the extensive stocking program that introduced African tilapia *Oreochromis* into Lake Nicaragua in

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[1] S. L. Chown and K. J. Gaston, "Island-hopping Invaders Hitch a Ride with Tourists in South Georgia, Nature 7 December 2000, 637.

the 1980s, resulting in the decline of native populations of fish and leading to the imminent collapse of one of the world's most distinctive freshwater ecosystems. The alteration of Lake Nicaragua's ecosystem is likely to have effects on the planktonic community and primary productivity of the entire lake – Central America's largest – destroying native fish populations and likely leading to unanticipated consequences[1].

Sport fishers have also had an influence, importing their favourite game fish into new river systems, where they can have significant negative impacts on native species. For example, the northern pike (*Esox lucius*) has invaded rivers in Alaska and is replacing native species of salmon. While the northern pike occurs naturally in some parts of Alaska, it was introduced to the salmon-rich south-central area in the 1950s, probably by a fisherman who brought it to Bulchitna Lake. Flooding in the 1980s subsequently spread the pike into the streams of the Susitna and Matanuska river basins. Pike have now occupied at least a dozen lakes and four rivers in some of the richest salmon and trout habitat in the Pacific Northwest. Rainbow trout are even worse. Originating in western North America, they have been introduced into 80 new countries, often with devastating impacts on native fish.

Pets are also a problem. Domestic cats can plunder ecosystems that they did not previously inhabit. On Marion Island in the sub-Antarctic Indian Ocean, cats were estimated to kill about 450,000 seabirds annually[2]. Exotic pets may escape – or be released when they have outlived their novelty – and become established in their new home. Stories of crocodiles in the Manhattan's sewer system are probably fanciful, but many former pets are becoming established in the wild. For example, Monk parakeets (*Myiopsitta monachus*), descended from former pets that were released possibly in the 1960s, have invaded some 76 localities in 15 U.S. states.[12] Native to southern South America, they are the only parrots that build their own nests, some of which support several hundred individuals and have separate families living in different chambers. Some believe that they soon will become widespread throughout the lower 48 states, posing a significant threat to at lest some agricultural lands by feeding on ripening crops. And Burmese pythons, *Python molurus*, have become established in Everglades National Park, where they reach a very large size and even prey on alligators.

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[1] K. R. McKaye *et al*., African Tilapia in Lake Nicaragua, BioScience 45 (1995): 406–411.
[2] L. Winter, "Cats Indoors!" Earth Island Journal, Summer 1999, 25–26.

Pet stores often advertise invasive species that are legally controlled. For example, the July 2000 issue of the magazine *Tropical Fish Hobbyist* recommended several species of the genus *Salvinia* as aquarium plants, even though they are considered noxious weeds in the United States and prohibited by Australian quarantine laws.

The globalisation of trade and the power of the Internet offer new challenges, as sales of seeds and other organisms by mail order or over the Internet pose new and very serious risks to the ecological security of all nations. Controls on harvest and export of species are required as part of a more responsible attitude of governments toward the potential of spreading genetic pollution through invasive species. Further, all receiving countries want to ensure that they are able to control what is being imported. Virtually all countries in the world have serious problems in this regard, an issue that some countries are calling "biosecurity."

Biodiversity is dynamic, and the movement of species around the world is a continuing process that is accelerating through expanding global trade. By trying to identify which species are especially likely to become invasive, and hence harmful to people, ecologists are improving the quality of invasion biology as a predictive science so that people can continue to benefit from global biodiversity without paying the costs resulting from species that later become harmful.

Previous examples indicate the characteristics that can make a species invasive. For instance, coastal ecosystems are frequently invaded by micro-organisms from ballast water for three main reasons. First, concentrations of bacteria and viruses exceed those reported for other taxonomic groups in ballast water by 6 to 8 orders of magnitude, and the probability of successful invasion increases with inoculation concentration. Second, the biology of many microorganisms combines a high capacity for increase, asexual reproduction, and the ability to form dormant resting stages. Such flexibility in life history can broaden the opportunity for successful colonisation, allowing rapid population growth when suitable environmental conditions occur. And third, many microorganisms can tolerate a broad range of environmental conditions, such as salinity or temperature, so many sites may be suitable for colonisation[1]. Insects are a major problem because they can lay dormant or travel as

1 Ruiz *et al*., note 1 p. 192.

egg masses, and are difficult to detect. The African tilapia introduced to Lake Nicaragua adapted well, because they are able to grow rapidly; feed on a wide range of plants, fish, and other organisms; and form large schools that can migrate long distances. Further, they are maternal mouth brooders, so a single female can colonise a new environment by carrying her young in her mouth[2]. Rapid growth, generalised diet, ability to move large distances, and prolific breeding are all characteristics of successful invaders.

On the other hand, it is not always simple to distinguish a beneficial non-native species from one at significant risk of becoming invasive. A non-native species that is useful in one part of a landscape may invade other parts of the landscape where its presence is undesirable, and some species may behave well for decades before suddenly erupting into invasive status. The Nile Perch (*Lates niloticus*), for example, was introduced to Lake Victoria in the 1950s but did not become a problem until the 1980s, when it was a key factor in the extinction of as many as half of the lake's 500 species of endemic fish, finding these fish attractive prey[3]. That said, ecologists over the past several decades have agreed on some broad principles for guiding risk assessment. First, the probability of a successful invasion increases with the initial population size and with the number of attempts at introduction. While it is possible for a species to invade with a single gravid female or fertile spore, the odds of doing so are very low. Second, among plants, the longer a non-native plant has been recorded in a country and the greater the number of seeds or other propagules that it produces, the more likely it will become invasive. Third, species that are successful invaders in one situation are likely to be successful in other situations; rats, water hyacinth, micro organisms, and many others fall into this category. Fourth, intentionally introduced species may be more likely to become established than are unintentionally introduced species, at least partly because the vast majority of these have been selected for their ability to survive in the environment where they are introduced. Fifth, plant invaders of

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[2] McKaye *et al.*, note 1 p. 194.

[3] A. J. Ribbink, "African Lakes and Their Fishes: Conservation Scenarios and Suggestions," Environmental Biology of Fishes 19 (1987): 3–26; T. Goldschmit, F. Witte, and J. Wanink, "Cascading Effects of the Introduced Nile Perch on the Detritivorous-phytoplanktivorous Species in the Sublittoral Areas of Lake Victoria," Conservation Biology 7 (1993): 686–700; and R. Ogutu-Ohwayo, "Nile Perch in Lake Victoria: The Balance between Benefits and Negative Impacts of Aliens," in O. T. Sandlund, P.J. Schei, and A. Viken, eds., Invasive Species and Biodiversity Management. Dordrecht, Netherlands: Kluwer Academic Publishers, 1999), 47–64.

croplands and other highly disturbed areas are concentrated in herbaceous families with rapid growth and wide environmental tolerances, while invaders of undisturbed natural areas are usually from woody families, especially nitrogen-fixing species that can live in nitrogen-poor soils[1]. And sixth, fire, like disturbance in general, increases invasion by introduced species. So ecosystems that are naturally prone to fire, such as the fynbos of South Africa, coastal chaparral in California, and maquis in the Mediterranean,[2] can be heavily invaded if fire-liberated seeds of invasive species are available (these are all shrub communities adapted to cool, wet winters and hot, dry summers, where fire is a regular phenomenon; they are rich in species, with fynbos having about 8,500 species that include many endemic Proteaceae, chaparral having about 5,000 species, and maquis having 25,000 of which about 60 percent are endemic to the Mediterranean region – Groombridge and Jenkins, 2002).

Other ecological factors that may favour nonindigenous species include a lack of controlling natural enemies, the ability of an alien parasite to switch to a new host, an ability to be an effective predator in the new ecosystem, the availability of artificial or disturbed habitats that provide an ecosystem the aliens can easily invade, and high adaptability to novel conditions[3].

It is sometimes argued that systems with great species diversity are more resistant to new species invading. However, a study in a California riparian system found that the most diverse natural assemblages are the most invaded by non-native plants, and protected areas worldwide are heavily invaded by non-native plants and animals (see the box on page 01)[4]. Dalmatian toadflax (*Linaria dalmatica*) is invading relatively undisturbed shrub-steppe habitat in the U.S. Pacific Northwest, wetland nightshade (*Solanum tampicense*) is

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[1] M. L. McKinney and J. L. Lockwood, 'Biotic Homogenization: A Few Winners Replacing Many Losers in the Next Mass Extinction,' Tree 14 (1999): 450–53.

[2] C. M. D'Antonio, T.L. Dudley, and M. Mack, "Disturbance and Biological Invasions: Direct Effects and Feedbacks," in L. Locker, ed., Ecosystems of Disturbed Ground (Amsterdam: Elziveer, 1999).

[3] Pimental, Lach, Zuniga, and Morrison, note 3 p. 191.

[4] N. L. Larson, P.J. Anderson, and W. Newton, "Alien Plant Invasion in Mixed-Grass Prairie: Effects of Vegetation Type and Anthropogenic Disturbance," Ecological Applications 11 (2001): 128–41; and J. M. Levine, Species Diversity and Biological Invasions: Relating Local Process to Community Pattern," 5 May 2000, 852–54.

invading cypress wetlands in central and south Florida, and garlic mustard (*Allilaria officinalis*) is often found in relatively undisturbed systems in the northern parts of North America.

This work helps resolve the controversy over the relationship between biodiversity and invasions, suggesting that the scale of investigation is a critical factor. Theory suggests that non-native species should have a more difficult time invading a diverse ecosystem because the web of species interactions should be more efficient in using resources such as nutrients, light, and water than would fewer species, leaving fewer resources available for the non-native species. But even in well-protected landscapes such as national parks, invaders often seem to be more successful in diverse ecosystems. Even though diversity does matter in fending off invasives, its effects are negated by other factors at larger scales. The most diverse ecosystems might be at the greatest risk of invasion, while losses of species, if they affect community-scale diversity, may erode invasion resistance[1].

The economic impacts of invasion

One reason invasive alien species are attracting more attention is that they are having substantial negative impacts on numerous economic sectors, even beyond the obvious impacts on agriculture (weeds), forestry (pests), and health (diseases or disease vectors). The probability that any one introduced species will become invasive may be low, but the damage costs and costs of control of the species that do become invasive can be extremely high (such as the recent invasion of eastern Canada by the European brown spruce longhorn beetle (*Tetropium fuscum*), which threatens the Canadian timber industry).

Estimates of the economic costs of invasive alien species include considerable uncertainty, but the costs are profound – and growing (see box). Most of these examples come from the industrialised world, but developing countries are experiencing similar, and perhaps proportionally greater, damages. Invasive alien insect pests – such as the white cassava mealybug, *Phenacoccus herreni,* and larger grain borer, *Prostephanus truncates,* in Africa – pose direct threats to food security. Alien weeds constrain efforts to restore degraded land, regenerate forests, and improve utilisation of water for irrigation and fisheries. Water hyacinth and other alien water weeds that choke waterways currently

[1] Ibid.

cost developing countries in Africa and Asia more than US$100 million annually. Invasive alien species pose a threat to more than $13 billion of current and planned World Bank funding to projects, in the irrigation, drainage, water supply, sanitation, and power sectors[1]. And a study of three developing nations (South Africa, India and Brazil) found annual losses to introduced pests of $138 billion per year[2].

In addition to the direct costs of management of invasives, the economic costs also include their indirect environmental consequences and other nonmarket values. For example, invasives may cause changes in ecological services by disturbing the operation of the hydrological cycle, including flood control and water supply, waste assimilation, recycling of nutrients, conservation and regeneration of soils, pollination of crops, and seed dispersal. Such services have both current-use value and option value (the potential value of such services in the future). In the South African fynbos, for example, the establishment of invasive tree species – which use more water than do native species – has decreased water supplies for nearby communities and increased fire hazards, justifying government expenditures of US$40 million per year for manual and chemical control[3].

Many people in today's globalised economy are driven especially by economic motivations. Those who are importing non-native species are usually doing so with a profit motive and often seek to avoid paying for possible associated negative impacts if those species become invasive. The fact that these negative impacts might take several decades to appear make it all the easier for the negative economic impacts to be ignored. Similarly, those who are ultimately responsible for such "accidental" introductions, for example through infestation of packing materials or organisms carried in ballast water seek to avoid paying the economic costs that would be required to prevent these "accidental," but predictable, invasions. In both cases, the potential costs are externalised to the larger society, and to future generations.

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[1] S. Noemdoe, "Putting People First in an Invasive Alien Clearing Programme: Working for Water Programme," in J. A. McNeely, ed., The Great Reshuffling: Human Dimensions of Invasive Alien Species," (Gland, Switzerland: IUCN–The World Conservation Union, 2001), 121–26

[2] D. Pimentel *et al.*, "Economic and Environmental Threats of Alien Plant, Animal, and Microbe Invasions," Agriculture, Ecosystems and Environment 84 (2001): 1–20.

[3] Ibid.

Responses

Customs and quarantine practices, developed in an earlier time to guard against diseases and pests of economic importance, are inadequate safeguards against the rising tide of species that threaten native biodiversity. Globally, about 165 million 6-meter long sealed containers are being shipped around the world at any given time. In the United States, some 1,300 quarantine officers are responsible for inspecting 410,000 planes and more than 50,000 ships, with each ship carrying hundreds of containers; they inspect only about 2 percent of the containers. While they intercept alien species nearly 50,000 times a year, it is highly likely that at least tens of thousands more enter the country uninspected each year. In Europe, inspection at the port of entry is also desperately overextended, and once a container enters the European Union, no further border inspections are done. This is a recipe for disaster.

Instead, a different set of strategies is now needed to deal with invasive species. These include prevention (certainly the most preferable), early eradication, special containment, or integrated management (often based on biological control). Mechanical, biological, and chemical means are available for controlling invasive species of plants and animals once they have arrived. Early warning, quarantine, and various other health measures are involved to halt the spread of pathogens[1].

The international community has responded to the problem of invasive alien species through more than 40 conventions or programs, and many more are awaiting finalisation or ratification[2]. The most comprehensive is the 1992 Convention on Biological Diversity, which calls on its parties to

> prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species *(Article 8h)*.

A much older instrument is the 1952 International Plant Protection Convention, which applies primarily to plant pests, based on a system of phytosanitary certificates. Regional agreements further strengthen this convention. Other instruments deal with invasive alien species in specific

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[1] J. Kaiser, "Stemming the Tide of Invading Species," Science, 17 September 2000, 1836–841.

[2] C. Shine, N. Williams, and L. Gündling, A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species (Bonn, Germany: IUCN–The World Conservation Union, 2000).

regions (such as Antarctica), sectors (such as fishing in the Danube River), or vectors (such as invasive species in ballast water, through the International Maritime Organisation). The fact that the problem continues to worsen indicates that the international response to date has been inadequate.

On the national level, legal measures can sometimes be a very straightforward method of preventing or managing invasions. For example, to deal with the problem of Asian beetle invasions, the United States now requires that all solid-wood packing material from China must be certified free of bark (under which insects may lurk) and heat-treated, fumigated, or treated with preservatives. China might reasonably issue a reciprocal regulation, as North American beetles are a hazard there.

The nursery industry is by far the largest intentional importer of new plant taxa. Issuing permits for imported species is a good way for the agencies responsible for managing such invasions to keep track of what is being traded and moved around the country. Some people believe that it is impossible to issue a regulation containing a list of permitted and prohibited species, at least partly because the ornamental horticulture industry is always seeking new species. But the Florida Nurserymen and Growers Association recently identified 24 marketed species on a black list drawn up by Florida's Exotic Pest Plant Council and decided to discourage trade in 11 of the species (the least promising sellers in any case)[1].

Sometimes nature itself can fight back against invasive alien species, at least when they reach plague proportions. For example, the zebra mussels that have invaded the North American Great Lakes with disastrous effects are now declining because a native sponge (*Eunapius fragilis*) is growing on the mussels, preventing them from opening their shells to feed or breathe. The sponge has become abundant in some areas, while the zebra mussel population has fallen by up to 40 percent, though it is not yet clear whether the sponges will be effective in controlling the invasive species in the long term.

Biological control, the intentional use of natural enemies to control an invasive species, is an important tool for managers. Some early efforts at biological control agents had disastrous influences, such as South American cane toads (*Bufo marinus*) in Australia, Indian common mynahs (*Acridotheres tristis*) in

[1] Kaiser, note 1 p.200.

Hawaii, and Asian mongooses (*Herpestes javanicus*) in the Caribbean. Not only did these species not deal with the problem species upon which they were expected to prey, but they ended up causing havoc to native species and ecosystems. On the other hand, biological control programs are now much more carefully considered and in many cases are the most efficient, most effective, cheapest, and least damaging to the environment of any of the options for dealing with invasives once they have arrived[1]. Examples include the use of a weevil (*Cyrtobagous salviniae*) to control salvinia fern (*Salvinia molesta)*, another weevil (*Neohydronomus affinis*) to control water lettuce (*Pistia stratiotes*), and a predatory beetle (*Hyperaspis pantherina*) to control orthezia scale (*Orthezia insignis*) that threatened the endemic national tree of St Helena (*Commidendrum robustum*) -- Wittenberg and Cock, 2001.

Those seeking to use viruses or other disease organisms to control an invasive species need to understand ecological links. As just one example, when millions of rabbits died after the intentional introduction of the myxomatosis virus in the United Kingdom, populations of their predators, including stoats, buzzards, and owls, declined sharply. The impact affected other species indirectly, leading to local extinction of the endangered large blue butterfly (*Maculina arion*), because of reduced grazing by rabbits on heathlands, which removed the habitat for an ant species that assists developing butterfly larvae[2]. But the use of the myxoma virus in conjunction with 1080 poison on Phillip Island in the South Pacific successfully eradicated invasive rabbits, allowing the recovery of the island's vegetation (including an endemic hibiscus (*Hibiscus insularis*) (Coyne, 2001).

At small scales of less than one hectare, it appears possible with current technology to eradicate invasive species of plants through use of herbicides, fire, physical removal, or a combination of these, but the costs of eradication rise quickly as the area covered increases. Invasive alien mammals can be eradicated from islands of thousands of hectares in size, with the right

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[1] M. S. Hoddle, "Restoring Balance: Using Exotic Species to Control Invasive Exotic Species," Conservation Biology 18 (2004): 38–49; S. M. Louda and P. Stiling, "The Double-Edged Sword of Biological Control in Conservation and Restoration," Conservation Biology 18 (2004): 50–53; and R. Wittenberg and M. J. W. Cock (eds.), Invasive Alien Species: A Tool Kit of Best Prevention and Management Practices (Wallingford, Oxan, UK: Global Invasive Species Programme and Commonwealth Agricultural Bureau International, 2001).

[2] P. Daszak, A. Cunningham, and A. D. Hyatt. «Emerging Infectious Diseases of Wildlife: Threats to Biodiversity and Human Health,» Science, 21 January 2000, 443–49.

approach and technology. Rat eradication from islands of larger than 2,000 hectares has been successful, and large mammals have been removed from much bigger ones than that, primarily by hunting and trapping.

Environmentally sensitive eradication also requires the restoration of the community or ecosystem following the removal of the invasive. For example, the eradication of Norway rats from Mokoia Island in New Zealand was followed by greatly increased densities of mice, also alien species. Similarly, the removal of Pacific rats (*Rattus exulans*) from Motupao Island, New Zealand, to protect a native snail led to increases of an exotic snail to the detriment of the natives. And on Motunau Island, New Zealand, the exotic box-thorn (*Lycium ferocissimum*) increased after the control of rabbits. On Santa Cruz Island, off the west coast of California, removing goats led to dramatic increases in the abundance of fennel (*Foeniculum vulgare*) and other alien species of weeds. Thus reversing the changes to native communities caused by non-native species will often require a sophisticated understanding of ecological relationships. It is now well recognised that eradication programmes are only the first step in a long process of restoration (Klinger *et al*, 2002).

Sometimes native species become dependent on invasive ones, causing dilemmas for managers. For example, giant kangaroo rats (*Dipodomys ingens*) in the American west continually modify their burrow precincts by digging tunnels, clipping plants, and other activities. This chronic disturbance to soil and vegetation sometimes promotes the establishment of invasive species of plants that were originally imported as ornamentals from the Mediterranean so that they constitute a very large proportion of the vegetation on giant kangaroo rat territories. They have significantly larger seeds than do native species, so are favoured by the grain-eating kangaroo rats[1]. Because the kangaroo rats depend on non-native plant species for food and the non-native plant species depend upon the kangaroo rats to disturb their habitat continually, the relationship is mutualistic. This strong relationship may also inhibit population growth of native grassland plants that occupy disturbed habitats but have difficulty competing with non-native weeds for resources. This mutualism

[1] P. Schiffman, "Promotion of Exotic Weed Establishment by Engangered Giant Kangaroo Rats *Dipodomys ingens* in a California Grassland," Biodiversity and Conservation 3 (1994): 524–37.

presents an intractable conservation management dilemma, suggesting that it may be impossible to restore valley grasslands occupied by endangered kangaroo rats to conditions where native species dominate.

High-tech management measures are also being tried. For example, Australian scientists are planning to insert a gene known as “daughterless” into invasive male carp (*Cyrprinus carpio*) in the Murray-Darling River, the country’s longest, thereby ensuring that their offspring are male. The objective is to release them into the wild, sending wild carp populations into a decline and making room for the native species that are being threatened by the invasive European carp[1]. Using genetic modification can help eradicate an invasive alien species, but if the detrimental gene is released into nature and starts to flourish, many other species could be negatively affected. Thus the precautionary approach needs to be applied to control techniques as well as to introductions.

The problems of invasive alien species are so serious that actions must be taken even before we can be "certain" of all of their effects. In any case, mechanical removal, biocontrol, chemical control, shooting, or any other approach to controlling alien invasive species needs to be carefully considered prior to use to ensure that the implications have been fully and carefully considered, including impacts on human health, other species, and so forth. A public information program is also needed to ensure that the proposed measures are likely to be effective as well as socially and politically acceptable.

Conclusions

Ecosystems have been significantly influenced by people in virtually all parts of the world; some have even called these "engineered ecologies." This calls for a much more conscious and better-informed management of ecosystems, including dealing with non-native species.

For millennia, the natural barriers of oceans, mountains, rivers and deserts provided the isolation essential for unique species and ecosystems to evolve. In

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[1] R. Nowak, Gene Warfare: One small tweak and a whole species will be wiped out, New Scientist, 11 May 2002: 6.

just a few hundred years, major global forces have rendered natural barriers ineffective, allowing non-native species to travel vast distances to new habitats and become invasive alien species. The globalisation and growth in the volume of trade and tourism, coupled with the emphasis on free trade, provide more opportunities than ever before for species to be spread accidentally or deliberately. This inadvertent ending of millions of years of biological isolation has created major ongoing environmental problems that affect both developed and developing countries, with profound economic and ecological implications.

Because of the potential for economic and ecological damage when an alien species becomes invasive, every alien species needs to be treated for management purposes as if it is potentially invasive, unless and until convincing evidence indicates that it is harmless in the new range. This view calls for urgent action by a wide range of governmental, intergovernmental, private sector, and civil institutions.

A comprehensive solution for dealing with invasive alien species has been developed by the Global Invasive Species Programme[1]. It includes ten key elements.

An effective national capacity to deal with invasive alien species

Building national capacity could include designing and establishing a "rapid response mechanism" to detect and respond immediately to the presence of potentially invasive species as soon as they appear, with sufficient funding and regulatory support; and implementing appropriate training and education programs to enhance individual capacity, including customs officials, field staff, managers, and policymakers. It could also include developing institutions at national or regional levels that bring together biodiversity specialists with agricultural quarantine specialists; and building basic border control and quarantine capacity, ensuring that agricultural quarantine officers, customs officials, and food inspection officers are aware of the elements of the Biosafety Protocol.

[1] The Global Invasive Species Programme (GISP) was established in 1997 as a consortium of the Scientific Committee on Problems of the Environment (SCOPE), CABI, and IUCN, in partnership with the United Nation Environment Programme and with funding from the Global Environment Facility (GEF). See J. A. McNeely, H. A. Mooney, L. E. Neville, P. J. Schei, and J. K. Waage, eds., Global Strategy on Invasive Alien Species (Gland, Switzerland: IUCN–The World Conservation Union, 2001).

Fundamental and applied research at local, national, and global levels

Research is required on taxonomy, invasion pathways, management measures, and effective monitoring. Further understanding on how and why species become established can lead to improved prediction on which species have the potential to become invasive, improved understanding of lag times between first introduction and establishment of invasive alien species, and better methods for excluding or removing alien species from traded goods, packaging material, ballast water, personal luggage, and other methods of transport.

Effective technical communications.

An accessible knowledge base, a planned system for review of proposed introductions, and an informed public are needed within countries and between countries. Already, numerous major sources of information on invasive species are accessible electronically, and more could also be developed and promoted, along with other forms of media.

Appropriate economic policies

While prevention, eradication, control, mitigation, and adaptation all yield economic benefits, these are in the form of public goods and hence are likely to be undersupplied because it is difficult for policy makers to identify specific beneficiaries who should pay for the benefits received. New or adapted economic instruments can help ensure that the costs of addressing invasive alien species are better reflected in market prices. Economic principles relevant to national strategies include ensuring that those responsible for the introduction of economically harmful invasive species are liable for the costs they impose; ensuring that use rights to natural or environmental resources include an obligation to prevent the spread of potential invasive alien species; and requiring importers of potential such species to have liability insurance to cover the unanticipated costs of introductions.

Effective national, regional, and international legal and institutional frameworks

Coordination and cooperation between the relevant institutions are necessary to address possible gaps, weaknesses and inconsistencies, and to promote greater mutual support among the many international instruments dealing with invasive alien species.

A system of environmental risk analysis

Such a system could be based on existing environmental impact assessment procedures that have been developed in many countries. Risk analysis measures should be used to identify and evaluate the relevant risks of a proposed activity regarding alien species and determine the appropriate measures that should be adopted to manage the risks. This would also include developing criteria to measure and classify impacts of alien species on natural ecosystems, including detailed protocols for assessing the likelihood of invasion in specific habitats or ecosystems.

Public awareness and engagement

If management of invasive species is to be successful, the general public must be involved. A vigorous public awareness program would involve the key stakeholders who are actively engaged in issues relevant to invasive alien species, including botanic gardens, nurseries, agricultural suppliers, and others. The public can also be involved as volunteers in eradication programs of certain non-native species, such as woody invasives of national parks.

National strategies and plans

The many elements of controlling invasive alien species need to be well coordinated, ensuring that they are not simply passed on to the Ministry of Environment or a natural resource management department. A national strategy should promote cooperation among the many sectors whose activities have the greatest potential to introduce them, including the military, forestry, agriculture, aquaculture, transport, tourism, health, and water supply. The government agencies with responsibility for human health, animal health, plant health, and other relevant fields need to ensure that they are all working toward the same broad objective of sustainable development in accordance to national and international legislation. Such national strategies and plans can also encourage collaboration between different scientific disciplines and approaches that can seek new approaches to dealing with problems caused by invasive alien species.

Build invasive alien species issues into global change initiatives

Global change issues relevant to invasives begin with climate change but also include changes in nitrogen cycles, economic development, land use, and other fundamental changes that might enhance the possibilities of these species becoming established. Further, responses to global change issues, such as sequestering carbon, generating biomass energy, and recovering degraded lands, should be designed in ways that use native species and do not increase the risk of the spread of non-native invasives.

Promote international co-operation

The problem of invasive alien species is fundamentally international, so international cooperation is essential to develop the necessary range of approaches, strategies, models, tools, and potential partners to ensure that the problems of such species are effectively addressed. Elements that would foster better international cooperation could include developing an international vocabulary, widely agreed and adopted; cross-sector collaboration among international organisations involved in agriculture, trade, tourism, health, and transport; and improved linkages among the international institutions dealing with phytosanitary, biosafety, and biodiversity issues and supporting these by strong linkages to coordinated national programs.

Because the diverse ecosystems of our planet have become connected through numerous trade routes, the problems caused by invasive alien species are certain to continue. As with maintaining and enhancing health, education, and security, perpetual investments will be required to manage the challenge they present. These ten elements will ensure that the clear and present danger of invasive species is addressed in ways that build the capacity to address any future problems arising from expanding international trade.

Indicative costs of some invasive alien species (in US$)

Species	Economic variable	Economic impact
Introduced disease organisms	Annual cost to human, plant, and animal health in the United States	$41 billion per year[I]
A sample of alien species of plants and animals	Economic costs of damage in the United States	$137 billion per year[II]

Species	Economic variable	Economic impact
Salt cedar	Value of ecosystem services lost in western USA	\$7–16 billion over 55 years[III]
Knapweed and leafy spurge	Impact on economy in three US states	\$40.5 million per year[IV] direct costs \$89 million indirect
Zebra mussel (*Dreissena polymorpha*)	Damages to US and European industrial plants	Cumulative costs 1988[V]–2000: \$750 million to 1 billion
Most serious invasive alien plant species	Costs 1983–1992 of herbicide control in Britain	\$344 million/year for 12 species[VI]
Six weed species	Costs in Australia agroecosystems	\$105 million/year[VII]
Pinus, Hakeas, and *Acacia*	Costs on South African floral kingdom to restore to pristine state	\$2 billion[VIII]
Water hyacinth (*Eichornia crassipes*)	Costs in seven African countries	\$20–50 million/year[IX]
Rabbits	Costs in Australia	\$373 million/year (agricultural losses)[X]
Varroa mite	Economic cost to beekeeping in New Zealand	\$267–602 million[1]

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The Global Invasive Species Programme (GISP) has news and links on various aspects of invasives at http://www.gisp.org/.

A sociological analysis of biological invasions in Mediterranean France

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Abstract

Because our contemporary world is the product of complex interactions between natural and anthropic processes, human sciences are more and more incited to analyse issues previously restricted to biological sciences. Thus, for the last few years the French Ministry of Sustainable Development has been trying to involve social scientists into its national research program about invasive species. In this context, we have initiated an interdisciplinary research about two invasive plants in Mediterranean France, *Cortaderia selloana* and *Baccharis halimifolia*. This contribution proposes to present the preliminary results of our sociological survey and some epistemological reflections raised from our interdisciplinary collaboration.

The understanding of these two case studies, Cortaderia selloana and Baccharis halimifolia, by sociology means to analyse in a larger way the social processes implemented: who are the stakeholders involved in the debate relative to these two species and also to invasive species in general? What are their discourses and attitudes? What are the social, economic and symbolic stakes? And, last but not least, what does or doesn't the public know about invasive species?

The research in process is based on a qualitative survey, mainly consisting of interviews. The sample includes:

a. economic actors involved in production and trading of *Cortaderia selloana* and *Baccharis halimifolia*. (horticulturists, professional organisations);
b. social actors involved in gardening and landscaping: local council, architects-landscapers, managers of green or natural areas, inhabitants with *Cortaderia selloana* and/or *Baccharis halimifolia* in their gardens.

As with most environmental issues, the question of biological invasion invites us to combine the views of different disciplines. As a biological process capable of having an impact on the ecosystem, some of the causes and consequences of biological invasion are found in human society (McNeely 2001). In order to be complete, analyses of the process of biological invasion therefore have to mobilise knowledge and methods taken from both Life Sciences (LS) and the Human and Social Sciences (HSS). Even though it has been fashionable for three decades to preach the pluridisciplinary (i.e. the juxtaposition of knowledge from a variety of disciplines) and even interdisciplinarity (effective collaboration at various stages of the research process) approaches, implementation often remains difficult, not to say conflictual. The analysis of biological invasions is not free of these methodological and epistemological problems.

This article offers a first assessment of the interaction between Life Sciences and Social Sciences in the analysis of biological invasion and attempts to explain the causes of the interdisciplinary tensions observed. As a way of avoiding the risk of epistemological rigidity an alternative approach is then proposed. This interdisciplinary implementation of methodological doubt is illustrated by current research on *Cortaderia selloana* (pampas grass) and *Baccharis halimifolia* (groundsel).

When the concept of biological invasion leads to epistemological wars

The Life Sciences have examined the process of biological invasion in some depth. Identified by Darwin and investigated by Elton (1958), biological invasion has, for a decade or two, given rise to the exponential development of biological research and surveys. In contrast, the appearance of the HSS in this field is very recent. In France it was calls for tender from the Ministry of Ecology and Sustainable Development (MEDD) that prompted several research teams to tackle the problem. These recent pluridisciplinary studies on biological invasion met the classic difficulties already observed in the realm of the environment. The senior officials or researchers driving these research programmes have all had a scientific training as biologists, physicists or top-flight engineers. What they ask of the social sciences is direct help with decision-making; they ask of sociology that it should

> explain how we can make populations aware of environmental problem and change their behaviour (Henry & Jollivet 2002 p.66).

As Claude Henry and Marcel Jollivet (2002 p.67) stress, the social sciences are seen in these programmes as being "disciplines that can be influenced" in that they are "seen as secondary to the earth sciences or ecology and their subject-matter should be determined by questions raised by the Life Sciences". While some HSS researchers find this situation discouraging, it has motivated others to develop critical analyses of the environment and the scientists who study it, no longer perceiving biologists as collaborators but as objects of study. This is how some research that has tried to be interdisciplinary has become the theatre of a "war of the sciences" (Stengers 2001), fed by an implied disciplinary pecking-order ("soft" science pitted against "hard" science) and epistemological incomprehension.

The concept of biological invasion has lent itself particularly well to the growth of this war of the sciences. The first French Social Science publications on the subject examine the scientific controversies around the concept of biological invasion (Dalla Bernadina 1999, 2004 and Pelligrini 2005) instead of pluridisciplinary collaboration. The studies concentrate on the strategies of dramatisation adopted by certain biologists, the symbolic and ideological baggage contained in the notion of "biological invasion" and the effect of dubbing *Caulerpa taxifolia* the "killer algae". In a similar vein the landscape gardener Gilles Clément appoints himself the defender of "refugee plants" (Clément 2002), denouncing the xenophobic character of the notion of biological invasion. It should be noted that the notion of biological invasion does not have the monopoly on what I have called the "xenophobic temptation" (Claeys-Mekdade 2000, 2003). This "ecological ambiguity" as investigated by P. Alphandéry, P. Bitoun and Y. Dupont (1991) is inherent in the very principle of preservation, whether of nature or culture. Far from being a French speciality, the Life Science *versus* Social Science polarisation around the concept of biological invasion is also found in writings in English.

