Invasive alien species: the urban dimension

Case studies on strengthening local action in Europe

Compiled by: Chantal van Ham, Piero Genovesi and Riccardo Scalera

EUROPEAN UNION REPRESENTATIVE OFFICE

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ISSG Invasive Species Specialist Group

DBU Deutsche Bundesstiftung Umwelt

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Contents

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Foreword

Invasive Alien Species (IAS) pose a significant threat to biodiversity in Europe, like elsewhere in the world. This threat is likely to increase in the future unless meaningful action is taken at all levels to control the introduction and establishment of these species and address those already introduced. It is estimated that the economic impact of IAS only in the European Union causes some 12.5 billion Euros worth of damage each year.

Although the challenges posed by IAS are common to many European countries, there is currently no dedicated European legislation to address them. At the European Union level, the European Commission in its Biodiversity Strategy to 2020, proposes filling this gap by developing a dedicated legislative instrument, which is due to be presented in 2013. This instrument would tackle outstanding challenges related to IAS pathways, early detection and response, containment and management of IAS. This is one of six key objectives of the EU 2020 Biodiversity Strategy adopted in May 2011: "*By 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS*".

Local and regional authorities have an important role to play in implementing international, EU and national biodiversity targets and can greatly contribute to raising awareness about IAS among decision-makers and citizens.

The examples of local action presented in this publication bring evidence of the threat which IAS pose to European cities and urban environments, and provide solutions which can be adopted in an attempt to combat biological invasions. Most of the case studies compiled in this publication concern actions undertaken at the local or regional levels; however it is important to highlight the international nature of IAS. Only collaboration between countries in Europe, and worldwide, will allow addressing the movement of alien species and hence their invasive spread.

With this publication, IUCN highlights the key role that European local authorities play in addressing the risks associated with biological invasions. IUCN aims to strengthen collaboration with all stakeholders in the urban environment and offers its scientific knowledge and expertise to support achieving the ambitious requirements of the future EU legislation.

Luc Bas
Director
European Union Representative Office
IUCN

Preface

Are urban environments pivotal to understanding and managing biological invasions?

By Riccardo Scalera and Piero Genovesi

The story of a rabbit population deep burrowing in a graveyard area, loosening the roots of trees, making tombstones fall, and horrifying people, may look like the plot of an old B horror movie. Yet, this is what the experts report about the situation in Helsinki, where in 1985 rabbits established a feral population descended from pets dumped in the wild. Outside their natural range (the rabbit is native to the southern Iberian Peninsula), this species is considered as a key driver of ecosystem change, as it can cause extensive erosion of soils by overgrazing and burrowing, which can cause significant impact on the composition and local abundance of native wildlife. The most renowned case is that of Australia, where introduced rabbits have devastated large areas of cropland. But also in Europe the impacts caused by this species can be very severe, also in terms of economic loss. For example, until now the estimated economic impact of rabbits in Helsinki exceeds 2 million Euros. The damage caused by their introduction has been known for thousands of years in Europe. Pliny the Elder, an erudite natural philosopher and encyclopaedist of the early Roman Empire, wrote in his Natural History (77 AD) that the invasion of this species in the Balearic Islands was such a severe problem that the help of the late Emperor Augustus and the Roman troops was sought to control them.

The history of biological invasions in Europe dates back to at least the Neolithic Age, especially in the Mediterranean region. Many alien species have now become an integral part of our landscapes and cultures, which is the case for the Mediterranean cypress in Tuscany or the pheasant in many areas of Europe. Nevertheless, in the last centuries, and particularly decades, the increasing movement of people and goods across the globe has sharply increased the opportunities of alien species to be introduced and become invasive. As shown by the many contributions published in this report, the urban environment – often characterised by high levels of disturbance, high intensity of transport, and high environmental heterogeneity – has usually played a crucial role in biological invasions. This is also due to the fact that a number of potential pathways, such as botanical gardens, zoos, nurseries and private gardens, concentrate within urban environments. In addition, urban areas are privileged centres for some of the most prominent pathways and vectors, including trade of pets and ornamental plants etc. which can increase the propagule pressure that facilitates the invasion processes. Not surprisingly, many studies have demonstrated that cities are hotspots of invasions, particularly for plants. Human settlements are often the point of origin of many invasive species, which spread into adjacent landscapes along transport corridors such as railways, waterways and roads, in many cases eventually invading natural areas.

Furthermore, urban environments in many cases host an important proportion of the overall biodiversity, and as a result, invasive alien species represent a serious threat to the native wildlife in urbanised areas, that are often already under “siege”. Generalist predators such as feral cats, for example, prey on a variety of native species living in urban areas, which may suffer severe population declines. According to some estimates derived from scaling up local studies to the national level, the about 9 million cats living in Great Britain, for example, killed 52–63 million mammals, 25–29 million birds and 4–6 million reptiles and amphibians during a 5-month survey period. However, the management of cats, along with many other invasive alien species, particularly those kept as pets, is often opposed by a large part of the public, and it is therefore crucial to improve our capacity to explain the reasons behind any control program, to mitigate the conflicts that these interventions may raise. In fact, the opposition is often a consequence of lack of awareness or misinformation regarding the actual impact of such species. The situation is well exemplified by the case study of the Grey squirrel. This North American species, introduced to Great Britain, Ireland and Italy on several occasions since the end of 19th century, outcompetes the native red squirrel, has significant economic impact on agriculture and is also reported to be a garden

pest by digging up flower bulbs, eating the bark of ornamental plants, and damaging infrastructure, for example by chewing timber and wires and stored goods, tearing up insulation and building their dreys in lofts. In Italy the species is currently managed by a LIFE programme funded project. The LIFE programme, as evidenced also by the case studies in this publication, is actually one of the key financial instruments in Europe to manage invasive alien species both locally and regionally over the last 20 years. Yet, one of the main obstacles affecting the sound implementation of the activities of the Grey squirrel project involves the removal of animals, which is related to the continuous opposition from associations and groups of citizens, along with the difficulty to have scientifically correct media coverage, which in turn has affected the political support to the project.

It must be noted that not all invasive alien species raise this kind of public empathy, and many invasives are considered a real nuisance. For example, the Japanese knotweed is almost universally disliked. The most extreme situation is to be found in the UK, where the plant is famous for its ability to devalue the built environment. It is not uncommon for banks to refuse to lend money for the purchase of a house that has knotweed within a certain distance of its boundary and developers are very wary of sites where there is a suspicion of knotweed presence. Japanese knotweed is often an indicator of a poor social environment and of urban decay, so many groups have become involved in eradication / control campaigns. The media have taken a keen interest in the plant and every season this generates hundreds of articles. In the UK, local action groups have rallied around the knotweed case, such as the Cornwall Knotweed Forum and various invasive species forums have followed suit.

Also the invasive Spanish slug, which feeds on horticultural plants in private kitchen and vegetable gardens and in agricultural fields, has a clear impact on provisioning ecosystem services, especially in northern Europe. It can reach very high densities, which really annoys people and forces them to withdraw their gardening activities. Spanish slugs feed on all above-ground parts of plants and are usually found in man-made habitats. In the last decades, due to the unintentional translocation of eggs and young slugs as contaminants of soil, horticultural (and maybe ornamental) plants and compost, and as stowaways with packing materials and gardening equipment, the species has spread widely in Europe.

The impact of invasive alien species is more easily recognised when it affects human health. Many species are known to be specific disease vectors or pose a direct health threat. An example is the Common ragweed, one of the most pollen-allergenic plants, representing a serious health risk for humans. The pollen of this native to North America which is rapidly spreading in Europe is a potent trigger of hay fever, rhinoconjunctivitis, and may often cause severe asthma-like symptoms. In Europe the incidence of ragweed allergy ranges widely from 2-50% of the allergic population (roughly ¼ of the European population shows general allergic rhinitis). The impact of Common ragweed on human health – affecting mostly children and urban populations (but also horses, dogs and cats) – is not restricted to areas invaded by the plant (e.g. construction sites and wasteland). In fact, due to transport of ragweed pollen by air masses, allergy reactions are recorded in distances of hundreds of kilometers from the site where the plant is situated. In addition, the Common ragweed also contains volatile oils that may cause skin irritation and hypersensitivity dermatitis. The associated economic costs are estimated to be around 4.5 billion Euros per year. In Italy, for example, the costs of human ragweed allergy have been calculated to amount to almost 2 million Euros per year in the Milan province only. Nevertheless there is still a general lack of awareness among the public and the competent authorities, and this of course represents a major constraint for the sound management of the problem.

It is clear that the urban environment can play a much wider and important role in addressing the risks of biological invasions, e.g. by making citizens aware of the importance of biodiversity and promoting the implementation of dedicated actions by the competent administrations. For example, many institutions usually based in towns, such as botanical gardens, zoos, aquaria, university departments, natural history museums, conservation agencies and institutions, can be key players in global conservation programmes, by attracting and leveraging hundreds of millions citizens, thus contributing to public outreach and raising awareness. These institutions might offer unique opportunities for dedicated environmental education programmes, in this way contributing significantly to raising awareness to prevent the introduction of new invasive alien species (e.g. through specific information activities targeting the general public or specific stakeholders). Finally, as shown by the case studies, local administrations can be of fundamental importance for the successful implementation of conservation related activities, i.e. from research projects to eradication/control initiatives.

