Université de La Réunion

Ecole Thématique – Invasions Biologiques

Résumé des Sessions

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Contents

Invasions – traits biologiques

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Résumé

Parmi les espèces introduites dans un pays, certaines deviennent envahissantes, d'autres non. Comprendre les facteurs, ou traits biologiques, qui permettent à une espèce de franchir tous les filtres dans le processus d'invasion, reste encore une des grandes questions de la science des invasions biologiques. Plusieurs hypothèses ont été proposées (par Charles Elton en 1958 et Baker en 1965) portant sur des traits biologiques (telle qu'une croissance rapide) ou écologiques. Des travaux récents suggèrent cependant que la prédiction des invasions biologiques basée uniquement sur des traits biologiques reste très difficile. De nombreux facteurs doivent être considérés, y compris : une préadaptation au nouveau milieu, une tolérance écologique élevée, le mutualisme, et les processus évolutifs tels que l'hybridation et la polyploïdie. Des facteurs environnementaux peuvent aussi faciliter l'invasion d'une espèce dans son milieu introduit. Notamment, les facteurs d'ordre climatiques contrôlent souvent l'établissement et l'invasion qui en suit des espèces introduites. Les perturbations du milieu, liées à une baisse de la compétition et de la prédation, un enrichissement du sol en nutriments, facilitent aussi les invasions.

Summary

Understanding why different introduced species have different chances in successfully overcoming various barriers during the invasion process remains a central theme in invasion biology. Charles Elton (1958) has put invasion biology on the map as a field of science. He speculated that differential success of species might be due to characteristics of the recipient environment, whereby areas characterised by high species richness are more resistant to invasive species establishment and that high human-mediated disturbances promote invasiveness. This idea of 'biotic resistance' does not seem to hold up against empirical evidence, which suggests that species rich communities tend to be more susceptible to invasion ('the rich get richer') over broad spatial scales and somewhat resistant at fine spatial scales.

Historically, various life-history traits have been associated with successful plant invasions. For example, Baker's (1965) ideal weeds include those taxa with short generation times, high fecundity, competiveness, etc. However, recent evidence paints a much more complicated picture and indicates that predictability is very difficult based on species traits alone. While many comparative studies of taxa in both their native and introduced ranges indicate that Baker's characteristics are important, they fail to explain the mechanisms underlying these observations. However, comparative analyses of congeneric taxa with known invasive and non-invasive taxa, e.g. pines, provide promising approaches that can lead to taxon-specific predictions of invasiveness based solely on traits.

The ambiguity of traits associated with the invasion success of plants has led to more generalised hypotheses on the processes that may govern invasion success. These include ecological attributes such as pre-adaptations

(novel traits being introduced to new environments), broad ecological tolerance, novel weapons (chemicals produced by aliens that suppress natives), mutualistic facilitation (mutualisms give invader a competitive advantage) and enemy release (liberation from natural enemies leading to increased fecundity). More recently, invasion biologists have also recognised the importance of evolutionary processes in determining invasion success. Most notably these include hybridization and admixture (often leading to hybrid vigour), polyploidization and even *in situ* evolution. Admixture and hybridization can lead to immediate phenotypic novelty, and can include broader climate and physiological tolerances. Of course these evolutionary processes would greatly benefit from high introduction numbers and therefore propagule pressure (the number[s] and size[s] of introduction events) has been consistently linked with invasiveness. These effects may be amplified by extrinsic factors, such as suitability for deliberate introductions for human usage, e.g. horticultural or forestry.

From an environmental perspective numerous attributes may enhance invasion probability. Recent evidence suggests that climatic constraints may be important in determining establishment success and subsequent invasion. Environmental disturbance through anthropogenic impacts are also often correlated with invasion success. This may be due to decreased competition, nutrient enrichment, lowered predation, etc., often leading to successful establishment by disturbance specialists, or species with wide environmental tolerance. The latter has been consistently linked with the size of a species' native range distribution, i.e. those with large native range distributions seem to tolerate broad environmental conditions, and are often more likely to become invasive. Island ecosystems appear particularly susceptible to the impacts on invasions compared to mainland ecosystems. There might be a link with biotic resistance (i.e. low species diversity) with the main driver being resource availability and low resource utilization in these systems.