Words are never neutral... but some words are less neutral than others. The notions of invasion, autochthonous and allochthonous have political and cultural implications that have attracted the attention of Social Science researchers specialising in the analysis of (often hidden) meanings, signs and symbols. For example Groening G. and Wolschke-Bulmahn J. (1992) give an historical perspective to the interest shown by scientists of the Third Reich in eradicating exotic plants. Again, Jonah H. Peretti (1998) while highlighting the etymological similarities between the words "native, natural, nation and nationality", reminds his readers that

> The purism of biological nativism has historically been associated with fascist and apartheid cultures and governments.

Mark Sagoff (1999) comments on the dangerous similarities between the arguments for policies to eradicate certain allochthonous plants and certain immigration policies:

> These undesirable characteristics include sexual robustness, uncontrolled fecundity, low parental involvement with young, tolerance for “degraded” or squalid conditions, aggressiveness, predatory behavior, ...

In the article “The aliens have landed! Reflections on the Rhetoric of Biological Invasions”, Banu Subramiam (2001) notes the possible similarities between nationalism, xenophobia and the notion of biological invasion.

What all these different approaches have in common is that they expose the grain of ideology concealed in the concept of biological invasion; incidentally this is common to most scientific concepts irrespective of their discipline of origin, the Social Sciences included. This criticism is particularly vocal in the case of biological invasion where it touches on delicate issues that are seen as black-spots in our history (invasions, colonisation, genocide, fascism, etc.) and which continue to produce negative effects such as illicit immigration, ghettos, racism, ethnic wars, etc. Such criticisms of the concept of biological invasion are rejected by biologists who, as a reaction, generally tend to dig in their heels. For example, in his article “Confronting introduced species: a form of xenophobia”, Daniel Simberloff (2003) concludes,

> Because the stakes are so high, and it is far more difficult (often impossible) to remove introduced species once they are established than to keep them out in the first place, the “innocent until proven guilty” philosophy that has guided national and international policy until now (see, e.g., National Research Council 2000) is inadequate and should be replaced with a philosophy of “guilty until proven innocent””.

In this situation, emotions tend to carry more weight than scientific discussion. The legitimate anxieties of biologists and managers of “natural” spaces in the face of proliferation clash with the equally legitimate worries of Social Sciences faced with the risk of drifting into dangerous ideologies. While taking an emotional step back may calm the conflict between Life Sciences and Social Sciences, this is not enough in itself in that affect hides a deep epistemological distortion. These two major fields of learning represent radically different conceptions of the world. Scientific ecology is linked to militant ecology, just as the human sciences are linked to humanism. Ecology and the Life Sciences in general place nature at the centre of their world-view, whereas sociology and all the Social Sciences take mankind as the core of their conception of the world. The first conception, known as biocentrism, places the human race and its works outside nature, considering its presence to be essentially a source of disruption. The second conception, known as anthropocentrism, considers nature to be a necessary resource that serves the development of humanity. Thus, even stripped of an emotional dimension that is particularly acute in discussions on biological invasion, the dialogue between Life Sciences and Social Sciences has to confront a deep epistemological distortion.

In favour of heuristic collaboration: an interdisciplinary practice of methodological doubt

These epistemological conflicts are not devoid of heuristic interest. As the sociologist Georges Simmel (1995) stresses, conflict is a type of socialisation. It is therefore important that these discussions should take place. However, if dialogue between the Life and Social Sciences is limited to this sort of contact, implementing interdisciplinary collaboration will remain difficult if not impossible. This conflict, based on the radicalisation and moralisation of the anthropocentrism *versus* biocentrism polarities can, however, be partly overcome.

If this is to happen the Life Sciences need to integrate the ideological, cultural and social dimensions inherent in environmental questions while the Social Sciences must not minimise the genuineness of the biophysical processes observed. The interdisciplinary practice of methodological doubt is a possible avenue. To achieve this, sociologists have to abandon their monopoly on criticism while the biologists must relinquish their monopoly on scientific accuracy. Equity, respect and mutual trust are indispensable. And, it must be remembered, interdisciplinarity cannot come about by decree; it must be built on the basis of dialogue and interpersonal affinity. The entry of the Humanities and Social Sciences into the analysis of biological invasion brings with it a type of socio-historical relativism. It is not the role of this relativism to deny the genuineness of the biophysical processes observed by the Life Sciences. It should not be the aim of the Social Sciences to either legitimise or delegitimise the notion of biological invasion. It is rather to analyse the meaning social actors ascribe to their actions. This is what human beings protect by fighting against biological invasion and for the maintenance of biodiversity; it is also, if not primarily, their ecosystem: the ecosystem which enables them to live as well as the ecosystem as an arena of cultural and symbolic projection. Mankind could probably continue living without the elephant, panda or tiger just as we have adapted to the extinction of the mammoth. But today the elephant, panda and tiger, and many other species are part of the natural, cultural and economic heritage of our "cyber-world". At the heart of biocentrism, even in its most radical forms (deep ecology), mankind remains present, a reformed destroyer become enlightened manager. But do we not risk crossing the narrow line between fear of extinction and fear of change? Between the conservation of nature and the total immobilisation of nature to the point of denying that change is at the core of biophysical processes, there would appear to exist a broad range of possibilities that deserve to be explored more fully.

A case study: *Cortaderia selloana* and *Baccharis halimifolia*

The ongoing interdisciplinary study being performed with the biologist Anne Charpentier could have fallen, and may indeed yet fall, prey to this war of the sciences. This dialogue between sociology and biology has, however, been facilitated by local scientific history. In fact, it could be argued that the "war of the sciences" has already been fought between our two institutes located in the Rhône delta. On the one hand, for several decades the Sansouïre Foundation, a research centre and centre for the management of protected areas, has been producing Life Science studies of the region. On the other, the DESMID-UMR Espace-CNRS, directed by the sociologist Bernard Picon, has been generating Social Science knowledge about the same territory. The work of the Sansouïre Foundation has led them to fear the risk of deterioration of the ecosystem of the delta due to the increased pressure of human activity. The work of the DESMID-UMR Espace-CNRS has highlighted that even though the Camargue is an international byword for untamed nature, it is in fact the result of several centuries of human activity, where the biological richness is the result of the exceptional interaction between two artificial hydraulic systems, one dependent on agriculture and the other on the salt industry (Picon 1978). The disciplinary bases of our two institutions were conducive to the crystallisation of this type of epistemological conflict. But with time, like two old brothers in a love-hate relationship, bridges have been built. This is what sociologists call the integration of criticism (Boltanski & Chiapello, 1999). The Life Sciences slowly took seriously the assertion that this socio-natural milieu is of man-made origin, and the Social Sciences accepted that even though they may be artificial, the wetlands of the Camargue are nonetheless biologically rich and fragile.

This then is the scientific background to our biological/sociological interdisciplinary research on Selloana Cortaderia and Baccharis. The aim of the sociological investigation was to confirm and argue the hypothesis that the roots of the contemporary invasive process lie in socio-economic changes. These changes are thought to be the result of the increased ornamental use of these plant species by both private gardeners and those responsible for managing public spaces (parks, roundabouts, etc.); the processes by which these plants are grown and distributed by the producers and retailers probably play an important part in this invasion. Our fieldwork takes as its starting-point identified plantations or highly contaminated zones in both the public and private sectors where there is a strong probability that planting was deliberate. Using a survey of the private and public actors who undertook such planting, we have tried to identify both the commercial and production circuits that supplied the plants as well as the decision-making processes that led them to choose these particular plant species. Our approach is genuinely interdisciplinary in that the perimeter within which a plant species has moved is taken as the criteria for determining the boundaries of our sociological sample.

Our preliminary survey revealed the difficulties of tackling the subject of biological invasion with professional horticultural producers and distributors. There are two reasons for this: firstly, the “worrying” dimension of the phenomenon can cause horticultural professionals to be wary, fearing increased control of their business activities; secondly, our questions about their production techniques and methods of distribution probed strategic economic information that they were usually reluctant to share. The difficulties encountered in the field during the preliminary survey enabled us to redefine the protocol for the main survey. We realised that when writing our questionnaires or making initial contact with horticultural professionals we should not focus directly on the question of biological invasion; it was better to broaden the initial question and make it one about the sociology of taste: which species do customers demand? What changes in taste have they seen that make customers abandon one species for another? What part do exotic species play? etc. In fact, interviews with horticultural professionals revealed that the production of particular species is very closely related to changes in taste and is influenced by fashion. On this point, several professionals stressed that although pampas grass was fashionable in the 1980s, demand has now dropped off. This result from the sociological survey feeds directly into biological studies into questions regarding latency times.

The question of taste raised by certain professionals also highlighted the importance of social actors who have a role as "taste maker", particularly landscape gardeners who are backed up by the sort of popularisation provided by the mass-market press in the fields of gardening and decor and, to a lesser degree, women's magazines. These "taste makers" also have a major influence in the management of public spaces. The increasing use of calls for tender for the creation and management of public green spaces has resulted in more and more customers using landscape gardeners (landscape architects or gardening/landscape consultancy companies, etc).

Although the feeling of distrust characteristic of our professional respondents was lacking in private respondents, they compensated for it by a marked degree of surprise. The frequent laughter that punctuated our interviews was a sure sign that respondents found our survey bizarre. We should take this surprise seriously when we analyse our results as it reveals a disparity between the concerns of the researchers and those of local actors. This is confirmed by the details of the interviews. Residents knew little or nothing about the process of biological invasion. When the interviewer introduced the expression into the discussion some respondents spontaneously assigned it a meaning that was often quite close to the scientific definition, without, however, considering that pampas grass might be concerned. Residents appreciated pampas grass for its pleasing appearance, its hardiness and its ability to blend into the local landscape. Several residents even thought it was a local species. Nothing, however, was said about groundsel as none of the residents interviewed knew the plant.

Whilst levels of information and involvement[1] were low in all the residents interviewed, in contrast the managers interviewed showed widely differing levels of involvement. The ongoing survey of managers of natural and urban green spaces reveals a range of responses ranging from total uninvolvement

[1] The term "involvement" is used here in its conceptual sense, as defined by Michel Callon (1986), i.e. as a factor that seals alliances.

with the corollary of a minimisation of any danger, through to very marked involvement with the corollary of a dramatisation of the problem of so-called "pest". These varying degrees of involvement make or unmake alliances between social actors. For example, alliances are forged between biologists worried by biological invasion and hunters responsible for managing green spaces who see the access to their territory being limited by the spread of *Baccharis halimifolia* and *Cortaderia selloana*. Conversely, tensions can be observed between certain biologists and landscape gardeners. Two communities can be distinguished, one calling for conservation and protection against "attacks" by man against nature, the other perceiving man as a "restless animal in constant movement, freely channelling diversity" (Clément 2002). The most uncomfortable mismatches are often those which oppose partners whose centres of interest are, in fact, close. The conservation biologist and the landscape gardener have a common desire to sublimate nature, particularly plants. They also share a common heritage in the learned botanical societies of previous centuries. Some biologists see this heritage as part of the misspent youth of their discipline, which they try to correct or redeem by combating the proliferation of exotic plants. In contrast, for certain landscape gardeners this heritage laid the foundations of the "planetary garden" (Clément 1997), constantly broadening the range of plants available for them to create with.

But essentially material considerations have thrown up barriers between the stand taken by certain media gardening experts and local horticultural professionals. The range of plants available to the landscape gardener is seriously limited by the budget allocated by local authorities and the damage inflicted on plants by certain users of public green spaces, not to mention the depredations of the Mediterranean climate whose excellent public image conceals drought, both summer and winter, violent storms in both Spring and Autumn and savage winds, particularly the Mistral. But whilst difficult material conditions reduce the palette available to the landscape gardener, they do not necessary exclude exotic plants. For example, an entrepreneur in the Nîmes region responded that in the 1980s he planted pampas grass in a large number of public projects, particularly on roundabouts and roadsides because he found the species hardy.

Using an internet search engine for the term "pampas grass" reveals two worlds that seem totally unaware of the other's existence. On the one hand there are the naturalist sites warning of the evil consequences of biological invasion, particularly citing pampas grass and groundsel, while on the other are horticultural sites, both professional and amateur, stressing the attractive qualities and hardiness of the species. Bridges are, however, starting to be built between these apparently irreconcilable worlds. For example, some naturalists have opted for a strategy of involvement rather than one of stigmatisation and are trying to involve the horticulturists in their campaigns. This was the thinking behind the publication of the guide to invasive plants of the Mediterranean region (AME, Conservatoire Botanique Méditerranéen de Porquerolles and ARPE 2003). As a trade-off, some actors in the world of horticulture may find in these awareness campaigns material for sales pitches that are in line with the rapidly expanding phenomenon of responsible consumption (Hayden Reichard and White 2001). For example a horticulture firm in the Mèze region explicitly withdrew invasive species from their catalogue and announced the fact on the internet[1].

To be continued …

The fashions of the 1980s were certainly responsible for the proliferation of pampas grass in our Mediterranean regions. But the same social process of distinction-imitation that constitutes fashion now seems to be promoting Mediterranean plants. The acclimatisation of exotic plants was initiated by gentleman adventurers and scholars who endowed Mediterranean France with some spectacular exotic gardens. In their day these gardens had a major influence on fashion. What is happening today? A number of sociological surveys (OCS 1987, Chamboredon 1985, Picon 1978, Aspe 1999) have found that since the 1970s a new middle class has moved to the country and the outskirts of the cities in search of improved quality of life and a return to nature. A characteristic feature of these social groups is that rather than defining their identity in terms of their place in the system of production, they do so in terms of lifestyle. These emerging social groups have drawn on localities imbued with referents about identity and have made them their own. The interaction between the structuring of a social group, investment in an identity and concern for the environment may explain the present fad for

[1] "In our horticultural work we have been particularly careful to eliminate "invasive plants", i.e. exotic plants that thrive so healthily in our climate that they might one day threaten our local flora. This is why we have stopped growing certain common plants such as *Carpobrotus edulis*, *Baccharis halimifolia, Buddleja davidii* and *Cortaderia selloana* because they are invading specific milieus such as coastal dunes or wetlands. For each of these species, instead of giving a description our catalogue gives a selection of plants that can be used as substitutes. If you want more information on this subject you can contact the scientific bodies with which we carried out our research". (http://perso.wanadoo.fr/jardin-sec).

Mediterranean plants. Will the "proliferation" of this social group contribute to limiting the "proliferation" of invasive plants? To be continued…

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The salinisation of weeds in Australia – can invasive plants please stand up!

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Abstract

The development of public concern in Australia over salinity, and its eventual official acceptance as an important economic and environmental issue, has clear implications for those organisations trying to get invasive plants onto the national agenda for the first time. Both issues began from a base of poor public awareness, low levels of funding for research and public programs, and widespread political disinterest. By 2000 salinity had been accepted as an important national problem. The weeds issue in Australia, however, is 10-20 years behind salinity in its drive to achieve public and political recognition. This paper examines how salinity secured its place on the national agenda, and outlines some of the elements in a new campaign to gain equivalent recognition for weeds.

Background

Although weed research has been conducted in Australia for many years, with some notable successes in biocontrol, the investment has been very limited compared to other fields of natural resources management. The outstanding comparison in recent years in Australia has been with salinity, which costs the economy somewhere between \$200m and \$400m per year. The annual direct cost of weeds just to the agricultural economy in Australia, in terms of control costs and lost production, is about \$4 billion, that is, 10-20 times that of salinity. Furthermore, this figure does not take into account the impact of weeds on the natural environment, very large indeed in Australia, but difficult to cost.

Given the comparative differences in economic impact, it would be reasonable to expect that public investment in counter measures would be in the same proportions. However, the opposite has been the case. Support for weed control, in fact has been about 5-10% that of salinity. Weed extension services, managed mostly by state agricultural agencies in Australia, have been in decline for many years. Employment opportunities in the field have been shrinking, and weed research contracting. The Government of South Australia, for example, which is almost twice the size of France, employs the equivalent of just one weed researcher.

This striking discrepancy is due to several factors:

– Weed control has been caught up in the decline of publicly funded extension to the agricultural sector.

– There has been very little interest in invasive plant issues for many years on the part of decision makers in government, both senior policy makers and politicians. The typical view has been that weed control is a poor investment, a 'black hole' for public funds, and of little interest to the community. A survey of federal politicians in 2002, asking which of 20 issues they wanted to hear about on the national 'Science Meets Parliament' day held in Canberra that year, put 'weeds, pests and quarantine' last.

– This lack of official interest has been mirrored by very low levels of public understanding. There is little awareness of the extent and seriousness of the national situation, especially by urban dwellers (who make up over 80% of the Australian population). A public survey of 1200 city and town dwellers in 2003[1] confirmed this. Most town and city people did not even believe weeds were an environmental issue.

– Salinity was 'discovered' by the media and the general public as an issue of national concern from the mid to late 1980s. Over about 10-15 years salinity became firmly established on the national agenda of major environmental issues, and well recognised by the public and governments as important and requiring serious attention. Substantial public resources to combat salinity resulted, such as the $1.4 billion National Action Plan announced in 2000[2].

– Until very recently, weeds in Australia have been where salinity was in 1980 – politically invisible, attracting insignificant resources compared to the size of the problem, and generally an 'unsexy' issue that failed to attract media and public attention.

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[1] Collins, D. (2003), *National Benchmark Survey Report: Weeds Public Communication Campaign*, report by MARS Pty Ltd for the Weeds CRC, Sydney

[2] www.napswq.gov.au/about-nap.html

A communication strategy

The establishment of the Cooperative Research Centre for Australian Weed Management (Weeds CRC) in 2001, after a previous 6-year life as a more research-focused body, was marked by a new determination on the part of its managers to follow the example of salinity and steer weeds onto the national policy agenda. Labelled informally as a campaign to 'salinise weeds', the CRC set up a communication program as well as three scientific research programs and an education program. For details of these programs see www.weeds.crc. org.au.

The main elements of the Weed CRC's overall communication strategy are:

- Bench level – help researchers package and deliver their project results.
- Discipline or Program level – identify key issues and audiences, and prepare and deliver messages to these audiences in a range of different ways.
- Organisation level – help position the organisation as a useful and important player in the national dialogue on invasive species. The CRC is only one of many interested parties or 'stakeholders' across Australia.
- Public awareness – alert the general public to the issue of invasive plants and its many facets.
- Political recognition, translating to policy change and better government and industry support for research and action programs.

The first and second elements are routine for any scientific organisation with a good communications program. This involves a mix of skills and communication mechanisms, generating a variety of publication types for technical and non-technical audiences, workshops and exhibitions, a dynamic web site, and use of the mass media, to name just a few means of delivering information. Access to good writers and graphic skills is critical.

The third point concerns the recognition the organisation receives, its reputation and its credibility. Careful quality control of all products and messages is normally a good preservative!

The fourth and fifth points are closely tied, and are the main subject of this paper.

Public awareness and political recognition

The Weeds CRC recognised early that there was a clear lesson in the way salinity was elevated to ‘an issue of national importance’ in Australia. Despite years of researchers expressing their concerns to each other, it wasn’t until clear and simple messages on salinity were formulated, accompanied by strong images, that any real progress began to be made. In particular, the following initiatives were critical to getting salinity onto the national agenda:

– The scientific story was set out in simple terms and published in brochures and articles outside the research literature. The Salinity Audit[1] in particular was a key study and document.

– The Audit allowed economists to join the dialogue, especially government policy makers who needed to assess the impact of salinity and cost new programs.

– The media were given stories and images that met their needs – e.g. strong accounts of environmental harm, such as loss of animal and bird life, loss of valued landscape, loss of tourist amenity, and declining water quality. Other angles were loss of livelihood, cost, drama, tragedy, greed, neglect, poor management, and other well known favourite media angles. High quality images were integral to the message.

– An initial period of ‘shock-horror’ stories was followed by a more positive phase suggesting solutions, and good news stories of farmers and community groups tackling salinity successfully.

– A coalition of lobbyists with strong scientific credentials emerged to counter a ‘red neck’ push for massive engineering solutions that failed to understand the limits of the Australian natural environment. Named the Wentworth Group, it drafted and widely circulated a ‘plain English’ manifesto/vision[2], published in a simple and attractive format. The group was credible, outspoken and articulate, and attracted much media attention.

The rise of salinity awareness in Australia had some simple elements that we in the weeds business can learn from. The following figure is a simplified flow chart that shows six phases of activity. Although the chart is generally a fair representation of the process, in reality some aspects or sub-issues may progress

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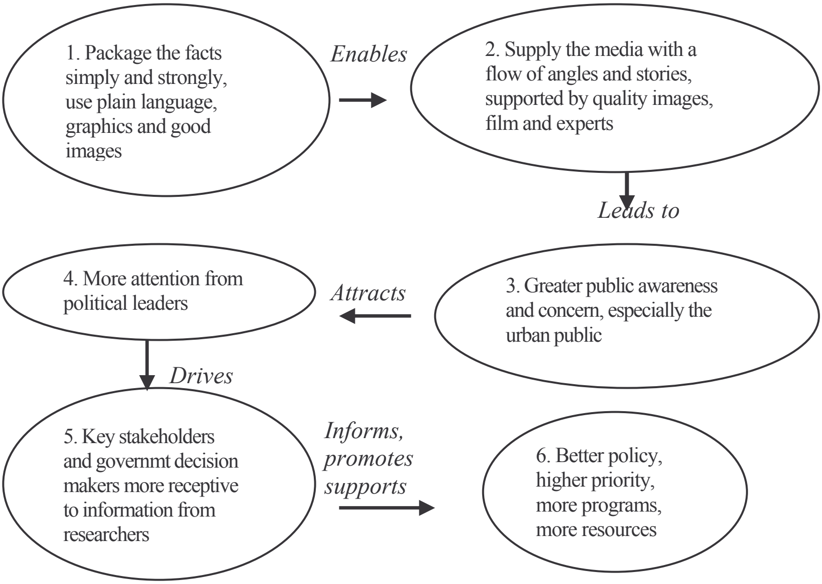
[1] MDBMC (1999), The Salinity Audit of the Murray-Darling Basin, MDBC, Canberra.

[2] Wentworth Group of Concerned Scientists (2002), *Blueprint for a Living Continent*, WWF Australia, Sydney.

much faster, or slower, depending on a variety of pre-existing conditions, such as awareness levels, vested interests, personal positions, and politics.

Chart 1. Stages in taking a strong science-based issue through the media to achieve higher public awareness and greater political recognition



In addition, there were other elements in the salinity story that tipped the balance:

– A big national story for the media

A 1000-km long bloom of blue-green cyanobacteria occurred along the Darling River in the summer of 1991-92[1]. This focused national attention on high water extraction for irrigation, low flow and poor catchment management. This spectacular event was featured on TV and the front pages of newspapers across Australia, and was a landmark in public awareness of water quality, especially in the cities.

1 MDBMC (1994), The Algal Management Strategy for the Murray-Darling Basin: a component of the natural resources management strategy. Murray-Darling Basin Ministerial Council, Canberra.

– Access to highest levels of government

  Access was gained directly to the Prime Minister through the Prime Minister's Science, Engineering and Innovation Council, especially for the chairman of the Wentworth Group

– An existing decision-making framework

  A national political coordinating mechanism for water and salinity existed in the Council of Australian Governments, supported by other state-federal structures and committees.

– Strong public support

  A strong community-based movement to care for land and water already existed – especially 'Landcare'[2], a national network of the converted with over 4500 groups, with whom the message resonated strongly. Other networks were also important. The salinity cause was greatly helped by being one of the issues adopted by the environmental movement that emerged as a force in the 1980s in Australia.

– Resources

  A strong economy and political support enabled new funding to flow.

Table 1. Comparing strategies for gaining policy change – salinity and weeds in Australia from 1980

Strategy elements	Salinity from 1980	Weeds from 2000
Survey public awareness and attitudes	✓	✓
Package the facts simply and graphically	✓	✓
Supply the media with many fresh stories and images for at least a year	✓	✓
A major natural phenomenon that seizes public and media attention	✓	✗
Achieve wide and strong public support, especially urban	✓	✗
A strategic coalition of high profile, articulate and credible professionals to lift the debate	✓	✗

[2] Youl *et a., Landcare in Australia*, www.landcareaustralia.com.au.

Strategy elements	Salinity from 1980	Weeds from 2000
Develop a package of science-based solutions	✓	✓
Secure support of major industry players	✓	✗
Gain access to highest levels of government, and 'sell' package at all levels	✓	✗
Participate in and support new programs	✓	✓

Highlights in the weed campaign in Australia so far

Some excellent groundwork has been done since 1997 with Weedbuster Week[1], a national week of attention on weed control activities involving the public and schools in particular, with support from research and government agencies.

The public awareness study done by the Weeds CRC in 2003[2] clarified some public attitudes to the language being used. The word 'weed' is a public relations failure, and most people think 'trivial or boring' when they hear it. If they have a garden it means 'nuisance', nothing serious. They cannot relate the word 'exotic' at all to weeds, since that means 'exciting and desirable'. Not even the word 'species' worked, since that either suggested animals or something scientific. However, we consistently found that the term 'invasive plant' was easily understood and conveyed the sense of a real problem. We now try to use the term wherever possible in public statements.

As mentioned earlier, the same survey revealed that the city and town dwelling public simply did not recognise invasive plants as an environmental issue. However, after being given some basic facts, people tended to react quite strongly, even demanding to know why more action wasn't being taken. Exactly the same result was obtained in 2005 by a federal government department in their own social research. Using focus groups, the 2003 survey identified the following topics as especially important to this wide community audience:

– loss of native plants and animals,
– loss of familiar and valued natural landscapes,
– economic cost,

[1] www.weedbusterweek.info.au/
[2] See footnote No. 1 page 226.

– health (especially respiratory ailments),
– use of chemicals in the environment.

These issues are, in effect, ‘buttons’ to push in the public psyche when we want their attention on invasive plants. We have made strong use of the first four, but have refrained from using the public concern about chemicals because we feel much of the public fear of chemicals is not based on fact or good science. However, that is not to say that chemicals are always used well.

Using this survey, the Weeds CRC designed an illustrated booklet[1] that outlined the national invasive plant problem, actually using these ‘buttons’ as chapter subjects. The document also proposed a series of long-term control and prevention measures costing $270m over ten years. This was a deliberate strategy by which the problem was graphically laid out, at the same time proposing some positive and costed solutions.

The community of scientific and public groups concerned with invasive plants in Australia has been fortunate in having a strong and able ally in the World Wildlife Fund for Nature. WWF has been an astute and effective lobbyist. For instance, it made good use of the fact that minor parties held the balance of power in the Australian Senate, and was able to persuade them to hold a Senate Inquiry into invasive species[2]. This created some ‘political space’ in which to present and re-present messages on invasive species to influential politicians and the media.

WWF also commissioned a series of research papers on invasive plants. The most influential of these was ‘*Front Door Wide Open to Weeds*’[3], a critique of a sloppy quarantine regime which allowed half the plants on earth to be imported into Australia with no risk assessment. With strong press interest and an embarrassed Minister, rapid policy changes followed which now promise to close the worst loopholes by 2006.

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[1] Martin, P. (2004), *‘Killing us softly – Australia’s green stalkers’*, CRC for Australian Weed Management, Adelaide. Also at www.weeds.crc.org.au/ publications/books.html

[2] Australian Senate (2004), Inquiry into the regulation, control and management of invasive species and the Environment Protection and Biodiversity Conservation Amendment (Invasive Species) Bill 2002, Canberra, available at www.aph.gov.au/Senate/committee/ ecita_ctte/invasive_species/tor.htm

[3] Spafford-Jacob, H., Randall, R. and Lloyd, S. (2004). *Front Door Wide Open to Weeds: an examination of the weed species permitted for import without risk assessment*. A Weeds CRC and University of Western Australia report prepared for WWF Australia. WWF Australia, Sydney.

We have been pleasantly surprised to secure more interest from the media than we had expected. The Weeds CRC has been issuing one press release a week since December, and has secured the services of an excellent journalist to keep up what he calls ‘a rolling thunder’ of dramatic stories.

The combination of media exposure and lobbying has led to invasive species starting to gain some acceptance by political parties as an issue. All parties gave weeds some recognition in the 2004 national election, for instance. In particular, the conservative coalition adopted a policy called ‘Defeating the Weed Menace’. This coalition was returned to power in late 2004, and $32m of new funds were then made available over four years for new weed projects, including research. This was an excellent outcome, which hopefully marks the start of a new period of political recognition for invasive plants.

Some difficult relationships

The relationship with the nursery and garden industry is both important and delicate. Important because most new invasives have been imported deliberately for the parks and gardens business – and delicate because of vested interests and a history of very little regulation. The ‘trade’ widely resents what it sees as ‘interference’ in their business, and a significant number of traders simply do not understand the link between their activities and the natural environment. The way forward should be through information sharing and cooperation, although tighter regulations on which plants can be traded may still need to follow.

At present the Weeds CRC and the major national nursery association are trying to work together, and a new project to better inform gardening media writers about the invasive plants issues is about to begin. Ultimately our goal is to have the public ask at the counter of their local nursery whether a plant might ‘jump the fence’ before they buy it – and to have the staff trained and ready to answer! This approach also engages and empowers the industry to train their staff and prepare their members for the shift in public opinion that we are working towards. Hopefully this process might encourage nurseries to cull their plant lines a little as well, and remove the species about which they get the most questions!

On the whole we have found the public quite responsive to suggestions about which plants are invasive, so we are hopeful that improved public awareness and attitude change is indeed possible in the long term.

Another challenging relationship for us as the messenger bearing unpleasant truths is one with the northern Australian cattle industry. In recent months we have had the ‘buffel kerfuffle’, when we dared to suggest that African buffel grass (*Cenchrus ciliaris)* was having an environmental impact. In northern Australia, buffel is one of a suite of African pasture grasses that invade high quality native woodlands. Their high biomass means that in the annual burn at the end of the dry season, they burn too hot for the native vegetation, killing the trees. They are, in effect, ecosystem transformers, and are forcing a transition from Australian eucalypt woodland to African grassland. The potential exists for this to happen over vast areas of northern Australia, and the process is now underway.

At the same time buffel has become an important pasture species for many cattle enterprises, although cattlemen disagree about its value.

The future

The concept of ‘invasive species’ gained some currency in policy corridors in Australia in 2004-05, partly due to the Senate Inquiry of that name, and it could be that major new weed programs may come under an ‘invasive species’ umbrella. This has not happened yet, however, and the term ‘weeds’ remains in the names of committees at all levels of government.

The media campaign to lift public awareness and influence key players and decision makers will continue at the current level for another 6-12 months. We also plan to step up our use of television where we can afford it. A second survey of public attitude and awareness will be held later this year, and a third is planned for 2007. Before long we will begin to publicly lay out solutions as we see them, although we will need to ensure the timing of that is right – in particular, after we have effectively conveyed the seriousness of the situation.

Finally, there is an urgent need to rationalise and simplify the vast amount of confusing information available via Australian web sites to commercial plant growers and sellers. The general public also need a clear, simple and consistent source of advice on what to plant and what not to plant. The huge range of climates within the country, and multiple jurisdictions able to regulate plant sales, makes the creation of such an information service a major challenge. The ideal solution is for all parties, research, government and commercial, to collaborate in its construction.

National Weedbuster Week: an Australian model for raising awareness about weeds

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Abstract

Weedbuster Week is a national weed awareness program in Australia that has been running since 1997 with the cooperation of all State and Territory Governments. Weedbuster Week aims to:

– raise public awareness and understanding about the problems that weeds cause;
– help the public make the connection between their gardening, farming or grazing habits and potential environmental degradation;
– provide the public with the information and skills required to play a responsible role in the sustainable use of land and water resources; and
– foster community ownership, acceptance and support for weed management projects.

The mascot for Weedbuster Week is Woody Weed, a lovable but noxious rascal who spreads himself around the countryside like any successful weed.

The Weedbuster Week campaign started as a Weed Awareness Week in Queensland, Australia, in 1994. In 1997, with encouragement from all state and territory governments and the Cooperative Research Centre (CRC) for Weed Management Systems, National Weedbuster Week was launched. Weedbuster Week is held in the second week of October and has also been adopted in New Zealand and South Africa.

Introduction

Weedbuster Week commenced in Queensland in 1994 when it was identified that there was a need to educate the community about weeds and their effects on primary industries and the environment. It took place in New South Wales and the Australian Capital Territory in 1996 and complemented their past Weed Awareness weeks and other similar events.

Weedbuster Week became a national program in 1997 with support from the Weeds CRC. A national coordinator was appointed with the support of the National Weeds Strategy Executive Committee through Natural Heritage Trust (NHT) funding for a period of three years. For more detail about the history of Weedbuster Week, see Vitelli *et al.* (1999). A National Weedbuster Week Committee was also established in 1998, it comprised of a member from each State and Territory and three Weeds CRC education officers. Currently there is not a national coordinator or a functioning national committee. However, funding has been approved and the appointment of a new national coordinator should take place in mid-2005.

National Weedbuster Week (NWW) has proven to be an effective tool to increase the profile of weeds and for community groups involved in aspects of weed management to entice others to join. A key part of this can be attributed to social marketing. One of the original proponents of NWW, Deborah Beck, explained the use of social marketing and NWW as a tool in a Queensland weed awareness project (Beck 1996). The concept revolves around organising fun activities whilst reducing the effects of weeds on the environment, primary industries and society. Products that are linked to the NWW theme are used to promote the theme of the week and the Weedbuster concept. These products are then available at other times for on-ground programs. Products are the typical materials used in advertising campaigns and include T-shirts, baseball caps, stickers, posters and drink bottles. Other products relate specifically to weed awareness, such as the WEEDeck® cards used for identification. Weedbuster is the 'brand' and has its own logo. If only Weedbuster was as recognisable as some of the many logos used by fast-food companies, car manufacturers and so on.

Fig. 1 - The Weedbuster logo

NWW also has a mascot, Woody Weed. Woody is a lovable but noxious rascal who spreads himself around the countryside (like any successful weed), 'scaring' children and harassing wildlife. Dressed in bright purple and green, he travels the length and breadth of the country raising awareness about weeds. He has even travelled to New Zealand, the USA and South Africa to spread the word! Woody is always available to meet his fans, whether they be school children or high-level politicians.

Fig. 2 - Woody Weed

Since 1997, many thousands of Australians have attended and/or participated in a NWW event (Nugent *et al.*,1999). Common activities have included:

– on-ground weeding and replanting activities,
– displays in shopping centres, Local Government Offices, libraries and stores
– seminars,
– field days and machinery days,
– media promotion,
– weed identification workshops, and
– competitions (especially for children e.g. design a weed poster).