1 Introduction

IAS and policy responses

Invasive Alien Species (IAS) are animals and plants that are introduced by human action, either accidentally or deliberately, outside their natural ranges. They are acknowledged as a serious threat to biodiversity, and as such are a growing driver of species extinction and one of the most difficult to reverse. Global trade and travel reduce geographical barriers for species movements. Free from native predators, pathogens and competitors, new non-native species often flourish and can create severe problems for native plant and animal species.

Although a Pan-European strategy to combat IAS exists, there is currently no dedicated European legislation to address the impacts of IAS. As part of the EU Biodiversity Strategy to 2020, the European Commission is developing a legislative instrument on IAS, which will ensure effective harmonization with decisions and recommendations resulting from international and European targets on biodiversity conservation. This will establish a profound basis for effective identification of IAS and their pathways, as well as a prioritisation of species to be controlled or eradicated. An essential aspect of this new legislation will need to ensure that measures are in place to manage pathways to prevent species' introduction and establishment. In parallel to the development of the EU legislation, countries are developing strategies for dealing with IAS. In Switzerland, for instance, a national strategy on IAS is currently under development.

Recognising the benefits of strengthening collaboration in support of biodiversity and ecosystem conservation and management at the local level, cities, local and regional authorities and other urban actors have a critical role to play in implementing national and international biodiversity targets.

The challenges for urban areas

Metropolitan areas are particularly vulnerable to IAS, due to the amount of commodities arriving or passing through for trade and commercial activities which are key pathways for IAS. The characteristics of the urbanized landscape – highly influenced by human activities and located close to managed and natural ecosystems – also favour the spread of such species.

In addition, urban areas can act as a "source" of IAS into other environments, due to citizens being the ultimate recipients of the international wildlife trade in non-native plants and animals (e.g. see gardening and pet trade). The consequence of such trade is that non-native animals and plants are either accidentally or intentionally released (or dumped) in the urban environment (e.g. American sliders in fountains and ponds, exotic squirrels in parks, ornamental plants and lawn clippings and weeds in green areas, including diseases and pathogens harmful to both citizens and wildlife in general). These exotic species may further spread into adjacent habitats and cause invasions.

Specific problems that some IAS pose in urban areas are: allergenic (Common ragweed), damage to monuments (Tree of heaven), health issues (Tiger mosquito), and landscape damage (Red palm weevil).

Urban environments, where major cultural centres, such as museums, universities, zoological and botanic gardens, are located, can play a key role in helping address the risks associated with biological invasions by contributing to raising awareness among citizens and decision-makers on the issue.

About this publication

Highlighting the major threats which IAS pose to native biodiversity in Europe, IUCN made a request to its European network for case studies describing actions for reducing the impact of IAS in cities and other urbanised areas.

The main aim of the publication is to raise awareness, exchange knowledge and best practices that contribute to solutions for IAS in the urban context. This publication gives an overview of the case studies IUCN collected. It showcases approaches to control, manage and eradicate IAS, or to prevent their introduction and establishment in urban environments in Europe. In this context, the urban environment is defined as: land covered by artificial surfaces (e.g. for residential areas, industrial and commercial sites). This is the geographical area of cities and towns, as well as their surrounding areas, drawn upon for the provision of goods and services.

This publication presents knowledge, experience and examples of approaches to combat the impact of IAS on biodiversity at the local level from a diversity of stakeholders, such as local and regional authorities, scientists, trade associations, NGOs and other civil society groups.

The document does not provide a representative overview of the situation for IAS in Europe's urban areas, nor in individual countries, and does not include all IAS that can have an impact on biodiversity. The problems with specific IAS described in individual countries, can often be found in other European countries as well or even globally, as

highlighted by the last two case studies on Japanese knotweed and the House crow.

The case studies provide insights on the specific problems, challenges and impacts, as well as actions and approaches and lessons learned, for selected IAS and geographic locations, as perceived by the stakeholders who responded to the request for case studies by IUCN.

With this publication, IUCN intends to inform the competent authorities in Europe who are responsible for implementing action on IAS, with knowledge and expertise as well as guidance and examples. This publication offers the opportunity to strengthen European partnerships to facilitate sharing of lessons-learnt, transfer of best practices, increase knowledge on the benefits for local governments and cities of investing in the control, prevention and management of IAS.

2 Case studies

Management of the perennial invasive alien plant Giant goldenrod (*Solidago gigantea*) in the Greater Vienna area

© Katharina Lapin

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Background

The ongoing distribution of invasive alien species has become a major issue for the protection of global plant diversity. Many invasive alien plant species have been distributed for ornamental reasons. In the last decades, the spreading of invasive plant species from urban environments to rural habitats, where invasive species can cause dramatic changes in plant species composition and promote the loss of endangered native species, has been recognized.

Riparian habitats play an important role in the distribution of seeds via rivers, and due to natural and anthropogenic disturbances, riparian habitats are preferred areas for invasion by alien plant species. This case study describes the development of invasive species in a riparian ecosystem in Lower Austria along the recent alluvium of the river Danube. The outlet of the river Traisen was heavily regulated and relocated in the past, causing massive changes in ecological connectivity and limiting the riparian vegetation to a narrow band.

The perennial invasive alien plant, Solidago gigantea (Asteraceae), was introduced from North America to Europe as an ornamental garden plant around 1850. Today, S. gigantea is one of the most common invasive alien plants in wetlands, meadows, reforestations and river banks and still a very popular ornamental garden plant.

Problems and challenges

Due to its fast clonal growth, *Solidago gigantea* competes successfully with native species. Once established, its dense stands exclude almost all other plant species. The massive distribution of *S. gigantea* therefore endangers native plant composition and diversity. The distribution of non-native species has consequences for evolutionary processes like hybridization, niche displacement or competitive exclusion of native species.

The, in some areas, massive dominance of invasive species renders removal of these invaders economically unaffordable and in most cases also ineffective, and therefore undesirable. Successful conservation management of invasive species and ecological restoration of riparian vegetation requires participative solutions including human land-use concepts and natural ecosystem services. Small-scale and long-term restoration efforts are recommended.

Scope and size of impact

To assess the quality of plant diversity as well as vegetation coverage and development, a grid of coordinates was placed over the research area and soil samples taken in the years 2010, 2011, 2012 and 2013. Seed bank analysis, phenological observations as well as eradication and germination experiments were performed.

The occurrence of seeds of *Solidago gigantea* shows a positive but not significant relationship with the total aboveground cover of the herb layer. The Shannon diversity index of aboveground plant species composition, representing the species diversity of each plot, is negatively related to increasing number of coverage of *Solidago gigantea*. The Pilou´s index of evenness, representing the evenness of the aboveground species composition in the herb layer of analyzed plots, is negatively related to seed density.

The vegetative development of the species *Solidago gigantea* starts in May very rapidly. There are no significant differences between the four observed populations. Within two weeks the first shoot emerged and the leaves develop up to 25%. The populations of *Solidago gigantea* are fully developed in June. By the end of August the yellowing starts and lasts until October, when the plants start to die back. The results of the observation of the generative development of *Solidago gigantea* show no significant differences between the populations of different sites. The first visible flower buds appear in June. In July the flower buds are clearly visible. The blooming starts in the beginning of June and lasts until October. The maturity of fruits and the distributing of seeds start in the end of October. Analysis of the seed bank and the phenological development of invasive plant species help to specify monitoring measures.

Studies have shown a significant occurrence of invasive alien plant species in the study area. Because of the fast clonal growth, *Solidago gigantea* competes successfully with native species. Once *Solidago gigantea* is established, its dense stands exclude almost all other plant species. Sites with open structures and sites of habitat types like tall oat grass meadows and semi-dry grasslands are mostly invaded by *Solidago gigantea*.

Approach and activities

Active monitoring is performed with the aim of reducing the occurrence of invasive species in protected riparian areas, focused on the protection of endangered native species.

Eradication experiments correlated to phenological data optimize the management of the invasive species *Solidago gigantea*. The goal of achieving conservation targets requires active monitoring measures to protect hitherto non-invaded areas from biological invasion and maintain the integrity of protected natural areas for the protection of native flora.

Constraints and obstacles

Besides the management of *Solidago gigantea* within the invaded riparian area, early diagnosis and pre-screening are important for successful control. A further challenge is the required awareness raising and educational work to stop the distribution of invasive plant species popular in urban gardening into rural habitats.

We observe a lack of communication and information channels between the stakeholder groups: nature conservation and garden plant producers and gardeners. A legislative response currently does not exist, meaning that invasive plant species like *S. gigantea*, may be legally distributed.

Social dimension

The invasion of alien plant species into natural habitats cannot be prevented without an exchange of knowledge and various levels of participation.

The use of invasive species for gardening purposes should be discussed and explained rather than

simply legally restricted. This is important for the awareness of all stakeholders of the impact of invasive species on natural habitats.

Results and lessons learned

Results show an increasing impact on native species composition. When comparing germination performance to that of native plant species in the riparian habitats, *Solidago gigantea* shows high competitive abilities. The species richness (Shannon index) and evenness (Pilou´s index) are observed to decrease.