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Evaluation des risques d'établissement et d'invasion lors de l'introduction d'espèces exotiques

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Résumé

L'évaluation des risques poses par les espèces introduites est une composante majeure de la gestion des espèces envahissantes. L'évaluation des risques a pour objectif d'anticiper et de prédire le niveau de danger qui constitue l'introduction de nouvelles espèces dans un pays ou une région receveuse. Il existe principalement quatre approches pour évaluer les risques basées sur a) les espèces, b) les milieux, c) les vecteurs d'introduction, et d) les services ecosystémiques. On distingue une évaluation des risques ***avant*** *et* ***après*** *l'introduction de l'espèce en question. Plusieurs protocoles ont été proposés, dont le protocole d'évaluation des risques pour l'Australie (« Australian Weed Risk Assessment »). Bien que certains auteurs mettent en question leur efficacité, l'évaluation des risques devrait être inclue dans les stratégies de gestions des espèces envahissantes.*

Summary

In this section we will have a short introductory lecture, then spend some time working in groups discussing own experiences. Each group will report back to the group as a whole.

Definitions

The aim of a risk assessment is to identify events that could occur, explore the likelihood and consequences of such events, and evaluate the overall risk. For a species-based risk assessment, the event in question is that a species can be introduced and have some undesirable impacts (usually as a result of it becoming invasive). So this can be decomposed into the likelihood of introduction, establishment, and spread, with consequences in terms of increased distribution, increased local abundance, and various types of impact.

Need to be clear that risk assessment is simply one aspect of risk management, and these are separate from cost:benefit analysis and inform (but do not supplant) decision making. For example, if you want to change a light-bulb, one identified risk is that you fall off a ladder. This risk is not affected by the need to change the light bulb but the decision to take the risk is and how you manage it might be, i.e. the focus on negatives does not imply invaders have no benefits, but is an essential step in the process.

Different types

In invasion biology there are essentially four approaches to risk assessment: species-based; area-based; pathway-based; and ecosystem services or function based, with species-based and pathways usefully separated into pre-border assessments and post-border assessments. Another way of exploring risk assessments is based on transport, establishment, abundance, spread, and impact (TEASI).

Various approaches are available, from some very common ones (e.g. Australian Weeds Risk Assessment Protocol) to much more specific ones (e.g. using gravity models to predict likelihood of movement of Propagules between lakes). But most quantitative models measure establishment alone. This has led to a drive to include impact more explicitly into the process.

The types of model used can be thought of as quantitative statistical models; semi-quantitative scoring; qualitative expert assessment. Researchers favour quantitative models, but in practise most people actually use expert assessment.

The information used varies in complexity from Invasiveness of congeners or similar organisms; invasiveness elsewhere; invasive traits; to a mechanistic understanding of the processes and so risks.

Final considerations (from Leung et al. 2012)

- Uncertainty exists, but regardless, decisions must be made
- The world is complex and heterogeneous, but the numbers of end points of interest are few and manageable
- All models are abstractions of nature, but some are better than others

Discussion

We will split into six groups, each with a different type of risk assessment. The aim is to discuss your practical experience as to how such risks are assessed, what could be done to improve the risk assessments, and what needs to be put in place to allow this to happen. Think more broadly in terms of risk management, including risk identification, how to analyse risk, and how it can be treated and communicated.

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Ecosystèmes émergeants

Présenté par Christop Kueffer, ETH, Zurich (christoph.kueffer@env.ethz.ch)

The ecology of the Anthropocene

The environmental change that brings about the ecology of the Anthropocene can be characterized by at least six attributes: it is 1. man-made, 2. large, 3. very fast, 4. multi-dimensional, 5. variable, unknown and unpredictable, and 6. of global extent and affecting even remote wilderness areas. 75% of Earth's ice-free land has been altered as a result of human settlements and land use (Ellis et al. 2010), and most remaining wild land is to be found in unproductive places such as at high latitudes and in deserts. In the case of certain environmental variables, not only the mean value changes but also the variability around the mean. For instance, while between 1961 and 1990 the average summer temperature of individual years varied in Northern Switzerland by 4 °C around the mean of 16 °C, with climate change the yearly summer temperature of a 30-years period could in the future vary between 17.5 and 24.5 °C (variability of 7 °C) (Schaer et al. 2004). A consequence of such increased variability is that species and ecosystems must be able to adapt not only to a mean summer warming of 4.5 °C, but also to an increase of the temperature of the hottest summers by 6 °C to 24.5 °C, while still experiencing summer temperatures of only 17.5 °C in other years. The global extent of many environmental changes also has important implications. First, there remains little leeway for prevention and reversibility; once a problem has been recognized in one area, it is likely to be present in many other areas as well. Second, causes and effects can be interlinked across very large distances. For instance, $C0_2$ emission in an industrialized country can be a cause for a drought in Africa. Finally, much environmental change is difficult to contain. Climate change, air pollution, or invasive species do not stop at the boundaries of protected areas. The implications are that even remote wilderness areas are increasingly characterized by anthropogenic impacts, establishing protected areas is not sufficient to preserve vulnerable biodiversity, and reference systems of non-anthropogenic nature are lost.