The Weedbuster website (www.weedbusterweek.info.au) is a key part of activities. Event organisers can register their events through the website, then interested people can use the website to find a suitable event to attend. In 2004 there were 235 events registered on the national Weedbuster site. The Weedbuster website has fact sheets and other information that can be downloaded. In October 2004 the website had a record number of hits of 62 421.

Working with the media has been a major part of Weedbuster Week. In 2004, for example, the campaign resulted in 358 items appearing in the media. Circulation was 7 050 545 with an Advertising Value Equivalent (AVE) of $1 819 161. This compared to 194 media items (circulation to 3 220 261), in 2003. Five media releases were prepared and sent together with media alerts. [Source: Independent Media Monitors Report Commissioned]

One advantage of having a national coordinator and a coordinating committee is being able to plan ahead for media with a long lead up time. Many glossy magazines, for example, have a deadline of three months or more.

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Potential threat of *Solanum elaeagnifolium* Cav. to the Tunisian fields

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Abstract

Silverleaf nightshade (*Solanum elaeagnifolium* Cav. # SOEL), native in the American continent, is now considered a weed in several temperate areas of the world. Recently, the European and Mediterranean Plant Protection Organisation (EPPO) categorised it as a weed requiring international measures to contain its spread. It is a summer growing perennial herb, reproducing by seed and from creeping perennial roots. It usually grows in places disturbed by people or livestock, especially those with irrigation. However, its deep root system enables it to endure considerable drought. According to Pottier-Alapetite (1981), the genera Solanum is represented in Tunisia with seven species and SOEL was not present in the country before 1960. It was first detected around 1985 in the governorate of Kairouan, as it started to become troublesome in Sbikha. In the absence of a serious effort to prevent its establishment, due to the lack of scientific information about its identification and adverse impacts, the species became a real threat for irrigated areas in arid and semi-arid regions. It is well established in Sbikha and became a successful invader. Several species traits, coupled with man activities (cultivation, irrigation, trade, etc.), largely facilitated its establishment and spread. The lack of regional and national action plans is enhancing SOEL invasion. Actually, we are working with regional and national authorities and the Food and Agriculture Organisation (FAO-Tunisia) to prepare a national plan to manage SOEL invasion, to minimise adverse impacts of established alien plant species and to prevent further plant invasions.

Introduction

The Tunisian vascular flora counts more than 2100 species, grouped in 115 family and 742 genera (Nabli, M.A., 1989). The topography of the country makes endemic plants unusual (16 species and 18 sub-species). Origins of the flora of the central and southern parts of the country are Mediterranean (76%), Saharo-Arabic (16%) and west Asiatic (8%). The Mediterranean flora decreases from the Center (85%) to the South (18%), where the dominant vegetation becomes Saharo-Arabic. Thus, the Tunisian flora in the semi-arid and arid regions is mostly Mediterranean. According to Pottier-Alapetite (1981), the genera *Solanum* is represented in Tunisia by only seven species (*S. dulcamara* L., *S. laciniatum* Ait., *S. lycopersicum* L., *S. melongena* L., *S. nigrum* L., *S. sodomaeum* L. and *S. tuberosum*). Although, its volume untitles "Flore de la Tunisie, Angiospermes-Dicotylédones-Gamopétales" was published in 1981, the investigation was done from 1947 to 1959. Therefore, we can presume that Silverleaf nightshade (*Solanum elaeagnifolium* Cav. # SOEL) was not present in Tunisia before 1960.

SOEL was first detected in the governorate of Kairouan, around 1985, as it started to become troublesome in Sbikha (Chalgaf[1], personnal communication). In general, we recognise that an invasion has occurred only after the expression of its impact, a long period of time after its introduction (Mack *et al.*, 2000). Therefore, we can assume that SOEL was first introduced in Sbikha since several decades. Its proliferation during the last decade could simply represent the end of a prolonged lag phase in its new range. Without an effective surveillance of invasive alien plant species, early detection is inconsistent and sleeper species remain in a quiescent phase for long periods before they begin to proliferate (Mack *et al.*, 2000). SOEL introduction in Tunisia was most likely accidental through international trade and tourism.

With no serious effort to prevent its establishment, since scientific information about its identification and adverse impacts was lacking, what had once been small isolated populations are clearly becoming more abundant, and the individual populations are growing. In 2003, the regional agency for agriculture development in Kairouan (C.R.D.A.-Kairouan) invited us to include this species in our research program. As a first step, we pointed out four objectives:

1. review the scientific literature regarding this species to confirm its identification as an alien species;
2. monitor its distribution and dynamic;
3. attempt to explain its invasion process; and
4. formulate local, regional and national proposals to face this problem.

[1] Ezzeddine Chalgaf, Chef Arrondissement de la Production Végétale au C.R.D.A, Kairouan

SOEL profile

SOEL is a summer growing perennial herb, well adapted to semi-arid regions with 300 to 550 mm of annual rainfall (Boyd et al., 1984). Its deep root system enables it to endure considerable drought and out survive shallow-rooted vegetation (Benalla and Frankston, 1998.). But, it usually grows in places with summer moisture or irrigation (Boyd *et al.*, 1984). Seedlings produce an extensive root system within few months and shoots start to emerge from established plants as the soil warms in late March. Stems are generally erect, 30 to 90 cm high and densely covered with fine hairs and slender orange prickles. Its leaves are alternate, lance-shaped with wavy margins and covered with typical star-shaped hairs. Aerial shoots are connected with an extensive root system through branched vertical and horizontal parts (Tanji *et al*., 1984). SOEL may begin to flower in early May and its flowers are usually purple to violet. The fruits are smooth globular berry, changing in color as they mature, from green stripes to motley yellow and orange to brownish.

Within its native range, southwestern U.S.A, northern Mexico or possibly Argentina (Boyd *et al*., 1984), it is a problem in disturbed areas such as road-sides, construction sites, livestock feeding and watering areas, and cultivated fields. In the United States, it is listed as a noxious weed in 21 states (Roche 1991). It is found on virtually all soil types, except for deep sands and those subject to flooded conditions. But, it typically occurs on coarse-textured, sandy soils and appears to prefer loamy and droughty soils (Boyd *et al*., 1984).

This weed is recognised as an invasive alien plant species in many countries, such as Australia, India, Greece, Israel, Sicily, South Africa, Zimbabwe, Egypt, Morocco, Algeria, Tunisia, Spain, Taiwan, etc. Australian landowners must eradicate or control SOEL where it is regionally prohibited and they must take all reasonable steps to control it and prevent its spread on their land and approximate roadsides where it is regionally controlled (Benalla and Frankston, 1998). Recently, it was categorised as a weed for which internatio-nal measures are needed (EPPO, 2004).

SOEL distribution in Tunisia

The Kairouan plain is located in the central part of Tunisia. Few rivers such as oued Nabhana, Merguellil and Zeroud cross it. The region is characterised by a hot and arid climate with eight dry months and 36°C as mean annual maximum temperature. Eleven districts form the Kairouan governorate (Sbikha, Chebika, northern and southern Kairouan, Hajeb el ayoun, Chrarda, etc.). Irrigation is intense in Sbikha and Chebika, about 30 000 ha, and the irrigated area represents 16%, 62 000 ha, of the cultivated area in the governorate (Chalgaf[1], personnel communication).

SOEL is a noxious weed in Sbikha, where it is frequent and abundant in irrigated fields, along roadsides and riversides. It is sub-noxious in Chebika, since it is frequent but slight abundant. Several satellite populations were observed in Northern and Southern Kairouan, Cherarda and Hajeb el ayoun. The species was detected in the bordering governorates of Sousse, Mahdia, Sidi-Bouzid, Sfax and Zaghouan. Even though it can grow in a wide range of environmental conditions, it is well adapted to semi-arid regions (Sbikha) and usually grows in places disturbed by people (roadsides and irrigated fields).

SOEL invasion process

Although the history of biotic invasions is very ancient, the phenomenon has grown rapidly in recent times as a result of globalisation (Mack *et al*., 2000). Almost all introductions today are in some way facilitated by human activities. Stages necessary for successful introduction and subsequent invasion include

1. introduction into a new habitat,
2. initial colonisation and successful establishment, and
3. subsequent dispersal and secondary spread into new habitats.

When introduced in small numbers, immigrant plants are not likely to survive, because of stochastic forces in the new environment (Mack *et al*., 2000). To become established or persistent, they must withstand challenges to their survival. Some factors could increase the probability that some members of a new population will survive; these factors include cultivation and repetitive introductions that reinforce the size of the population and its genetic diversity (Kolar and Lodge, 2001).

SOEL population survey indicates that it is well established in Sbikha since several years. In irrigated fields and along roadsides, it forms dense and persistent batches. Several events coupled with species characters could explain its establishment. The practice of irrigation in the region since many decades, lack of scientific information about the species identification and adverse environmental and economic impacts, limited use of herbicides in the region and common use of cultivation as a weeding method during the hot season, grazing of infested fields, ease of introduction and movement, absence of an action plan against invasive plant species, and poor coordination between government agencies and cultivators may represent key events favoring SOEL establishment. Several SOEL traits could explain its establishment in Sbikha: climatic match between its native habitat (semi-arid) and the new habitat, multiple reproductive strategies, high seed production, seed dormancy, benefits of genetic diversity, long flowering and fruiting periods, short juvenile period, deep and dense root system, fire-resisting attributes and absence of natural enemies.

Having reached a threshold size, this established population is much less subject to stochastic forces. SOEL became a successful invader since it was able to increase in abundance and to spread from its point of entry. Short-distance migration induced a lateral expansion of the source population from Sbikha toward the southern delegations (Northern and southern Kairouan, Chebika, etc.). This expansion was facilitated with man activities since the species is detected in irrigated fields and along roadsides. Long-distance dispersion generated new satellite colonies such as those detected in the governorates of Sousse, Zaghouan, Sidi-Bouzid, Mahdia and Sfax. In Chott-Meriem (Sousse), a colony was detected at the garden of a landowner in Sbikha. These findings underline the role of man as a dispersing agent. Such satellite populations should expand rapidly until they coalesce with the parent population.

SOEL is going to be naturalised in its new environment since it successfully establishes new self-perpetuating populations and is dispersed widely through-out the Kairouan plain. Further, it was established that the flora migration between the Tunisian natural regions is common (Table 1) and source-sink dynamics allow invader populations to establish in sub-optimal conditions through frequent or continued immigrant dispersal from source populations (Pulliam, 1998). That's why SOEL represents a potential danger to the Tunisian agriculture.

Natural Regions	Recorded species	Exclusive species
Nord-East	981	28
Mejerda Valley	412	4
Cap Bon	929	26
Central part of Tunisia	980	24

Table 1. Tunisian flora richness and movement between natural regions (Nabli, M.A., 1989)

Semi-arid vulnerability to invasion by exotic plant species was explained by the presence of open niches for some or most of the year (Baker, 1986). The weed shift from being simply persistent to becoming invasive can be explained by the expansion of irrigated areas in arid and semi-arid regions. A rapid anthropogenic climate change might encourage alien species and decline native plant species or could leave open niches, susceptible to invasion by species that can thrive in the new conditions (Dukes and Moony, 1999). Under some circumstances, a short-term increase in water availability can facilitate the long-term establishment of alien plant species in arid and semi-arid regions (Burgess *et al*., 1991).

The importance of disturbance in promoting the spread of invaders is well recognised. In many areas of the world, alien plant species thrive along roadsides. Thus, roadside weeds should be some of the earliest species to shift their ranges as climates change (Dukes and Moony, 1999). Milchunas and Lauenroth (1995) established that water and nitrogen supply to steppe communities over five years increased alien species establishment. Cultivation can be a potent force in promoting the persistence of non-indigenous populations, thereby eventually allowing them to become established and even invasive (Mack *et al*., 2000).

SOEL management

Usually, Tunisian cultivators and managers consider weeds as less harmful than other crop enemies, a valuable forage source for sheep and easy to manage with hand weeding and tillage practices. SOEL is simply not controlled along roadsides, in vacant places and in slight infested areas. Hoeing, tillage and glyphosate are control methods used in irrigated fields against established stands. The shortage of scientific information and the absence of a regional action plan render these methods inappropriate and contribute to enhance SOEL propagation.

Conclusion

SOEL is recognised as an invasive plant species in many countries of the world. It is a potential threat for Tunisian irrigated fields in arid and semi-arid regions. In fact, it is becoming a noxious weed in Sbikha and is invading new territories. Its coordinated control should be implemented with the contribution of governmental agencies, cultivators, land managers, and the public. If no action is taken to contain the species from spreading, it will eventually become naturalised-occupying the land close to its carrying capacity and replacing local species. The regional action plan should prevent weed dispersal from source population (prevent seed production and dispersion, prevent vegetative propagation, prohibit grazing in infested fields, etc.). The national action plan should involve a regular monitoring of SOEL population in arid and semi-arid regions, early detection and rapid action to prevent satellite population establishment, and prevention of repeated introductions through legislation and control. Further, the national action plan should address an inventory of invading plant species and encourage efficient cooperation at national and international level to prevent or minimise adverse impacts of invasive plant species.

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Management of invasive plants
/
Gestion des plantes envahissantes

The European Strategy on Invasive Alien Species: what to do for preventing new invasions and mitigating impacts caused by biologic invasions?

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Abstract

Biological invasions are now acknowledged as a major threat to biological diversity at a global scale, and the number of new incursions is increasing at an alarming rate. Many international instruments and technical guidelines dealing with this threat have, in recent years, stressed that prevention of new invasions and mitigation of impacts caused by introduced species is a priority for protecting not only the environment, but also our economy and well being. Unfortunately, our ability to respond to biological invasions is still very limited, partly for technical reasons – as the inability to promptly detect new incursions or to eradicate unwanted species once prevention has failed – but also for the inadequacy of our legal and political frameworks, that often do not allow the application of effective prevention measures. It is therefore urgent to develop more stringent policies, at the national and supranational scale, aimed at improving our prevention measures, at increasing our ability to detect new alien species, at promptly eradicate newly arrived alien species and at implementing more effective containment measures. International cooperation is a particularly important and complex aspect of invasions prevention - for example for regulating the trade of species based on a black, grey and white lists systems – and in this regard it is critical to develop regional and international coordinated policies.

In order to respond to these challenges, European states have approved a pan-European Strategy on Invasive Alien Species, which is the first example of a regional implementation of the guiding principles on invasive alien species approved under the Convention on Biological Diversity. Aim of the European strategy is the prevention of new invasions as a priority, the rapid eradication of newly established alien species when prevention fails, and an effective mitigation of the impacts caused by those species that cannot be eradicated. To reach these objectives, an holistic approach is needed, and it is also critical

to gather the support of all the societal sectors involved, including the academic world, the stakeholders, and the political level both at the national and European level. Scientists are called to collect and circulate information on alien species, and more in general to improve our understanding of the epidemiology of invasions; this also to allow the incorporation of a science-based "risk analysis" into national and regional authorisation procedures of imports. Decision makers are called to revise national legal frameworks in order to bridge the gaps and inadequacies limiting response mechanisms. Last but not least, we need to raise the awareness of the general public and the academic world, and the commitment of decision makers on the threats posed by invasive alien species, that are crucial for gathering the support needed for implementing a coordinated policy on the issue.

What limits the ability to respond to biological invasions in Europe?

Biological invasions are a major threat to biological diversity at a global scale, and the number of new incursions is increasing at an alarming rate in all taxonomic groups (i.e. Genovesi 2001, Pascal *et al* 2003, Weidema 2000), causing a growing threat to biological diversity, economy and human well being (Mack *et al*. 2001). To address this threat, it is now internationally acknowledged that prevention is the best alternative; more specifically, the technical work carried on in the framework of the convention of biological diversity (Wittenberg and Cock 2001) has shown that the best response to biological invasion is a hierarchical approach, based on

– prevention of new introductions as the priority;
– early detection and eradication, when prevention fails;
– eradication of established invasive alien species when feasible;
– when eradication is not feasible, control if appropriate (Guiding Principles on IAS – Decision VI/23 on Alien Species that threaten ecosystems, habitats and species; CBD COPVI, The Hague, April 2002).

At the European level, the ability to apply the hierarchical approach to plant invasions has been very scarce so far. A leading role in the prevention of unwanted plant introductions has been played by the European Plant Protection Organisation (EPPO), that has developed a quarantine list of species whose introduction into Europe is strictly regulated. However, the mechanism for adding a new species into the list is rather complicate and only in limited part science based: it requires

– a formal proposal of a Member Government based on a plant risk analysis,
– a recommendation by the EPPO Working Party on Phytosanitary Regulations to the EPPO Council supporting the addition;
– a formal support to the proposal by at least 3 Member Governments. Only after this process, the Working Party can take a decision on the proposal, decision that is normally taken by consensus.

The result of this complicate system, is that at present only seven species are included in the quarantine list, and only nine more are in the alarm list of the EPPO (G. Shrader, this book). Furthermore, it must be stressed the regulation of species movements required by these lists by governments is voluntary, and there is no mechanism for imposing to states the adoption of any measure.

Also the ability by European institutions to respond to new plant incursions has proven to be rather scarce. For example, differently to other parts of the world, no eradication of any alien plant species has ever been completed in Europe so far (Genovesi 2005). While in the 1972-2000 period the California Department of Food and Agriculture has attempted eradications of 18 species and 53 infestations, completing a large proportion of these attempts (Steve Schoenig, this book).

The scarce ability of Europe to respond to biological invasion, is only in part due to technical problems. If, in fact, the free market system of Europe indeed amplifies the difficulties to regulate the movements of plants, on the other hand Europe is a rich region with a very solid scientific and technical background, and the technical reasons cannot explain why we are much behind other regions of the world – i.e. South Africa, New Zealand or Australia - in the implementation of more stringent policies to address the problems caused by biological invasions.

An example showing some of the factors limiting the ability to address biological invasions is the case of the *Caulerpa taxifolia*. The establishment of this alien alga was accidentally detected in 1984, at a very early stage of the invasion, when it occupied 1 m^2 only; in 1989 it had invaded about 1 ha, in 1989 3 ha, and in 1991 the alga expanded to about 31 ha. In the mean while, from 1991 to 1997, instead to eradicating the plant, there was a long debate within the French and the international academic world on the origin of the alga, its impact, and the potential long-term effects (Meinesz, 1999). Only in 1995 the Bern convention adopted a recommendation (n. 45) on controlling proliferation of *Caulerpa taxifolia* that urged governments to control proliferation of the alien alga and eradicate its colonies wherever possible. Unfortunately, when this recommendation was adopted, it was far too late for containing the species, that had already expanded to a large portion of the Mediterranean basin. The case of the *Caulerpa taxifolia* shows that even when a new incursion is detected promptly and the eradication is technically easily practicable, the limited awareness on the problem (not only by the general public, but also by the academic world and among the decision makers), and the inadequacy of the regional and national legal frameworks often do not allow the application of the needed prevention and early response measures.

But apart from limited awareness and inadequate legal framework, other key elements concur to limit the European policy on invasive alien species, including the need of transboundary cooperation, the general reluctance by European countries to regulate trade, and also the inadequate capacity to respond to new incursions (awareness, legal, lines of authority)

It is indeed urgent to develop more stringent policies, at the national and supranational scale, aimed at improving the European regulation policies of alien plant movement, and at increasing the ability to promptly eradicate newly arrived alien plants. Regional co-operation is a particularly important and complex aspect of invasions prevention – in particular for regulating the trade of species based on a black, grey and white lists systems - and in this regard it should be explored the possibility to increase the role of the EPPO for developing an science based system of lists.

Considering the general scarcity of resources for environmental policies, it is critical to make best use of the existing tools – as in the case of the EPPO –, to involve key stakeholders, and to give priority to the use of codes of conducts and best practice, instead of imposing new regulations.

The European Strategy on Invasive Alien Species

In order to provide a coordinated approach to the challenges posed by biological invasions in our continent, European states have approved a pan-European Strategy on Invasive Alien Species (Genovesi and Shine, 2004), representing the first regional implementation of the guiding principles on invasive alien species approved under the Convention on Biological Diversity. The European Strategy has been approved by Bern convention members in December 2003 (42 European States and the European commission), has been welcomed by the Convention on Biological Diversity and by the Council of the European Union in December 2003. At last 3rd World Conservation Conference, the plenary of IUCN members approved a recommendation calling the countries of Europe to develop and implement national strategies or action plans based on the European Strategy on Invasive Alien Species, and urge the European Union to support the implementation of the Strategy.

The role of the European Union and of the commission is critical for the implementation of a pan-European policy, whose enforcement indeed requires an inter-sectoral approach and the involvement of all societal stakeholders. In fact, the legislative process under the EU imposes a consultation process that can enhance the involvement of all sectors of the society in the development of a policy on alien species, and has impact on many different sectors including market regulation, environment, agriculture, regional policy, research and development, policing and law and order, international trade, transport, public health, education and culture.

Conclusions and recommendations

Aim of a pan-European strategy for mitigating the impacts posed by biological invasions to the biological diversity of Europe, its economy and the well-being of all Europeans, shall be the prevention of new invasions as a priority, the rapid eradication of newly established alien species when prevention fails, and an effective mitigation of the impacts caused by those species that cannot be eradicated.

To reach these objectives, an holistic approach is needed, and it is also critical to gather the support of all the societal sectors involved, including the academic world, the stakeholders, and the political level both at the national and European level. Scientists are called to collect and circulate information on alien species, and more in general to improve our understanding of the epidemiology of invasions; this also to allow the incorporation of a science-based “risk analysis” into national and regional authorisation procedures of imports. Decision makers are called to revise national legal frameworks in order to bridge the gaps and inadequacies limiting response mechanisms. Last but not least, we need to raise the awareness of the general public and the academic world, and the commitment of decision makers on the threats posed by invasive alien species, that are crucial for gathering the support needed for implementing a coordinated policy on the issue.

The European Strategy on Invasive Alien Species indicates the main elements of a European policy on the issue, and its principles have found a general agreement by all European states and several international institutions. It must be stressed that although the free trade system of Europe limits the ability to respond to invasions, inaction by many states is also due to limited awareness and inadequacy of legal and policy tools.

In this regard, the supranational legislative system of Europe – with centralised responsibility on trade, agriculture, fishery, forestry etc. – provides an unique opportunity for developing an effective regional action on invasive alien species. Europe urgently needs to revise its regulatory systems, and to develop technical tools such as inventories of alien species, lists of experts and contact specialists, reports on cases of successful prevention

To meet this aim, European states and institutions are called to be more active on prevention and mitigation of this threat, supporting the implementation of the European Strategy on Invasive Alien Species. In the implementation of the Strategy, European States and Institutions shall consider revision of existing regulations and development of new ones. And in their actions, States and Institutions shall promote participation of all societal sectors directly or indirectly involved in the movement and management of alien species

Europe needs to move from a reactive approach to invasions, to a proactive policy, based on prevention and prompt reaction to incursions. This will require an extraordinary effort by the European states, institutions and academics. But this is a key challenge for this millennium, if we intend to preserve not only the biological diversity, but also the economy and well being of our region.

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Evaluating the costs and benefits of Yellow Starthistle Control in California under uncertainty

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Abstract

Yellow starthistle (YST) has been a problem in California for well over 75 years and is considered to be the most significant exotic weed species in the state. It is also a serious problem in the Western states of Oregon, Washington and Idaho. It directly threatens rangeland and natural ecosystems by displacing forage, and indirectly threatens them through its higher use of water. A biological control program is currently underway to identify and import natural enemies that will provide a permanent control to YST.

Given the challenge of the biological control program three options are available to manage YST:
1. stop the biological control program and allow YST to continue to spread unchecked;
2. expand the biological control program;
3. expand the biological control program and spot treat YST in critical areas.

Even with an expanded biological control program, the biological control of YST is uncertain. However, the exact probability, of success for the program is uncertain. Instead, qualitative assessments of the probability of success (i.e. high, medium, low) are used.

This study compares the cost of each program with the expected benefits due to rangeland improvement and increased water availability in watersheds. It will also show how to incorporate qualitative assessments into cost/benefit analysis using Probability Threshold Analysis. Data for the rangeland values are from land appraisers, watershed data are from hydrological models, and the California Department of Food and Agriculture supplied the data on the cost of the biological control program.

Introduction

This study compares the benefits and costs of controlling yellow starthistle in California. Yellow starthistle has been a problem in California for more than 70 years (Jetter *et al* 2003). It is one of the most significant weed species in the state and is slowly spreading into other Western states. Based on surveys completed in 2000, over 12 million acres are infested in California and an additional 28 million acres are susceptible to infestation (Jetter et al 2003). The density of yellow starthistle varies directly with the amount of rainfall during California's rainy season. In years of heavy rainfall, yellow starthistle will grow abundantly and crowd out annual grasses and other native plants.

Land that is most susceptible to yellow starthistle infestations is previously disturbed or degraded land that receives full sun. California's degraded rangelands and roadsides are especially susceptible to yellow starthistle invasions. Yellow starthistle may interfere with grazing, and lower yield and forage quality of rangelands, increasing the cost of managing livestock and lowering land values. Native species may be displaced by yellow starthistle in some areas and it may indirectly affect ecosystems due to its high water demands as compared to native plants and annual grasses. Yellow starthistle is a deep rooted plant that depletes the soil moisture more rapidly that annual grasses (Enloe *et al* 2004). Plot-scale estimates of water lost to evapotranspiration range from 0.22 acre feet per acre (af/acre) (660 m^3/ha) to 0.39 af/acre (1200 m^3/ha) (Gerlach 2004).

Currently a biological control program is underway to find and release agents into California. The program to date has had limited success. Given the uncertainty of success, and the potential for the program to take a long time before a successful control agent is identified, it may be worthwhile to spot treat localised infestations with a chemical herbicide if the benefits are greater than the costs. This analysis examines the benefits and costs of continuing the biological control program for another 10 years and funded at a level determined to result in a high probability of success. It also examines the benefits and costs of spot treatment for yellow starthistle control.

Methods and materials

Invasive species control should be undertaken by public agencies when the expected benefits to society are greater than the costs. An expected benefit adjusts the estimated benefits by multiplying it by the probability of success. The expected value of a biological control program ($\mathrm{EV_b}$) is: $\mathrm{EV_b} = P_s * B - C$ where P_s is the probability of success, B is the estimated benefit level if the program is successful, $P_s * B$ are the expected benefits, and C is the cost of the biological control program. Because probabilities are between zero and one an expected value is lower than an estimated value (*B* - *C*).

When calculating expected values, economists usually use an exact probability or a probability distribution. However, risk assessments of invasive species and biological control agents are often qualitative. For example, scientists may only be able to determine if a biological control program has a high or low probability of success within a given time frame. When a probability is unknown, a threshold probability analysis can be completed by setting the expected benefits of the biological control program, $P_s * B$, equal to the costs, C, and solving for P_s so that $P_s = C / B$ where P_s is now the threshold probability value. Once calculated, P_s can be compared to the qualitative assessment. If scientists familiar with control programs estimate that the probability of success for a particular program is greater than the threshold value, the control program should be undertaken.

Benefits and costs of the biological control program

Values need to be estimated for the cost of control and the benefits to controlling yellow starthistle. Scientists with the California Department of Food and Agriculture Biological Control Division have designed a biocontrol program estimated to have a high probability of success. The program is for foreign exploration, testing, release, and monitoring. The program would run for 10 years at a cost of $1.2 million a year.

The future costs of the biological control program need to be discounted to reflect the fact that a dollar 10 years from now does not have the same value (i.e. purchasing power) as a dollar today. The discount factor is $1/(1+r)^t$ where r is the discount rate and t is the year into the project. In this analysis a social discount rate of 3.5% is used (Moore 2004).

The benefits of the biological control program need to take into account the removal of yellow starthistle from infested land, and also the benefit of preventing its spread into new areas in the future. Therefore, all 40 million acres of land either infested or susceptible to infestation are part of the analysis.

Total benefits are calculated as the area of land, either infested or susceptible to infestation, times the average benefit per unit area. The average benefit per unit area is calculated as the difference in land values with and without yellow starthistle with no restoration of land. The advantage of using a land valuation approach is that it captures the present value of all benefits including changes in rangeland productivity, and difficult to measure benefits such as improved land access, and enhanced aesthetics from controlling invasive species (Plantinga and Miller 2001). Data on land values with and without yellow starthistle were obtained from interviews with agricultural land appraisers and with wilderness land managers who purchase land for environmental presser-vation and restoration. In all cases, the interviews revealed that the presence or absence of yellow starthistle may have some effect, but is not a significant factor in determining land values over and above the degraded status of the infested land. Land in California is generally so degraded that the next best alternative to yellow starthistle infested land is usually land infested with another invasive species.

The estimate of the lower-bound average benefit level per acre is US$2 (0.66 € per ha) and is due to lost interest on idle land (Jetter et al 2003). The estimate of the upper-bound average benefit level per acre is based on the change in land values as yellow starthistle spreads and infests relatively higher quality rangeland. The change in land values is estimated to be approximately US$50 an acre (17 € per ha). Given current rangeland values of about US$300 – 400 an acre (100 – 133 € per ha), land values decrease by about 13% to 16%.

Because the future costs on uninfested land accrue slowly over time as yellow starthistle spreads, the annual costs need to be calculated on the estimated surface likely to be newly infested each year with yellow starthistle and then discounted into current dollars. The spread function that best fits the discrete survey data on yellow starthistle infestations in California is $A_t = 100/(1+e^{3.72-0.05t})$ where A_t is the percentage of susceptible land estimated to be infested with yellow starthistle in year t.

It may also take time for the biological control agent to completely spread throughout the area infested with yellow starthistle. Some agents spread very quickly while others spread at a much slower rate. For simplicity in this analysis we assume that if the biological control program is successful, the biological control agent is introduced and has completely invaded all areas infested with yellow starthistle by the end of the 10 year program.

The total discounted benefits are calculated as:

$$B_I * 14000000 + \sum_{t=1}^{10} \frac{B_I * \left(A_t - A_{t-1}\right) * 40000000}{(1+r)^t} + \sum_{t=11} \frac{B_S * \left(A_t - A_{t-1}\right) * 40000000}{(1+r)^t}$$

where B_I is the per acre benefit for infested land (B_I = US$2 per acre (0.66 € per ha)), B_S is the per acre benefit for land susceptible to infestation (B_S = US$2 per acre (0.66 € per ha) for the lower bound benefit level and US$50 per acre (17 € per ha) for the upper bound benefit level), $(A_t$-$A_{t-1})$*40,000,000 is the estimated number of acres newly infested in year t and $1/(1+r)^t$ is the discount factor.

The first term calculates the benefits to land already infested with yellow starthistle at the start of the 10 year biological control program (the 12 million acres (4.9 M ha) estimated in the year 2000 plus an addition 2 million acres (810 K ha) infested from 2000 through 2004), the second term calculates the benefits to acreage infested while the biological control program is being completed, and the final term calculates the benefits from avoiding new infestations on susceptible acreage. A social discount rate of 3.5% is also used to discount the benefits.

Benefits and costs of spot treatment

Even if the yellow starthistle biological control program is a success, it will take time before the control agent in able to successfully invade and reduce weed populations. In the meantime, spot control of yellow starthistle in sensitive areas might be beneficial if the annual benefits of control using the chemical herbicide Transline are greater than the annual costs. Annual costs are compared to annual benefits because the decision to spot treat yellow starthistle needs to occur each year given the large seed bank that the weed produces.

The main benefit to spot treatment is from differences in water runoff between yellow starthistle and shallow rooted grasses or native plants. This difference is the water salvaged when yellow starthistle is controlled. The benefits of spot treatments are calculated as the acre feet (1 acre foot == 3000 m^3 per ha) of water salvaged by controlling yellow starthistle in an entire watershed times the benefit value per acre foot of water. To calculate the amount of water salvage that would take place if yellow starthistle was controlled, a hydrological model (SIMETAW) of water runoff that was developed by the

California Department of Water Resources was estimated when yellow starthistle was the dominant ground cover and when shallow rooted plants were the dominant ground cover. The model was applied to the Cottonwood Creek watershed in Tehama County, California and the Eastern Merced watershed in Merced County, California (Null 2005). The Tehama County watershed is 6,140 acres (2,485 ha) and located in a relatively high rainfall area. The Merced County watershed is 24,772 acres (10,025 ha) and is located in an area that receives lower rainfall. Because it is known with certainty that Transline controls yellow starthistle, actual benefits to water salvage are used.

Based on preliminary results, the model estimates the amount of water runoff over a 30 year simulation that is drawn from a distribution of rainfall in California. In about 30% of the years, rainfall is insufficient to cause any runoff whether yellow starthistle is present or an alternative vegetation is present on the land. For an average rainfall year, in order to get one extra acre foot (3000 m^3 per ha) of water, 1.29 acres (0.52 ha) of yellow starthistle infested land needs to be treated in Tehama County and 15.88 acres (6.43 ha) need to be treated in Merced County.

The value of water was determined from water market sales. Due to the relative scarcity of water in Merced County, the value of water salvaged is greater than in Tehama County. The value of an acre foot of water (3000 m^3 per ha) in Tehama County is US$100 (82 €) and in Merced County it is US$200 (164 €) .

The costs to treat yellow starthistle infestations include the costs of materials and application rates using a helicopter that sprays 5 to 10 gallons per acre (7.7-15.4 litres per ha). Total application costs are US$20 per acre (6.6 € per ha) (John Metkeski personal communication April 2005).

Results and discussion

At the lower-bound benefit level the threshold probability value is equal to 21% (Table 1). If the yellow starthistle biological control program is assessed to have a probability of success greater than 21%, then the program should be undertaken. The desired biological control program is assessed to have a "high" probability of success. However, what is meant by a "high" probability of success has not yet been defined precisely. A high probability may mean something close to 100%, or anything over 50%. It may mean an even smaller number because biological control programs may not always be completely successful and getting three successful biological control programs out of 10 may be the standard. At the lower-bound benefit level, more information on the value of benefits, or the probability of success, may be needed before a decision on whether to fund the program is made.

Costs	**Benefits**	**Threshold probability value**
*(US$ millions)**		*(%)*
10	48	21
10	401	2

* multiply by 0.82 for €

Table 1. Cost/benefit analysis of a yellow starthistle biological control program.

At the upper-bound benefit level, the threshold probability drops to only 2% (Table 2). While the definition of a “high” probability of success is unclear, it is reasonable to assume that that it is over 2%, and the yellow starthistle biological control should be undertaken.