The growth abilities of invasive alien plant species can have controversial functions for different interests. The invasive plant *Solidago gigantea* is one example of the destruction of natural habitats caused by human horticultural activities. Publicity work, scientific investigation and improvements to monitoring techniques will help to detect plants with invasive abilities earlier than was the case with *Solidago gigantea.*

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American bullfrog *(Lithobates catesbeianus)* in Flanders

© Riccardo Scalera

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Background

The American bullfrog was introduced in Flanders (northern Belgium) in the 1990s. The region is highly urbanized (456 inhabitants/km²), with natural areas only appearing as very small fragments in a matrix of built-up areas, arable land and the densest transportation network of Europe. The species most probably arrived together with live fish transports from other European countries. Subsequently, the bullfrog was distributed over several fish rearing ponds in the northeastern part of Flanders. Besides natural spread, the species was sold for a decade in garden centers and pet shops for ornamental purposes, leading to the emergence of the species outside of captivity scattered over Flanders around the 2000s. Reproducing populations in "the wild" are currently only present at five distinct locations, with four smaller ones (average infected area of these populations is 1.5 km²) and one large (around 200 km²). Because of the large amount of small, shallow, permanent and nutrient-rich ponds in Flanders, optimal conditions are present for successful reproduction. These conditions entail the presence of lots of algae (food for tadpoles) and the lack of predators in the breeding water bodies (e.g. piscivourous fish, carnivorous macro-invertebrate larvae). Although trade has been restricted over the last years, and relatively well complied with, natural dispersal is still ongoing and demands urgent actions (i.e. both prevention and field management).

Problems and challenges

Due to its broad global distribution and widespread effects on native biodiversity through various impact mechanisms, the American bullfrog is listed as one of the top 100 most invasive alien species in the world by IUCN. The species is suspected to cause substantial ecological damage around large parts of the globe, exerting an additional pressure to already declining amphibian populations. American bullfrog is known to impact native biodiversity in several ways. Firstly, there is a direct impact when adult individuals consume all kind of native biota (birds, amphibians, macroinvertebrates, mammals etc.). Furthermore, bullfrog tadpoles are strong competitors towards native juvenile amphibians for food (algae). Secondly, the species is a healthy carrier of pathogens, such as fungi and viruses, known to infect other amphibians. It may be carrier of chytrid fungus *Batrachochytrium dendrobatidis*, which may be disastrous for native amphibians, but seems to have little impact on bullfrogs.

Bullfrogs are considered a major threat to biodiversity in general, and amphibians in particular, since they are highly competitive and can act as structuring predators in aquatic ecosystems. In Europe, the American bullfrog is listed on the SEBI worst list of invasive non-native species with high impact on biodiversity as well as the DAISIE list of the worst invasive aliens in Europe. For the same reasons, the species is included in the appendix to the Bern Convention recommendation n° 77 (1999) as a species which has proved to be a strong threat to biological diversity and for which eradication is strongly recommended. Moreover, the EU Wildlife Trade Regulation (338/97) Appendix B prohibits import of the species into the EU since December 1997.

Scope and size of impact

The impact that bullfrog causes, has an ecological nature. At this point, only one river valley (Grote Nete) is affected strongly by the species, apart from some small local infections outside this region. However, to prevent further colonization, natural dispersal needs to be halted. The ecological impact in this region is, although not yet quantified, probably severe, as described before. Among the infected ecotopes with conservation value in the region are eutrophic ponds with diverse plant communities, moist willow thickets on nutrient rich soils, reedlands and mesotrophic ponds. The species has invaded 8 nature reserves and 15 Natura 2000 areas in Flanders. Over the last decade, the species' area of occupancy increased to 17km^2. It has been observed in at least 70 km^2 grid cells in Belgium since 1996, but meanwhile disappeared from some of these through natural factors and, partly, eradication measures.

Based on interviews with private pond owners and fishermen that cooperated within an EU-Interreg funded eradication project, bullfrogs are sometimes regarded as a nuisance species in eutrophic ponds used for recreational fishing. This is primarily due to the high densities of bullfrog larvae that can be attained in such habitats, the presence of which is perceived as a negative influence on the quality of the pond as a habitat for fish and/or aesthetic value of the pond. Some newspaper articles in Flanders and The Netherlands also bear witness to nuisance caused by male vocalisations in the breeding period.

Approach and activities

In order to achieve a comprehensive approach to combat invasive alien species, policy makers, scientists and managers collaborated and initiated the European Interreg IV A project Invexo 'Less invasive plants and animals, more biodiversity' (cross-border region Flanders – The Netherlands, 2009-2012), case American bullfrog. This study aimed to determine whether the further spread of the species could be stopped, and how the present populations might be eradicated. In particular, attention was paid to prevention, early detection, research on ecology and control, and the operationalization of management, taking into account key elements such as communication, collaboration and innovation.

- Prevention. During the project several communication actions were set-up and focused towards the nature conservation community and animal lovers, policy makers, managers as well as the wider public. Themes that were dealt with encompassed: discouraging the purchase and pet keeping of the species, to avoid escapes to nature, to explain the need to manage/eradicate the species outside of captivity. These communication actions were disseminated through different channels, such as spoken, written and visual media. In addition, information sessions, workshops and seminars were organized.

- Rapid detection. Setting-up a detection system for new observations of the species (early warning system) is essential in combating invasive species. For this purpose, existing channels were used that allowed for rapid reporting (www.waarnemingen.be and www.waarneming.nl). In addition, at the beginning of the project, interested volunteers followed training sessions on recognition of the species

(sound, behavior and appearance), and were asked to investigate on a regular basis the presence of the species in a km^2 square assigned to them. Reports of the species were then validated by experts, either by verifying with known distribution data, feedback from the observers, or an actual site inspection. These efforts led to the discovery of a reproducing population in two breeding ponds in Baarlo (Limburg, The Netherlands), north of Roermond and east of Eindhoven, as a direct result of increased media coverage. This population was subsequently removed by the Invasive Species Team of the Dutch authorities.

- Research on ecology and control. In Flanders, American bullfrogs mainly occur in aquatic habitats on sandy soil, in the Campine area (province of Antwerp). The small (2000 m^2), shallow and permanent ponds in this region warm up fast, have in many cases a high supply of nutrients (algae) and limited predation. The ponds are turbid, have little or no submerged aquatic plants and contain a high fish biomass. The land habitat of the species was investigated by radio telemetry and proved to consist mainly of swamp forests. Finally, the infection rate by fungi and viruses in adults and tadpoles was investigated from a number of test areas. These infection rates turned out to be rather low, but in some cases Ranavirus, chlamydia and chytrid fungus were detected. Combating the species in small and isolated populations will be most effective using double fyke nets. A follow-up in the coming years is obviously essential, so that any new reproduction can be prevented, and remaining individuals are removed. As an alternative to active control, passive control (habitat restoration) seemed the most feasible option in large and connected (meta-) populations. The introduction of pike can contribute to a reduction in the food supply for tadpoles, and increased predation on bullfrog larvae. Finally, research under laboratory conditions showed that chemical sterilisation of adult males could be a path that merits further investigation.

- Operationalization of management. The insights gained in distribution, ecology and control were brought together and operationalized through a pilot project. Responsibilities and costs of control actions were mapped to combat the species in an isolated population in Arendonk (Antwerp). Here, a close communication was performed and agreements were made between a central coordinating body (regional and local government), pond owners (private) and managers (municipality-social economy company). The model approach seemed to work well at all levels: coordination, awareness raising (both owners and municipality were positive), efficient implementation (double fyke nets are practical) and cost (fyke nets are relatively cheap, low transportation costs and personnel costs). The developed approach can work as a model for other similar eradication actions of American bullfrog in Flanders and The Netherlands and in other urbanized areas.

After the Interreg project finished, the project consortium continued their activities (2013-present), focusing on eradication of the isolated populations, and halting the spread of the one large population at its borders. New techniques, such as environmental dna (e-dna) for presence detection are nowadays fine-tuned. Insights in the actual occurrence, rate of spread, optimal management and detection techniques, will all result in a management plan. This plan will be surveyed by governmental bodies, and carried out by the mentioned partners (NGOs, social economy, volunteers, governmental agencies).

Constraints and obstacles

The constraints bullfrog control suffered from are seemingly less important than for other vertebrate species. Public opinion was rapidly won, due to a good communication strategy, but probably also facilitated by the rather voracious behavior of the species. Also, the need for urgent actions was rapidly taken up by funding agencies (both European and regional). Detection and management techniques seem to be adequate, but need to be carried out at the time-scale (several years) needed to obtain sufficient result. On the other hand, prevention is a permanent issue, as well as the elaboration of a legal framework to force access to manage invaded ponds on private property or to oblige pond owners to manage established populations at their property.

Social dimension

The Interreg project insisted on close collaboration between governments, the general public and NGOs. As all were involved from the early beginning, no real problems were encountered. Social economy has played a major role in the execution of management in the field. NGOs have played a big role in coordinating and carrying out early warning, monitoring the territory for bullfrog presence.

Results and lessons learned

Currently, all four isolated bullfrog populations in Flanders are managed with the developed management techniques. The population in the Netherlands, which was discovered as a consequence of the early warning action, has also been removed. As for the larger river Valley population in Flanders, eradication will hardly be feasible, but further spread will be halted. Maintaining the eradication and containment actions for several years will be the most important challenge.