Reconciling conflicting perspectives for biodiversity conservation

In an increasingly human-dominated world, the context for conservation action is extremely variable, being determined by three, largely independent factors: (1) the degree of anthropogenic change (historic vs. novel nature); (2) the importance of deliberate (land-use) versus inadvertent (e.g., climate change) human influence on ecosystems; and (3) land-use priorities (conservation vs. production). Given this variability, there is a need to integrate four strategies, often considered incompatible, for safeguarding biodiversity: (i) conserving relicts of historical biodiversity through intensive and continuous management; (ii) creating artificial *in situ, inter situ,* and *ex situ* conservation settings that are resilient to anthropogenic change; (iii) co-opting novel ecosystems and their opportunistic biodiversity as the wildlands of the future; and (iv) co-producing biodiversity in cultural landscapes.

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Le Parc National du Kruger – Etude de cas

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Résumé

Avec plus de 350 plantes introduites, le parc national du Kruger, qui s'étend sur plus de 20,000 km^2, est le parc le plus envahi d'Afrique du Sud. Etant donné la superficie, la gestion des plantes envahissantes est difficile. Nous présentons ici une approche de gestion intégrée du parc basé sur des zones et espèces prioritaires.

Nous avons d'abord étudié la répartition spatiale des espèces exotiques dans le parc pour comprendre les facteurs environnementaux contrôlant leur distribution. Les questions suivantes ont été abordées :

- *Le parc limite-t-il les introductions d'espèces?*
- *Quels critères influencent la perméabilité ?*
- *Observe-t-on une variation des facteurs selon les espèces?*

Nous avons pu démontrer que la répartition des espèces diminue rapidement au-delà de 1500m de la frontière du parc. Le parc semble donc avoir un effet « barrière » limitant l'avancée des espèces exotiques dans le parc. Des facteurs environnementaux caractérisant l'extérieur du parc permettent d'expliquer l'avancée des espèces exotiques dans le parc. Les bassins versant à fort taux d'écoulement des eaux, la densité du réseau routier extérieur et l'absence de milieux naturels en limite extérieure de parc favorisent l'entrée des espèces. Nos résultats ont permis d'adapter la gestion du parc. Le contrôle et le suivi des espèces exotiques se font maintenant de manière prioritaire dans la zone-tampon en frontière du parc et une zone de contrôle en amont du parc a été mise en place.

Parmi les espèces envahissantes dans le parc, Opuntia stricta est la plus abondante. Introduite 1950 dans un jardin du personnel du parc, elle s''est reparti sur plus de 80,000 ha. Plusieurs actions de lutte ont été mises en place : le traitement a l'herbicide, et l'introduction de deux agents de lutte biologique. La distribution d'Opuntia est maintenant sous contrôle ('containment') grâce à une approche intégrée combinant plusieurs méthodes dans des zones différentes.

Alien Plants in Kruger National Park

Invasive Alien Species (IAS) are one of the major threats to biodiversity in protected areas and pose a significant management challenge. One of the first steps towards managing IAS in protected areas is establishing which alien species are present, followed by ongoing surveillance and prevention efforts to combat new introductions (Foxcroft et al. 2009). Information on the identity and traits of alien species is needed for conducting risk assessments and prioritising species for control, as well as for monitoring management effectiveness in preventing new introductions (McGeoch et al. 2010). It also provides a first step towards monitoring the extent of occurrence of alien species in national parks. An online checklist was compiled to provide a taxonomic list of alien plant and animal species for South Africa's 19 national parks (including marine protected areas) (see Spear et al. 2011). An online index with common names is also provided. The checklist is intended to serve, (1) as a baseline against which future improvements in knowledge of the alien fauna and flora in South African National Parks (SANParks) may be compared and (2) for future monitoring of the success of alien species prevention and control (Foxcroft 2009). In Kruger National Park, A total of 442 alien plant species was recorded.