In Tehama County only 1.29 acres (0.52 ha) of yellow starthistle infested land needs to be treated in order to obtain one acre foot (3000 m^3 per ha) of water in an average rainfall year (Table 2). At a value of US$100 (82 €) per acre foot, the total benefits of controlling yellow starthistle is US$476,000 (390 K €). With total control costs estimated to be US$92,000 (75 K €), the net benefits are US$353,000 (290 K €) a year for a year with average rainfall. Spot treatment of yellow starthistle would be justified in average rainfall years in areas in Northern California that receive greater amounts of rain.

In Merced County however, due to the larger amount of acreage that needs to be treated in order to obtain one additional acre foot (3000 m^3 per ha) of water, the total benefits of US$312,000 (256 K €) in Merced County is lower that the Tehama County total benefits of US$476,000 (390 K €), even though the value of water in Merced Country is twice the value of water in Tehama County. At a total cost of US$372,000 (305 K €) to treat almost 25 thousand acres (10 K ha), the total costs in Merced County are higher than in Tehama County, and the net benefits are negative. Spot treatment of yellow starthistle should not take place in lower rainfall areas such as Merced County.

County	Size of water-shed	Acres (ha) eradicated to obtain 1 acft of water	Water recovered	Value per acre feet (3000 m^3 ha^{-1})	Total benefits	Total costs	Net benefits
	acres(ha)		*acft(m^3 ha^{-1})*	*US$(€)*	*US$000(000€)*		
Tehama	6,140 (2,485)	1.29 (0.52	4,760 (14 M)	100 (82)	476 (390)	92 (75)	353 (290)
Merced	24,772 (10,025)	15.88 (6.43)	1,560 (4.7 M)	200 (164)	312 (256)	372 (305)	-183 (-150)

Table 2. Benefits and costs of spot treating yellow starthistle

In years of low rainfall neither county has sufficient water runoff to justify treatment. In years of high rainfall the market value of water falls, and again it may not be worthwhile to treat infestations even though yellow starthistle populations are denser.

Conclusion

Biological control programs of invasive plants are initiated to protect natural resources, the environment, agricultural production and urban landscapes. Many invasive species that enter and become established impose large costs on these different groups. However, biological control programs are expensive and it is not always certain whether the program will be successful. Because the assessment of the yellow starthistle biological control program is qualitative, a threshold probability analysis was completed of the costs and benefits. The results show that at the higher-bound benefit level the break-even probability value is very low, so that the program evaluated should be undertaken. At the lower-bound benefit level a more precise definition of what a “high” probability of finding a successful biological control agent needs to be made before a decision on whether to undertake the program can be made.

Because the biological control program may not be successful, or if successful it may take a long time before control is achieved, the benefits and costs of spot treatments were also examined. The results indicate that, in average rainfall years, the value of the water salvaged in Tehama County, where rainfall is relatively large, is greater than the costs. In dryer counties such as Merced County it does not appear that treating infestations will result in enough additional water to justify the costs.

This study shows the benefits of applying rigorous economic analyses to weed management scenarios, particularly for high cost activities like biological control, in Mediterranean type environments where water runoff is a key environmental service degraded by exotic weeds. The results of such analyses are a critical tool for convincing governments to initiate and support weed management activities based on key measurable and achievable public benefits.

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Integration of State weed programs and community-based weed councils in California

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Abstract

California is occupied by over 1200 species of naturalised non-native plants. Of these, at least 200 have been identified as invasive and/or noxious. Over the past 100 years the state has had a very successful weed eradication program. Over 17 weed species have been permanently eradicated and 14 others are near eradication status. This program has traditionally been carried out by the state and many county agriculture departments. With serious budget reductions over the past 20 years this program has diminished, inspite of growing introductions of invasive plant species. California has also undergone a demographic shift from agricultural economy to urban environmentalist majority.

California has responded by forming a set of 52 Weed Management Areas (WMAs) which cover the entire state and serve as local weed control councils which pull together all interested partners both public and private. These WMAs greatly enhance the previously existing state program. They focus on:

- local weed prioritisation,
- strategic planning based on GIS weed location maps,
- education and outreach programs,
- demonstrations plots for integrated weed management methodologies,
- regionally-based grant writing and
- co-operative control projects. Some groups rely heavily on non-technical volunteers known affectionately as "weed warriors".

This program has attracted $5 million dollars from our state legislature and the US Congress recently authorised $100 million for WMAs across the nation. This talk will emphasise what factors have led to the most effective WMAs in California.

Introduction

California is occupied by over 1200 species of naturalised non-native plants. Of these, at least 200+ have been identified as invasive and/or noxious. Over the past 100 years the state has had a very successful weed eradication program. Over 14 weed species have been permanently eradicated and many others are near eradication status. The statewide program has traditionally been carried out by the state and county agriculture departments. With serious budget reductions over the past 20 years this program has diminished in spite of growing introductions of invasive plant species. California has also undergone a demographic shift from agricultural economy to urban environmentalist majority and this makes maintaining budgets in agricultural departments increasingly difficult.

Statewide weed eradication program

As the lead agency in California for the detection and eradication of noxious weeds, the California Department of Food and Agricultures (CDFA) administers the A-rated Noxious Weed Eradication Program, but does so in cooperation with the local county agricultural commissioners and other federal, state, county, city, Native American tribes, and private individuals and entities. A-rated noxious weeds are designated of highest statewide importance by the CDFA. A-rated noxious weeds are noxious weeds that are determined to be of limited distribution and subject to state-enforced quarantine and eradication when found and identified anywhere in the state. In addition, Q-rated weeds are treated as temporary A-rated weeds until an investigation as to their invasive character is completed. B-rated noxious weeds are subject to state-enforced quarantine and eradication from plant nurseries, aquarium and pet stores, etc. Both B-rated and C-rated noxious weeds are subject to local quarantine and eradication at the discretion of the local county agricultural commissioner.

The CDFA Noxious Weed Program has primary responsibility for eradication of those A-rated weeds that are still eradicable at either the statewide level or at the regional level. In the 1970s the CDFA early detection program involved as many as 12 professional staff equivalents; however, increasing budget problems at both the state and county levels have reduced staff size by more than half.

Currently, there are 24 A-rated weeds under statewide eradication, local eradication or containment within California. These are:

1. Biddy biddy – *Acaena spp.*
2. Punagrass – *Achnatherum brachychaetum*
3. Camelthorn – *Alhagi pseudalhagi*
4. Alligatorweed – *Alternanthera philoxeroides*
5. Fertile capeweed – *Arctotheca calendula*
6. Plumeless thistle – *Carduus acanthoides*
7. Musk thistle – *Carduus nutans*
8. Diffuse knapweed – *Centaurea diffusa*
9. Iberian starthistle – *Centaurea iberica*
10. Spotted knapweed – *Centaurea maculosa*
11. Squarrose knapweed – *Centaurea squarrosa*
12. Skeletonweed – *Chondrilla juncea*
13. Yellowspine thistle – *Cirsium ochrocentrum*
14. Wavyleaf thistle – *Cirsium undulatum*
15. Bearded creeper – *Crupina vulgaris*
16. Golden thistle – *Scolymus hispanicus*
17. Leafy spurge – *Euphorbia esula*
18. Halogeton – *Halogeton glomeratus*
19. Dalmatian toadflax – *Linaria genistifolia* spp. *dalmatica*
20. Scotch thistle – *Onopordum acanthium*
21. Illyrian thistle – *Onopordum illyricum*
22. Taurian thistle – *Onopordum tauricum*
23. Harmel – *Peganum harmala*
24. Wormleaf salsola – *Salsola vermiculata*

To date, the A-rated Noxious Weed Eradication Program has eradicated 14 weeds from the state, although eradications have usually only been successful for weed species that were found to be highly localised as eradication success declines rapidly with increasing area of weed infestation (Rejmanek & Pitcairn 2002) . These 14 weeds are:

1. Whitestem distaff thistle – *Carthamnus leucocaulos*
2. Dudaim melon – *Cucumis melo var. dudaim*
3. Giant dodder – *Cuscuta reflexa*
4. Serrate spurge – *Euphorbia serrata*
5. Russian salttree – *Halimodendron halodendron*

6. Blueweed – *Helianthus ciliaris*
7. Tanglehead – *Heteropogon contortus*
8. Creeping mesquite – *Prosopis strombulifera*
9. Meadowsage – *Salvia virgata*
10. Heartleaf nightshade – *Solanum cardiophyllum*
11. Austrian peaweed – *Sphaerophysa salsula*
12. Wild marigold – *Tagetes minuta*
13. Syrian beancaper – *Zygophyllum fabago*
14. Perennial sowthistle – *Sonchus arvensis*

Weed management areas and other co-operators

California has responded to the need for more local weed control infrastructure by forming a set of 52 Weed Management Areas (WMAs), which cover the entire state and serve as local weed control councils that organise many diverse interested partners both public and private. These WMAs greatly enhance the previously existing state program. They focus on:

- local weed prioritisation,
- strategic planning based on GIS weed location maps,
- education and outreach programs,
- demonstrations plots for Integrated Weed Management methodologies,
- regionally-based grant writing, cooperative control projects.

The groups rely heavily on non-technical volunteers known affectionately as "weed warriors". This program has attracted $5 million dollars from our state legislature and the US Congress recently authorised US$100 million (80 M €) for WMAs across the nation. This paper will emphasise what factors have led to the most effective groups in California.

The California Department of Food and Agriculture's (CDFA) Weed Management Area Program was formalised with the passage of California Assembly Bill 1168, Frusetta (Chapter 961, Statutes of 1999) and later extended by California Senate Bill 1740, Leslie (Chapter 315 Statutes of 2000). Both of these bills authorised the Noxious Weed Management Fund within the California Department of Food and Agriculture (CDFA).

The state WMA cost-share funding supplements existing local budgets in weed management collaborations and helps jumpstart weed management pilot projects. The local weed management area determines its priority weed targets based on local concerns and statewide priority lists. The weed management area also decides on priorities for individual projects, which treatment methodologies to use, and whether the weeds should be managed, contained or eradicated. Weed management areas are not a set of individual county programs, but rather are a linked network of highly effective groups, which are working in cooperation to solve a rapidly spreading statewide problem, that does not recognise borders or fences. This is an action-oriented program, focusing on on-the-ground control. Although mapping, planning and education are critical to the long-term success of the weed management areas, these activities are secondary with respect to attacking high-priority weed infestations now.

These two pieces of legislation have provided an initial impetus and have given new hope to landowners and public land-holding agencies that have been losing economic and biological resources to the spread of noxious weeds. The bills have provided a total of US$5.4 million (4.4 M €) over a period of five years to local public and private partnerships to form local weed management areas and aggressively control high priority weed infestations. Weed management areas create a mechanism for landowners, land managers (private, city, county, state and federal), special districts, and the public to combine their actions to control noxious weed problems they hold in common. These are partnerships for a better environment.

The following statistics highlight progress since 2000:

- Over US$ 5,355,000 (4.4 M €) were distributed to 36 Weed Management Areas (WMAs) since 2000, resulting in over 95,515 acres (38,654 ha) of high priority weed infestations treated under this program.
- Most sites had close to 98 percent control. Additionally, at over 468 sites, 100 percent of targeted weeds were prevented from seeding (leading to permanent eradication) for over five years.

- This state seed money has been matched locally by a total of US$ 15,582,314 (12.8 M €) of "in-kind" resources (donated equipment or services) and matching cash dollars. Of these resources, $ 6,874,819 (5.6 M €) is direct matching cash from county government and outside grants.
- The number of countywide WMAs in California has grown from seven in early 1998 to 54 by 2004. The groups cover all counties in California.

- Over 1,587 individuals attended regular WMA meetings throughout California in 2004. New local partnerships have been created among public agencies, private landowners, agriculturalists and conservationists.
- An estimated 206,688 landowners and citizens have participated in noxious and invasive weed education events statewide since 2000.

The program was designed to achieve permanent and lasting results. Projects are carried out with clear objectives and are monitored to measure their success. The CDFA implements an intensive program to train WMA participants and coordinate and evaluate WMAs throughout the state. The CDFA Statewide Weed Management Area Coordinator works with CDFA district personnel to provide training in control methodology, monitoring, strategic planning, mapping, and weed education.

Agencies and groups that participate in weed management areas	
County Agricultural Commissioners	California Department of Transportation
University of California Cooperative Extension	California Department of Fish and Game
Resource Conservation Districts	Audubon Society
Natural Resource Conservation Service	Master Gardeners
County Farm Bureau	The Bureau of Land Management
Forestry industry	Public Works
California Native Plant Society	California Invasive Plant Council
California Department of Food and Agriculture	Utilities
California Department of Forestry	Bureau of Reclamation
Pest Control Representatives	**Schools**
California Department of Parks and Recreation	Ranchers
Cattlemen's Association	Farmers
Regional Water Quality Control Boards	United States Army Corps of Engineers
United States Fish and Wildlife Service	United States Forest Service
National Park Service	Cities

Agencies and groups that participate in weed management areas	
Departments of Water and Power Sierra Club	Several other non-profit organisations

Outreach and education program components

A successful weed control program requires widespread awareness of the problem among landowners and citizens. On-the-ground control efforts must work in conjunction with vigorous education and awareness campaigns. The CDFA enhances these awareness campaigns by helping weed management area groups distribute outreach materials across the state. A Web site at www.cdfa.ca.gov/weedhome to catalog existing outreach materials was established to avoid duplicated efforts.

Selected outreach materials include:

Flyers and brochures

Over 25 weed management areas have created a noxious weed brochure that highlights the main priority weeds for their county.

Control methodology handbooks

The Contra Costa/Alameda WMA created a 30-page yellow starthistle control handbook for private landowners.

Expo displays

Professional and eye-catching expo displays produced by over 10 weed management areas present information about weed identification, the harmful impact of weeds, and mitigation efforts.

Public weed workshops

Public workshops, which can be technical in nature for treatment methodology, can also focus on the impacts of noxious weeds.

Weed awareness week

Many weed management areas invite their communities to participate in personal guided tours to give people a first-hand look at weed impacts.

Print media campaigns

Hundreds of newspaper and magazine articles featuring local weeds and weed management areas have been published across the state.

Public library resources center

Collections of weed resource materials, including books and videos, and a weed section have been established in local libraries for the benefit of the community.

Mapping and inventory

The strategic approach to regional noxious weed management requires accurate information on where target weeds grow. For this reason, the CDFA provides weed management areas with guidance and training in weed survey and mapping. Computer-based mapping is crucial for strategic planning, project monitoring and outreach.

The CDFA staff has conducted weed mapping seminars as well as one-on-one trainings across the state on Global Positioning System (GPS) and Geographical Information System (GIS). Many of the weed management areas have acquired GPS receivers to precisely locate weed infestations in rural areas and transfer the data to GIS computers.

The CDFA has also taken the lead in the formation of the California Weed Mapping Steering Committee, which has members from the California Department of Fish and Game, University of California, California Department of Pesticide Regulation, United States Department of Agriculture, seven county agriculture departments and many weed management areas. The Committee develops mapping standards, offers training, and identifies data gaps and resources.

The CDFA, along with the California Department of Transportation, county agricultural commissioners offices, and local weed management areas, have also formed a cooperative yellow starthistle mapping and assessment project on the western slope of the Sierra Nevada mountains. This project has resulted in the mapping of yellow starthistle at a high level of resolution and an eastern boundary of starthistle spread, called the “no spread line,” has been established. Immediately west of this boundary, a containment zone has been determined and key outlier populations have been identified. The eradication and control of yellow starthistle in these areas is a high priority among relevant weed management areas.

Other co-operators

Other state and federal agencies have become more involved in the early detection and eradication of A-rated weeds. At the statewide level CDFA programs also work with the California Invasive Species Council (900 members) and the California Native Plant Society (9000 members).

Conclusion

At the same time as weed introductions into California have increased we have been faced with cut-backs in governmental programs to combat weeds. The loss of scientifically trained biologists at the statewide level has also taken away dedicated experts that have regional expertise. It seems feasible, however that most early-detection and rapid-response functions can be met at the local level. The CDFA, with the help of state government support, has responded by forming local weed control councils called Weed Management Areas. This local transfer of duties and activities in invasive weed management has been very encouraging when there is cost-share financial support to catalyze local investment. This allocation of such responsibility and actions to stakeholders at the local level provides a model that could be used effectively in other Mediterranean areas, as resources for tackling such major problems for the public good will always be limiting.

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Invasive alien plants and coastal landscape quality

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Abstract

The University of Calabria got in touch with a group of European researchers and experts interested in tackling the problem of invasive alien species using an integrated approach.

In fact, in looking at the spontaneous expansion of invasive exotic plants in many coastal areas of the Mediterranean, the implications for costal landscape dynamics are likely to become subject of discussion.

We are in line with the statement that "Invasive alien species are now considered to be the second cause of global biodiversity loss after habitat destruction", as it is stated in the Introduction to European IAS Strategy, and with his objectives and aims. But the question is: are there cases and situations in which the phenomenon can be seen as an adaptive environmental response to agricultural land uses abandon, biodiversity impoverishment and loss, soil degradation, environmental anthropic pressure?

Moreover, we believe that talking about biodiversity protection and conservation is totally inappropriate for those parts of the European Mediterranean coast environment with an already impoverished wildlife condition. Therefore, in those cases, the risk is to conserve and protect bio-poverty and bio-uniformity.

On the contrary, it is fundamental to think about "ecopoietic" actions (a newly coined term meaning actions able to trigger new natural and/or ecological processes where environmental conditions are too impoverished and degraded for spontaneous improvements) in order to jointly treat human and natural ecosystems. In other words, actions to improve landscape quality. We think that the IAS' threat (with focus on Ailanthus, owing to his extra-competitive behaviour and possible economic uses of his biomass) is a specific and percei-

> vable problem which might be used to explore this difficult and complex argument.
>
> The contribution will explain the contents of a research proposal on the matter, that needs to be carried on at European level.

Introduction

First of all, I think it is necessary to specify that my background is different from the majority of participants to this international workshop. In fact I am an architect, and I have always been dealing with urban and regional planning problems. The topic of “invasive alien plants” (IAP) rushed in my interest while I was studying the environmental dynamics of a specific landscape (the Tyhrrenien coast of Calabria and Lucania Regions). Secondly I believe that, in order to set in the right perspective the issues I will discuss in this presentation it is necessary to clarify that in dealing with Landscape -a polysemic word, used in many contests and meanings- I refer to the meaning stated by the European Landscape Convention (ELC).

Finally, I also think it is necessary to give you an interpretative framework of landscape’s quality, that will be useful in representing and analysing the IAP impact at the landscape scale.

Preamble: the “quality landscape triangle” approach

The definition of the Landscape, given by the ELC, is:

> Article 1-a:
>
> “Landscape” means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors.

In my opinion, it would be better to say “the interaction of natural **and** human factors, without the *and/or* choice, because this would have enforced the concept, and stated clearly that landscape is produced by two drivers’ categories - i.e. Nature and Human actions.

This would have also enhanced the role of Nature, whose relevance is also underestimated in the following definition in Art. 1 - c.:

> "Landscape quality objective" means, for a specific landscape, the formulation by the competent public authorities of the aspirations of the public with regard to the landscape features of their surroundings."

In Art. 1 – c. the ELC definition of landscape quality stresses the political aspect of the formulation of the public's aspirations, with regard to their own habitat. Therefore, it takes into consideration **just** human factors, leaving aside the other fundamental aspect of landscape: "Nature" (that is to say the biotic and abiotic factors beyond human control).

On the other hand, for what concerns Natural drivers, I believe that the widely discussed biodiversity should be used as a useful tool to characterise and assess landscape, rather than an objective *per se*.

As a matter of fact, the more natural **and** human factors are in harmony, the higher is landscape's quality (we tend to use simplifications that are useful for our purposes when dealing with such complex topics!). We have a "quality" result whenever, on one side, the settled community is able to benefit from natural factors and, on the other side, natural factors are not degraded, even if modified, by human action.

In this view, sustainability is a variable whose functions are development (where human factors are involved) and resilience (where natural factors are involved). Thus, landscape quality objectives refer to the improvement of the interaction between man and nature.

My general and ultimate disciplinary objective is to increase landscape quality, taking into account the real situations, strength and weakness factors both human and natural, potentiality and evolutionary processes, etc., avoiding slogans and subjective assessments as far as possible[1].
The landscape concept proposed by ELC is really innovative in the Preamble phrase

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[1] *"Landscape planning" means strong forward-looking action to enhance, restore or create landscapes,* is said in the European Landscape Convention. I am not entirely in line with that statement, because it seems to me impossible the planning of something that is dependent on processes outside human control (the "natural factors"). The deliberate contradictory title of a recent SIEP-IALE Conference, "Planning the uncertainty", shows how the discussion is open, on the matter. By the way, this debate goes beyond the matter of this discussion.

> landscape is an important part of the quality of life for people everywhere: in urban areas and in the countryside, in degraded areas as well as in areas of high quality, in areas recognised as being of outstanding beauty as well as everyday areas.

Thus, the still frequent view of landscape as an aesthetic matter is superseded, and the ecological dimension is stated. To be coherent with the above said concepts, I propose the representation of landscape quality through a triangle, assuming that the base represents the Geographical-physical dimension and the two other side represent respectively the Human and Natural factors.

In Fig. 1., the shaded triangle represents landscape *quality* and it lies within the "ecosystem resilience" circle. The circle's – and triangle's – centre states that the view is an anthropocentric one, as it necessarily is.

The maximum possible area covered by a triangle within the circle corresponds to an equilateral triangle. Therefore in this case, for a given landscape dimension (A), Human and Natural factors have the same weight and do not prevail one against the other, and the landscape quality is the maximum possibly achievable. Therefore, this case represents sustainable landscape conditions.

If Human factors pressure increases and the Natural factors side is compressed (Fig. 1.a) the equilibrium between the two forces is broken and the triangle area becomes smaller. In the same way, if Natural factors pressure exceeds the Human ones (Fig.1.b), the balance changes in favour of the Natural component, but the quality area still decreases. The landscape quality degrades in both cases, being the result of interaction of human and natural factors.

Although not in its maximum potential, in figure 1.a and 1.b the landscape quality variation still lies within the resilience circle. Both human and spontaneous natural factors are in the continuous and always dynamic interrelation (adaptive dynamics) and can still bring landscape quality up to its maximum potential.

Fig. 2.a and 2.b show the exceeding resilience occurrence. The landscape system is not able to absorb disturbances or positive pressures (this has not necessarily a negative meaning). Functions and structure of the ecosystems will change, as well as landscape identity. A new landscape needs to be developed, i.e. a new equilibrium between different agent factors has to be

found in order to maximise landscape quality (a new equilateral triangle within a newly defined resilience circle).

If each factors' arrow is assumed to be composed by different drivers, the exceeding resilience may be reached in a sudden, catastrophic way, or by the continuous sum of single or multiple drivers.

Many people told me that the situation of fig. 1.b is always better off than that of 1.a. (the red circle means that the matter is subject of discussion). I don't believe so, if you consider that the triangle's area is not the landscape itself, in which a higher degree of naturalness is always a positive feature, but it is quality, i.e. an abstract judgment on the result of the interaction etc. etc.

The Invasive Alien Species is a good topic to test this aspect of the model. The IAS problem can be seen as a part, a driver, belonging to the brown-Human arrow in the case of deliberately or unintentionally introduced species, and belonging to the green-Natural one when their proliferation is spontaneous, after they are established or naturalized. The ability to establish themselves, invade, out-compete natives and take over the new environments, could match with fig. 1.b or 2.b, depending on the dimension, duration and impacts of the occurrence. The landscape's quality is reduced, if we agree to consider IAS "to be the second cause of global biodiversity loss" as The European Strategy on Invasive Alien Species states.

From reflecting on landscape quality .... to Ailanthus altissima – As I've already said, the issue of IA Plants became part of my interests while I was studying the characteristic features of the coastal Tyrrhenian areas of Calabria and Basilicata, in the light of the above-described approach.

The landscape is characterised by the Apennine chain, which runs parallel, more or less close to the sea, with few flat areas and some stretches, where the rocky coast is very high above the sea. The strong steepness and morphologic features of the coastal chain – scored by short mountain streams almost perpendicular to the coastline – implies the presence of very different ecosystems within a limited area.

The bio climate of the lower altitudes can be referred to as humid meso-Mediterranean, while in higher altitudes there is a mountainous humid temperate bio climate type, with abundant winter rainfalls, which are intercepted by the coastal chain causing rainfalls and fog even through the summer. This determines the growth of deciduous vegetation (very beautiful beech woods and chestnut, *Quercus virgiliana* or *cerri*s, …) even at altitudes generally typical of sclerophyll forests.

In brief: it is a very ”green” coast with the presence of both zonal and extra-zonal biomes, with a potential vegetation rich in plant associations, ranging from halophyte and psammophyte populations in sandy and rocky coastlines, to shrubby formations of the lentisk, myrtle, heath and strawberry tree maquis, and from holm-oak, manna-ash and hornbeam forests, to thermophilic and cold beech woods… (There is high potential for vegetation, but the same is not true for the actual vegetation nowadays).

Still in the Seventies of the last century, the area had the fundamental features of a beautiful, rural landscape: the sea unpolluted, thanks to the total absence of industries and a very low demographic density, a favourable climate, a good morphology and aspect of the coast, orientated to the South-West, long beaches with the high mountains behind, the green valleys sloping upwards through the mountains, the hilly fields grown with olives, figs and vegetable production descending to the deep blue sea, extended sandy beaches, and picturesque villages up to the hills spotting the scenery.

The “modernisation” process of the coastal area had been triggered by tourism along with the general evolution of the local communities’ lifestyle and the buildings expansion in all even grounds had been impressive, although there were some differences among the various municipalities, which however did not change the general trend. The population moved from the mountainous interior and from historical centres to the coast; farming and forestry activities were basically abandoned in favour of economic activities directly and indirectly associated with tourism; the coastline had been transformed into a long, linear, low density settlement built along the new coast road, designed to be a long distance connection and gradually became a urban-type road.

Undoubtedly, the changes occurred in the coastal landscape led to a general improvement of the life conditions of its inhabitants, but the above mentioned improvement modalities implied very strong pressure on the environment, so that today landscape quality can be referred to triangle 1-b, in which the human factors push at the expense of the natural, or even to triangle 2-b, where ecosystem resilience has been compromised, and environment's transformations are irreversible.

We could call what happened in coastal Thyrrenian landscape "the great reshuffling"[1].

In short, the two arising key problems are:

– the ecological shatter, something worse than fragmentation, due to the urban settlement sprawl, to the abandon of agro-forestry land uses, to fires, to the construction of buildings everywhere, to roads and paths for accessibility to the new houses, etc.;
– the loss of identity due to the trivialisation of the settlement, which no more match the sites' morphology, and due the disappearance of the previous urban hierarchy and characterisation, flattened by the uniformity of land uses tourism-dominated, the abandon of the most of the typical local agricultural and handicraft activities, etc.

Disorder, or mess, is maybe the words that better describes the present situation in the coastal landscape. Such a disorder can be observed at a very small scale (for instance, disused beach facilities along the shoreline, sand excavation equipment abandoned along some stream stretches, general carelessness along the roadway edges, heaps of rubbish in the riverbed); or at a large scale (muddled land uses, lack of urban structure and hierarchy as well as buildings' use destinations functionally mismatching the surroundings…).

However, regardless of whatever judgement we give on landscape quality, it should be said that the dynamics of the Tyrrhenian coast are actually consistent with the definition of Landscape quality objective proposed by the ELC (see above). In fact, the competent public authorities, which have allowed the mentioned dynamics, rightly interpreted the aspirations of the people living in that area.

Of course, some people complained and still complain against the uncontrolled construction of buildings along the coastline. Needless to remind that we are dealing with complex issues; that the territory is a "hypo integrated" system, where the different stakeholders, including Nature, are carriers of different

[1] J.A. McNeely, "The great reshuffling: how alien species help feed the global economy", from www.iucn.org/biodiversity/ ....

interests, often contrasting; and that, anyway, there is a multitude of viewpoints, drivers, situations acting within the landscape dynamics. However, as far as landscape is concerned, (i.e. the result of the action and interaction of natural and human factors), what has to be pointed out is that people perception is such as to permit the result of a general mess.

The element of change that seemed and seems to me more insidious and less legitimated by local communities development's needs, is related to vegetation. It is insidious, because it is never talked about by anyone, while criticism and objections are always addressed to buildings sprawl – although such objections don't give rise to positive results. All debates and proposals on the "conservation" of local identity, and the efforts to enhance environment and historical heritage, are focussed on monuments and historical centres, forgetting that vegetation is a basic component of the landscape feature.

The most striking phenomenon was and is the increasing bareness of the landscape in winter, due to seasonal leaf fall. Very, very green in spring, green in summer/autumn tending to yellow-dry in the sites without tall trees, nearly bold in winter. I realised that an important factor of landscape trivialisation was a gradual transformation of spontaneous as well as cultivated and ornamental vegetation, with a progressive replacement of the evergreen sclerophyllous plants with the deciduous one. And the most diffused species was the *Ailanthus altissima*, which is competitive and winning also against the *Robinia pseudoacacia.*

I have a very limited expertise in dealing with the characterisation of local vegetation. Yet, it fell upon me to emphasise to what extent many areas of potential Mediterranean maquis were gradually covered by the invasive *Ailanthus* forests and groves and to point out its contribution to the hazardous or even dangerous "enrichment" of the seasonal green. The phenomenon was underestimated in the scientific spheres, unknown in the public opinion and institutional spheres, the species was only known by some rare person as "false walnut".

Contradictions and doubts: what to do?

After the Rio Convention and Kyoto treaty, the climate change, biodiversity and environmental items dominated the media and the public opinion, the scientific experts were locally working at the designation of the Nature 2000 sites[1], two new National Parks had been created close to the Tyrrhenian coastal area (Pollino and Cilento), everyone was talking about Nature conservation and protection, and about sustainable development as the key task for the future. The aim of everyone was the tourist exploitation of the said "high quality natural resources" of the coast, or the "uncontaminated Nature of sea and mountains" of Calabria and Basilicata.

The divergence of environment's improving objectives from the real landscape dynamics' was and still is strongly evident. Difficulties in implementing the international Conventions and protocols, due to the mismatching between international obligations of a country and his internal structure, are well known[2]. But another deceptive matter pervades the biodiversity strategies when passing from the global to the local scale: protection and conservation are non-consistent objectives where landscape quality is already sub-optimal, i.e. where the disorder hinders the spontaneous ecological enrichment. In those situations, the risk is to conserve and protect "bio-poverty" and "bio-uniformity". Therefore, in those cases, it is not to protect and conserve which is necessary, but rather to change and transform, yielding new biodiversity and landscape quality through strategies and actions that may be defined with the plain neologism "ecopoietics"[3], able to bring back to equilibrium Natural and Human factors.

Striving to find a way to reduce the above said divergence, the invasive *Ailanthus* diffusion matter seemed to be a good opportunity to refocus the attention on the ecological aspects of the coastal environment.
In the meanwhile, the European Strategy on IAS enhanced the relevance and placed credit to IAS phenomenon.

To tackle the matter, a group of researchers from the Università della Calabria and other European research bodies, are setting together on this underlying

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[1] Along the 64 km (by air) of Calabrian coastal landscape, n° 27 Nature 2000 sites had been designated, (SIC, Siti di importanza comunitaria), 4 of them laying down the coastline; n° 4 had been designated along the 15 km of Lucanian coastal landscape.

[2] See the debate of the recent Bioplatform electronic conference "Landscape scale biodiversity assessment: the problem of scaling", March 2005, *Section III, Political and economical scale in relation to biodiversity*.

[3] "ecopoietic" results by joining the two Greek words *oiko*-home and *poiesis*-creation. It synthetically explains the idea of actions able to trigger new natural or anyway ecological processes where environmental conditions are too impoverished and degraded for spontaneous improvements

hypothesis: the spontaneous expansion of many invasive alien species is nowadays proportional to coast landscape environmental degradation, and is inversely proportional to the general level of care and maintenance provided to the territory by the settled community. The diffusion and, in some cases, the outbreak of IA plants is therefore considered as an indicator of environmental distress and vulnerability[1].

The objectives of the group are not only the "struggle against the *Ailanthus*", but also to assess the possible integrated actions for the recovery, restoration or rehabilitation of the coastal land uses, vegetation protection and improvement. At the same time to find the possible economic use of Ailanthus biomass as incentive for the endorsement of reclamation and eradication techniques and control strategies, and to study and develop the relative production and transformation technologies.

The adoption of the "Ecosystem approach" proposed by the biannual CBD Conference of the Parties Directives[2], gave the chance to deal with the matter in a problem-solving view, thus various stakeholders, decisions makers, and public agencies and authorities had been involved. We are working in the intent of submitting a proposal on 6°FP European Research.
Many important questions arose, and are still open.

As a matter of fact, even if IAS

> have been receiving much attention ... and in recent decades they have become one of the most trendy fields of research in ecology[1],

the studies focus is on biological processes, and far less on impacts, and don't take account of different quality level and state of landscapes involved.

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[1] The EU Strategy for IAS suggests to "include invasive alien species in existing wildlife monitoring arrangements" (See point 6, Box 19). We propose to test the indicator for assessing not only wildlife, but also the general environmental quality of landscape. The indeterminacy in the indicator significance and efficiency is however still wide, if the "Number and cost of invasive alien species"- allocated in the focal area Threat to biodiversity- had been assigned for "testing, developing and documenting" to the Experts Group of the ECCHM (European Community Clearing-House Mechanism) Coordination Team on Biodiversity Indicators and Monitoring (July 2004).

[2] CBD Conference of the Parties, COP Decision V/6 VI/12 and (Feb. 2004) VII/11

[1] *Large scale correlates of alien plant invasion in Catalonia (NE of Spain)*, Joan Pino, ..., Biological Conservation 122 (2005) 339-350.

The impacts are only and nearly always defined as negative, but it is not yet clear from which point of view IA plants damage or threat biodiversity. On the other hand, the concept of "biodiversity" (as well as ecosystem, food web, etc.), is still mostly an abstraction which make sense when related to humans, but not in relation to the community of plants and organisms... Somebody says:

> the urgency of the situation and the lack of co-ordinated problem solving are only just dawning on an unprepared Mediterranean basin[2].