Additional information

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- Early warning: http://waarnemingen.be/invasive_alert_view.php and http://waarnemingen.be/exo/be/nl/1724.pdf
- Agency for Nature and Forest http://www.natuurenbos.be/~/media/Files/Themas/Soortenbescherming/Overlast_schade/Stierkikker%20L%20catesbeianus%20FICHE.pdf

Canada geese in Flanders urban areas

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Background

The Flanders–Brussels region (Belgium) is one of the most urbanized regions in Europe. The highly fragmented and mostly relatively small natural areas in this region are very prone to biological invasions, impairing on the quality of nature. With its high degree of urban sprawl, Flanders is a suitable habitat to opportunistic non-native species with flexible life history strategies, such as invasive Canada geese (Branta canadensis).

Many urban and suburban areas in Belgium are excellent Canada goose habitat. City parks, lawns and recreational areas provide spring, summer, and fall forage. These areas can contain water reservoirs, lakes, ponds and marshes, often dotted with islands, which provide safe nesting sites for geese. In addition, the traditional predators of geese are present in lower numbers in most urban areas, and hunting pressure is low here. The Canada goose is primarily a grazer and mainly feeds on grasses and aquatic plants. The geese also take advantage of food provided by people in urban areas and feed on agricultural crops.

In Belgium, Canada goose populations have grown at a tremendous rate from 1990 onwards and are still on the increase. The species started breeding in Belgium in 1973. Since 1920 the species has been imported in substantial numbers in Europe for ornamental and hunting purposes. The geese easily adapted to the Belgian environment and have lost the migratory behaviour they display in their North American native range. Large flocks of residential birds can exert substantial impacts on ecological, economic and social values.

The geese in Belgium most often breed along small mesotrophic or eutrophic ponds in the vicinity of grasslands. They are also increasingly found near wooded ponds and on islands in large rivers. They are especially common in man-made habitats (parks, golf courses, urban and agricultural areas) but are also known to colonize semi-natural wetlands and coastal areas.

Problems and challenges

Canada geese are listed among the worst invasive alien species threatening biodiversity in Europe. Moreover, impact scoring for 26 established non-native birds in Europe has shown Canada geese to have the highest actual environmental impact and also the highest impact on the economy.

Canada geese are herbivorous and feed on various plant species. High geese densities can be responsible for overgrazing, fouling and trampling of vegetation such as reed beds and meadows. With their long necks, they are able to reach rooted aquatic plants, which can lead to reduced densities of these plant species. Also, their feeding activities can agitate the pond bottom, leading to increased turbidity and therefore, a general deterioration of structure and quality of water bodies. Besides mechanical impact on native vegetation, due to their relatively inefficient digestion, geese produce vast quantities of nutrient rich feces, up to 500 grams per bird per day. This eutrophication of soil and water can have a severe impact on nutrient poor ecosystems and the achieving of nature management goals in such natural areas. In ponds and fens nutrient addition by goose feces can stimulate algae and weed growth. In addition, hybridization with native geese species has been reported regularly. Finally, Canada geese in Belgium have been shown to be a vector of wildlife disease such as *Bd*, the causal agent of the amphibian disease chytridiomycosis in Belgium.

Economic impact of geese occurs mainly through crop damage. In Flanders, this is especially the case on parcels with winter wheat and on temporary or permanent grasslands. Consumption of crops is often combined with trampling of vegetation and soil. Also, soil and water pollution cause management costs for maintaining areas suitable for recreation. Some people enjoy seeing geese in urban areas, whilst others consider them a nuisance. Large flocks leave behind large amounts of fecal material. Defecations can reduce the water quality of (swimming) ponds and can spoil lawns of (sub)urban parks, golf courses, apartment complexes etc. Also, geese are attracted by open expanses of grasses, such as runways of airports. Flocks of birds represent a human safety hazard by increasing the possibility of goose-plane collisions.

Scope and size of impact

Quantitative data on the actual ecological impact of geese in Belgium are lacking. Management is therefore largely backed by risk analysis of potential environmental impacts, anecdotal evidence and fragmentary data on economic and social impacts. For notorious invasive non-native species such as the Canada goose, where eradication could be considered a policy option, a sound scientific basis for this choice is, however, essential for public acceptance of the management objective and associated measures.

However, in Flanders, several case studies illustrate that the presence of geese is putting a mortgage on the outcome of nature restoration projects. In particular, this is true for restoration efforts of Natura 2000 habitats such as mesotrophic and oligotrophic fens, transition mires, lowland hay meadows and natural eutrophic lakes. Although rarely backed with scientific data, impact on local fauna has also been suggested through competition for food and space. More specifically, concern has been raised about direct aggression of Canada geese towards other breeding bird species through their strong territorial behaviour. Where high breeding concentrations occur, this could locally prevent smaller water birds from establishing territories. Circumstantial evidence also suggest that meadow birds like Black-tailed godwit, for which specific conservation schemes exist in Flanders, might be affected.

As the problem is not only present in Belgium, but also in neighbouring countries, impact is to be considered significant in a European context. In the Netherlands, agricultural crop damage by Egyptian and Canada geese together has been estimated at 870,000 euro in 2010. If no population reduction of these geese would be aimed for in The Netherlands, the number of Egyptian geese are expected to increase from 10,000 to 28,000 breeding pairs by 2020. For Canada geese these numbers would go up from 5,500 breeding pairs up to 25,000. The estimated damage to agricultural crops under this scenario was estimated to approach 3 million Euros. When considering impact on biodiversity, Canada geese may hamper costly nature restoration projects because of the nutrient enrichment trough their feces. Typically, a fairly limited number of geese can already exert considerable damage to vulnerable ecosystems.

Approach and activities

Populations of geese having impact on biodiversity and society include invasive non-native greater Canada goose *Branta canadensis*, native Greylag goose *Anser anser*, feral Domestic goose *A. anser f. domestica*, mixed populations of wild and domesticated Barnacle goose *Branta leucopsis*, as well as a number of non-native species like Egyptian

goose *Alopochen aegyptiacus*, Bar-headed goose *A. indicus* and Magellan goose *Chloephaga picta.*

The EU co-funded Interreg IV-A cross-border project *INVEXO* (www.invexo.be) (2009-2012) focused, among others, on the management of native and non-native summering geese. The general aim was to develop an integrated, sustainable management in favour of biodiversity, agriculture and the recreational sector. The approach combined efforts on prevention with ethical management methods and a clear communication to the different stakeholders and the public.

Before, Canada geese were hunted. In Flanders, the species is a game species, implying sustainable hunting and not attempting to decrease population numbers. Also, the pricking of eggs or destruction of nests, aiming at preventing reproduction of the species, is common practice for several years. However, population models have shown that egg reduction has only limited effect on population numbers. The Invexo project served as a platform to set up a more structural management approach of geese, involving all stakeholders: managers, policy makers, hunters, conservationists, farmers and representatives from the recreational sector.

The approach was to work towards an adaptive management cycle in order to come to a joint work plan and consensus goals for reducing the negative impact of the species. The project added value in enhancing coordination of already applied management measures (hunting and egg reduction) in the field. Importantly, during this project molt (flightless period) captures of Canada geese were applied on an international scale. On average, 2,200 geese were removed from the population every year. To our knowledge, Invexo represents one of the very few projects in Europe that has actually realized coordinated cross-border management of geese against legal, political and social constraints.

Constraints and obstacles

Many of the sites where Canada geese occur are publicly accessible lakes and ponds in parks and green areas. Therefore, hunting is often difficult to apply and other methods are needed. Molt capturing of Canada geese appeared to be a promising management method as many individuals can be caught simultaneously and public opinion can be considered more positive towards this method. The technique was conveniently applied in all sorts of waters, also in more densely populated areas.

A general management plan for summering non-native geese is still needed for both indigenous and non-native species. Clear management objectives, with differentiated goals for the various species, and consensus amongst stakeholders is needed. It is further assumed that not the number of geese in itself is a challenge, but the extent to which damage occurs. Therefore, it is advisable that, next to the elimination of geese, other ways of preventing damage are explored in the future.

The lack of studies on the impact of exotic geese and/or summering geese is still a bottleneck. For species for which eradication is considered a sound scientific basis for this choice is essential for public acceptance of the objective and corresponding measures.

The debate on management choices needs information regarding expected population trends and what measures would have the most impact. Population models should be informed with data on breeding success, recruitment, mortality, survival, and high-quality data on the applied management e.g. the number of culled birds through shooting and molt captures.

Differences in legislation between Flanders and The Netherlands proved to be a very challenging constraint to overcome and were responsible for large differences in management effort between the two countries. Notably, in Flanders and The Netherlands, humane despatching of birds after capture was a critical factor in gaining public support for management measures.

Social dimension

A huge effort was made into communication towards different stakeholders involved in geese management: hunters, farmers, conservationists and the public. Together with a sound monitoring of geese populations, this investment in awareness raising and gaining public support was essential to the successful execution of management measures. This included e.g. the regular organization of stakeholder meetings to provide feedback on management results, an expert workshop on humane despatching, workshops on goose hunting, the organization of a symposium on invasive species and geese in particular, the publication of a brochure on egg pricking for field workers, a booklet for farmers on what to do in case of goose damage, a game of the goose to get people and children to know the different species and a recipe book with goose products.