KNP as a natural barrier preventing invasions

Human land uses surrounding protected areas provide propagules for colonization of these areas by non-native species, and corridors between protected-area networks and drainage systems of rivers provide pathways for long-distance dispersal of non-native species. However, the influence of protected-area boundaries on colonization of protected areas by invasive non-native species is unknown. We drew on a spatially explicit data set of more than 27 000 non-native plant presence records for South Africa's Kruger National Park to examine the role of boundaries in preventing colonization of protected areas by non-native species. The number of records of non-native invasive plants declined rapidly beyond 1500 m inside the park; thus, we believe the park boundary limited the spread of non-native plants. The number of non-native invasive plants inside the park was a function of the amount of water runoff, density of major roads, and the presence of natural vegetation outside the park. Of the human-induced disturbance, only the density of major roads outside the protected area significantly increased the density of non-native plants. Our findings suggest that the probability of incursion of invasive plants into protected areas can be quantified reliably.

Managing Opuntia stricta

Opuntia stricta (Cactaceae) is the most widespread invasive alien plant in South Africa's Kruger National Park (Foxcroft & Richardson, 2003). Its invasion of the park since the early 1950s represents a discrete invasion event with a defined single source The species (O. stricta var. stricta) was first recorded in the KNP in 1953 when it was grown as an ornamental plant in Skukuza village (Lotter & Hoffmann, 1998). It soon naturalized and by about 1980 was spreading rapidly around Skukuza. The species has invaded nine Opuntia management units (units developed for the integrated control of O. stricta , as described by Lotter & Hoffmann, 1998) covering some 66,000 ha.

Attempts to control O. stricta have been conducted in the KNP since 1985, with the implementation of a herbicidal control programme (Foxcroft & Hoffmann, 2003). Herbicides have been unsuccessful because populations are replenished from soil-stored seeds, many small plants are overlooked in spraying operations, and insufficient follow-up work was carried out. Biological control using the phycitid moth Cactoblastis cactorum commenced in 1988 and has made some contribution to slowing the spread, mainly by stunting growth and extending the time that plants take to reach sexual maturity (Hoffmann et al ., 1998a,b). The release of the cochineal bug (Dactylopius opuntiae) in 1997 considerably improved the biological control of O. stricta (Foxcroft & Hoffmann, 2003). The species is, however, still expanding its range in the KNP and in many other parts of South Africa. Detailed information on the invasion dynamics of this species in the KNP could assist in planning more effective intervention strategies.

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Interface Science – Politique

Présenté par Christop Kueffer, ETH, Zurich (christoph.kueffer@env.ethz.ch)

Science - Policy – Summary

"Development of a national strategy summarizing goals and objectives should be the first step in formulating an alien species plan. The ultimate goal of the strategy should be preservation or restoration of healthy ecosystems. An initial assessment, including a survey of native and alien species (and their impacts) will help define the starting-point and serve as a base for comparison as the programme progresses. The support of all stakeholders must be engaged during the entire programme, ideally using a social marketing campaign. Legal and institutional frameworks will define the basic opportunities for prevention and management of invasive alien species. There are four major options (or better, steps) for dealing with alien species: 1) prevention, 2) early detection, 3) eradication, and 4) control.

Prevention of introductions is the first and most cost-effective option. Early detection of a potential invasive species is often crucial in determining whether eradication of the species is feasible. The possibility of early eradication or at least of effectively containing a new coloniser makes investment in early detection worthwhile.

When prevention has failed, eradication is the preferred course of action. Eradication can be a successful and cost-effective solution in response to an early detection of a nonindigenous species. However, a careful analysis of the costs and likelihood of success must be made, and adequate resources mobilised, before eradication is attempted. The last step in the sequence of management options is the control of an invasive species when eradication is not feasible. The aim of control is to reduce the density and abundance of an invasive organism to keep it below an acceptable threshold" (from Wittenberg & Cock 2001)

Backcasting

Backcasting is long established in strategic planning. It starts with defining a desirable future and then works backwards to identify pathways that lead to such a goal. In invasive species management, backcasting may start by identifying habitats that might be particularly vulnerable to invasions in the future (e.g. areas that are not yet heavily invaded, rich in threatened species, characterised by empty niches, or experiencing rapid environmental change), then forecasts the future abiotic and biotic conditions in these habitats, and finally asks which types of species might be likely to invade these habitats given predicted future conditions. Such future risk species might be those that can fill an empty niche, are pre-adapted to the (emerging) abiotic conditions of not yet invaded habitat, are a pest or competitor of rare native species, or might hybridize with a unique endemic species. The basic underlying assumption of such a backcasting approach is that invasion risks depend on the ecology of the potentially invaded habitat (including its management). Different species invaded different habitats; and future habitats might be threatened by other species than past habitats because of environmental change.