But the most important problem we would like to point out, before defining what to do with IA diffusion, is a theoretical issue. Let us consider these arguments sequence:

– Where succession cannot be driven forward by the vegetation itself (autogenic succession), the changes occur because of external (allogenic) influences.
– Those external influences may be spontaneous, or anthropogenic (i.e.: ecopoietic actions).
– IA plants encroaching on coastal habitats, in which they were not present before, may be the "spontaneous" response to soil degradation that hinder the autogenic successions of autochthonous Mediterranean maquis vegetation. The degradation of soils is connected to their lower value, where agricultural uses are abandoned, or to a lack in possibility/capacity of care and maintenance if urbanised.
– Anthropogenic actions to help the succession of autochthonous vegetation need human energies and resources, in term of awareness, know-how, funding, organisation, work, etc. The ecopoietic actions, as well as conservation and protection, are not zero-cost. Besides, the low quality of Thyrrenian landscape is connected to a shortage of those energies and resources.

Thus, we face an inescapable -although too schematic- choice:

– Let the green arrow of Fig. 1.b or 2.b do its work, accept the allogenic succession driven by pioneer plants, allow them to colonise lands and soils abandoned or disregarded by the settled community, and invasive exotic plants diffusion too, if and where they will be able to prevail on

[2] P.E. Hulme, *Islands, Invasions and Impacts: a Mediterranean perspective*, in: Fernandez-Palacios J.M. & Morici C. (eds) 2004, Ecologia insular, AEET, Cabildo Insular del La Palma, pp. 359-383.

autochthonous. A new landscape will develop, providing a new array of ecological functions.

– Find the energies and the resources to support the implementation of control strategies and the reclamation and eradication activities, as well as energies and resources for ecopoietics activities to improve the ecosystems performances.

If the choice is the first one, many naturalists are likely to be happy, and only with the time it will become clear whether that was a good choice.

If the choice is the second one, then the work becomes difficult.

The main risk I foresee in second choice is the going on of the divergence between environment's improving objectives stated in agreements and declarations, and the real dynamics of a landscape where the settled community do not have enough resources to provide for.

Everybody knows how difficult is to implement novel sustainable economic systems, in which "competitive" manufacturing processes and commercial activity are based on environmental technologies. This is even more difficult in historically relatively poorer regions (ref.: Human factors) and environmentally rich (ref.: Natural factors) regions, where agricultural and forestry land uses are now marginalised by the current relevant economic system, based on tourism[1]. We are talking about Calabria and Basilicata. Never the less, we see similar occurrences not only in Mediterranean Sea, but also in the landscape of many other coastal regions, with mild and attractive Mediterranean Type climate.
Actually, the dynamics of those regions seem to be moving along the first choice, i.e. the less human energy absorbing. To counteract the IA plants' spontaneous, negative diffusion in Mediterranean coastal landscape (the said "silent invasion") an even partial economic way to solve the problem has to be found.

We thought that a way could be using the invasive biomass obtained from eradication. Our objective would therefore be studying the environmental technologies needed to implement such uses and activities.

[1] That is to say the economic system which, more than any other one, finds in quality landscape the primary/basic fostering factor, exploits the landscape quality, sometime till the worn out of the places' quality (namely: the beauty), both on natural and human factor sides.

Even if technology cannot solve all environmental problems, in the specific case they could be of sound help. Obviously, that cannot be the only way to reverse the trend of a tourism-based economy of a region, nor the overexploitation of its Natural resources. Equally, it is evident that not in every place where IA plants encroached on coastal ecosystems the quality and quantity of their biomass are susceptible of economic exploitation.

The *Ailanthus* case seems to be a good one, both for biomass quality and quantity, in several Mediterranean coastal landscapes.

Here, I can only list the possible uses:

– biochemical exploitation: bio-herbicide production, pharmacological uses, soil chemicals and weed control application;
– energy from biomass: potential use as chipped wood, potential use in pellet manufacturing;
– raw material for wood working industry: potential use in the panel industry, potential use in the pulp and paper industry, potential use in other wood working sectors.

The economic uses of biomass encounters much opposition, because it seems not consistent with the efforts and strategies currently developed to prevent IA plants introduction and their diffusion[1].

From a general and theoretical point of view this might seem true. But at in some local, specific situations, IA plants diffusion is already a spontaneous “Natural factor” which is degrading landscape quality. Moreover, in those situations, the IA plants impacts already reduce the ecosystems’ functions and change the landscape’s characteristics. Their sprawl suggests itself that there is a lack of means for landscape care. Therefore, in those situations, why not take into account the even marginal potential added value, achievable through their biomass exploitation?

I hope that the questions I posed will create good and constructive opportunities for discussion.

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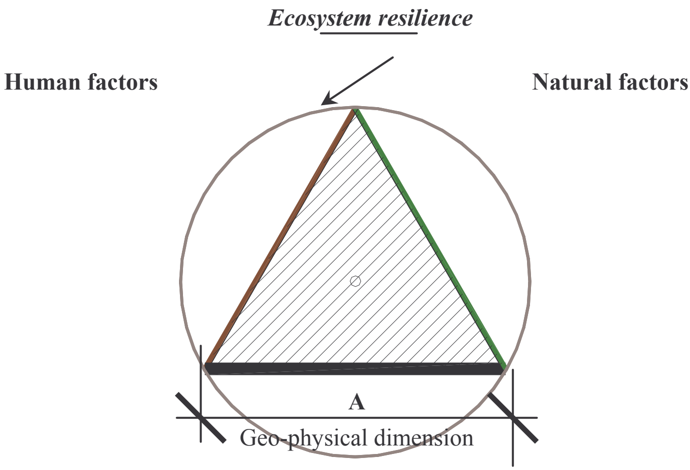
[1] Must be considered that the eradication activities produce heaps of biomass. The disposal of vegetable materials gives rise to practical and economic problems, as many experiences have already proven.

The Quality Triangle: a representation of landscape quality
Fig. 1: sustainable landscape condition
Fig. 1.a: over exploitation condition
Fig. 1.b: under exploitation condition

Fig. 1



The shaded triangle represents landscape quality and it lies within the "ecosystem resilience" circle. We assume that the three sides of the triangle represent respectively:

1. Human factors; 2. Natural factors; 3. Landscape geographical and physical dimension.

The maximum possible area covered by a triangle within the circle corresponds to an equilateral triangle, which has all sides of the same length. Therefore in this case, for a given landscape dimension (A), Human and Natural factors have the same weight and do not prevail one against the other, and the landscape quality is the maximum possibly achievable. Therefore, this case represents sustainable landscape conditions (fig 1).

Fig. 1.a

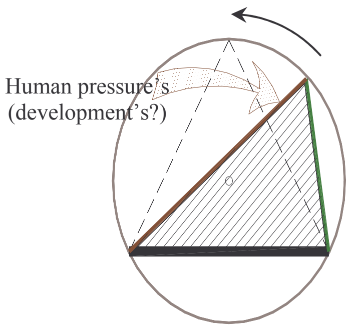
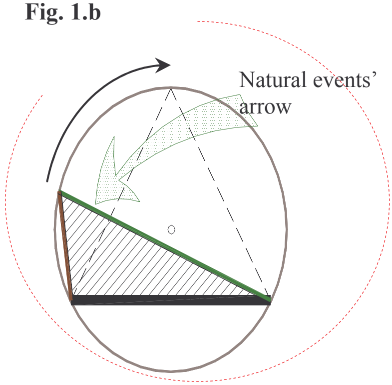


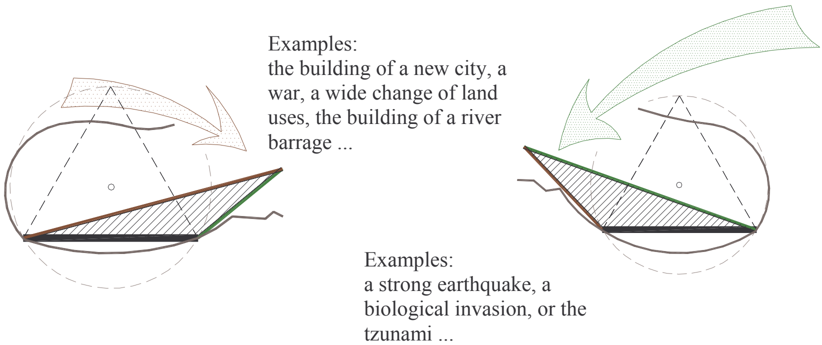
Fig. 1.b



If human factors pressure increase and the natural factors side is compressed (Fig. 1.a) the equilibrium between the two forces is broken and the triangle area become smaller. In the same way, if natural factors pressure exceed the human ones (Fig.1.b), the balance change in favour of the natural component, but the quality area still decrease. The landscape quality degrades in both cases, being the result of interaction of human and natural factors.

Although not in its maximum potential, in figure 1.a and 1.b the landscape quality variation still lies within the resilience circle. Both human and spontaneous natural factors are in the continuous and always-dynamic interrelation (adaptive dynamics) and can still bring landscape quality up to its maximum potential.

Fig. 2.a **Fig. 2.b**



Exceeding resilience: In figure Fig. 2.a and 2.b, instead, the landscape system is not able to absorb disturbances or positive pressures (the occurrence has not necessarily a negative meaning). Functions and structure of the ecosystems will change, as well as landscape identity. A new landscape needs to be developed, i.e. a new equilibrium between different agent factors has to be found in order to maximise landscape quality (a new equilateral triangle within a newly defined resilience circle).

Considering the IAS spontaneous diffusion as a part of the green natural factors arrow, are there landscape situations in which their role may be seen as positively pioneering, in an allogenic succession?

Eradication of *Carpobrotus* (L.) N.E. Br. in Minorca

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Abstract

In 2001 the Consell Insular de Menorca started a LIFE Nature project with the objective of the conservation of threatened plants. Three main threats were identified as a major concern for the conservation of plant species included in the Annex II of Habitats Directive. One of these was the presence of the exotic invasive plant Carpobrotus. The project included several actions to control and eradicate it. Two preparatory actions were developed at first: a detailed GIS cartography of its distribution and the selection of an eradication method using experimental plots. The cartography soon revealed as useful tool for the planning and coordination of the eradication works, but also showed the exact amount of Carpobrotus in the island, not known before the project: 27,8 ha.

The eradication started in august 2002. The first works were in places with the plant still in isolated patches, but with clear signs of an expansion process. Afterwards the eradication continued along the southern coast of the island. Here it was mainly located around urban areas. In November 2003 the works gone in a final stage with the eradication in places with high density, located mainly in the north coast. At the end of the project two sums stand out: 24 ha have been eradicated and 900 tons of Carpobrotus remains have been moved. Especially the transport of eradicated plants had been a major handicap to solve along the project. Now this threat is highly minimised in Minorca, it just remains in two places.

Introduction

The expansion of alien invasive species has become a major worldwide concern in recent years with regard to biodiversity and environmental preservation (Vitousek *et al.*, 1996; Mack *et al.*, 2000; Perrings *et al.*, 2000). This situation has triggered several statements from political authorities at all levels (local, regional, national, European, etc.). In fact, the control and eradication of alien species is considered a priority issue in order to evaluate and support the financing of project proposals concerning biodiversity and environmental preservation.

The Mediterranean region, due to its rich biodiversity and narrow endemism (especially in plant species), is more sensitive to the problem of invasive species. The Balearic Islands is no exception, Moragues & Rita (2005) estimated the alien flora of the islands to be 15.9% of the total. In Minorca a recent survey on the flora of the island (Fraga *et al*., 2004) shows that alien flora accounts for 12%, and only in the last fifteen years has the naturalisation of introduced plants been higher than any other period with historical records.

In July 2001 the European Commission approved the funding of a LIFE-Nature project proposal focused on the conservation of endangered plant species in Minorca (LIFE2000NAT/E/7355 Conservation of areas with threatened species of flora in the island of Minorca). The project sought to achieve this main objective by means of three methods: legal tools (management plans), control of threats and awareness-raising.

The presence of the alien invasive plant, *Carpobrotus* (L.) N.E. Br., posed a major threat to the conservation of the endangered flora (Fig. 1). Therefore, a significant number of measures within the project focused on its control and eradication. A brief explanation is given on how the process evolved from its preparation through the development of the eradication to the final results, as well as the main difficulties and problems encountered.

Carpobrotus in Minorca

Records show that the presence of *Carpobrotus* in Minorca dates back as far as 1824 (Fraga *et al.*, 2004). Like many other exotic plants, it was first introduced as a medicinal plant (Rodríguez, 1874). However, people soon began to appreciate it as a garden plant, not only due to its attractive blossom, but also because of its high tolerance to the harsh climatic conditions on the rocky coastline, especially on the north coast. Here the predominating north winds (tramuntana) hinder the cultivation of most ornamental plants greatly. It is not known when exactly *Carpobrotus* began its naturalisation, but on examination of photography files it seems that the largest populations, in the north-east of the island (Favàritx), date to less than thirty years ago.

Fig. 1. Carpobrotus competing with the endemic *Dorycnium fulgurans* (Porta) Lassen

Despite this early naturalisation process, concern that the plant was invasive arose as late as 1996 with the drawing up of a survey regarding plant distribution on the islands of Mallorca and Minorca. The same year some eradication measures were developed in the nature reserve of Albufera des Grau. The objective of these measures was the complete eradication of *Carpobrotus* from Favàritx, the most extensive population on the island. Finally this was not possible due to the opposition of landowners, a situation that has reoccurred within the development of the current LIFE project. Simultaneously, the most important environmental NGO on the islands, GOB (Grup d'Ornitologia Balear i Defensa de la Naturalesa), also carried out eradication measures in the east of the island.

These early elimination measures, despite being localised and having no continuity, were extremely useful as a starting point to make the island's entire local population as well as the local political authorities fully aware of the issue. Consequently, concern regarding the expansion of this invasive species grew as did the involvement of local authorities to solve the problem. As a result of this situation, the LIFE-Nature proposal was drawn up and developed in the last four years.

Preparing the eradication

At the onset of the project the location of *Carpobrotus* on the island was known, but not the precise distribution, nor the total surface area covered by the plant. Furthermore, previous experiments tested several eradication methods. However, the results were not contrasted with factors such as environmental impact or plant regeneration, or were not monitored at all. This lack of knowledge was an important obstacle to developing eradication measures with minimum efficiency in terms of cost and time consumption. In order to clarify these doubts two preparatory measures were included in the project: a detailed cartography regarding its distribution and experimentation of eradication and regeneration of natural vegetation methods. The second measure was undertaken by means of establishing experimental plots in the area with a higher density of the invasive plant (*Favàritx*).

It took approximately nine months to carry out the cartography. It was implemented using a GIS system to make it useful and easy to update. This action was not merely a survey of the distribution, other data were recorded simultaneously, which were useful for acquiring further information regarding its ecology and also for ascertaining which zones are more prone to its presence and expansion. A quantitative idea of its presence was determined once the measure was completed: 25.8 ha were directly covered by it. In addition, the final result, a complete set of maps, proved extremely useful for organising and planning the eradication measures.

In the experimental plots the most efficient eradication method was soon revealed: pulling out the plants by hand, other methods proved too costly economically and in time. Even the differences in environmental impact, mainly due to soil disturbance, were minimal between the different methods.

Eradication

Initially, measures were prioritised in the areas where *Carpobrotus* was expanding in natural areas, mainly on public property. However, measures were also undertaken on private property pending agreement from the owners. Nevertheless, in some coastal residential areas a high degree of agreement was reached with the owners to eliminate the plant from private gardens.

The coordination and planning of the work was relatively easy thanks to the detailed cartography. For each zone to work, several maps were plotted clearly indicating the location of *Carpobrotus*, not just on the map, but also in relation to other factors which could influence the method of work: orography, roads, vegetation, etc.

An important stage in the eradication of the plant is the removal of *Carpobrotus* remains. Previous experience has shown that any remains left in place soon become an active focus of regeneration. This is due to the large number of seeds that survive in the fruit for a long time. In fact, removing and transporting the remains posed a major difficulty throughout the project (Fig. 2), mainly in two ways: the sheer volume of the remains and the degree of accessibility of the populations. A study of each zone was necessary prior to eradication so as to plan and coordinate the human and technical resources required to remove the remains. Several methods of transportation were used throughout the project. Where sites were closed to the roads, remains were directly deposited in the vehicles. Where the plant was further away from an accessible road, remains were first placed in plastic bags, while large 2 m^3 bags were used in the most inaccessible places. In extreme cases, i.e. populations situated in natural areas with a high ecological value and no roads, air transport was used to move the remains to an accessible place for final transportation. The cooperation of the Conselleria de Medi Ambient of the Govern de les Illes Balears in this action was greatly appreciated. Besides transportation of the remains, they had to be deposited somewhere where they could not become a focus of dispersal. In our case, it was decided to bring all remains to the waste treatment facility on the island.

Fig. 2. Removing the remains from difficult places has been a major obstacle in the elimination works.

The eradication was carried out by means of contracting teamsof workers from private companies. Each team was made up of a minimum of four persons and all their work was supervised by the project's technical staff. There were five teams of workers during the project in periods of three to nine months. The work commenced in August 2002 and continued until the end of March 2005, although it was intermittent, divided into three periods:

August 2002 to June 2003 – At this time the cartography was not completed. The work began in areas where *Carpobrotus* was still in isolated patches, and in low density. These places were prioritised as they could easily become new large foci of dispersion. Afterwards the work moved to the south coast where the plant was also in low density and mainly in accessible places around coastal residential areas.

November 2003 to April 2004 – The experience gained in the first period and the completed cartography allowed the work to commence in places with a higher density of the plant and which were less accessible. In fact this was the period with the most intense work as there were up to three teams working at a time. The work of each one was complementary, while one team was eradicating the plant with sophisticated technical means in difficult areas, the other was working in more accessible zones in the southwest and west of the island.

November 2004 to March 2005 – The final period of eradication was primarily given over to inspecting previous work, mainly to eliminate small areas which were overlooked or some new patches which were not detected in the cartography but were noted by local people. A major part of this final period extended beyond the LIFE project duration and its cost was assumed by the Consell Insular de Menorca.

Simultaneously as this work was undertaken, particularly, in the periods without work teams, the technical staff of the project inspected the cleared areas to detect regeneration of the plant from vegetative reproduction or by seeds.

Besides all this work, the eradication of an invasive plant, to be real, must be sustainable. The best means to accomplish this, besides active elimination measures, is to reach a high level of local awareness of the issue. Therefore, the project encompassed several measures with this objective in mind. Today the main use of *Carpobrotus* is in gardens, so an awareness-raising campaign was launched during the project, not only to warn about the invasiveness of the plant and the threat it poses to the indigenous flora, but also to propose alternatives to it for gardening. All the alternative plants were endemic, with a recognised value as decorative plants.

Keeping the people informed of the project's development, and particularly the measures related to the control of *Carpobrotus*, was another means to raise the awareness of the local population. Not only regarding the threat it poses to indigenous flora, but also the economic cost that its control and eradication implies.

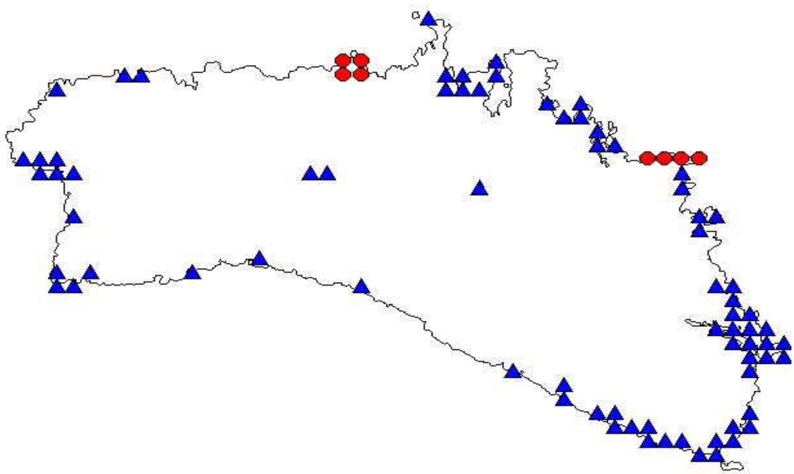

Fig. 3. Situation of *Carpobrotus* today in Minorca. (▲) places where the plant has been eradicated. (●) Places where *Carpobrotus* still grows in natural habitats.

However, perhaps the best way to make people aware of what the eradication of an invasive plant entails is to involve them in the work. Two excursions were organised in the project, in which the local population participated in eradicating *Carpobrotus*. Both had a positive response in terms of the number of participants, more than a hundred in one of them, and in the amount of work carried out. Each excursion resulted in the elimination of one hectare of the invasive plant.

Results

After four years of measures to curtail the expansion of *Carpobrotus*, it can be said that the situation is much better than at the outset. The map of figure 3 shows the present distribution of *Carpobrotus* in Minorca, today it is restricted to two zones. The persistence of those is not a lack of resources or time during the project; it is simply due to the opposition of landowners to its elimination.

Table 1 shows a quantitative summary of the results and the efforts required to undertake this work. However, the most outstanding result of this project is that it has shown that the eradication or strict control of an invasive plant species is possible. To do so, good knowledge of the situation, effective planning and coordination and a considerable concentration of resources and efforts are necessary. The experience developed in Minorca can be easily exported to other regions in the Mediterranean with a similar situation.

Municipilaty	Surface (m^2)	Days of work	Worked hours	Kg	m^3
Ferreries	2.654	6,5	225	5.918	18,75
Es Castell	25.317	62	2.135	177.260	537,10
Sant Lluís	20.493	41	1.483	61.479	186,30
Alaior	850	5	171	7.804	23,64
Es Migjorn Gran	475	2	70	1.780	5,39
Maó	144.463	93	3.586	375.025	1.136,44
Es Mercadal	3.000	9,75	340	20.217	61,27
Ciutadella	36.533	33	1.031	182.665	555,00
TOTAL	233.785	252,25	9.041	832.148	2.523,14

Table 1. Quantitative summary of the elimination of *Carpobrotus* in Minorca.

The future

Although the project drastically reduced the distribution of *Carpobrotus* on the island, the situation is far from being controlled in the long term. A common feature of invasive plants is their great capacity to regenerate rapidly. This has been evident in the inspections of cleared areas in Minorca. In some areas, just a few months subsequent to the eradication, the germination of new plants was extensive. Moreover, *Carpobrotus* is still grown widely in many gardens, especially in coastal residential areas. This situation calls for continuity of the measures developed in the LIFE project at all levels, particularly with regard to local awareness of the issue. However, this may not be enough and it is likely to remain a never-ending problem. We think some legal measures are imperative to put an end to this situation. Among these, the most useful measure would be to declare *Carpobrotus* a pest, not only to prevent the plant from regenerating, but also to authorise its eradication anywhere the plant is spreading in natural habitats.

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La lutte biologique contre les plantes envahissantes méditerranéennes : comment gagner du temps?

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Abstract

La mondialisation dissémine les plantes au-delà des frontières géopolitiques et géographiques. Dans ce cadre, la lutte biologique classique est la seule stratégie permettant une gestion écologique, économique et permanente des plantes envahissantes. Quand cette stratégie est choisie pour lutter contre une plante méditerranéenne, la première étape consiste à mener une étude bibliographique de ce qui existe et a été fait ailleurs sur ladite plante. Les réseaux scientifiques et les bases de données internationaux, qui sont des sources disponibles pour rassembler et échanger la connaissance scientifique en lutte biologique, devraient être mieux exploités. Dans cet article, nous présentons plusieurs exemples de plantes, issues de groupes fonctionnels écologiques typiques des plantes envahissantes des écosystèmes méditerranéens, comme les cactacées, les graminées annuelles, les plantes aquatiques, les arbres et les légumineuses. Dans chaque groupe, nombre de plantes sont déjà sous contrôle ou déjà en cours d'étude dans au moins 1 des 5 régions climatiques méditerranéennes du globe. Les données sur la distribution d'un auxiliaire comme agent de lutte biologique, son efficacité, les paramètres liés à son exportation et des lâchers sont autant d'informations cruciales pour la mise en place d'un programme de lutte biologique dans un nouveau territoire. Le but de cet article est de cibler les opportunités de collaboration pour évaluer le transfert technologique avec, et entre les régions méditerranéennes envahies par de mêmes espèces, où une gestion durable, axée sur la lutte biologique, n'a pas encore été considérée.

Introduction

Après la destruction de l'habitat, les plantes envahissantes sont considérées comme la seconde plus importante menace pour la préservation de la biodiversité. L'augmentation du volume des marchandises échangées et les activités anthropiques disséminent les plantes au-delà des frontières géopolitiques ou géographiques, induisant des pertes dans les agrosystèmes et les écosystèmes. Par exemples, la centaurée du solstice (*Centaurea solstitialis*) d'origine eurasienne et l'herbe à alligator (*Alternanthera philoxeroides*) d'origine argentine (Julien 1995), respectivement envahissantes en Californie et dans le sud de l'Australie, couvrent plus de 4 millions d'ha de terre, induisant des changements majeurs pour la biodiversité et les populations d'espèces végétales. De plus, l'agriculture et la foresterie ont assuré le transfert vers de nouvelles régions d'un matériel végétal qui souvent s'est échappé des cultures pour envahir l'écosystème local.

Même si les moyens d'introduction restent finalement inchangés au fil du temps, c'est l'accélération de ces introductions qui rend la gestion plus complexe. Dans la prise en compte des stratégies de lutte, la priorité n'est pas toujours donnée à la lutte biologique (LB) et ce, pour des raisons d'ordre économique, psychologique et écologique. Cependant la LB classique est la seule stratégie œuvrant pour une gestion écologique, économique et permanente des plantes envahissantes. En effet, l'introduction raisonnée dans le milieu envahi, par une plante exotique, d'un auxiliaire phytophage, lui même exotique ou d'un agent pathogène spécifique de la plante cible, est une solution écologiquement durable. D'aucuns argumentent sur le coût et la durée de mise en œuvre d'une telle stratégie, mais peut-on tenir un double langage en affichant des politiques de maintien de la biodiversité, et par ailleurs ne pas se donner les moyens de stratégies de lutte respectueuses de l'environnement? L'objectif de cet article est de mettre l'accent sur certains programmes de LB en cours dans certaines régions à climat méditerranéen, et qui peuvent être transposables dans d'autres régions. Les bons résultats d'un programme peuvent réduire, voire éliminer la composante psychologique (=crainte). De plus, l'accès aux informations, aux protocoles, aux études d'impact, aux analyses de risque et aux auxiliaires étudiés, aura un impact important sur la réduction des fonds engagés pour initier un nouveau programme, et influera donc sur la composante économique.

Les exemples de plantes ont été choisis au sein des principaux groupes fonctionnels écologiques typiques de plantes envahissantes des écosystèmes méditerranéens comme les cactacées, les graminées annuelles, les plantes aquatiques et les arbres.

Cas d'études

Le cas des *Opuntia spp.*

Originaires d'Amérique centrale, les Opuntias ont envahi des zones climatiques diversifiées. Particulièrement répandus dans le bassin Méditerranéen, ils colonisent les habitats rocheux entrant en compétition avec les endémiques. Ce complexe d'espèces a fait l'objet de très nombreux programmes de LB, et est surtout à l'origine du plus célèbre succès de LB australienne, avec l'introduction en 1926 du lépidoptère argentin foreur de tige *Cactoblastis cactorum* (Pyralidae). En six années, ce papillon associé à des champignons pathogènes a réduit 90% des 24 millions d'ha d'Opuntia (Dodd 1940).

Ensuite, ce papillon a été introduit pour contrôler différents Opuntias, en Afrique du Sud (1933), à Hawaii (1950) et dans les îles caraïbes (1957) (Julien & Griffiths, 1998). Grâce à sa relative plasticité biologique et écologique, son introduction a permis de réduire les populations d'Opuntias en deçà d'un seuil de nuisibilité.

Cependant, ce succès mondial a son revers. Depuis les îles Caraïbes, l'insecte est arrivé accidentellement en Floride où il s'est attaqué à un Opuntia indigène. Cet exemple a servi d'argument contre la LB en général, et en particulier contre l'utilisation d'un organisme auxiliaire dans différentes régions du monde. Il serait dangereux de tomber, avec cet exemple, dans une négation ferme et définitive de l'usage de la LB. Chaque auxiliaire est particulier et ne doit être en aucun cas considéré comme « coupable » avant que l'on prouve qu'il est « innocent » (MacEvoy & Coombs, 1999). L'utilisation de *C. catorum* comme agent de lutte dans le bassin méditerranéen pourrait être envisagée (EPPO, 2003), mais il est nécessaire de définir au préalable le statut exact des Opuntias exotiques : plantes cultivées pour ses fruits, plantes ornementales, ou envahissantes ? Il va de soi que la réponse sera différente selon les pays concernés, et parfois même à l'échelle régionale d'un pays. Ce cas soulève un problème plus global sur l'évaluation des risques et des bénéfices d'un programme de LB (Wajnberg et al, 2001).

Le cas de l'orge à tête de méduse (*Taeniatherum caput-medusae*)

Cette graminée annuelle est une plante envahissante dans l'ouest des USA, Californie comprise, où elle a colonisé plusieurs millions d'hectares de prairies.

Elle est originaire du bassin méditerranéen jusqu'à l'Asie centrale. L'importance des surfaces couvertes par cette orge sauvage aux USA est à l'origine des recherches d'auxiliaires pour la LB dans son aire d'origine. Quatre agents pathogènes furent récoltés sur *T. caput-medusae* (Tableau 1), et sont à l'étude pour leur spécificité. La zone couverte par les explorations est représentative de la distribution naturelle de cette plante, rendant les travaux exhaustifs.

Agent pathogène	Organe attaqué	Localité
Ustilago phrygica (Ustilaginaceae)	inflorescences	Anatolie (Turquie), Nicosie (Chypre) Rila (Bulgarie)
Tilletia bornmuelleri (Tilletiaceae)	inflorescences	Erzurum (Turquie)
Fusarium arthrosporioides	Collet	Thessaloniki (Grèce)
Puccinia graminis (Pucciniaceae)	Feuilles et tiges	Erzurum (Turquie), Nicosie (Chypre)

Tableau 1. Agents pathogènes sur *Taeniatherum caput-medusae* en Eurasie en 2001-03 (Widmer & Sforza, 2004)

Ustilago phrygica et T. bornmuelleri sont particulièrement prometteurs, car ces champignons systémiques empêchent toute fructification. Cette plante affectionne les zones semi-arides sur des pelouses argilo-calcaires exposées au soleil. En Eurasie, *T. caput-medusae* cohabite avec *Bromus tectorum*. Cette dernière est hautement envahissante en Amérique du Nord, en particulier au Canada, et est déjà présente en Nouvelle Zélande avec une introduction depuis l'Europe et l'Australie (Novak et Mack, 2001). L'introduction de *T. caput-medusae* dans le sud australien, où l'écosystème de bord de mer est proche de l'optimum de la plante, pourrait avoir des conséquences dramatiques. La connaissance des ennemis naturels serait alors un gain de temps dans l'établissement d'un programme de gestion de l'exotique et la prise en compte ici d'une stratégie de LB.

Le cas des jussies (*Ludwigia grandiflora* et *L. peploides*) et autres plantes aquatiques

Ces plantes aquatiques à croissance rapide se développent dans les milieux humides stagnants ou à faible courant. Ce ne sont pas à proprement parlé des plantes d'origine méditerranéenne puisque introduites depuis les régions intertropicales d'Amérique du sud, cependant elles colonisent de nombreuses régions à climat méditerranéen du globe. A ce jour, peu d'études approfondies ont été menées en LB ; seul un coléoptère Chrysomelidae, *Lysathia ludovi-*

ciana, indigène des USA a été utilisé avec succès dans le Sud Est des USA (McGregor *et al.*, 1996). Au regard de la colonisation rapide des jussies, notamment en France, cet insecte pourrait faire l'objet d'un programme de faisabilité et d'étude d'impact.

Une espèce du même genre a été étudiée en Afrique du Sud, laquelle non seulement a montré une forte spécificité, mais aussi un réel impact vis-à-vis d'une autre plante aquatique envahissante, *Myriophylum aquaticum* (Cilliers, 1999). D'une façon générale, la LB contre les plantes aquatiques (*Eicchornia crassipes*, *Alternanthera philoxeroides*) a été couronnée de succès aux USA et en Afrique de l'est, notamment avec les charançons *Neochetina eichorniae* Warner et *E. bruchi* Hustache. Au vue de l'étendue de l'aire colonisée par *E. crassipes* en Californie (Center *et al.*, 2002), il est bon de surveiller attentivement cette plante dans le bassin Méditerranéen.

Les acacias (*Acacia dealbata*)

Le mimosa (*Acacia dealbata*) a été introduit depuis l'Australie avec de nombreuses autres espèces du même genre, comme plante ornementale dans toute l'Europe, surtout méditerranéenne, l'Afrique du Sud et la Californie. Seule l'Afrique du Sud a initié un programme de LB en utilisant 3 espèces de charançons australiens du genre *Melanterius sp.*, consommateurs de graines (utilisés contre *A. melanoxylon*, *A mearnsii* et *A. cyclops*). Cependant l'étude n'a pas été plus approfondie. Nombre de candidats potentiellement intéressants, car spécifiques des acacias sont connus dans l'aire d'origine (Old *et al.*, 2003) (Tab. 2). Parmi eux, des acariens du genre *Aceria* sp. (Eryophiidae), bien connus en LB pour leur haut degré de spécificité d'hôte, seraient à considérer en premier lieu. Il est à noter que, parmi les principaux « succès » en LB en Afrique du Sud sur les Acacias, la rouille *Uromycladium tepperianum* sur *A saligna* et la guêpe galligène *Trichilogaster acaciae-longifoliae* sur *A. longifolia* ont chacun bloqué la production de graines (donc la dissémination de l'espèce vers de nouveaux territoires), mais pas du tout la valeur forestière du bois d'Acacia.

Ennemis naturels	Organe attaqué	Spectre d'hôte	Agent relâché
Aceria sp (Eryophiidae)	Inflorescences	*A. saligna, A. mearnsii, A. melanoxylon*	Non
Melanterius sp (near maculatus) (Curculionidae)	graines	*A. mearnsi, A. longifolia, etc.*	Oui
Bruchophagus acaciae (Eurytomidae)	graines	*A. Mearnsi*	Non
Trichilogaster acaciaelongifoliae (Pteromalidae)	graines	*A. longifolia*	Oui[1]
Trichilogaster trilineata (Pteromalidae)	Tiges, inflorescences	*A. mearnsi, A. baileyana*	Non
Uromycladium notabile; U. alpinum (rouilles)	Apex et feuilles	*A. mearnsi, A. buxifolia*, A. Saligna, etc.	Non[2]

[1] *Trichilogaster acaciaelongifoliae*. utilisé en LB en S.Af sur *Acacia longifolia* (Dennil *et al*, 1999).