Results and lessons learned

Management measures intervened in reproduction (pricking eggs) and in the number of birds (culling trough molt capturing and shooting). Measures were implemented opportunistically in space and time, resulting in a mixed, diffuse deployment throughout the project area. The combined management efforts were closely monitored and trends in the average number of geese per municipality and per year were modeled and show a significant decrease in the number of Canada goose since the beginning of the project. However, it was unclear which population response (e.g. dispersion, reproduction) was responsible for this decline. When the province of East-Flanders, where molt captures were applied most intensively, was considered separately, a significant yearly decrease was noted.

Recent research indicates that Canada geese disperse over large distances within Western Europe, blurring a possibly significant effect of a local action over the years. Future work will include dynamic population modeling to estimate the combined effect of management measures, as well as thorough monitoring of geese populations as the basic elements of a sound adaptive management plan for geese in the region. In addition, this approach requires continuous dialogue between partners and stakeholders. In this respect, the Invexo project has provided a strong impulse.

The continuous effort in communication towards different stakeholders was instrumental in creating support as well as policy initiative for further measures. The Agency for Nature and Forest is currently working on management regulations for different goose species, with the ultimate goal of structural measures for reducing damage by invasive geese.

To continue geese management measures in an adequate and evaluable way in the future, an adaptive management strategy is preferred. Such management is based on pre-defined and widely accepted operational goals. This approach requires continuous dialogue between partners and stakeholders and sound scientific monitoring.

Additional information

- www.invexo.be
- Folder on egg pricking for field workers: http://www.oost-vlaanderen.be/docs/nl/jv/9668folder%20ganzeneieren%20prikken.pdf
- Booklet for farmers on what to do in case of goose damage: http://www.west-vlaanderen.be/kwaliteit/leefomgeving/proclam/documents/ganzenwijzer%20brochure%20+%20formulieren.pdf
- Game of the goose to get people and children to learn about the different species of goose: http://www.rlm.be/files/ganzenbord_2012.pdf
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- Goose recognition and fact sheet: http://www.oost-vlaanderen.be/docs/nl/x8/8305ganzenvouwblad_rlm.pdf

Invasive plants and prevention in the green sector in Belgium

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Background

In 2010, the AlterIAS [ALTERnatives to Invasive Alien Species] project was launched in Belgium (www.alterias.be). It is an 'Information and Communication' LIFE project dedicated to invasive plants and prevention in the green sector. Ornamental horticulture is recognized as one of the main pathways of introduction of invasive plants. In Belgium, the major part (80%) is still available in nurseries. Voluntary plantations are starting points of invasions. In cities and municipalities, a lot of invasive ornamental plants are used in green areas. When planted in parks or gardens, they escape and spread in a wide range of semi-natural and disturbed habitats throughout the country. The project aims at (1) raising awareness among horticulture professionals, gardeners and horticulture teachers about the risk of invasive plants and (2) reducing introduction of these plants in nurseries, green areas and gardens through the implementation of a voluntary Code of conduct. The target audience of the project includes horticulture professionals (nursery professionals, landscape architects, garden contractors, public green managers), horticulture teachers and garden amateurs. All invasive plants in Belgium are targeted by the AlterIAS project. Communication actions are realized at the national level through different awareness campaigns planned for a period of four years.

Problems and challenges

In Belgium, there are around 60 plant species listed as invasive, including terrestrial and aquatic species. Invasive plants are considered as a threat for the environment, causing biodiversity loss, ecosystems degradation and sometimes public health problems (e.g. *Heracleum mantegazzianum*) with high economic consequences for society (mostly control costs). There are no global statistics on the economic impact of invasive plants in Belgium, but only specific data related individual species. A project is in progress (ALIEN ALERT) to collect data on the economic impact of each species.

Scope and size of impact

In Belgium, invasive species are included in the *Harmonia* information system (http://ias.biodiversity.be). The environmental impact of each species is assessed through a standardized protocol taking into account 1) dispersal potential; 2) colonization of semi-natural habitats; and 3) negative impact on indigenous species and ecosystems. Through this protocol, species are classified in a black list (high impact) or a watch list (moderate or unknown impact) system. The assessment is based on international scientific literature. In addition, several research projects (e.g. IMPLANBEL, ALIEN IMPACT) were conducted in Belgium to assess ecological and economic impacts of invasive plants. A wide range of ecosystems (forests, riverbanks, ponds, coastal dunes, grasslands, rocky habitats, heathlands, etc.) are impacted by the 58 invasive plant species naturalized in the country. Assessments included both habitats of high conservation value and disturbed habitats (e. g. roadsides, railways, wastelands, urban habitats, etc.).

Approach and activities

AlterIAS is a communication project focused on prevention, which is considered as one of the most effective options to reduce deliberate introductions of invasive plants. Varied communication actions are realized (e.g. articles in press or in horticulture magazines, information sessions, TV or radio broadcasts, etc.) and several communication tools are used (folders, brochures, posters, documentary film, newsletter, etc.). A voluntary Code of conduct was developed in consultation with horticulture professionals, scientists and representatives of administrations. Five measures were approved: (1) know the list of invasive plants in Belgium; (2) stop the trade and the plantation of some invasive plants; (3) disseminate information on invasive plants; (4) promote the use of non-invasive alternative plants and (5) participate in early detection of new invaders. Restrictions of use target a list of 28 species negotiated with the sector. The Code was launched in September 2011. This voluntary instrument is based on individual commitment. Among horticulture professionals, numerous cities and municipalities have adopted the Code. Indeed municipalities are directly concerned as public departments responsible for plantation.

Constraints and obstacles

Raising awareness on invasive plants is difficult due to differences in public perception, especially with horticulture professionals who are used to cultivating, selling or planting some of these species. Communication efforts face controversial issues like the confusion between alien and invasive alien plants (only a small proportion of alien plants become invasive), the invasiveness of species (the invasive character and the environmental impacts assessed by scientists is sometimes refuted), the lack of knowledge on invasive plant cultivars available within the market, the choice of alternative plants (native or exotic), native expanding plants (often considered as 'real' invasive plants in nurseries), the lack of regulation and/or self-regulation tools in neighbouring countries.

Moreover, communication should be focused on positive messages. Negative communication with alarming terms or military metaphors re-enforces the feeling of being guilty instead of encouraging concrete solutions. The elaboration of the Code and the consultation of the horticultural sector were relatively laborious and challenging due to (1) the difficulty of mobilizing horticulture professionals and (2) the controversial issues mentioned above. Discussions between scientists and horticulture professionals were sometimes difficult due to the conflict in value between those who enjoy the economic benefits of exotic plants and those who are concerned about the harm some of these plants may cause to biodiversity and society. It has to be noted that invasive plants at the very beginning of the invasion process or invading only very specific habitats were hardly perceived as detrimental by horticulture professionals, especially when they have a high economic and esthetic value. Finally the Code was unanimously accepted by horticultural federations after 9 months of negotiation, which is a short period of time when compared to the elaboration of legislative tools. This 'environmentally safe' charter is attracting new partners over time. Thanks to constant efforts in communication, a positive trend in the dynamic of partners is observed, but the promotion of the Code is a time consuming task, which requires specific human resources

fully dedicated to this action. The Code has been launched in September 2011 and will require more than two years to be widely adopted – accepted by the horticultural sector in Belgium (the AlterIAS project ends in December 2013).

Social dimension

The Code of conduct was elaborated through a series of round table discussions involving scientists specialized in invasion biology, representatives of administrations responsible for environment and main horticultural federations/associations active in Belgium. Two target groups were consulted amongst the latter, i.e. ornamental plant producers and sellers (nurseries and garden centers) and ornamental plant users (public green managers, landscape architects, garden contractors and representatives of botanical gardens). The Code was officially launched by organizing a ceremony of signature with main horticultural federations/associations. Journalists were invited and the event was covered by the press (several articles were published in large newspapers). The Code is now promoted through a communication campaign untitled 'Plant different'. Different communication tools are used to encourage people to subscribe to the Code. General public (gardeners) can also participate to this approach by signing the charter (online registration).

Results and lessons learned

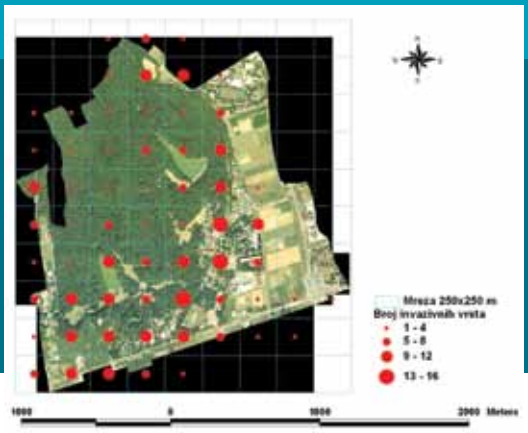
The AlterIAS project is organized according to three communication campaigns: (1) a general awareness campaign ('prevention starts in our gardens'), (2) a Code of conduct campaign ('Plant different') and (3) a campaign in horticultural schools. On January 31st 2013, the AlterIAS project (1) was mentioned in 43 press articles and 71 articles in magazines or federation journals; (2) has participated in 60 horticultural events in order to meet the target audience and disseminate information; (3) has animated 146 information sessions to horticulture professionals, gardeners, students and teachers; (4) has participated in 10 radio reportages and 18 TV reportages (including all retransmissions). The impacts of these actions (target audience reached, number of participants, number of copies, audience, etc.) will be detailed in the final report. The effectiveness of actions (change of attitudes, communication action most efficient, etc.) will be assessed through social surveys. The following communication materials were produced and disseminated: a website, a project folder, a Code of conduct folder, a folder on invasive aquatic plants and alternatives (reprinting), a brochure on alternative plants, a self-regulation instrument (the Code of conduct on invasive plants in Belgium), a 40 minutes documentary film, and a didactical toolkit for teachers in horticultural schools. Up to now, the Code has been adopted by more than 700 partners throughout the country, including 435 horticulture professionals (incl. all selling points of garden centers), 397 gardeners and 45 organizations (horticultural and non-horticultural).