Social Marketing

Different factors that can be involved in shaping human perceptions of invasive species: First, it is important to consider what is being valuated: multiple effects of an invasive species, the invasive species, the invaded ecosystem, available management options, and involved actors. Second, people refer for their valuation to different types of knowledge (scientific facts, general knowledge, tacit knowledge based on personal experiences) and value-related factors (e.g. emotions, interests, cultural and historical aspects, and worldviews), and social relationships also matter. Valuation is further complicated because facts are often highly uncertain or entirely unknown (‘ignorance’), and rapid social and cultural change can render opinions unstable.

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Dette d'invasion: Concept, calcul et étude de cas.

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Résumé

Les invasions biologiques représentent une composante majeure du changement climatique mondial. Il reste cependant difficile d'en estimer l'impact. Nous proposons un cadre conceptuel pour quantifier les invasions en fonction du risque d'établissement future et de l'augmentation du phénomène des invasions (ou dette d'invasion). La dette d'invasion peut se décliner sous plusieurs façons : a) le nombre supplémentaire d'espèces envahissantes, b) la superficie supplémentaire des milieux envahis, et c) le cout supplémentaire de l'impact des invasions. Notre étude de cas porte sur les Acacias d'Australie introduits en Afrique du Sud. D'après des modèles de niche climatique, les Acacias d'origine d'Australie peuvent occuper au moins 26% dela superficie terrestre du globe, menaçant tous les points chauds de la biodiversité. En Afrique du Sud, nous avons estime la dette d'invasion à 46 espèces supplémentaires, 487 000 km^2 envahi en moyenne par espèces et un cout environnemental de plus de 12 0000 millions de dollars. Nous recommandons donc que les stratégies de gestion des plantes envahissantes tiennent compte de la dette d'invasion. Nos travaux soulignent l'importance de la gestion préventive pour éradiquer les espèces envahissantes de demain.

Introduction

Invasive alien species have major economic and environmental impacts. These impacts are increasing in extent and severity. How to quantify and report on this increasing biodiversity threat has been a matter of debate. Understanding large-scale patterns in the vulnerability of regions to biological invasions requires a reliable documentation of past and current invasions and an understanding of possible drivers such as climatic, land-cover, economic and demographic variables (Essl et al. 2011). At a global scale, the pattern and extent of invasive species are generally poorly documented. Consequently, the extent of the invasion problem is probably seriously underestimated. Moreover, the long time-lags between introduction and invasion (Essl et al. 2012) complicates the task of quantifying the potential future extent and impact of biological invasions.

Over the past decades, scientists and policy-makers have developed a wide range of pre-border invasive species risk assessments (Leung et al. 2012), but our ability to predict which species, if introduced, will become invasive is still limited. Therefore, recent proposals have called for more post-entry, adaptive management of biological invasions (Hulme 2012), but robust conceptual frameworks to guide such intervention are lacking. We argue that the concept of invasion debt is a crucial consideration for effective planning in this regard.

The term "invasion debt" has been used to describe the time-delayed invasion of species already introduced to a region (Seabloom et al. 2006; Essl et al. 2011). It is thus similar to the concept of extinction debt that was originally used by Tilman et al. (1994) to describe the time-delayed extinction of species that occur in remnant patches of natural habitat following habitat destruction. Similarly, even if new introductions can be halted, species already introduced still pose a considerable risk. Although invasion debt has been recognized as a major problem, it has not been operationally defined and no attempts have been made to quantify it.

Here, we demonstrate the concept of invasion debt using Australian acacias as a model group and quantify 1) introduction risk and invasion debt globally using a species-based approach; and 2) invasion debt in South Africa using an area-based approach. We propose that invasion debt can be quantified using climatic suitability and invasiveness, two reliable and widely available predictors of biological invasions.