[2] *Uromycladium tepperarium* (Sacc.) utilisé en LB en S.Af sur *Acacia saligna* (Morris, 1999).

Tableau 2. Principaux ennemis naturels australiens sur Acacias.

Le cas d'*Ulex europaeus*

Originaire de l'Europe de l'ouest, cette légumineuse a colonisé la Nouvelle-Zélande (NZ), l'Australie (sud-est Tasmanie-Victoria), le Chili, les USA et Hawaï. Son impact est tel qu'elle est considérée souvent comme la plante exotique la plus problématique dans ces pays (NZ, Chili). Du point de vue de la LB, tout commence en 1930 en NZ, où un charançon consommateur de graines, *Exapion ulicis* (Curculionidae), est importé de Grande-Bretagne. Ce dernier s'acclimatera, mais ne sera pas très efficace ; il en sera de même en Australie, en 1939, aux USA en 1953, à Hawaï en 1955, et au Chili en 1976 (Julien & Griffiths 1998; Norambuena, 2000). Les Apions relâchés en Australie et au Chili étaient issus d'une colonie maintenue en NZ, mais originaires de Grande-Bretagne, et n'ont pas joué, comme ailleurs, un rôle régulateur sur *U. europaeus*. À noter que les insuccès en Australie, NZ et USA sont dus à l'importation, en même temps que ce charançon, de son cortège parasitaire!

S'appuyant sur les expériences néo-zélandaises (pas totalement concluantes), de nouveaux agents, un acarien, *Tetranychus linterarius,* et un Lépidoptère, *Agonopteryx ulicetella* furent lachés à Hawaï et aux USA (1995) puis au Chili en 1997 (Julien & Griffiths, 1998 ; Norambuena *et al.*, 2000). Puis suivirent des lâchers en Australie, d'un acarien et un thrips, *Sericothrips staphylinus*. Il faut noter que l'insuccès de *T. linterarius* en NZ a ceci de paraxodal qu'il est prédaté par *Phytoseiulus persimilis*, un acarien introduit depuis… le Chili! (Ireson, 2003). Cependant à Hawaï et au Chili, *T. linterarius* et *A. ulicetella* se sont maintenus et ont un impact conséquent sur *Ulex europaeus*. Cet exemple illustre bien le gain de temps obtenu par les équipes chiliennes et hawaiiennes dans la mise en place d'un programme de LB. D'autres insectes en NZ et en Europe sont prometteurs (Ireson et al, 2003 ; Hill *et al.*, 2000) et pourront être considérés pour de futurs lâchers au Chili, en Australie et à Hawaii, ainsi qu'en Europe. En effet, *U. europaeus* pose des problèmes en Italie, au Portugal et en Espagne, où pourtant il est indigène, ainsi qu'aux îles Canaries et à La Réunion. En 2005, un programme australien met en œuvre des explorations afin de découvrir des insectes foreurs de racines sur les *Ulex* européens.

Conclusions et discussion

Ces 5 exemples (Tableau 3) illustrent bien les potentialités comme les limites, ou plutôt les précautions à adopter, qu'offre la LB contre les plantes exotiques en régions de climat méditerranéen.

Cas d'étude	Problème	Origine	Etude LB menée	Principaux agents étudiés	Agents relachés	Contrôle réussi
Opuntia spp.	US, AUS, NZ, Eur.	Central Am.	AUS, Caraibes, S.Af., Inde	*Cactoblastis cactorum ; Dactylopius* spp	oui	Oui
Taeniathe-rum caput-medusae	Californie	Eur.	USA	*Ustilago* phrygica; *Tilletia bornmuelleri*	Non	-
Ludwigia grandiflora	Eur., US, AUS	Trop., S. Am.	USA	*Lysathia ludoviciana*	Oui	Partiel
Ulex europaeus	Chile, NZ, AUS, US	Europe	Chili, NZ, AUS, US	*Exapion ulicis ; Agonopteryx unicetella ; Tetranychus lintearius ; Cydia succedana*	Oui	Partiel

Cas d'étude	Problème	Origine	Etude LB menée	Principaux agents étudiés	Agents relachés	Contrôle réussi
Acacia spp.	Eur.,USA, Chile, SA	AUS	S.Af.	*Melanterius* sp. near *maculatus, Aceria sp ; Trichilogaster sp.*	Oui	Oui

Tableau 3. Résumé des 5 cas d'étude pour le potentiel de gestion par la lutte biologique en régions mediteranéennes.

Nous sommes conscients que tout programme de LB n'est pas *de facto* transposable d'une région à une autre. Les contraintes d'ordre économique, psychologique et écologique sont à des degrés divers de réelles barrières à la mise en place d'une telle démarche.

A l'état initial de toute réflexion, le financement d'un programme relève d'enjeux locaux et nationaux où de nombreux partenaires doivent négocier et faire valoir leurs objectifs. Par exemple, dans un récent ouvrage sur les plantes envahissantes en France (Muller, 2004), les auteurs argumentent à la raréfaction des programmes de LB en Europe, et plus particulièrement en France, la diversification des territoires et des gestionnaires devant êtres impliqués. La tache est difficile, mais certes pas insurmontable. Pour preuve, le programme de LB contre le séneçon du Cap (*Senecio inaequidens*) dans le sud de la France, impliquant trois instituts publics et privés, dont l'antenne du Conservatoire Botanique en Languedoc-Roussillon. Plus au Nord, dans les prairies inondables du Val de Saône, un programme pour lutter contre l'euphorbe ésule (*Euphorbia esula*) a été initié en 2004. Cette espèce bien qu'indigène fait l'objet d'un programme de LB pour lequel interagissent plusieurs organismes français dont l'Office National de la Chasse et de la Faune Sauvage (Curtet *et al.*, 2005).

Des mobilisations sur fonds publics et privés sont par conséquent possibles. C'est donc bien au-delà du monde méditerranéen que la prise en compte de la LB se pose, et nous pourrions citer le cas de l'ambroisie, *Ambrosia artemisiifolia*, exotique nord américaine en Europe septentrionale et méditerranéenne, dont la nocivité est autant du point de vue agricole que de la santé publique.

Un autre obstacle à l'usage de la LB est la « crainte » de certains écologues, face à l'introduction d'un auxiliaire. Les cas de dérives bien connus dans la littérature ne doivent pas à eux seuls empêcher toute initiative dans la mesure où elle est encadrée, menée et développée par des personnes responsables et soucieuses des effets non intentionnels que pourrait engendrer la LB, comme tout autre mode de gestion mal évalué.

Enfin, l'acclimatation des auxiliaires introduits reste peu maîtrisable, voire même non prédictible, car faisant appel à des composantes plurifactorielles dont les traits de vie de la plante cible et de l'agent lui même, ajoutés au rôle de l'environnement local. C'est là que l'analyse de risques prend toute son importance. Face aux introductions mensuelles de plantes exotiques, et à l'installation durable de certaines, la réponse apportée par la LB comme mode de gestion est une parmi d'autres, mais ne doit pas pour autant n'être considérée qu'en dernier recours, quand la lutte chimique, par exemple, a failli. Reste en préambule à toute étude de faisabilité en LB classique la prise en compte de la législation et la réglementation en vigueur dans le pays d'origine et le pays d'accueil concernant l'importation d'auxiliaires vivants (cf. article de Coutinot et al. au sein de cet ouvrage).

La mise en réseau des connaissances à l'échelle des cinq régions méditerranéennes ne peut qu'accélérer la mise en place de gestions diversifiées adaptées aux agro- et écosystèmes. Des groupes de travail tels que ceux constitués durant ces ateliers à Mèze en 2005, sont autant d'opportunités de transmettre et d'échanger l'information. La création de bases de données par groupe fonctionnel écologique avec un historique sur la LB de chaque espèce étudiée, incluant les programmes en cours serait à envisager. Al'échelle de chaque région géographique, un groupe d'experts pourrait gérer ces bases en ligne avec l'appui des informations déjà disponibles (EPPO, EWRS, *Biocontrol of weeds world catalogue*, 1998). Le sujet est vaste mais très prometteur pour la gestion globale des plantes envahissantes par la lutte biologique.

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The Cooperative Islands Initiative:'Turning back the tide of invasions'

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Abstract

Islands are especially vulnerable to the impacts of invasive alien species (IAS). Native species and communities, as well as the livelihoods and lifestyles of island people have been seriously affected by alien invaders. Despite this vulnerability many islands also have unique attributes as sites where IAS may be effectively managed and their impacts mitigated or removed. Small, isolated islands, in particular, present important opportunities to prevent IAS arriving and establishing. They may also be ideally suited to undertaking eradications – an option which is seldom available to managers at "mainland" sites where the risks of re-invasion are much higher.

The Cooperative Initiative on Invasive Alien Species on Islands ("The Cooperative Islands Initiative, or CII") was launched by the New Zealand Government at COP7 to the Convention on Biological Diversity in 2002. This followed calls by island countries and states for cooperative actions against IAS on islands. While it is a global programme the CII has been initiated in the Pacific. To date 5 agencies are involved as partners. The goals of the CII are to build IAS management capability and to enhance cooperative actions. In addition to information-sharing and training, a focus of the CII is on "Demonstration Projects". At carefully selected sites prevention, eradication and control projects will be undertaken to raise awareness, to develop new approaches and techniques, and to build IAS management capability within island countries. Progress to date in the CII will be outlined, and its relevance to managing invasive plants on Mediterranean-type islands discussed.

Invasive Alien Species have significant impacts

Invasive alien species (IAS) are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health. They are one of the major threats to the ecological and economic well being of the planet (McNeely *et al.* 2001) and may soon surpass habitat loss as the main cause of ecological disintegration globally (Vitousek *et al.* 1997, Chapin *et al.* 2000). The recent increase in global human movement (and the intentional and unintentional introduction of new species) has caused rapid changes in many biological communities, including multiple extinctions. IAS have a range of effects on the environment, economy and society as a whole. Some of these impacts can include unemployment, impacts on infrastructure, food and water shortages, environmental degradation, loss of biodiversity, increased rates and severity of natural disasters, illness and lost lives.

Islands are especially vulnerable

Islands are especially vulnerable to the impacts of IAS (see Veitch & Clout 2002). As an indication of the vulnerability of island species, more animals have gone extinct from islands than any other ecosystem type in recent times. Of all documented bird extinctions since 1600 IAS appear to have played a role in at least half. A key example of this is the accidental introduction of the brown tree snake (*Boiga irregularis*) to Guam (in the Northern Marianas) in the 1950's that has caused the extinction, so far, of 10 of the island's 13 native bird species, 6 of 12 native lizards, and 2 of 3 bat species (Fritts 2000). In addition, these snakes cause power outages every 4–5 days, damage to household electrical appliances, and research and control costs totalling over $US5 million a year.

The Miconia tree (*Miconia calvescens*) – or 'the green cancer' covers 70% of Tahiti's forest canopy (from 3 initial plants) and threatens a quarter of the island's indigenous wildlife. It is recognised as the most invasive and damaging alien plant invader in many Pacific island rainforests. The tree forms dense thickets that stop sunlight from reaching the forest floor under which few plants below can survive. Miconia's shallow roots also have poor soil-holding properties and this can increase the rate of erosion. After only a few years' growth a single plant can produce millions of seeds each year – seeds that can be dispersed widely by birds or by people who inadvertently carry them to new areas on their boots or vehicles (Loope 1997).

Island people are reliant on their natural resources and IAS can impose a heavy toll on island economies through direct losses to agriculture, forestry, fisheries and other industries. For example, in Samoa an outbreak of taro leaf blight (*Phytophthora colocasiae*), a fungal disease, decimated taro production that formed a key part of the Samoan economy. It is estimated to have cost Samoa $US40 million to replace domestic consumption, lost exports and the cost of controlling the disease (more than the impact of three cyclones). In the Mediterranean an invasive marine seaweed (*Caulerpa taxifolia*) has changed the seafloor in large areas from diverse communities to a layer of seaweed. This has resulted in a reduction in the number of recreational divers- and consequent implications for coastal communities that rely on tourism and fishing.

Islands offer unique opportunities to manage IAS

Many islands contain unique ecosystems and assemblages of plants and animals and offer special opportunities to manage IAS. Firstly, their isolation by water from other landmasses means that it is easier to more-effectively prevent IAS (or previously eradicated ones) arriving on islands than is usually the case at "mainland" sites. While some terrestrial species, such as rats, are quite capable of travelling across water to reach "new" habitats (for example, by "rafting" on flotsam, or by "hitch-hiking" on boats), water barriers are quite effective at limiting the dispersal of many terrestrial IAS. Remote oceanic islands that are a long way from other landmasses may be less likely to be invaded by land mammals or weed seeds than near-shore islands. Islands uninhabited by people and well away from established transport routes might also be less prone to invasions. However, even on remote oceanic islands there is still some risk of invasion – especially as a result of deliberate or accidental human-assisted introductions. Secondly, small islands present advantages of scale in managing IAS. The logistics and economics of treating entire islands – or quickly and easily reaching critical sites on an island are important management considerations. Such access can be a critical factor in successful surveillance programmes, and in rapidly responding to a new incursion. Thirdly, the combination of their isolation and relatively small size means that eradicating IAS from entire islands can, in some cases, be contemplated using existing technologies and techniques. Fourthly, there are social dimensions which present important opportunities, and challenges, in managing IAS on islands. All islands, no matter how small or remote, will have people who have a stake in how they are managed. Successful outcomes from managing IAS on islands will hinge on the needs and wishes of these people being properly acknowledged.

The Cooperative Islands Initiative

The Cooperative Islands Initiative (CII) was proposed by island countries and was launched at 2002 Conference of the Parties to the UN Convention on Biological Diversity (CBD). It is a joint initiative between the New Zealand Government, the IUCN Invasive Species Specialist Group (ISSG), and the Global Invasive Species Programme (GISP). The initiative is aimed at building management capacity within island states (and countries with islands) to more effectively manage the threat posed by IAS. It focuses on enhancing information transfer and skills sharing, providing targeted training opportunities, developing better management techniques, employing 'best practice' procedures and providing coordination and technical support services. Linked to this initiative a regional invasive species programme is currently underway in the Pacific. An important focus of the Pacific Partnership is "Demonstration Projects" – carefully chosen projects where Best Practice procedures for managing IAS (prevention, eradication and control) are developed and applied, and where the participation of people with a stake in the outcomes of the management is encouraged.

Mediterranean regions of the world include many island systems. Similar partnerships to that set up in the Pacific could be applied to help tackle invasive plant species on these islands given the experience and demonstrated outcomes of the CII. This would be an aim highly relevant to this workshop. The EU has funded initiatives aimed at tackling invasive plants on Mediterranean islands (EPIDEMIE http://www.ceh.ac.uk/epidemie/) and the Nature Conservancy in California has had a significant project on Santa Cruz island off its coast (John Randall, the Nature Conservancy pers. comm.), but a coordinated international approach based on shared expertise and experience in weed prevention, eradication and control through the CII could reap global benefits.

Prevention ("the preferred management option")

Ideally, preventing potential invasive plants arriving at a new site is the best way to manage their impacts – "prevention is better than cure". This is especially true on islands where incursions can quickly lead to significant impacts. Once an IAS has established in a new location it can be very difficult, expensive and environmentally damaging to remove. For many IAS the best way (and perhaps the only way) to prevent their arrival on an island is to reduce the chance that they can leave their "original home" in the first place.

Travelling between and among islands groups is a way of life for many island people. Plants and animals are sometimes transported as food or gifts, or to be planted or released at a new site (Meyer 2000). Preventing plant invasions is especially difficult because their impacts are not easily recognised and support for management is not always forthcoming.

Eradication

Islands present unique opportunities to eradicate IAS – especially on small islands well away from other land areas. The range of animal and plant pests being targeted for eradication from islands is increasing – successful eradications for biodiversity conservation goals have now been undertaken on islands in most regions of the world. Many vertebrates have been successfully eradicated from islands around the world. Relatively fewer attempts have been made at eradicating invasive plants but the number of these is increasing (Rejmanek & Pitcairn 2002). In the Pacific, successful examples of plant eradications include the octopus tree (*Schefflera actinophylla*) from Palau, *Antigonon leptopus* from Niue, and Ivy gourd (*Coccinia grandis*), Jerusalem thorn (*Parkinsonia aculeata)* and fountain grass (*Pennisetum setaceum)* from Hawaii. Note, for plants the term eradication usually means control to zero density because of the persistence of the seed bank. It may take many years to reduce or eradicate an invasive plant. For example, an eradication programme targeted the parasitic weed *Striga asiatica* in North and South Carolina, has taken 45 years to reduce it down to very light occurrences(Rejmanek & Pitcairn 2002). Hence, it is critical to make provisions to get rid of new seedlings until the seed bank is depleted.

Provided appropriate surveillance procedures are in place it may be possible to identify potentially invasive plants soon after their arrival at a site, and remove every individual before they spread to establish viable populations. The principle of 'early detection & rapid response', which underpins most successful eradications, is particularly true in relation to invasive plants. Most successful weed eradications to date have involved them being detected early in the colonisation phase, and actions being taken to remove every individual as quickly as possible. For example, in New Zealand successful weed eradications (e.g. ragwort (*Senecio jacobaea*) and pampas grass *(Cortaderia* spp) on Raoul Island, lotus (*Lotus pedunculatus*) on Campbell Island and mist flower *(Ageratina riparia)* from the Poor Knights islands) were essentially situations where a few individual plants were found and promptly removed (Timmins & Braithwaite 2002, West 2002).

Many weeds are present in an area for some time before they develop into serious infestations (Mack *et al.* 2000). The "lag-phase" refers to a period early in the invasion process during which the density and total population size is low, and the rate of spread is comparatively slow. After the lag-phase there is a period of rapid increase in numbers and range. Eradication is likely to be most successful when started during the lag-phase when populations are small and localised. The feasibility of eradicating weeds declines rapidly with increasing area of weed infestation, to the point where some consider that eradication is unlikely for infestations greater than 100 hectares using current technology (Rejmanek & Pitcairn 2002).

Control

On larger islands, or at “mainland” sites where eradication is not feasible, control – limiting their distribution and/or reducing the densities – at selected sites may be the only management option to minimise the impacts of invasive plants. However, control regimes require on-going commitments to management and associated monitoring. For example, the sandbur (*Cenchrus echinatus*) was first documented at Laysan Island in the Hawaiian Islands National Wildlife Refuge, in 1961. By 1991 it had spread to become the dominant species over 30% of the vegetated area of the island. By displacing a native bunchgrass (*Eragrostis variabilis*), it diminished important breeding habitat for two endemic, endangered landbirds, as well as several species of indigenous seabirds and terrestrial arthropods. In 1991 Refuge staff started a year-round programme to eradicate *C. echinatus*. Application of glyphosate herbicide, combined with hand pulling, was the most effective strategy. The rate of finding new plants in a previously-cleared plot fell from as high as 85 plants per hour in autumn 1994 to 0.043 plants per hour (or one plant per 23 hours searching) in autumn 1999. This is seen as evidence that the seedbank is being depleted. *C. echinatus* is now so rare that it no longer affects the ecosystems of the island (Flint & Rehkemper 2002).

Summary

The CII is a global initiative whose focus is on managing the threats posed by IAS. In order to reduce the impacts of IAS, in both terrestrial and aquatic ecosystems, there is a need to develop and refine techniques to address a range of IAS in different habitats. These techniques need to be made available to appropriate agencies, through international and regional cooperation, so that lessons learnt in one country can be applied in another. Additional funding is also required to establish and maintain regional and national programmes to combat the harmful effects of invasive species.

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Posters

Checkclists and floras of invasive plants
/
Listes et flores de plantes envahissantes

Alien and invasive species in the Bulgarian flora - current state and challenges

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Currently the Bulgarian flora comprises some 3900 species. About 15% of these species are anthropophytes, of which 1/4 are archaeophytes, 1/4 neophytes and for 1/2 the present knowledge is insufficient to assess the exact time of entry in the country.

A subset of the neophytes are invasive and may or already threaten natural and semi-natural ecosystems. Recognising the crucial importance of this ecological problem, the Bulgarian Ministry of Environment and Water funded two projects at the end of 2004: 1) on the invasive plants and fungi and 2) on the invasive animals.

The overall goal of the invasive plant project is to strengthen the scientific basis for elaboration of a national strategy on invasive species and for recommending urgent measures for recovery of selected damaged populations and ecosystems.

The present knowledge and knowledge gaps about the alien and invasive plants in Bulgaria are discussed as well as the approaches and challenges in respect to: prioritisation of alien species according to their invasiveness, study of paths and means of entry in the country, information gathering and storage, field and experimental work, national legislation and raising public awareness.

Contribution to the knowledge on the invasive species in the flora of Montenegro

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Due to the fact that the flora of Montenegro is still incompletely known and partly studied, the most of efforts are put on field investigations of native flora of districts not included into Conspectus florae Montenegrinae (Rohlena, 1942), the most complete publication about flora of Montenegro.

At the beginning of 2000 started to grow the interest for the flora of human settlements, and the project: "The ecological and phytogeographical study of flora of the City Urban Area of Podgorica" has started. Special segment of this research is focused on aliens and invasive plants.

The major invaders are: *Ailanthus altissima, Amaranthus retroflexus, Chenopodium album, Conyza canadensis, C. bonariensis, Helianthemum tuberosum, Lepidium draba* and *Bidens subalternans.*

Examples of recent exotic invasive species in the Canarian archipelago, Spain

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There are about a hundred species of invasive plants at present in the Canarian Archipelago, Spain, as determined by a recent survey. This fragile island region, considered a tri-continental platform, has been under the influence of European culture, particularly the Mediterranean one, since it was introduced six centuries ago. Throughout modern times, its strategic position has meant a significant amount of change in its natural habitats, especially through progressive forestry and agricultural activities, such as the monoculture of species from other continents. As a consequence of this historical background, the passive and active invasion of all types of plant and animal species has aggravated in recent times. In addition, there are other factors: the exponential increase of the resident population (1.800.000 inhabitants), the decision to establish mass tourism as the main source of regional income, an unprecedented increase in the cultivation and propagation of hundreds of ornamental plant species and, ultimately, the lack of border control as regards the entrance of all types of living organisms. This situation has always favored the proliferation of invasive species, many of them becoming wild, occasionally in an alarming way, and becoming real plagues or bio-pollutants of natural protected areas, in which good samples of the autochthonous flora and potential phytocenosis still exist. Unfortunately, the control measures implemented by the local authorities are few and, at times, inefficient.

This poster shows the present localisation of *Escholzia californica, Pennisetum setaceum, Nasella neesiana* and *Maireana brevifolia* as examples of important recent invasions which have been registered chronologically with a certain degree of precision.

Exotic plant species in the Balearic Islands, Spain

Eva Moragues and Juan Rita
Spain

The invasions of exotic species constitute one of the most important current threats regarding the loss of biodiversity, especially in island environments. Man is the principal vector in the exotic plant dispersion. Many types of exotic vegetables have been introduced, and most of them have been included in our biota.

A first list of vascular exotic species which have been introduced in the Balearic Islands (Western Mediterranean basin) has been elaborated, identifying the most dangerous species. So far we have identified about 305 introduced species to be found, this means a 15,9 % of the total Balearic flora.

The most frequent alien origin was America (31,8 %), followed by the Mediterranean (18,4 %) and Africa (16,4 %). Besides, the most frequent life form of these aloctonous species are phanerophytes (34,4 %), followed in a not inconsiderable proportion by the annual cycle herbaceous species (therophytes) (29,5 %). This pattern is disharmonic when comparing it with the authoctonous flora which is characterised precisely by the scarcity of phanerophytes (8,4 %), especially trees, and a major proportion of therophytes (41,3 %). This disharmony shows that exotic flora does not arise from a group of plants taken at random from a wider source of Mediterranean origin, but rather that some life forms have been favored above others by selective forces. Trees and other large species were likely introduced for a specific use (ornamental, medicinal, forestry), while most annual species probably arrived as contaminants inside crop seeds.

Invasive alien plants in Croatia – Situation and vision

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No invasive alien plant species programme in Croatia is established yet. Additionally, there are no organised efforts in plant invaders inventory, monitoring or appropriate actions. However, national botanical community has been collected diverse botanical data (distribution, taxonomy, vegetation, biology, etc.) for centuries. In the recent times, index of Croatian vascular flora is developed as a taxonomic backbone for all activities and mapping standard is accepted and supported by GIS mapping tools. Also the Flora Croatica Database (http://hirc.botanic.hr/fcd/search.aspx) is fully operationally enable searching, remote data entering and on-line mapping. The majority of international standards are included. For invasive species the most of historical data are available or will be very soon. The steering committee must be established as coordination body inside the frame of Croatian Botanical Society and prepare Species Invasive Plants Monitoring Programme for national and international funds, as soon as possible.

Les plantes invasives des zones humides de la région de Jilel nord-est, Algérie

Mohammed Bouljedri, Boualem Mayache et Gérard De Belair
Algérie

De par son aire géographique et sa diversité bioclimatique, l'Algérie présente d'importantes potentialités en matière de biodiversité floristique répartie à l'échelle nationale sous différentes formes de végétations (arbres, arbustes, arbrisseaux, herbes). L'Algérie est donc parmi les pays de la Méditerranée qui occupent une place privilégiée comme réservoir phytogénétique.

La région de Jijel est la plus arrosée d'Algérie en raison de sa position la plus septentrionale de l'ensemble du pays. Elle constitue un carrefour bioclimatique qui favorise une grande diversité floristique particulièrement au niveau des zones humides.

Au fil des années cette flore s'enrichit par l'introduction de nouvelles espèces, dont la compétition prend très fréquemment l'aspect d'une lutte directe entre les végétaux. En effet, les espèces les mieux adaptées aux facteurs écologiques d'une station, celles qui présentent une croissance rapide et une aptitude à donner des peuplements denses sont favorisées par rapport aux autres (Ozenda 1982). Ces espèces peuvent poser de sérieux problèmes de concurrence et dégradent par conséquent la biodiversité par leur action colonisatrice du milieu.

Il est à signaler que l'Algérie ne dispose jusqu'à présent d'aucune liste officielle des plantes dites envahissantes, néanmoins des études sur la biodiversité des zones humides font ressortir un inventaire des espèces végétales en voie de disparition (De-belair & Samraoui 1998), sans faire allusion à l'action des espèces envahissantes.

Cependant, nos observations et nos prospections sur le terrain depuis quelques années nous ont conduit à constater que certaines espèces de plantes d'origines biogéographiques diverses présentent une grande faculté d'adaptation et un grand pouvoir de dissémination qui leur ont donné une chance d'acquérir une aire de distribution de plus en plus étendue et variée.

List of the 100 main alien plant species of Italy

Laura Celesti Grapow, Carlo Blasi, Giuseppe Brundu, Lucia Viegi and Ignazio Camarda
Italy

A project aimed at compiling a catalogue of the alien flora of Italy has been under way since 2004. Botanists, plant ecologists and local experts from each of the Italian administrative regions are participating in the project, with the following objectives:

– to organise the large amount of data accumulated on alien plant species in Italian territory over the last centuries into a comprehensive database;
– to report on the current state of non-native flora in Italy;
– to establish a basis for future research on plant invasion in the country.

The first result of the project is a list of the 100 most significant naturalised neophytes (alien plant species introduced after the year 1500) occurring outside cultivation in Italian territory.

For each species, data from Herbaria, literature and oriented field surveys have been collected in order to:

– establish basic background information, such as year of first introduction into the country;
– evaluate the immigration status, i.e. whether casual or naturalised, following the criteria proposed by Pyšek et al. (Taxon 53, 1, 2004);
– record habitat type, distribution and frequency in each of the Italian administrative regions, also for purposes of management.

100 of the World's worst invasive alien species

Michael Browne, Shyama Pagad and Sidharth Pagad
IUCN SSC Invasive Species Specialist Group (ISSG), New Zealand

The "100 of the World's Worst Invasive Alien Species" booklet is designed to enhance awareness of the fascinating complexity, and also the terrible consequences, of invasive alien species. Species were selected for the list according to two criteria: their serious impact on biological diversity and/or human activities, and their illustration of important issues surrounding biological invasion. To ensure the inclusion of a wide variety of examples, only one species from each genus was selected.

There are many other invasive alien species, in addition to those on this list of examples. Absence from the list does not imply that a species poses a lesser threat. We hope that, by raising general awareness, the risks of further harmful invasions will be reduced in future. The Global Invasive Species Database (www.issg.org/database) contains further information on these and many other alien invasive species. 12,000 copies of the booklet have been printed and distributed to date. Development of the list was made possible by the Fondation d'entreprise TOTAL. It has been translated into Spanish, French and Vietnamese (by IUCN Viet Nam).

Naturalisation of exotic plants in the Leucate region, France, Department Aude – history, distribution and model of naturalisation

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Geographisches Institut der Universität Mannheim, Germany

The area of Leucate (Corbières maritimes, Cap Leucate) including the Lido between the lagoon (Etang de Leucate) and the open sea can be considered as a hotspot of naturalisation of exotic plants in Mediterranean France. History of naturalisation in the area – and the actual distribution of some selected plants as *Saccharum spontaneum, Cortaderia selloana, Pittosporum tobira, Solanum mauritianum, Caesalpinia gilliesii* are presented. A special focus is led on the environmental consequences of the naturalisation of *Saccharum spontaneum* – and questions whether this naturalization could be linked to "Global warming". Finally a regional geohistorical model of plant naturalisation of subtropical and tropical origin is presented.

Naturalised exotic flora of Sardinia, Italy

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Dept. of Botany and Plant Ecology, University of Sassari, Italy

The first inventory of the alien flora of the island of Sardinia (Italy), was completed in the beginning of 2000 by the Dept. of Botany and Plant Ecology of the University of Sassari. The project was funded by the Nature Conservation Service of the Italian Ministry of the Environment. This first catalogue and the accompanying geo-database have been updated in the following years in the framework of the EU funded project EPIDEMIE. The Sardinian plant allodiversity was highly underestimated in the previous existing studies, mainly based on bibliographic records and herbarium samples. This first comprehensive inventory was compiled using historical data and oriented field GPS surveys. The total number includes all alien species ever recorded or surveyed in the territory of the Region, including cultivated species, ephemeral species, ornamentals, alien species recorded in garden centres, forest nurseries, etc.

The mapping part of the projects addressed the distribution of only a selected set of 110 alien species (i.e. a subset of the naturalised and/or invasive pool). We adopted a mixed vector-raster encoding approach, i.e. recording coordinate features of species location and leaving to GIS software the possibility of raster conversion and frequency estimates or other biodiversity measures, according to a grid of 310 cells (10 x 10 km), covering all the Sardinian territory. The outcoming distribution patterns have been empirically ranked in 8 categories according to the total number of records, to the total number of occupied cells, to the spatial distribution of the occupied cells and to the GIS topology of alien communities.

Plant diversity of Bulgaria and invasive alien species

Rayna Hardalova
Ministry of Environment and Water, Bulgaria

The plant diversity of Bulgaria is evaluated of about 3 700 vascular plants and more than 6 500 species of non vascular plants and fungi. The endemic plants figure out at 4,8% of the country flora. About 700 species of vascular plants are estimated as rare and endangered. The most frequent reason for it are the habitat destruction and ecological condition change.

During the last years an additional threat from Invasive Alien Species competing the native species has occurred as well. Recognising this threat, the Ministry of Environment and Water in collaboration with the authorities for phyto-sanitary control and scientists have undertaken actions for systematising of the existing information and for determining of the most suitable strategies for alien plants restriction. In this regard, legislative, administrative and practical measures are undertaken, especially toward the invasive species. Elaboration of a national Strategy for Invasive Alien Species is forthcoming.

Plant invaders in coastal Slovenia

Nejc Jogan
University of Ljubljana, Slovenia

In the territory of Coastal Slovenia about 20 plant species (further: SPI) are invaders in the narrower sense. That means that they are non-native and perfectly naturalised in natural or semi-natural habitat types where they are outcompeting the native flora and so radically changing the structure of the habitat. They were brought to Slovenia or neighbouring countries at least half a century ago incidentally or deliberately (as ornamentals or other cultivated plants). In about one third of SPI first records of their occurrence in the wild are more than a century old but in majority of them quick expansion of populations took place in the last 50 years.

The most "invasion prone" habitats are riverine ecosystems and disturbed submediterranean forest, where in certain areas we could not recognise the native vegetation anymore because it has been completely replaced by a neophytic plant community. About 2/3 of SPI are native to North America and about 1/3 to E Asia where they are quite widespread in similar climatic conditions. One third of SPI are phanerophytes and just a bit less hemicryptophytes and therophytes, respectively.

Some new neophytes for the North East of Morocco

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Recent field explorations in the middle and low Moulouya Valley (E Morocco) have revealed the presence of some new Chenopodiaceae for the flora of Morocco. These species are: *Suaeda aegyptiaca, Atriplex suberecta, Atriplex semibaccata* and *Bassia scoparia*. The latter three are clearly neophytes, escaped from cultivation in many cases, while the former is a native species of all countries eastward from Libya to Pakistan. This Suaeda is an invasive therophyte that grows on fields ruined after irrational irrigation practices, as well as a regular component of wadis and naturally disturbed places. We discuss if this Suaeda, here cited for first time for the Magreb countries, is a recently introduced species or a native Moroccan plant.

The two species of Atriplex, both native from South Australia, are nowadays expanding invasive plants. *A. semibaccata* is widespread in South Australia usually found in heavy soil, sometimes slightly saline, and is frequently an invader of disturbed areas. Many localities with similar conditions exist in NE Morocco, where this species seems to be quite common, but few mentions of this plant are made in recent floras. *Atriplex suberecta* appears to be much rarer and is cited here for first time. *Bassia scoparia* has been included in almost all recent floras but we know of very few localities or herbarium sheets.