A note is in preparation to address the results and the lessons learned from the Code of conduct experience in Belgium. The following recommendations can already be highlighted in order to implement such a voluntary instrument: (1) a list of invasive plants must be available in order to clearly define the species targeted; (2) the Code must be elaborated in consultation with the horticultural sector (the approbation by horticultural federations is required to support the Code); (3) a Code should be based on individual commitment (subscription process); (4) a communication campaign is needed to promote the Code (with subsequent resources in personnel and communication materials); (5) communication should be based on positive messages inducing the willingness of being part of the solution.

Additional information

- http://www.alterias.be
- http://ias.biodiversity.be

Diversity and distribution of invasive flora in Maksimir Park, Zagreb



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Background

The area where Maksimir Park is today was at its beginning, over 200 years ago, on the outskirts of Zagreb. It is now completely surrounded with artificial surfaces (mostly residential areas). On its 316 hectares, it represent a real oasis for flora and fauna in a matrix of habitats with: prevailing Sessile oak and Common hornbeam forest, pedunculate oak forest, meadows and lakes. Besides native flora, as a consequence of long term horticultural activities in park there are a number of non-indigenous plants, mostly tree species, of which some of them are recognised as invasive. Numerous surrounding gardens can also serve as source of propagules of many ornamental plants, which can naturalise and become invasive.

Problems and challenges

Today, several invasive plant species can be found in the park that are already imposing threats to biodiversity, with many more present that have the potential to increase this negative impact further. However, in the short-to-mid-term it seems that this is not going to impact the visitors' perception of the Park, and it won't affect the present diversity of activities taking place in park, and the high frequency of visitors to Park and Zoo. One exception to this might be the further expansion of ragweed (*Ambrosia artemisifolia* L.) that is already causing serious threats to human health i.e. allergy to its pollen. However, in the long-term, a decrease of biodiversity could decrease the monetary and non-monetary value of the Park, and its attractiveness for visitors.

Scope and size of impact

At present, some invasive species already cover significant part of the Park, like stands of black locust (*Robinia pseudoacacia* L.) that cover over 5% of area. This was partly as a result of planting efforts in

the past, but with its large seed bank in the ground, and influence on the soil, black locust continues to occupy new areas. In those stands, lower plant diversity in shrub and herbaceous layer is observed in comparison to natural Sessile oak and Common hornbeam stands. Furthermore, as mentioned before, the presence of ragweed can decrease the number of visitors during its long flowering period (August – October) and hence can result in lower income in this part of the year. There are also a couple of herbaceous invasive species that decrease plant diversity in the majority of grasslands in the park, like persian speedwell (*Veronica persicaPoir.)* and annual fleabane (*Erigeron anuus* (L.*) Poir*).

Approach and activities

To objectively evaluate the present state of distribution of invasive plants in the Park, the management of the Park initiated an extensive field inventory that took place in the year 2012. Collected data were analysed with respect to: habitats in which 23 observed invasive species were present, spatial pattern and frequency at multiple spatial scales. Based on this multi-criteria analysis three groups of invasive plants were identified. This should serve as basis for focusing future efforts for control and containment of invasive plants.

Constraints and obstacles

In future, for the effective control of invasive plants, there are at least three bottlenecks that can prevent the success of such control measures. The first one is a conceptual one and has to deal with the fact that Park is actually designed to have ornamental plants besides the native flora. From that point of view, complete eradication of e.g. black locust can be in contradiction of the major philosophy of the park as an area where visitors can see also non-indigenous plants. The second concern is that funds are limited for the Park management. Having in mind that a significant area of the Maksimir Park is covered by forest vegetation, changing the species composition is a costly and lengthy process. A third obstacle is the very limited influence on private owners of parcels surrounding the Park that can continue to grow ornamental plants, including invasive ones.

Social dimension

This part needs to be explored and tested in future, since results of the inventory intended to provide a basis for designing education activities. Similar actions were already done in the park with a focus on Red-eared slider turtle (*Trachemys scripta elegans*) with satisfactory success and response from visitors. Besides visitors, the education process should also be directed to private owners that surround the Park to decrease the number of potential invasive newcomers. Altogether, expected positive feedback of such education should have positive outcomes not only for Maksimir Park, but much more widely given the high number of visitors, not just from Zagreb.

Results and lessons learned

Field inventory and analysis of data resulted in a categorisation of 23 invasive plants in three categories: highly invasive (5 species); moderately invasive (7 species); least invasive (11 species). Additionally, spatial designation of the most invaded areas was developed. Both actions should help the Park management in planning future actions (monitoring, eradication, education).

Revealed spatial patterns of invasive plants indicated that fragmentation and disturbance are the two main driving forces of invasive plants success in Maksimir Park as well, as in many other areas. Given the main purpose of the Park, mosaic arrangements of habitats are welcomed (although this as a consequence inevitably leads to fragmentation) and occasional disturbance will be constant (organisation of various events that include increased frequency of vehicles and people), ensuring favourable conditions for invasive species. Increased control and monitoring in these areas is necessary, as well as a plan of future horticultural activities that should take into account today's knowledge about the potential invasiveness of certain species.

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Red-eared slider in Maksimir Park, Zagreb

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Background

Park Maksimir, which was originally formed on the outskirts of Zagreb at the end of 18th and the first half of 19th century, today is completely surrounded with town settlements. In these new surroundings, Park Maksimir still presents a shelter for many plant and animal species, despite its small area of only 316 ha. Besides forests, in Park Maksimir we can find meadows, lakes and streams, which also represent important habitats for various plants and animals, thereby contributing to its biological diversity. The Maksimir lakes were formed in parallel with the Park. Unfortunately, the same waterbodies in the park where the endangered species – European pond turtles – are present are also increasingly stocked with abandoned pet turtles (mainly Trachemys scripta elegans and some T. s. scripta). The lake system in the Maksimir park consists of five lakes with a large population of Red-eared slider.

Problems and challenges

The park is inhabited by a large group of *Trachemys scripta*, which directly competes with *Emys orbicularis* for the resources used. In the investigated lakes the *Trachemys* turtles were by far the predominant ones. Since *Trachemys* hatchlings were found and temperature measurements indicated conditions for possible reproduction of this species in former observations, it was important to find more evidence on *Trachemys* reproduction and to develop a management program. Therefore, as a follow-up to the previous Maksimir park turtle project conducted by the Croatian herpetological society, monitoring continued by the park staff.

Scope and size of impact

At present, we record a very big impact of *Trachemys* species on European pond turtle. At the start of the monitoring, which was in 2006, for this invasive species the estimation on the Third Maksimir lake was that Red-eared slider is present almost 7 times more than the domestic turtle. The ratio between these two species increases year by year dramatically in favour of the invasive turtle.

Approach and activities

In cooperation with the Croatian herpetological society, we monitored the Red-eared slider in the past 7 years to objectively evaluate the present state of their distribution, population size, sex and age structure, areas utilized, impact on *Emys orbicularis* and to record *Trachemys* nesting sites and hatching success. At the moment we are working on the development of a strategy and techniques to control and eradicate *Trachemys scripta* from *Emys orbicularis* habitats.

Constraints and obstacles

To establish an effective control of this invasive species in the future, we have to consider several constraints that pose restrictions: limited funds for taking measures to control the number of specimens as well as a possible negative public opinion about these measures. Although, the import of *Trachemys scripta elegans* was prohibited several years ago, the import of *Trachemys scripta scripta* is still possible.

Social dimension

The social dimension should be explored and tested in future, since results of monitoring should provide a basis for designing education activities. We already did some educational activities with satisfactory success and response from visitors. Besides visitors this education process should also be directed to owners and pet shops in order to decrease the number of potential invasive newcomers.

Results and lessons learned

Monitoring and analyses of data resulted in an estimated number of Red-eared slider, sex and age structure and recorded nesting sites as well as some data on egg number and egg sizes. The research is still in progress and those results should help the Park management in planning future activities, such as monitoring, eradication and public awareness.

The invasive *Trachemys scripta* together with environmental degradation constitute a threat to the survival of *Emys orbicularis,* limiting the availability of habitats for this species. Public education is one of the most important factors for reducing the risk of invasive alien species *Trachemys scripta* in the future.

Additional information

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Urban private gardens and spread of invasive plant species in the Czech Republic

© P. Petrik

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Background

For many introduced species, factors such as traits, date of introduction or pathway of introduction are known in well-studied regions, but the level of propagule pressure (to measure the number of individuals released in a non-native region) is not. Research on invasive species uses several proxies for propagule pressure, such as demographic and socio-economic surrogates (e.g. number of visitors to nature reserves, human population size or density, amount of trade and tourism, economic activity) but hard data on propagule pressure is extremely rare. It has been shown that the probability of naturalisation and invasion increases with increasing residence time and propagule pressure, i.e. the longer the species is present in the region, the more propagules are spread and the probability of founding new populations outside cultivated areas increases. High levels of propagule pressure or mass effects may overcome both biotic and abiotic barriers in the invasion process. Therefore propagule pressure is more important at early stages of invasion than later on, when characteristics of recipient habitats and species traits play a more important role.