Methods

Australian acacias were used as a model group as they are a speciose generalist group with few intrinsic species traits tightly linked to invasiveness. To calculate introduction risk, we developed two variants of climatic suitability for 828 Australian acacias and calculated the additional number of species which could invade each region of the world. In South Africa, we combined current distribution data and models of climatic suitability to calculate the additional number of species and invaded area. Total environmental costs (water use, grazing and biodiversity loss) were estimated over a 20 year horizon, using an annual area increase of 10% at a cost of US$ 17000 per invaded km2.

Results

According to two variants of climate suitability, Australian acacias, if introduced, could occupy 26 to 36 % of global land area. Many countries face a considerable introduction risk with eight countries being suitable for at least 100 acacia species. This represents a significant introduction risk.

In South Africa, although the two models of climatic suitability differed, the ranking of species appears to be very similar for both models. The invasion debt was estimated to double the extent of already invasive acacias and to increase the invaded area of all other Acacia species already introduced by 15 fold. More than two thirds of the introduced and naturalized species in South Africa have an area-based invasion debt that is greater than the area invaded by the most widespread invasive species currently, indicating a massive impending invasion problem. Although not all Australian acacias are likely to be introduced and not all introduced species will become invasive, the invasion problem will still be large even if only a fraction of the introduced species becomes invasive.

Over a 20-year period, the area-based invasion debt was estimated to reach between 39 km2 to 169,000 km2 per species. Given the environmental costs associated with Acacia invasions due to water loss, lost grazing potential and biodiversity loss, this translated into economic impacts between US$620,000 to US$2.8 billion per species. If left unmanaged, the total cost of the invasion debt of Australian acacias in South Africa over the next 20 years will be over US$12 billion.

Discussion

A focus on invasion debt provides the basis for objective policy and management initiatives. With invasion debt, the emphasis is placed on species that have already been introduced and consequently there is less uncertainty about the presence of suitable introduction pathways and the probability of individuals surviving the transport stage, which are major sources of uncertainty in predicting invasion risk prior to introduction.

There is a major risk from those introduced species that have small populations for a period (often many decades) before suddenly expanding and becoming seriously invasive, so called sleeper weeds. The challenge is to act early and target those species with small populations but large potential ranges: those with large invasion debt. The future benefit of controlling species with a large invasion deb is high relative to the cost of control. The eradication feasibility of species however decreases as the areas that they occupy increases. Species such as *A. paradoxa*, for example, should be prioritised for eradication as it has a very large invasion debt. Species such as *A. mearnsii* has a lower invasion debt because it has already invaded much of its potential range and is no longer a suitable candidate for eradication.

In a given region, the concept of invasion debt and its application can be used to assess the magnitude of the invasion problem and to prioritise species for control. Van Wilgen *et al*. (2011) suggest an approach for formulating management options for different species based on their current distribution, commercial value vs. impacts and other considerations. The quantification of invasion debt provides an additional layer for informing such strategic planning. It can also be used to compare the magnitude of the impending invasion problem, particularly in developing countries, or to compare invasion debt per taxon e.g. *Acacia* vs. *Pinus* among countries or regions. Despite many risk assessment approaches published in the academic literature, very few are effectively used in practice. Invasion debt is a useful concept that can be used both for raising awareness of invasion problems and for prioritizing control in a simple way.

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Further reading

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Stratégies de gestion

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Résumé

Des stratégies de lutte contre les invasions biologiques peuvent être établies selon : les espèces, les milieux, les voies d'introduction. Dans l'ensemble elles ont pour but de prévenir les introductions, éradiquer les espèces et gérer les espèces déjà envahissantes à travers le confinement. Nous présentons deux exemples de travaux récents menés en Afrique du Sud : a) une stratégie nationale de lutte contre les acacias australiens et b) la création d'une agence pour la détection, l'évaluation des risques et l'éradication des espèces introduites.

Summary

National strategies also need to incorporate different approaches, i.e. species-based, area-based, pathway-based, ecosystem function-based, but in essence there are three aims: prevent introductions, eradicate taxa that do get in, and strategically manage established infestations (through containment, impact reduction, or value addition).

I will take you through two recent examples of work conducted in South Africa: 1) the development of a national strategy for Australian acacias in South Africa; and 2) the development of a unit for invasive species detection, post-border risk assessment and eradication planning.

We will then split into groups and discuss several key issues that have emerged during the workshop, e.g.

- Developing measurable goals for prevention, containment, impact reduction, or value addition.
- How can bridge the knowing-doing gap?
- Different methods for listing species (The Middle East Flag approach: red, green, black and white)
- Resolution of conflict species?

Key reading

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