The Global Invasive Species Database (GISD)

Michael Browne, Shyama Pagad
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The Global Invasive Species Database (GISD) provides a broad audience with easy access to authoritative information on invasive alien species (IAS). It disseminates globally sourced information, including good practice, case studies, specialist's knowledge and experience. Species information is supplied or reviewed by expert contributors from around the world and includes: biology, ecology, distribution, management information, references, contacts, links and images. The database has a dual aim: to raise awareness about invasive alien species, their impacts, and the opportunities to fight back; and to be a management tool assisting decision makers, practitioners and communities to address their IAS problems. The GISD contains profiles of more than 300 species that threaten biodiversity, ranging from micro-organisms to plants and animals, terrestrial as well as aquatic. It currently receives an average of 40,000 hits/day (900 unique visitors/day). The GISD project has been remarkably successful thanks to the voluntary work of invasive species specialists from all over the world. Please visit our website at www.issg.org/database.

Managed by the Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission (SSC).

Legislation on invasive plants

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Législation relative aux plantes envahissantes

Plants as quarantine pests. Integration of French overseas departments specificities to the EU phyto-sanitary regulation system using an adapted PRA scheme

Pierre Ehret and Romain Camou
France

Alien plants are not yet considered as quarantine pests for the European Union, except for parasitic plants. French overseas departments, European outermost regions have however already integrated a few weeds in their quarantine list.

As the EU Council Directive 2000/29/CE (plant health regulation for EU) also concerns the protective measures against the introductions of harmful organisms into the French overseas departments, a great number of quarantine pests were the subject of pest risk assessments. In 2005, with the help of EU Poseidom funding, a new set of pest risk assessments will be conducted on alien plants.

After having merged the list of noxious weeds of other tropical and sub-tropical countries, and put aside the already present plants, the risk analysis will be conducted for a first selection of weeds suspected to be noxious either to main agricultural productions or to endangered ecosystems and native flora.

Pest risk assessment standards have already been adapted to alien plants and this exercise will help to find out how the technical justifications for import prohibitions and other regulations will be justified for this new kind of quarantine organisms in the European context.

The state of regulations on import/export of native species in Lebanon and the related threats in terms of invasive species

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National Center for Remote Sensing / National Council for Scientific Research, Lebanon

The ongoing policies in Lebanon thoroughly regulate the exportation of plant materials namely Cedar seedlings and seeds as well as wild aromatic species such as *Salvia triloba, Origanum syriacum* and *Ferula sp*. Whereas the importation of ornamental plants and foreign species is totally uncommitted to any kind of rules except for the regular quarantine upon reception. Moreover, despite the fact that plant biodiversity is very high in Lebanon (3800 species), the native flora is little known and few persons are able to distinguish plants at species level. This state of art makes our local vegetation very vulnerable to any introduction of potentially invasive species either for horticulture, agriculture or land management purposes. On the other hand, on the national level, few or no studies have ever dealt with invasive species and the only alien species mentioned is the Eucalyptus tree which is still considered locally as an "ecological" introduction. It seems thus alarmingly important to increase local awareness on the threats related to invasive species and to initiate the conception of a list of potentially invasive species as well as on priority basis improve people knowledge and expertise on the local flora.

Communication

Building community-based networks for the early detection of invasive plants

Peter Martin, Jane Morton and Kate Blood
Weeds CRC, Australia

Weeds cost the Australian economy over $4 billion per year. However, despite State government regulations and procedures, new species continue to appear and establish unrecognised, bringing substantial and long-term economic and environmental costs.

Whilst high levels of expertise in weed identification exist in herbaria and other government agencies, the number of skilled individuals involved is generally too low to be effective in preventing new weed incursions. In addition, once these plants are well established, resources are typically inadequate to control them, let alone eradicate them.

However, within communities across rural Australia, as in the cities, there are often many individuals with relatively high levels of botanical expertise whose skills and interests are rarely employed in the fight to prevent new weed incursions. They may be in current jobs, retired, or accomplished amateurs.

Using Queensland as a model for a possible national framework, this project aims to identify, develop and train a community-based network focused on the detection of new weed incursions. To this end the Weeds CRC is collaborating with the Queensland Herbarium, which is providing the home base and technical support for the new project. The CRC is providing guidance in project design and scientific matters, and ensures that the community liaison and network building required is well managed.

The paper will outline the project plan and review progress since the project began in May 2004. It will also outline progress with a similar 'Weed Spotter' project being developed by the State Government of Victoria.

Biology and conservation

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Biologie et conservation

Competition between the invasive species *Carpobrotus edulis* and the endemic species *Limonium emarginatum* in Gibraltar Straight

Orlando Garzón, Jesús M. Castillo and M. Enrique Figueroa
Spain

Carpobrotus edulis has been introduced on the coastline of the Straight of Gibraltar in Algeciras, Tarifa and Gibraltar. This neophyte is invading coastal cliffs and dunes where it is competing with different endemic plants, among them *Limonium emarginatum*, a protected species with a very restricted geographical distribution. We studied competitive interactions between *L. emarginatum* and *C. edulis* by analysing geographical and local distributions, habitats abiotic characteristics, root development, biomass production and solar radiation access for both species. Our results show that *C. edulis* is removing *L. emarginatum* at higher topographical levels in populations settled on both coastal dunes and cliffs, becoming a great deal for the conservation of this species.

Differences in salinity tolerance between *Spartinia densiflora* populations, an invasive cordgrass in SW Iberian Peninsula

Jesús M. Castillo, M. Enrique Figueroa, Pablo Leira, Enrique Mateos-Naranjo and Susana Redondo
Deparment of Plant Biology and Ecology, University of Seville, Spain

Spartina densiflora Brongn. is an exotic species with a South American origin. In its original area of distribution it appears from Patagonia to Brazil, and it is invading Europe, Northwest Africa and North America. This work aims to compare salinity tolerance in four *S. densiflora* populations from contrasting ecogeographic situations: a Patagonian low salt marsh (Quiroga Island, Santa Cruz, Argentina), an inland salt marsh (Mar Chiquita, Cordoba, Argentina), a brackish marsh (Lagoa dos Patos, Rio Grande do Sul, Brazil) and an European middle salt marsh (Odiel marshes, Huelva).

Our results may help to understand invasion mechanisms of cordgrasses. We have analysed leaf growth, chlorophyll fluorescence, water potential and leaf gas exchange in *S. densiflora* plants from these populations that were grown at three salinity treatments (0.5, 20 and 40 g/l). The experiment was carried out during 75 days in a greenhouse with controlled conditions. In the genus Spartina, population differentiation in salinity tolerance has been identified in *Spartina* paterns, a brackish marsh species, and *Spartina alterniflora*, a low salt marsh species, but our results seem to show no significant differences between populations in each of the analyzed variables. However, *S. densiflora* invades a wide range of habitats with contrasted salinities.

Different ploidy levels could explain reproductive matter of invasive *Oxalis pes-caprae* L. in Mediterranean Regions

Sílvia Castro, João Loureiro, Conceição Santos, Garbiñe Ayensa and Luis Navarro
Spain

Oxalis pes-caprae L. is a native plant from South Africa and it was introduced in several areas of the world, especially in the Mediterranean climate regions such as Mediterranean basin, parts of Australia and California, where it is a widespread invasive weed. This species is tristylous (with long-, mid- and short-styled floral forms) in its native habitat and it presents a self- and morph-incompatibility reproduction system. In the exotic range of distribution the short-styled morphotype is dominant and reproduces mainly asexually by bulbils. In this study 21 populations were sampled along a transect through the Iberian Peninsula. In three of the populations studied two morphotypes (short- and long-styled) were detected. No fruit and seed set were observed in all the analysed populations. The flow cytometry technique as an innovative and rapid approach to study ploidy level and nuclear DNA content was applied to the populations where the different morphotypes were detected. Ploidy differences between short and long-styled plants were observed. These differences could explain *O. pes-caprae* incapacity of sexually reproducing in many places throughout its exotic range. Its asexual reproduction system gives it a high spreading capacity that transforms it in a problematic invasive plant.

Exotic plants in temperate forest of Chile: pattern, processes and implications for conservation

Pablo Becerra and Ramiro Bustamante
Universidad de Chile, Chile

Plant invasion by exotic plant is regarded a threat to biodiversity, being humans the main drivers of this invasive process. Faced to this increasing threat it is mandatory to know the "site" conditions that will enhance (or inhibit) plant invasion. In this work, we evaluated some attributes of vegetation that explain the diversity of exotic species yet existing in sclerophilous and temperate forest of Central Chile: cover of native trees, cover native species, richness of native species, precipitation and pool of exotic plants available for invasion. We used data published by phytosociological studies. For a within-community analyse we used data of eight communities and for the between-communities analysis we used data of eleven communities. We used stepwise regression analysis and we found that tree cover and cover of the total of native species were negatively related with the richness of exotic species. In a between-communities analysis, precipitation (positive relation), richness of native species (positive relation) and cover of native trees (negative relation) were the most important variables to explain the diversity of exotic species.

In conclusion, simple structural variables are necessary to predict the magnitude of invasion by exotic plants. This study provides a tool to forecast and eventually prevent the magnitude and extent of plant invasion in native forests.

Habitat distribution of exotic plant species on Mallorca Island

Eva Moragues and Juan Rita
Spain

The Balearic Islands archipelago is situated in the western basin of the Mediterranean Sea; it is made up of four main islands, the largest of which is Mallorca. The presence of alien species typical of other continents, and Mediterranean species whose recent arrival on the island has been recognised, makes it possible to identify a part of the flora which is unmistakably of aloctonous origin.

The naturalised and sub-spontaneous exotic flora has been classified and characterised, and also indexes have been tried out to value both the danger degree of each of these species, as the invasion sensitivity of the islands main habitats.

The 15,9 % of Mallorca's whole flora are naturalised or sub-spontaneous species, but only a 9,5 % could be considered as naturalised in a very broad sense. Mediterranean ecosystems are resistant to the invasion of exotic species, but it is also likely that there is a certain infra-valuation of these species since many of them, of Mediterranean origin, could have been introduced by humans in very ancient times. At the moment we are not able to discriminate them from those existing before man's arrival.

The most sensitive environments to invasion of exotic species are, in order of importance: roadsides, dry river beds, crop fields, and to a lesser extent rocky coasts, wetlands and dune systems. Very low infestation values have been found in woody communities, such as forests and shrubs. It would appear that in our Mediterranean islands the most mature, stable environments seem to be exceedingly resistant to invasion, whereas the open and/or permanently disturbed habitats are the most sensitive to be invaded by exotic species.

Invasive adventive species in Serbia – a threatening factor for the natural diversity of flora and vegetation

Olga Vasic
Natural History Museum Belgrade, Serbia and Montenegro

A hundred or so adventive plants present in Serbian flora, only few being invasive, may seem almost insignificant when compared with over 4000 autochthonous species and subspecies. However, the role of invasive species in threatening cultivated plants and natural diversity of autochthonous flora is far from insignificant. The degree of distribution, increased spreading intensity in last several years, population density and occupation of devastated habitats of autochthonous vegetation, show the troublesome ecological and biological advantage of these species and their absence of natural competition relationships. The most alarming example is *Ailanthus altissima* that starting from urban areas spread sub-spontaneously conquering the devastated areas along roads, and afterwards spontaneously penetrating even into naturally closed gorges and canyons vegetation. *Amorpha fruticosa, Asclepias syriaca, Echinocystis lobata* and *Solidago gigantea* spread mostly along river courses, and sometimes completely suppress autochthonous species or take over the dominant role.

The survival of autochthonous species is threatened or prevented, and there are changes in the natural structure, character and successions of vegetation that originally grew in such habitats. All these species were, in different time periods and for various reasons, introduced on purpose in the Serbian territory, but without any previous study or estimate of their behavior in the new environment, and without maintaining the mechanisms of control, limiting and suppressing the unwanted spreading.

Programme for the spreading of the reinforcement strategies of the autochthonous flora in front of the threat represented by invading plants in the coastal region of Xeraco (Valencia, Spain)

Christian Lurbe Puerto and María Pilar Donat Torres
Universidad Politécnica de Valencia, Spain

Different species of invading plants were introduced by private and public institutions in the last decades in the coastal regions of Valencia. The present work presents a programme of strategies adopted to avoid this threat and to reinforce the autochthonous flora.

The first step consisted in a detailed analysis of the autochthonous and allochtonous flora, completed with cartographic and vegetation studies. The stage and status of conservation of the taxa was also considered.

The study followed the classical phytosociological method of Braun-Blanquet and the methods included in the Handbook of Interpretation of Habitats for the design of the spreading campaign. First the interpretative-demonstrative capacity of the existent plant resources was evaluated and the fundamental topics of the message to be transmitted to the public were chosen. In a second step, the human and material resources available were identified. Finally, a code of conduct was elaborated in agreement with all institutions involved.

Spread from plantations: Spatial pattern of colonisation by the ornamental plant *Cortaderia selloana* in Southern France

Anne Charpentier
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We analysed the spatial distribution of ornamental plantations and colonising (self-sown) stands of *Cortaderia selloana* in the Rhone delta, Southern France (surface area: 77 000 ha).

The ornamental plantations and colonising stands were mapped using distance sampling method from census points along roadsides, and the data stored as Geographic Information System (GIS) layers. The spatial distribution of plantations reflected the urbanisation pattern of the study area. About 80% of the planted individuals (out of a total of 1173) were concentrated in the 3 main urbanized areas, while the rest of them were disseminated over the countryside in the gardens of isolated houses. The total number of colonising individuals was by 3 times higher than the total number of planted individuals. The spatial distribution of colonising stands was strongly correlated with the pattern of plantations. About 70% of the colonising individuals were located around the 3 villages. Nevertheless, the spread of colonising stands in the countryside also suggests long distance dispersal events. *Cortaderia selloana* was found to be colonising a large variety of semi-natural habitats (gardens, abandoned fields, hedges, canal banks, roadsides). Furthermore, few colonising individuals were in natural habitats, mainly consisting in grasslands. Considering the current diffusion of *Cortaderia selloana* from urbanised areas to the countryside via a large range of habitats largely available all over the study area, we suspect that *Cortaderia selloana* is probably at an early stage of colonisation and we expect a future expansion of this species.

Understanding the invasion of *Spartinia densiflora* in SW Iberian Peninsula through ecophysiological data

Jesús Manuel Castillo, M. Enrique Figueroa, Pablo Leira, Enrique Mateos-Naranjo, Juan Cosano and Susana Redondo
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Spartinia densiflora Brongn. is an invasive cordgrass in tidal marshes of SW Iberian Peninsula. Its invasion results in a drastic decrease in biodiversity of plant communities. A major concern within the present scenario is whether it might continue the invasion going up the rivers where it gets in contact with autochthonous glycophytes. In order to compare physiological traits of Spartina species and glycophytes, *S. densiflora, Spartina ciliata* (a species of the genus which grows in sand dunes in Brazil), and two glycophytes widely represented in riparian communities of SW Iberian Peninsula, *Typha dominguensis* and *Phragmites australis* were cultivated in three salinity treatments (0.5, 20 and 40 g/l) in a greenhouse for nine months and chlorophyll fluorescence, leaf gas exchange and leaf growth were recorded. In the 0,5 g/l treatment, the Spartina species showed lower fluorescence levels than those of glycophytes and higher photoinhibition and nonphotochemical quenching. Both Spartina species showed higher net photosynthesis rates at radiation c. 1500 µE/ m2 s than glycophytes and these differences disappeared at lower radiations. Net photosynthesis rates of Spartinas were negative at radiation lower than 50 µE/ m2 s. These physiological responses may explain why *S. densiflora* don’t settle on those places where glycophytes already grow, due to the shade effect of their canopy.

Global initiatives
/
Initiatives globales

Addressing globally the study and management of plant invasions

John N. Brock, Giuseppe Brundu, Lois E. Child, Carol Horvitz, Sandy Lloyd, Petr Pyšekand and Barbara Tokarska-Guzik
USA, Italy, United Kingdom, Australia, Czech Republic, Poland

EMAPi acronym stands for a series of International Conferences on the Ecology and Management of Alien Plant Invasions held biennially since 1992. The first conference, held in Loughborough, UK brought together the latest research and thinking on IAS within Europe. Since then, the conference has widened its scope having been hosted in Kostelec nad Cernymi lesy, Czech Republic; Tempe, Arizona USA; Berlin, Germany; La Maddalena, Sardinia Italy; Loughborough, UK; Ft. Lauderdale, Florida, USA. The number of participating countries and organisations has increased steadily over the years as an indication of the world wide importance of plant invasions and the need to network globally to exchange research outcomes, ideas and best practice in the management of invasive plants. It is against this background that academics, land managers, contractors and researchers need to exchange information, share knowledge and create best practice guidelines for detecting, preventing further spread, mapping, monitoring, managing and eradicating invasive species. With the increasing global concern for biological diversity, the understanding of IAS and their effects continues to be of prime importance in the study of environmental conservation.

The eighth conference in the EMAPi series will be held in Katowice, Poland in 2005 and the ninth to be held in Perth, Australia in 2007 will provide further opportunities to share knowledge on the ecology of individual species and continue discussions on best management practice. Abstracts of papers presented at the conferences are available to download on the IAS web pages at: http://www.lboro. ac.uk/research/cens/ invasives. index.htm. Selections of peer reviewed papers presented at the EMAPi conferences have been published in the series “Plant Invasions” (Backhuys Publ. Leiden, The Netherlands) and, occasionally, on international journals.

Are invasive plant species a problem in aquatic eco-systems of Portugal?

Francisca Aguiar, Maria Teresa Ferreira, Ilídio Moreira and Maria Cristina Duarte
Portugal

Riparian and aquatic ecosystems are amongst the more vulnerable habitats in the world to the invasion by exotic plants, and Portuguese ecosystems are not an exception. From the approximately 600 taxa that can occur in aquatic environments (i.e hydrophytes, helophytes and hygrophytes), 139 are exotic species, though only 17 are considered invaders or potential invaders. Some of these species are included in various lists of the world´s worst weeds. On a local basis, exotic species richness is generally low however its cover and biomass can be extremely high. Several plants only invade rice fields and related banksides (e.g. *Ammannia x coccinea, Echinochloa oryzicola*), while others such as the water-hyacinth (*Eicchornia crassipes*) and the parrot-feather (*Myriophyllum aquaticum*) affect multiple ecosystems including watercourses, drainage and irrigation channels, reservoirs, swamps and marshes, and can be very detrimental both as environmental weeds and to human activities. Some species are widely distributed in Portugal, such as the giant-reed (*Arundo donax*) and the knotgrass (*Paspalum distichum*), whereas others have a restricted distribution (e.g. *Eryngium pandanifolium*) or develop plant blooms under specific environmental conditions (i.e *Azolla filiculoides*). Wetland and pond reserves have also become heavily infested with exotic invaders, which are responsible for native displacement and other alterations on the ecosystem's structure and functions. We provide an overview of the existing invasive weed problems in aquatic ecosystems in Portugal and a summary of the case studies that were carried out in the last two decades in Portugal.

Study on invasive plants in the Mediterranean Basin

Sarah Brunel and Jean-Marc Tison
Conservatoire Botanique National Méditerranéen de Porquerolles, France

This preliminary study on invasive plants in the Mediterranean basin highlights:

- A great heterogeneity concerning the definition of “invasive plants”.
- The Mediterranean Basin has made less progress studying the topic of invasive plants compared to other Mediterranean countries (Chile excepted). Many countries have no data available on invasive plants (Lebanon, Syria), other countries only begin actions and programmes (Bulgaria, Croatia, …).
- Many research studies are undertaken, but few take into account the horticulture and landscape professions or communication with the public (education programmes, press release, …).
- Two species are considered to be highly invasive: *Carpobrotus sp.* in the northern coastal region of the Mediterranean sea and *Solanum elaeagnifolium* in the southern coastal region.

The invasive plant programme in the French Mediterranean area

Sarah Brunel
Conservatoire Botanique National Méditerranéen de Porquerolles, France

The Conservatoire Botanique National Méditerranéen de Porquerolles has been running since 2001 the first programme taking into account invasive plants in a global way. It concerns the french mediterranean area, this is to say the regions Languedoc-Roussillon, Provence-Alpes-Côte d'Azur and Corsica.
The programme aims at :

- surveying major and emerging invaders in the country;
- collecting on-field information by network observers composed by land managers and volunteers. Data are stored in a database and restitued as maps;
- managing invasive plants with partners;
- bringing information and technical support to land managers confronted with invasions. The Conservatoire Botanique is the initiator of innovative managements actions (biological control, eradication);
- developing a partnership with horticulture and landscape professionals. Many plants judged as invasive are traded. Professionals producing, selling and planting these species have to be aware of the problem and to be associated to find appropriated solutions. We elaborated with these professionals the document « Invasive plants in the Mediterranean area » and the project is in course to propose alternative species to replace invasive plants in trade;
- communicating on invasive plants for different publics. Research results and studies in progress are brought via the media, the diffusion of documentation and the internet site www.ame-lr.org/plantes-envahissantes.

Weed biocontrol: will Europe ever catch up?

Richard H. Shaw and Djamila Djeddour
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Biological control is recognised as one of the most sustainable means of controlling invasive weeds worldwide. By using coevolved arthropods and pathogens from the pest's area of origin, practitioners are often able to redress the inbalance in nature brought about in the main by human activities. Such use of natural enemies is certainly common practice in most of the Mediterranean-type habitats with one notable exception. No biocontrol agent has ever been released against a weed target in a European country yet these countries have been the source for many of the releases in the past hundred years. This is even more remarkable given the breadth of knowledge and expertise that exists on European soil. The reasons for this slow take up are discussed and particular attention is paid to the confused and occasionally illogical regulatory environment.

Biology and management of invasive plants
/
Biologie et gestion des plantes envahissantes

Advances in implementing integrated invasive plant management to control aquatic weeds in Portugal

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We present a summary of the management efforts that are being done to control aquatic invasive species in Portugal, with emphasis to the water hyacinth (*Eicchornia crassipes*) and to the parrot feather (*Myriophyllum aquaticum*). Water hyacinth is widespread in watercourses and in drainage and irrigation channels of Central Portugal, and also in the Biosphere Reserve of Paúl de Boquilobo (NE Lisbon). The parrot feather occupies extensive areas in the Mondego and Vouga rivers (West of Portugal) and the related irrigation channels, and also in protected wetlands. Recent research includes promising long-term control methods, namely the biological control combined with the mechanical and chemical control.

Biocontrol agents of an annual grass (*Taeniatherum caput-medusae*)

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Medusahead ryegrass is the common name of *Taeniatherum caput-medusae subsp. asperum* (L.) Nevski. This winter annual grass has its origins in areas bordering the Mediterranean Sea extending to central Asia and has been introduced into the US in the late 1880s. Currently, it infests millions of hectares of rangelands and pastures, primarily in California, Colorado, Nevada, Oregon, and Utah. Medusahead crowds out native plant species and is almost worthless as forage. In the Mediterranean basin, It occurs naturally on dry rocky slopes (France, Turkey, Ukraine, Greece), but is also found on elevated plateaus (Morocco, Turkey, Spain). It is always found in non-disturbed soil, in wild areas or in crops abandoned for several years, like vineyards. In the U.S., current management strategies have been ineffective. For the first time, a study examines biological control, through the use of plant pathogens, as a possible management strategy. Aims are to identify countries of origin of medusahead, to observe and collect any candidate biological control agents and conduct host range testing. This paper presents a 4-year survey in 9 Mediterranean countries. Four different pathogenic fungi were found associated with medusahead, e.g. 2 smut fungi, (*Ustilago phrygica* and *Tilletia bornmuelleri*), 1 *Fusarium arthrosporioides*, and 1 rust fungus, *Puccinia graminis* var stackmanii. To date, preliminary host range testing with *U. phrygica* revealed a close association to the target weed, and no cross contamination with grasses of economic importance, such as wheat, barley, oat, and rye.

Biological and ecological study of an allergenic European invasive plant: *Ambrosia artemisiifolia* L.

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France

Biological invasions affect dramatically environment and human activities. The global cost associated to invasive species may amount billion euros per years.

Among invasives, Common ragweed (*Ambrosia artemisiifolia* L.) (Asteraceae), a weed imported from North America, has become an important issue in Europe. This plant is considered as a weed for spring crops as sunflower but also causes great troubles for human health by its abundant allergenic pollen release. In North America, Common ragweed is the first cause of hay fever. Moreover, this species is well adapted to a wide range of areas such as cultivated fields, open disturbed habitats, rivers or roadsides.

Many studies were carried out on human health impacts of pollinosis but comparatively only few punctual data are available on its biology and ecology, in particular for European populations.

We started a study to investigate their comparative demography across the range of colonised habitats in France for this species. The capacity to grow in such environments, described by development parameters as dry shoot mass, was analysed in regard to plant fitness. Our preliminary results suggest a high variability of life history traits according to the different representative habitats analysed. More precisely, plants from cultivated fields showed different patterns than other environments for density evolution and growth parameters. These preliminary data will help us to understand the adaptive strategies of this invasive plant but also the factors that control populations with management perspectives kept in mind.

Biology, ecology and management of *Centaurea solstitialis* in California

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Yellow starthistle (*Centaurea solstitialis*) was thought to be introduced from Eurasia to California as an alfalfa seed contaminant in 1949 during the Gold Rush era. Today, it is estimated to cover over 6 million hectares in California, and an additional two to three million hectares in the other western states. In California, yellow starthistle is the most important and widespread invasive species and is found in open areas on roadsides, rangeland, wildlands, hay fields, and pastures. Plants are highly competitive and form dense infestations with deep root systems that rapidly deplete soil moisture and prevent the establishment of other species. Starthistle is also poisonous to horses, causing a nervous disorder called chewing disease. A number of control strategies are effective, including integrated approaches. For example, late season tillage can detach roots from shoots and prevent recovery. Timely mowing on plants with a high branching pattern can be effective. Sheep, goats or cattle grazing before spines form but after bolting can also suppress populations. Prescribed burning at the initiation of flowering can kill plants before new seed are produced. Several biocontrol agents (six insects and one pathogen) have been introduced from the Mediterranean region to control yellow starthistle.

These organisms provide some reduction in seed production, but do not, by themselves, provide adequate management. Both postemergent and preemergent herbicides are available to control starthistle, with clopyralid and picloram showing the greatest success. Integrated approaches have also proved successful, including combinations of burning and herbicides or legume or perennial grass re-seeding.

Biology, ecology and management of *Taeniatherum caput-medusae* in California

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Medusahead (*Taeniatherum caput-medusae*) is a European native adapted to the semi-arid climate predominant in the western United States. It was first introduced to the US as a seed contaminant around 1887 and now occupies about a half million hectare of annual-dominated grassland, oak woodland, and chaparral communities. The high silica content can reduce livestock forage by as much as 75%, and can also slow the rate of tissue decomposition, leading to heavy litter build-up that may remain intact for two or more years. The water use efficiency of medusahead is not as great as other invasive annual grasses, but its thatch layer excludes other species and can lead to monotypic stands. For this reason, medusahead is considered one of the greatest threats to biodiversity in wildlands. Removing the thatch by either tillage or mowing in the fall can reduce the competitiveness of medusahead and provide better than 50% reduction the following year. Mid-spring sheep grazing can also reduce medusahead by greater than 80%. Since medusahead matures about two or more weeks later than most range species, timely controlled burns can provide selective and very effective control of the exposed seedheads. Integrated approaches can also be effective. For example, when thatch layers can be reduced by late season grazing, disking, mowing or burning, a fall application of the herbicide imazapic can give excellent control. Similarly, a combination of late spring prescribed burning followed by fall imazapic treatment is also very effective and may even provide complete control.

Contribution for the management of dune ecosystems invaded by *Acacia longifolia* (Andrews) Wild: a case study from Portugal

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Portugal

One of the most threatening invasive plant species in the Portuguese dune ecosystems is Sydney golden wattle (*Acacia longifolia* (Andrews) Willd). This species was planted at the beginning of 20th century to curb sand erosion but has now proliferated, generally after fires, causing significant negative ecological impacts. In the context of a research project (INVADER www.uc.pt/invasoras), experimental areas in a Natural Reserve are being used to evaluate efficiency of control methodologies (mechanical and biological control) and to assess recovery potential at soil, seed and vegetation level.

First results show that *A. longifolia*, despite not resprouting in some situations, can sprout vigorously after cutting. High re-invasion potential, due to both resprouting and germination, associated to elevated costs, demand other kinds of control to be taken into account. Biological control is being tested in quarantine conditions, and if proven safe will permit a more sustainable control. The biocontrol agent considered is monospecific, feeds on *A. longifolia* floral buds, preventing seed formation, and to a less extent on foliar buds. Both strategies will ultimately weaken the trees, contributing to improve the efficiency of control measures. The studies at soil, seeds and vegetation level are making available an important set of data to the evaluation of the recovery potential in this system, which will be essential for the proposal of a coherent post-control restoration plan.

This local scale results will be discussed considering their use in broader scales along the Portuguese coastal areas, namely in a potential management plan for *A. longifolia* control.

Control of *Pistia stratiotes* near Doñana Natural Park (SW Spain)

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Spain

Pistia stratiotes (Araceae), a tropical aquatic-floating weed that invades channels and wetlands has now been recorded throughout 35000m2 in SW Spain. Given the risk this species represents for native wetlands, a Control Program has been initiated based on the physical removing -by hand and machinery- and specific application of low-impact herbicide if necessary. The eradication is being undertaken within the Andalusian Program for the Control of Invasive Exotics (Plan Andaluz para el Control de las Especies Exóticas Invasoras).

This initiative of the Regional Environmental Council of Andalusia (Consejería de Medio Ambiente), who co-funds (together with the EU), directs the works and technical planning through the experts and scientists within the staff, counts with the cooperation of partners from research and academic centres, acting as assessors on specific topics. This approach brings together the financial resources and experience in environmental management harboured by the Public Administration and the necessary scientific knowledge to face ecological complexity of the case.

Pronounced slopes of the channels borders, limitations for the extensive -instead of specific- use of herbicides and absence of previous experiences or studies on the species in Spain are the main difficulties to manage *Pistia* invasion.

Developing management strategies for *Lepidium latifolium* in sensitive areas near water

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Lepidium latifolium is a herbaceous perennial that is establishing large populations along riparian corridors, riverbanks, floodplains, and wetland habitats throughout the western United States. While herbicides exist that are effective in managing this pest, they are not registered for use in areas near water. Research was conducted to develop management plans for *L. latifolium* in these areas. *L. latifolium* suppression and recovery of resident vegetation was documented with integrated approaches including disking, mowing and/or herbicides registered for use in areas near water. Cultural techniques alone provided no suppression of perennial pepperweed 1 year after treatments. However, mowing plants at the flowerbud stage followed by applications of glyphosate at 3.33 kg ae/ha to resprouting tissue provided 81 and 98 % biomass reduction compared to untreated controls 1 year after treatment. Applications of triclopyr or 2,4-D (registered for use in water) was highly variable, with reduced suppression compared to glyphosate. Optimal control occurred in areas disked in the fall followed by mowing and herbicide treatments the following spring. Biomass was reduced 80, 90, and 98% with triclopyr, 2,4-D and glyphosate respectively. Recovery of vegetation was limited in dense infestations unless treatments included disking. Disked areas resulted in < 10% bareground 1 year after treatments, while mowed plots averaged 50% bareground when *L. latifolium* cover < 20%. Based on these results several management plans were developed based on the density of infestations, presence of desirable grass species, land use objective, and ability to mow/disk. Successful adoption of these plans occurred because land managers were the driving force for the initiation of this project.

Elaboration of a methodology for the control of the *Carpobrotus spp.* on the sand dunes of the Hérault department

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The *Entente Interdépartementale pour la Démoustication du littoral méditerranéen (EID Méditerranée)* has developed during the past fourty years precise knowledge and expertise in the management of coastal natural environments of the Mediterranean. Making use of this experience, EID Méditerranée was able to work on the control of invasive plants, particularly since 1997, after the realisation, in partnership, of a first inventory of the principal pest species. These investigations dealt with wetlands as much as coastal environment in the strict sense.

In spring 2004, EID Méditerranée made a diagnosis in the department of Hérault, to estimate the sand dunes' colonisation by the invasive plants, the *Carpobrotus spp.*

Following this diagnosis, an experimental operation against the *Carpobrotus spp.* was carried on at a test site in the Hérault department. The plants were pulled up and the dune environment restored. The Conservatoire Botanique National Méditerranéen de Porquerolles was a partner of this operation.

The environment restoration was realised by revegetation, using sand dunes' species whose feasibility and effectiveness had been tested during an earlier experimental operation of sand dunes' revegetation (during 2000 and 2001).

A methodology for monitoring invasive and native plant evolution is under evaluation.

Good performance in both sun and shade habitats leads to the spreading of invasive *Carpobrotus spp.* in Mediterranean ecosystems

Eva Moragues, Anna Travese and Fernando Valladares
Spain

The high floristic diversity of Mediterranean ecosystems is threatened by the harmful introduction of exotic plants. Insular coastal habitats are especially vulnerable to these introductions. In the present study we have evaluated vegetative (clonal) growth dynamics and the potential colonisation rates of the invasive species *Carpobrotus spp*. For over two years (2001-2003) we evaluated branch growth rates of this creeping plant, comparing two habitats (rocky coast vs coastal dunes) and two different environmental conditions (sun vs shade) in four populations of Mallorca island (Spain). In one population of each habitat we estimated the level of plant stress by measuring chlorophyll fluorescence and the light received by each branch to determine whether these parameters were correlated with growth rate. Carpobrotus branches grew at similar rates in all populations, regardless of the type of habitat. However, growth rate was greater in plants in the shade than in those completely exposed to sunlight, and was also greater for main than for lateral branches. The good performance of Carpobrotus in the shade (more efficient occupation of space) was due not only to its phenotypic plasticity, expressed in different allocation patterns in sun and shade individuals, and to its clonal growth, which allowed for the continuous search of the best neighbour patches, but also to the relatively moderate shade of the understories where it can be found. Annual growth of main branches was c. 40cm, which explains the vigorous habitat colonization capacity of *Carpobrotus spp*., with the consequent native flora displacement. Results indicated that the clonal growth and the plastic morphological response to light of this highly invasive plant are efficient mechanisms for its rapid colonisation of space and successful establishment in the vicinities of the coastal zones in Mediterranean environments.

How to recover an area invaded by silver wattle (*Acacia dealbata* Link): a Sisiphus work? The case in Peneda Geres National Park (Portugal)

Manuel Miranda Fernández and João dos Santos Bento
Portugal

Peneda Gerês National Park is a mountain protected area in the NW Portugal where *Acacia dealbata* Link has been introduced in the late XIXth century. After a long spreading period, a wildfire occurred in 1989 leading to the "explosion" of its population. It became one of the major risks to the natural habitats of the Park, such as riparian strips of *Alnus glutinosa* (L.) Gaertner and oak forests of *Quercus robur* L. Since then, control actions have been undertaken, using mechanical and chemical methods. Nevertheless, the invaded area has been growing, reaching more than 1% of the Park area in 2000.