Problems and challenges

Due to several factors (high environmental heterogeneity; high levels of disturbance; high intensity of transport) human settlements harbour more plant species than surrounding landscapes. Human settlements are major sources for spread of alien species into adjacent landscapes along transport corridors such as railways, rivers and roads. Whilst the flora of railway corridors, roadsides, harbours or transfer areas has been studied and the role of these habitats as entry points for introduced species has been documented, the flora of private areas is poorly unknown (probably due to the difficult access) and the role of private gardens as primary sources of propagules of alien species has not been assessed.

Still, many alien species are deliberately planted in private gardens, protected against environmental hazards. In contrast to public urban areas, which are widely studied and for which many species inventories exist, for the private urban environment there is limited knowledge on species deliberately planted and their role for invasions. Obtaining quantitative data on the frequency of individual species planted will provide a relatively accurate estimate of the real propagule pressure, which is a function of the planting frequency, duration of planting (for how long the species is cultivated in the region) and reproductive species traits (seed set and dispersal ability). Such knowledge will allow assessing the role of cumulative propagule pressure and species traits over the period of cultivation in the target region and relate it to the naturalisation success (in terms of successful and failed escapes from cultivation).

Key questions in relation to our project in the Czech Republic are:

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

Approach and activities

The presented project (Naturalisation of garden plants as a result of interplay of species traits, propagule pressure and residence time, Czech Science Foundation, 2011-2015) is based on a novel approach that combines data from floristic inventory (providing estimates of propagule pressure), common garden study (providing information on species traits) and historical sources (providing information on residence time in the region), for a set of species differing in invasion success in the Czech Republic. The processes implicated in biological invasions are conceptualized as occurring along the introduction–naturalisation–invasion continuum. As all naturalised species are potential invaders, it is important to understand the process of naturalisation and factors that determine its outcome. However, this is often difficult due to the studies on alien species being biased towards observations of the most successful invaders, while failed introductions (including intentional) are rarely recorded. Therefore, we focused on the early stage of the naturalisation/ invasion process – the escape from cultivation.

The project will facilitate the analysis of the role of several factors related to naturalisation by using newly collated data from species inventories in private gardens and common garden experiments. This will make it possible to explore to what extent successful naturalisation is determined by (i) biological traits of species, and (ii) stochastic and socio-economic factors represented by the frequency of planting and time since introduction. Such data will make it possible to test the quality of existing weed risk assessment schemes (WRA) by using an unbiased species pool. At the species level, it will identify particular species that are likely to become invasive, although their invasion may not have been yet realized, and will provide managers and state authorities with background information for taking appropriate decisions.

To cover the range of climatic, geographical, cultural and socio-economic aspects we cover a wide range of urban and countryside settlements types in the Czech Republic. The types include several “urban type categories” (large cities, villages, old urban city parts and new urban sprawl as a significant phenomenon of last decades). We are aware that garden flora consists of a huge number of species, subspecies, varieties and hybrids and therefore it is impossible to sample it in its completeness within the framework of a five-year project. Therefore to keep the sampling robust, consistent and minimise identification biases we group some critical taxonomic groups into aggregates. For the species covered by the inventory we searched for the information on their planting from historical garden catalogues.

We collate detailed information on traits of selected alien species that fall into the following categories: (i) frequently cultivated and known to escape from cultivation; (ii) frequently cultivated but not known to escape; (iii) rarely cultivated and not escaping; (iv) rarely cultivated but escaping. The traits studied are: plant height, seed production, propagule weight, epizoochory (external animal dispersal), terminal velocity of diaspores (anemochory), buoyancy (floating capacity), persistence of seed in the soil (type of seed bank), specific leaf area, and seedling establishment (germination under field conditions).

Constraints and obstacles

The presented project is a basic research project based on observational field study, not on management activities leading to the eradication of alien species. Therefore the associated risks are linked to sampling data during the inventory or during the common garden experiments and the interpretation of the results. The main constraint of sampled data relates to changes in planting habits over time. We are aware that the frequency of planting recorded at present, for some species, might represent a weak link to the naturalisation or invasion in the past. This potential bias will be partly overcome by using the frequency data from historical garden catalogues and the residence time of a species in the region.

Social dimension

We assume that the results of the project will affect several types of stakeholders. Even though the stakeholders and policy makers are not directly included in the project, they will gain from the sampled data (inventory of aliens in private gardens) and testing the appropriateness of WRA and planted species. The outputs will be important for policy makers (Ministry of Environment, Ministry of Agriculture and State Phytosanitary Administration) when establishing the legislative tools (e.g. Black/grey/white lists of alien species).

Results and lessons learned

During the two first years of the project we sampled ~100 of cities/villages in the Czech Republic. The number of taxa recorded in private gardens reached 1544. For the species studied in detail we collated historical data from local flora and garden center catalogues to estimate their residence time in the region. Data from the inventory and literature review were used e.g. for updating the catalogue of alien plants in the Czech Republic (Pyšek *et al.* 2012a,b), and for assessing the impact of alien species (Hulme *et al.* 2013). The most frequently planted species are shrubs like *Buxus sempervirens* or *Syringa vulgaris* but also herbaceous plants, such as *Sedum spurium, Phlox paniculata or Tagetes patula*. Surprisingly, among the most recorded species are only a few species known to be invasive in the Czech Republic (*Lysimachia punctata, Rhus typhina, Solidago canadensis, Lupinus polyphylus, Aster* sp.).

Common garden observations on selected alien plants cover mostly reproductive traits. The traits studied are plant height, seed production, propagule weight, epizoochory (external animal dispersal), terminal velocity of diaspores (anemochory), buoyancy (floating capacity), persistence of seed in the soil (type of seed bank), SLA (specific leaf area) and seedling establishment (germination under field conditions). Based on a large field survey of private gardens in the Czech Republic, we determined the frequency of planting of the studied species and whether the species have been reported to escape from cultivation. According to our preliminary results (for the subset of annual species), the most important traits related to the probability of escape from cultivation are plant height, followed by buyoancy of propagules, seedling establishment and terminal velocity. Suprisingly, the frequency of planting does not seem to influence the naturalisation success.

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Invasive hogweed species in Keila municipality, Harju county

© Arne Ader

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Background

The invasive species of hogweed, particularly (Heracleum sosnowskyi) were introduced in Estonia in the 1950s. Back then they were believed to be a valuable source for agricultural purposes (ensilage, honey). After the actuality in agriculture discontinued, the species still spread from the agricultural areas to natural areas/settlement areas by water/wind. They are widely present in all counties as well as in major islands. This species is listed as a threat to the national biodiversity balance. The latest inventory for this species was carried out in 2009 and as a result 1,491 colonies with a total area of 1258 ha were mapped. Out of this amount, 222 hectares were situated in Harju county (county were Keila is located) and from that approximately 60 hectares are located in the Keila area. It appears that these colonies are located in the very close proximity of the densely located areas, near the frequently used main road. In addition to the environmental and health issues, the very vital colonies near the main entrance into the town have caused a decline in landscape aesthetic value.

Problems and challenges

This species acts as a huge threat to domestic natural resources. Hogweed plants grow very quickly and already during very early spring they outgrow domestic species. Massive leaves shade the ground and significantly reduce the survival possibilities for the other species. This phenomenon is a major threat for valuable meadow-habitats in Estonia. In Autumn, after wilting, unattached soil is prone to erosion

with possible decreased quality of groundwater bodies. As the plants contain liquid substances which are poisonous, they pose a significant threat to human health. The liquid substances contain *Furanocoumarins,* which cause burn-like injuries if exposed to direct sunlight. The liquid is dangerous even after a few days after cutting the plant, first symptoms can occur several hours after contact. Its injuries heal slowly, scars can be visible for years. Especially threatened are children due to their sensitive skin and unawareness about the possible consequences.

Scope and size of impact

The species is well adapted to spread linearly and therefore often exists in the proximity of rivers and in riverbeds. These areas are valuable habitats, hold high biodiversity potential and have an important role in Estonian green infrastructure. In Keila, this is also the case, as most of the colonies are located near the Keila river and at the same time at the proximity of the densely populated areas. High plants deteriorate the visibility from the road and may cause traffic threats and reduce the recreational value of the landscapes.

Approach and activities

An up-to-date public digital database is being kept in order to keep track of the location and size of the colonies. This is a very effectively functioning tool to keep track of the colonies and to organize management activities. For that purpose relevant information is collected from various stakeholders – environmental NGOs, local authorities, landowners and citizens. It provides a possibility to take this information into account while planning annual public procurement for eradication activities. Adequate monitoring is considered to be one of the key elements in order to safeguard the successful solutions for *Heracleum sosnowskyi* problems. In Estonia, dependent on the local conditions, three eradication methods are used: (1) mechanical destruction of the roots (2) mechanical poisoning and (3) manual poisoning. The most widespread method in Keila area and elsewhere is manual poisoning. The effectiveness of the poisoning depends a lot on the skills and knowledge of the professionals conducting the activities.