A Life EU project was developed between 2001 and 2003, aiming to recover the natural habitats in an area of 120 ha. But the main focus of this project was to remove the invasive species, leaving the treated area in a very unstable situation and most suitable for re-invasion.

Considering the monitoring that we have made within this project, some critical issues are discussed: design of the control area, definition of control priorities, habitat recover and establishment of a reference situation. These issues are at the basis of a long term management plan, in order to avoid Sisyphus stone to roll down the slope once again.

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Invasion of Sardinian coastal habitats by the exotic *Cortaderia selloana* (Schultes) Asch. et Gr.

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Cortaderia selloana (Schultes) Asch. et Gr., was introduced in Italy as ornamental at the beginning of 1800s. The introduction in Sardinia has been significant mainly since 1960s. Despite being associated predominantly with disturbed habitats, such as roadsides and abandoned agricultural fields, this species has become increasingly invasive in conservation areas, such as coastline, garigues, temporary river beds and sand dunes. The present research aimed to: (a) give a first contribution to the knowledge of the ecology of this neophyte; (b) evaluate the rate of spread since the first records; (c) produce a geo-database to update for future monitoring. The geo-database stores *C. selloana* distribution records and data collected by GPS field surveys according to different study scales. A GIS engine was used to topologically overlay field and distribution data with environmental thematic layers, such as DEM, land-use, soils, road and riparian network. Phenological field observations and laboratory trials have provided additional general information on the species ecology, actual and potential distribution pattern. This study highlights the invasiveness of this species that is presently increasing its range on the island of Sardinia, also thanks to repeated introductions which continuously augment the propagule pressure, along the coast, along the road-network, and that is reaching some of the other small islands of Sardinia. Prediction of the invasion has been performed by different GIS methodologies with similar results. Monitoring is a very first priority but, of course, further spread and utilisation should be avoided to control economic and environmental losses.

Management of invasive plants in the Balearic Islands

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The Ministry of Environment of the Balearic Government, began in 1992 some different actions mainly focused on the control and eradication of *Carpobrotus sp*. During all this period other public (central and local governments, university, research centres, etc.) and private initiatives (ONG's, owners, etc.) have been developed as well.

Carpobrotus sp. grow mainly in the coastline competing with a lot of endemic and threatened species. Different localities have been monitored to eradicate these invasive species. Other species which can be described as invasive in the Balearic Islands and potentially dangerous for natural species are: *Ailanthus altissima, Arundo donax, Opuntia maxima, Oxalis pes-caprae*. The list of invasive species for the Balearic Islands is about 23, and the list of potentially invasive species is about 34.

This contribution presents some examples of all these activities:
- localisation and distribution of *Carpobrotus sp*.;
- eradication by manual methods;
- edition of some material as to publish the threats from invasive plants to politicians and public opinion;
- list and catalogue of introduced species in the Balearic Islands and evaluation of their invasive capability;
- organisation of invasive species (flora and fauna) information through a database project (BIOINTRUS).

La Morelle jaune (*Solanum elaeagnifolium* Cav.), une espèce envahissante des cultures cotonnières du Nord de la Syrie

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La morelle jaune (*Solanum elaeagnifolium* Cav.) est une mauvaise herbe très nuisible vis-à-vis des cultures cotonnières au nord de la Syrie. Cette adventice infeste surtout la région du nord et commence à gagner d'autres zones du nord au sud. L'extension de l'espèce est progressive d'un champ à l'autre et d'une zone à l'autre au fur et à mesure des années. Les agriculteurs ont du mal à contrôler cette invasion aussi bien a l'intérieur de leurs champs qu'à l'extérieur. Très rares sont les agriculteurs qui pratiquent un désherbage chimique contre cette adventice dans leur rotation. La lutte est pratiquée exclusivement par des désherbages manuels (arrachage, binage, sarclage). Le cotonnier subi 2 désherbages manuels (sarclage) au cours de son cycle. L`invasion de l'espèce s'étend aux cultures de céréales irriguées. Nous avons observé une propagation à de nouvelles régions au centre de la Syrie, dans les vergers d'oliviers et les bords de route et à côté d'une culture de blé.

L'état actuel de l'extension est sur 6 départements, de même, le degré d'infestation de la morelle jaune est plus élevé dans les champs de coton que dans les céréales. Cette vaste invasion en Syrie incite à étudier les facteurs qui permettent de mieux comprendre la biologie et la dynamique des populations de cette redoutable adventice vivace.

Le traitement chimique effectué au stade de floraison de *S. elaeagnifolium* en bord de route avec le glyphosate (round up à 12 l/ha) a eu une excellente efficacité. Pour le cotonnier, les herbicides utilisés (trifluraline) n'agissent que sur la germination de la mauvaise herbe et n'ont aucune action sur les repousses issues de la régénération de *S. elaeagnifolium*. Ces résultats ont favorisé la forte extension de *S. elaeagnifolium*. Nous avons observé sur certains sites, une Orobanche parasite de *S. elaeagnifolium*.

The effects of roads on the invasive success of exotic plants in protected areas

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Invasive processes are regarded as one of the main threats to biodiversity. Human disturbances and the structure of native vegetation influence the success of plant invasion. In this study, we investigated if trails and vegetation structure affect richness and abundance of exotic plants into a protected area of Central Chile: Reserva Nacional Altos de Lircay (RNAL). We selected two trails which differed in disturbance intensity and crossed across patches of forest and matorral. We disposed transect perpendicular to trails and at regular intervals we registered the species richness and abundance of exotic plants using quadrat 2 x 2 areal extent.

Exotic plants were less abundant at trails with low intensity. At the most disturbed ones we registered 7 exotic species (13% of the total). We did not found differences in the richness of exotic species between forest and matorral. In forest patches we detected a negative relationship between the abundance of exotic plants and the distance from the edge of trails. This relation disappeared at the matorral. Inside forest, the abundance of exotic species was inversely correlated with the canopy cover.

In summary, the nature of trails and the structure of native vegetation determine the abundance of exotic species. These attributes seem to be good predictors of the invasive success of exotic plants in protected areas.

Tiny wasp big concern

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In order that a plant will establish naturally in its own niche or as an invader it must fulfill certain chain of formal demands: starting with seeds germination through growing and survival ending by normal blooming and seeds formation. One missing ring will cause a collapse of this sensitive chain and will avoid the plant establishment. It is therefore logic to believe that short and simple chain is a crucial for better chances of invader establishment. Therefore it is relatively easy to explain the quick establishment of the apomictic dandelion as an invader. On the other hand there are difficulties to explain how Ficus, one of the most complicated plants in term of pollination, become a threat as an invader in Israel.

Ficus rubiginosa, originated in Australia, was introduced as an ornamental tree into Israel for about 40 years ago. Twelve years ago entered its genuine pollinator, an agaonid wasp; *Pleistodontes imperialis*, which pollinates this plant and as a result creates fleshy fruits. Since then it became a nuisance which filth the streets and parking lots, it also germinates in the cities every place including cracks of pavements and buildings, the chances that this plant, which is dispersed by many birds and bats, will widen up his dispersion toward the open habitats mainly along rivers is very high.

The theoretical possibilities of the wasp's arrival into Israel are by wind, ship and aeroplane.

Our field and lab experiments revealed the wasp biology and its interaction with the plant: we found that this wasp can stay alive between 8 to 40 hours, depends on the storage and temperature conditions. Wasps within their figs are more protected than free wasps. Since arrival to Israel by aeroplane from Australia take about 24 hours, it seems likely that these wasps arrived within figs via air transportation. The travel on ship takes longer than the wasp survival rate, drifting by wind (as happened in New Zealand) is likely only if one of the surrounding countries have these trees, their pollinators and the wind conditions are suitable for such journey.

Study of vegetative growth of different population of *Ambrosia artemisiifolia* L.

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Ambrosia artemisiifolia L. is a summer annual weed which is considered as an invasive plant in France. If it is not controlled, this weed can become adominant species in different habitats (natural or cultivated). Its ability to produce large populations in very different situations is not usual in French flora. To understand and to prevent the spread of this species, its biology must be better known. The aim of this study was to compare vegetative development and growth of *A. artemisiifolia* under two nitrogen regimes.

Methods

The three population of *A. artemisiifolia* resulted from seeds harvested in 2003 from different populations in a set-aside, in a spring-pea field and on a river bank. Seeds were harvested from at least 50 randomly chosen mature plants. The 2005 experiment was conducted in greenhosue. A sample of 5 g of seeds was stratified in a fridge for fiwe weeks at 4°C in darkness. At cotyledon stage, the seedlings were replanted in pots (diameter: 11 cm, volume: 1 liter, one plans per pot) filled with pure water. Pots were placed at sufficient distance from each other to avoid any competition for light before stem elongation. Appearance of new leaves on the main stem was recorded each week. The greenhouse was unheated, with a minimum temperature of 15°C and without artificial light. Individual plant width, height and dry weight were measured weekly.

Results

Plants watered with the nitrogen solution grew taller, larger and heavier and procuded more lateral branches thah those receiving only pure water. *A. artemisiifolia* watered with nitrogen solution oproduced approximately twice number of leaves on the main stem. Terminal buds on main stem were only produced on plants watered with the nitrogen solution. In contrast, the origin of the seeds, i.e. the environment in which the seeds were harvested, did not influence plant growth and development significantly.

Synthesis of reflexions
/
Synthèse des réflexions

Definitions of invasive plants

Joseph M. Di Tomaso and Dave Richardson, animators and moderators of the working group

The consensus of the group was that the biological definitions of each hierarchy of non-native plants, as described by Richardson *et al.* (2004) and Pysek *et al.* (2000) were scientifically sound. However, the specific terms used did not fit each individual Mediterranean region, country, or target audience, i.e., general public, policy makers, politicians, etc., nor did they conform to the definition of an invasive plant as defined by the European strategy on invasive alien species (Genovesi and Shine 2004). In particular, the term invasive is typically used to describe plants that cause (or potentially cause) significant ecological or economic impacts and it was perhaps not useful to use the term to describe non-native plants that are widespread but do not cause perceivable damage to ecosystems. Consequently, it was agreed that the term used in different situations may be different and not necessarily those used by Richardson *et al.* (2004) and Pysek *et al.* (2000), but the intention in the use of these terms is consistent. To avoid misunderstanding, the terms used to describe non-native species, i.e., alien, exotic, invasive, transformers, etc., need to be clearly defined when used. In particular, definitions should always include objective criteria on the extent of spread, and should be applied for a given period – i.e. definitions must be time and context specific (as many species will move to different categories over time). This is essential to allow for inter-regional comparisons.

In addition, the measure of invasiveness should be impact driven, and not strictly determined by quantitative measurements of cover. This is because impacts can include more than just competition for limited resources. For example, impacts can be significant even when the invaders have low percentage cover, such as the effects of pollen swamping of native and sensitive species related to the invasive plant, invasive species that harbor deleterious insects, pathogens or viruses, or invasive species that cause harmful effects to higher trophic level organism.

Bullet points:

1. The biological definitions in the hierarchy of spread and impact of non-native species is scientifically sound, but the terminology used is specific situations may differ. Regardless of the term used, the definition of invasiveness must include significant ecological and economic impacts.
2. The measure of invasiveness is impact based, and not strictly determined by cover or distribution measures.
3. We will produce a synopsis or table that cross references the terminology used to describe high impact species from region to region or country to country.

Databases

Michael Browne, animator and moderator of the working group

Different interests/expectations out of the working group session

- How to translate information from global to local?
- sharing information;
- collecting data on all Mediterranean regions of the world;
- having reliable information to analyse (data quality);
- centralised information about Mediterranean species;
- verifying quality of the work at local level;
- GISIN initiative;
- influencing people involved in global trade (WTO) and providing them with easily accessible information;
- finding ways of linking databases more effectively;
- where does data come from and how do we assess the quality?
- standards and sharing (definitions, criteria, vocabulary);
- adata base to support rapid response to incursions;
- identification tools to support prevention.

Data elements and standards

There are international standards for recording the names of organisms and for collection/observation and survey data, but the invasive species community needs to develop specific extensions to those standards for data such as:

- biostatus
  - native, introduced, etc.,
  - eradicated, intercepted, reported, established, etc.,
  - invasive, not invasive etc.;
- impacts;
- pathways (cause, route, vector);
- habitat;
- management;
- invasive attributes,
- risk assessment results;
- legal status.

Work is currently underway within GISIN to address some of these issues.

Issues discussed

- Data on invasive species is still sparse, so baseline surveys of IAS in MTE countries are of primary importance. Collection records must be guided by available international standards.
- We identified and discussed some basic data elements commonly used by the IAS community. We focussed on data elements that would support prevention and rapid response activities.
- Documenting the source of data is vital. We focused on the importance of referencing the source of taxonomic nomenclature being used and of the importance of voucher specimens. People creating databases should refer to sources that define standards.
- There is a difference when we talk about species generally and when we talk about species in a certain location. We have to make the distinction to make it clear for the person using the data. Location should be stated explicitly in every case.
- We have to normalise data and in order to compare with data of other people.

Recommendations

- Promote data collection.
- Develop standards and vocabulary for invasive species data and information.
- Analyse existing data bases/existing best practice, identify gaps and learn from the assessment to propose specific add-ons for IAS in MTE countries.

2010 targets proposed by the working session

- Programmes are developed to collect data on IAS in MTE countries.
- To use the Global Invasive Species Database in the interim as a readily available repository for IAS data and to develop a separate interface for data on invasive plants in MTE countries.
- IAS extensions to existing data exchange standards (e.g. risk assessment and predictive modelling) will have been developed and adopted to facilitate data sharing e.g. via GISIN.
- To support the development of national databases for MTE countries where requested.

Raising awareness of the benefits of biological control

Richard Shaw, René Sforza and Andy Sheppard, animators and moderators of the working group

There is a need for a public awareness communication network for biological control solutions of invasive alien plants in Mediterranean climates.

Recommendation 1: definition of target audience

– politicians,
– policy makers,
– stakeholders (e.g. horticulture),
– community groups.

Recommendation 2: facilitate biological control

Objectives

– Advocate best practice biological control;
– inform/educate/raise awareness on biological control as an effective management tool for IAS particularly in areas where it remains underutilised (e.g. Mediterranean basin) – poorly understood,
    - benefits, risks and costs of biological control,
    - the scientific basis and process of risk analysis,
    - limits of biological control and its role in IWM and ecosystem management,
– Facilitate the adoption of regulations sympathetic for introductions of beneficial exotic organisms built on an accepted basis of risk analysis,
    - regional (e.g. European) and National regulations frequently poorly developed or inappropriate for certain agent types or inconsistent [e.g. Portugese Environment Ministry assists in risk assessment, UK Agricultre Ministry provides no assistance but requires assessment, while in Italy no assessment is required],
    - responsibilities toward neighboring countries,

– Share knowledge on existing biological control programs and their target invasive alien plants,
  - agents used,
  - countries used,
  - needs for extension to new regions,
  - likelihood of success.

Recommendation 3: promote flagship cases

– Cosmopolitan evil weeds and their costs/ecological impacts; *Ambrosia artemisiifolia. Orobanche* spp., *Ailanthus altissima;*
– successful biological control; e.g. *Opuntia* spp. (worldwide); *Hypericum perforatum* (worldwide), *Acacia* spp. in South Africa, *Chondrilla juncea* (Australia and USA);
– successful insect biological control projects in Europe – for Europe;
– cosmopolitan future targets for potential cost sharing e.g. *Solanum elaeagnifolium*, *Carpobrotus edulis, Ailanthus altissima.*

Mechanism (built onto existing initiatives)

– CBD Guiding principle for alternatives to pesticides;
– GISP Target 10 (Management) /GISD;
– Global Strategy for Plant Conservation (targets adopted by CBD COP 6);
– Regional Strategies on Invasive Alien Species (e.g. EPPO/Council of Europe/Cooperative Islands Initiative);
– Horticultural Industry public awareness campaigns alerting public to threats of IAS’s (BC may be the only option left for some IAS’s that started as garden escapes.

Linkages (existing networks)

– IAS sites generally,
– Global/National analysis of the costs of invasive species.

Accompaniment of the horticulture and landscape professions

Valerie Vartanian, Bernard Pical and Francis Brot, animators and moderators of the working group

Many of the plants that are invasive to natural areas come from gardens and public landscapes. Some regions have laws to address these invasive plants and have created lists to ban their sale. Usually, however, these plant lists are inadequate and reflect mostly plants invasive to agriculture which are in many cases accidental introductions. Horticulturally derived plants, those used in gardens and landscapes, are poorly represented. Therefore, until laws and regulations can be established in places where they do not exist and existing laws revised to include scientifically identified invasive alien species, working with the horticulture industry to adopt a voluntary program to reduce the availability of invasive species will be critical in our work to preserve biodiversity.

To work with the horticulture industry on adopting and implementing a Voluntary Code of Conduct, education and motivation must be addressed. Not only do nursery and landscape architects need to be more aware of the repercussions of releasing invasive plants, the gardening public who demands these plants must also be made aware. An informed buying public helps greatly when nursery businesses begin the process of removing invasive stock from their shelves. The buying public can also put pressure on businesses that are not in compliance using their purchase power as a reward to those businesses that do not sell invasives.

Since this is a voluntary program, there needs to be motivation or at least the avoidance of negative repercussions to even begin recruiting businesses. Motivation may come in the form of increased business or avoidance of regulation. Resistance to implementing these guidelines

Listed below are areas in which education needs to take place and ideas on motivation for the industry:

Education

- Nurseries need to have a better understanding of pollination biology regarding the effect that their invasive stock has on natural populations of plants.
- Develop genetically sterile plants or cultivars (sterile equating to no pollen or seed production).
- Educate the public to pressure large store chains to stop selling invasive plants.
- Develop informational brochures on invasive plants and their alternatives for distribution in businesses.
- Get news media involved.
- Do educational workshops for landscape architects/designers.
- Educate designers of "tourist" landscapes.
- Have workshops for horticulture industry media.

Motivation and tools to help the horticulture industry

- Reduce the demand from the public for the invasive plants in stock.
- Talk with local politicians on ideas to help subsidize nurseries/growers to buy out invasive stock.
- Work with cities to changes approved plant lists used for public landscaping.
- Get schools involved in weed pulling or biocontrol releases – this is a good visual for the media.
- Create special awareness days for invasives (Arbor Day – cut down an invasive tree!). Implement the Codes of Conduct.

Trade and measures

Ian M. Smith, Serge Muller and Laurent Clop, animators and moderators of the working group

Recommendations

Regulatory restrictions has ben elaborated by the European Union on the plant health regulation for Mediterranean EU members. Other Mediterranean countries should follow the same approach.

Encourage cooperation between horticultural trade and authorities and public to create codes of conduct at a local scale:

- It is essential to identify the species,
- system of surveillance to monitor what is happening,
- making an evaluation if it is possible to eradicate, contain or control,
- best way is regulation which could apply to sale, movement, planting,
- plant protection service are elements which could be implicated,
- encourage initiatives with nursery industries, communication, creating a favorable environement.

Introduction and measures

Gritta Schrader, Eladio Fernández-Galiano and Hélia Marchante, animators and moderators of the working group

After a vivid discussion the main conclusions of the group were that:

– Prevention of introduction is essential;
– some legal basis for the prevention of introductions of invasive alien plants does exist but there are several gaps; there was a different perception concerning a more stringent approach versus the legislation not being a realistic option;
– an increased application of codes of conduct and recommendations ("soft law") by relevant bodies is needed;
– communication and cooperation between relevant sectors;
– taxonomy and research have to be strengthened;
– more information is needed from the countries on species present and causing impacts and species not present.

Human nature and invasive plants

Jeff Mc Neely, animator and moderator of the working group

Role of economic arguments: important to politicians: How to mobilise them? Is more research needed?

Motivation of people

- Develop research of social science on IAS (need to understand what people think to better communicate) and develop international cooperation (with an interdisciplinary approach).
- Misunderstanding: public see new species and think that it is good because it increases biodiversity. Important communication on decrease of species for years, now IAS issues seems contradictory. Public consider some IAS as part of their environment.
- Need to communicate on specific species present in areas where people go.
- Information is needed on the impact of alien plants so that people can understand why it is harmful. Knowledge of people in biology is very weak, most of people live in cities so they are not aware about environmental issues.
- Some invasive species were introduced because they are useful (Spartina against erosion, Pinus for forestry in Chile), difficult to use the economic argument in such cases.
- Approach of people of nature is very sentimental. but what they consider as nature can be quite artificial.

Communication should focus on actions (not only present problems), propose practical measures that people can do. Involvement is a key point. Communication is more effective is focused on few species that are present at a local scale near where they live.

Need for easy message but scientists should also communicate uncertainty.
More research is needed on ecological relations between species.

Evolution for 30 years: Distrust of public in sciences (e.g. say no to GMO).

- How to use economical impact to convince people?
- Economical impact is not as high in Europe as in Australia or California.
- Difficult to evaluate. IAS can also be a resource.
- Economical argument can be used to convince politicians but not very effective for general public.
- Arguments on human health can be also effective.
- Prevention is important.

Summary

- Need to improve international cooperation to exchange experience on IAS, and increase research. Important to have an interdiciplinary approach.
- Question of values: we should avoid to say if a species is good or bad.
- Need simple, consistent, accurate and credible messages to communicate to the public.
- Science is no longer the only source of knowledge.
- Most of people are urban, not easy for them to understand IAS issues.
- Global scale: what Europe consumes influence the environment in the entire world.
- Involve people.
- Economic assessment: economic arguments used in others Mediterranean type area can not be used as such in Europe.
- Need to target.
- Balance of cost/ benefits.
- Prevention.

Recommendations

- Cooperative programme on economics for Mediterranean types area.
- International cooperation in cultural dimensions.

Communication on invasive plants

Peter Martin and Rami Salman, animators and moderators of the working group

Define the outcomes of a communication strategy

A. Fewer incursions 1, 2, 4, 5, 8, 9, 17
B. better and cheaper weed control 4, 5, 9, 14, 15, 19, 20;
C. better public awareness 1, 2, 3, 6, 7, 8, 12, 18;
D. more support to weed science 2, 5, 8, 9, 10, 16, 17, 20;
E. invasive species part of curricula (schools, professionals…) 3, 4, 8, 9, 11, 14, 15, 19, 20;
F. politicians more aware and more supportive 1, 2, 18;
G. more communication/cooperation among agencies 2, 5, 7, 8, 10, 11;
H. better public policy/programmes – better quality work in the public sector 7, 8, 9, 12, 14, 15, 19, 20;
I. easily accessible information network 4, 5, 6, 8, 11, 12, 15, 19;
J. people stop planting invasives in their gardens 1, 3, 4, 6, 7, 8, 9, 17, 18, 19;
K. using positive public awareness – positive messages (more a mechanism);
L. train the customs and all others responsible for entry of invasives 8, 15, 17;
M. media strategy – get the media to initiate contacts – Get media interested 6, 7, 12, 18;
N. educate landscape architects and other professionals (agriculturalists are major actors to be engaged) 4, 6, 7, 9, 17;
O. border control regulations and regulations within the commercial sector 2, 8, 17;
P. early detection – Alert system 1, 4, 5, 6, 8, 9, 10, 12, 14, 17, 19;
Q. build appreciation on native plants – cultural dimension 1, 3, 4, 5, 6, 7, 8, 9, 12, 14, 15, 18, 19,
R. monitoring strategy to measure change (change of attitude) (not applicable for identifying audience),
S. engage people and make them feel responsible (private and public land owners): all;
T. landscape architects use indigenous plants 4, 6, 7, 9, 11, 12, 14, 15, 19.

Types of Audience (Who do we talk to/engage/connect to?)

1. The general public,
2. politicians (ministers and local / regional / federal governments),
3. schools (teachers and students),
4. gardeners, farmers and horticulturalists,
5. scientific societies / native plant enthusiasts / amateur societies,
6. garden writers,
7. media (editors / high level media people),
8. policy makers,
9. horticulture industry,
10. other scientists,
11. collaboration among different international universities – post graduate studies / distance learning,
12. NGOs,
13. funding bodies within the countries,
14. professional land managers within the public sector / private sector,
15. training of trainers (training on identification…),
16. donor agencies / private donors for their public image,
17. legislators / custom officers (training),
18. trend makers (stars, athletes…),
19. people who manage invasives / weed officers ,
20. chemical industry / weed industry.

Main recommendations (outcomes)

Communication is a fundamental tool to help deal with invasive species, and the main outcomes should include:

– focus communication to stop the use of main known invasive species – stop public use paid by public money;
– as part of a strategic communication effort, develop a communication strategy with specific messages for specific target audience that includes a comprehensive list of invasives in each country;
– communicate the declaration of Meze to: Mayor of Meze, local media, governments, websites of participating organisations, press releases…

Developing predictive models of invasive plants

Emma Underwood, Francisca Aguiar and Giuseppe Brundu, animators and moderators of the working group

Summary

1. Predictive models are useful multipurpose tools for managing invasive plant species, (e.g., to help prioritise management and control efforts and make up for a lack of data). However, conveyance of model results needs to be linked with effective communication on their specific limitations.
2. While examples exist of predictive model results being tightly coupled with applied action, the potential strength of predictive models is to inform strategic, long-term conservation priority setting and planning, rather than short-term day to day management.
3. Numerous predictive variables are important to consider and need to be selected and tested with respect to different species and plant functional types. Types of variables likely to be important include: environmental and climatic factors, invasion pathways and propagule pressure and human-related factors (e.g., distance from roads, urban areas). Other location descriptors such as the spatial extent of infestation, relationship with horticultural activities, and interactions with land use change or climate change scenarios are additional considerations.
4. Predictive models should be conducted at specified temporal scales to account for necessary factors (e.g., climate change is only appropriate to include in long-term predictions).
5. Predictive models should be developed using information from both native and invaded ranges. One potential cross-mediterranean approach is to develop predictive models for species which are highly invasive in a subset of the five mediterranean regions but currently not problematic in the other ones. Candidate species, encompassing a variety of life forms could include: *Carpobrotus acinaciformis* (L.) L. Bolus and/or *Carpobrotus edulis* (L.) N. E.Br.; *Acacia mearnsii* De Wild*; Pinus* sp.pl. (e.g *P. pinaster, P. halepensis, P. radiata)*; *Cortaderia selloana* (Schultes et Shultes.f.) Asch. et Gr.; *Chrysanthemoides monilifera* (L.) T.Nord.

Recommendations

- Exchange of presence and absence data, invasive species lists, information on severity and behavior of species in native and invaded ranges is an important first step to conceptualising the predictive model framework.
- Developing cross-Mediterranean predictions for a suite of invasive species representing different life forms and levels of invasion would be informative.
- Understanding the potential impact of invasive species in mediterranean-type ecosystems is a useful extension beyond identifying spatial patterns of invasions.

Cooperative Islands Initiative– Managing IAS on Mediterranean Islands

Alan Saunders and Rami Salman, animators and moderators of the working group

Is a focus on islands appropriate?

Very appropriate

– islands are important and vulnerable ecosystems;
– unique cultures – and sometimes uninhabited;
– important IAS management opportunities (prevention and eradication?);
– potential to demonstrate SUCCESS and to inform others;
– islands could be a setting for learning lessons and exporting them to other islands and even to continental ecosystems.

What are the constraints to managing IAS on islands?

– public awareness and support (social),
– Political psupport (political),
– laws and regulations (institutional),
– agency support and funding (institutional),
– strategies and priorities(institutional),
– knowledge and prediction (scientific),
– technology (operational),
– skills (operational),
– best practice (operational).

In addition to all the above, other specific Mediterranean constraints are:

– sharing of information on what is to be done / what has been done (no platform or culture of information sharing);
– changing land use / urbanisation and excessive tourism;
– increasing population ;
– regulation: In some countries it is not always feasible to impose legislation for islands (e.g. border control), as it has to be part of national legislation.

There is sometimes no full autonomy in some islands to impose regulations (e.g. Corsica).

How can these constraints be addressed?

All of these constraints (political, institutional, scientific, operational) will need to be addressed. The focus of this working group was to identify some specific short-term actions which should be taken. This will provide a platform for future initiatives to tackle all other constraints.

The working group decided to focus on information and experience sharing, raising awareness and initiating demonstration projects.

Recommendations – Actions to be taken

Information and Experience Sharing

By December 2005:

– A webpage/platform for experience and information sharing on IAS on Mediterranean Islands is designed and hosted by the IUCN Centre for Mediterranean Cooperation, including at least:
  - information on 10 projects on IAS in the Mediterranean (past or ongoing),
  - 20 documents that are of use to practitioners working on IAS on islands,
  - contacts of 40 experts working on IAS on islands.
– An electronic newsletter on IAS on Mediterranean islands is prepared and disseminated to at least 1000 people

Raising awareness on IAS

An education programme is initiated by July 2008 with the co-operation of the federal or regional ministries of education, aiming at the three principle levels of education (primary, secondary and tertiary).

Three main objectives:

– awareness,
– education,
– training.

Three main themes:

- cultural (island) identity,
- endemic biodiversity,
- border control.

Important to link with demonstration projects

Demonstration Projects

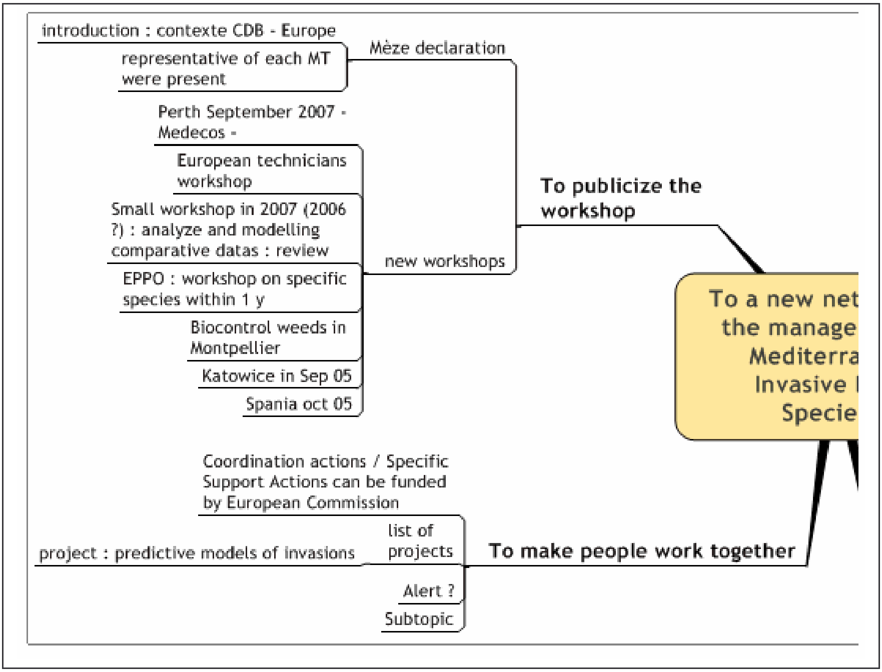
By July 2006, a task force consisting of representatives from Mediterranean countries with islands has met to identify some potential IAS Demonstration Projects involving prevention, eradication and control objectives. This task force will also identify how each project should be implemented.

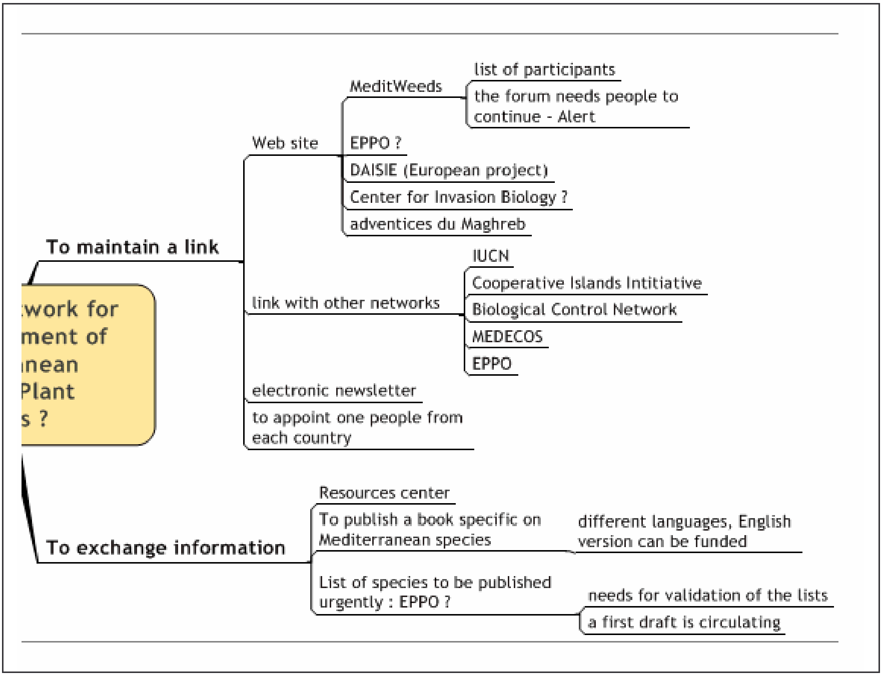
Demonstration Projects have objectives to raise awareness, generate support, improve knowledge and develop management capacity, in addition to socio-economic and ecological objectives.

A new permanent network for Mediterranean invasive plants

Philippe Feldmann and Sandy Lloyd, animators and moderators of the working group

(NB: THIS TABLE IS TO BE READ ON BOTH PAGES 404 AND 405).





list of participants
MeditWeeds
the forum needs people to continue - Alert
Web site
EPPO ?
DAISIE (European project)
Center for Invasion Biology ?
adventices du Maghreb
To maintain a link
IUCN
Cooperative Islands Intitiative
link with other networks
Biological Control Network
MEDECOS
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electronic newsletter
to appoint one people from each country
Resources center
To publish a book specific on Mediterranean species
different languages, English version can be funded
To exchange information
List of species to be published urgently : EPPO ?
needs for validation of the lists
a first draft is circulating

List of participants
/
Liste des participants

NB : Some people having contributed to the written/ oral preparation of posters did not attend the Workshop: in this case, only their organisation and/or e-mail are mentioned.

NB : Certaines personnes ayant contribué aux prestations orales ou écrites n’étaient pas présentes à l’Atelier : dans ce cas, seuls leur organisme d’origine et/ou leur e-mail sont mentionnés.

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