Constraints and obstacles

Financial constraints are considerable, as there are is no national funding currently foreseen, the processes are highly dependent on EU funding (ERDF, European Regional Development Fund). The fact that the only criterion to find a service provider for eradication activities is price, causes inadequate quality of the work. As a majority of the colonies are located on privately owned land, there is a need to find more effective legal and financial instruments to engage landowners in the eradication process.

Social dimension

In addition to the above mentioned negative social impacts, it should be mentioned that various environmental NGOs are engaged in processes dealing with *Heracleum sosnowskyi* problems. For example, the Estonian Semi natural Community Conservation Association has carried out several studies and inventories as well as eradication activities. NGO Ecomedia has contributed a lot to awareness raising.

Results and lessons learned

Due to the fact that *Heracleum sosnowskyi* shows a very high vitality and does not surrender after single eradication activities, the areas of the colonies have not shown a rapid reduction. There is a need for repeated measures during several years. The systematic eradication activities have been going on since 2003 in Keila area and during these years the populations have been reduced about 46.6%. Therefore there is still need for a continuation of effective activities.

1. Continuous activities – awareness raising, data collections, killing activities, monitoring
2. Sufficient and effective funding (not only using the cheapest ways)
3. Co-operation between governance levels and stakeholders

Additional information

- National abatement plan (in Estonian): http://www.keskkonnaamet.ee/public/putke_dokumendid/putke-kava-2011-2015_kinnitatud.pdf
- Land Board GIS database www.maaamet.ee
- National Environment Board information (In Estonian): http://www.keskkonnaamet.ee/keskkonnakaitse/looduskaitse-3/voorliigid/karuputke-torje-2/
- Keila Rural Municipality documents

Establishment of feral rabbits in the city of Helsinki

© Riccardo Scalera

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Background

European rabbits established a feral (an animal living in the wild but descended from domesticated individuals) population in Helsinki in 1985 at the latest. They descended from pets dumped in the wild. The population survived winters by both chance and adaptation in a landfill area with edible twigs cut from parks and compost of biodegradable waste for warmth. A strong spread took place in the beginning of the 2000s. Mild winters helped at this time, but the population is also able to survive cold and snowy winters (as the four consecutive until this year).

Rabbits are still bound to cultural habitats, such as parks and house yards. They use road and railway verges for dispersal. Their presence has accelerated the urbanization of red fox, stoat, eagle owl and goshawk. We do not know how harmful this gain in general predator diversity could be to indigenous rare prey species. Lacking such evidence, it may be considered a positive regulating ecosystem service.

Problems and challenges

The rabbits are not yet a risk to natural diversity, but to the plant diversity of parks. Most annual and perennial plants are palatable to them with few exceptions. Technical protection is expensive, but selecting only bad-tasting plants would devastate the horticultural diversity. Deep burrows are at most harmful in a sandy graveyard area, where they loosen the roots of trees, make tombstones fall (in one case on a person) and horrify people. In the future, the potential of burrowing at inappropriate places could increase damage beyond that caused by eating plants. The risk is related to destabilising buildings and constructions and making people fall in burrows.

Scope and size of impact

Rabbits kill bushes and trees in parks and urban gardens. In nature the effect has been small, but there is a potential in damaging indigenous herb vegetation in rich forests. The horticultural damage included a case of 70 elm trees in a park (the damage being substantial, as the Dutch elm disease has not yet arrived to Finland) and some very rare Syringa cultivars. Economic costs of rabbit damage and its control until now in Helsinki exceed 2 million Euros (a rough estimate). Their benefits include the recreational values of rabbits and their more abundant predators.

Approach and activities

Eradication of the species is considered impossible, so the activities are aimed at minimizing damage by:

1. protecting the most valuable trees and bushes

2. culling rabbits by gun, bow, trap, net and ferret

Neither chemical, nor microbial methods are used. The hunting in the city is organized by municipal and other local institutions. The activity of the authorities is not mandatory by legislation, but voluntary and proactive, in order to prevent potential damage to common property. The rabbit bag of the peak winter 2010/2011 was approximately 3,000 and of last winter 700 individuals. The cost of rabbit hunting and monitoring in 2013 was 185,000 Euros. The population size remains unknown.

Constraints and obstacles

Dumping pet rabbits has started the problem and it continues, and may have increased in spite of educational efforts. The city centre, where city and other public institutions are land-owners, can be purged of rabbits. They thrive quite well in the suburban zone with private ownership and minimal hunting activity. Their dispersal to adjacent agricultural areas can be expected when several consecutive mild winters occur. Legal obstacles of hunting city rabbits were removed rapidly by adjusting legislation, but small land-owners cannot be obliged to combat rabbits.

Social dimension

At first glance, the public regarded rabbits as ‘cute’, but after a year or two of activity in yards and garden plots that changed to an image of a pest. An animal welfare organization in the city constantly presses the city to give up killing rabbits and only protect the vegetation. An NGO specialised in rabbits (as in Stockholm) has not yet been established, although the citizens views on rabbit culling are heavily polarised. The city and state authorities and scientists have good cooperation, as well as most NGOs in the field of nature conservation at large. The funding has been mostly public, as most of the areas of the inner city are owned by public institutions (city, state and church).

Results and lessons learned

Rabbit control measures have been effective in the city centre. They may have helped to diminish also the population pressure outwards to the countryside. The control measures increased natural predation and the effect of strong winters in regulating the population has not been determined. Arguably, the winter mortality is not very high, but long winters make the reproduction season crucially shorter.

As the rabbit has been introduced by several individual pet owners, acting secretly, there are few possibilities to regulate this. The city has developed a transparent strategy of publicity in spite of the delicacy of hunting popular urban animals with good success. However, people have continued the bad habit of getting rid of pet rabbits by dumping them into the wild.

Additional information

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- www.hel.fi/hel2/hkr/julkaisut/2010/kaniraportti_web.pdf

The unrestricted spread of North American raccoon in Berlin

© Ingo Bartussek

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Background

The North American raccoon (Procyon lotor) had been purposely introduced to Germany in the first decades of the 20th century for fur farming. An official introduction of a pair into the wild took place in the nowadays federal country of Hessen in 1934. Whether this introduction founded today's estimated population of likely more than 500,000 individuals in all of Germany, or whether escapes of raccoons from farms were the reason for the population's establishment is not clear. It is proven however, that in 1945 the destruction of fur farms east of Berlin, in the nowadays federal state of Brandenburg, introduced another population in east Germany by that time, in locations roughly 350 km to the northeast of the population in Hessian (that today centers itself around and in the city of Kassel).

Now all areas of Germany as well as parts of its neighboring countries have a population of raccoons and the formerly separated populations in Germany have merged together into one large population that at best can be seen partially divided by habitat breaches and infrastructural barriers, i.e. in way of meta populations.

The raccoon is an omnivore species that is able to settle in rather any type of central European environment, but prefers complexly structured areas, wooden and riverine sites with adequate tree stands and also rural and urban settlements. The latter is clearly supported by the wide variety of shelter and food that urban areas provide, paired with lack of control, the absence of natural predators and misguided urban citizens that often have no good understanding of natural scenarios and processes.

Berlin is turning into a centre of Raccoon occurrence in East Germany now, since the city's surrounding environment has a stable and thriving population of raccoons since years and is of agricultural, wooden and rural type, hence leaving Berlin (with its size of around 90,000 hectares) the largest attractive urban settlement in the centre of the federal country Brandenburg for its raccoon population.

Problems and challenges

Like in most urban areas Berlin has a rather diminished biodiversity nowadays, e.g. the majority of the flora species are of exotic origin, real estate prices are on sharp rise and hence all vacant areas are filled up with constructions. The former "green belt" of the inner-Berlin border and its adjacent areas is not existing anymore since 1990. Housing projects with their associated support structures surround all the city borders since people prefer to live on the more calm edge of the settlement instead of in its turbulent and costly central parts.

Hence the loss of biodiversity by an introduced species like the raccoon is not so visible if at all relevant in an urban area like Berlin, where the destruction of small mammal retreat sites and bird as well as bat breeding or roosting locations by construction activities is common place, and the recreation activities of hundreds of thousands of peoples and their pets (dogs) for instance affect all water and park areas in the city.

Raccoons are reported from the federal country of Brandenburg to have caused losses to ground and hollow nesting birds, to be responsible for the reduction of herons in their breeding colonies and are predating on amphibians and turtles. However, most of these reports are anecdotal and local and no clear data exists. There is no comparable situation indicating such lack of data on losses among native species in other places where raccoons had been introduced (e.g. in the Caribbean, Canada's Queen Charlotte Archipelago or Japan). It must be assumed the non-native raccoon will not be an important predator of native biodiversity in urban settings like Berlin, but does surely suppress native species' existence in relevant capacity.

The relevance of raccoons in urban places like Berlin can cause damage to human possessions, especially houses, and the raccoons can have a role as possible transmitter or host of diseases and the associated spread of zoonoses, a variety parasites or animal health infections.

Recent studies of a project in northern Germany have provided data on the minor risk caused by raccoons for e.g. European type of rabies, mange or endo-parasites like the for humans dangerous fox tapeworm. They however agree that raccoons can play a role in transmission and spread of canine distemper virus and other parasites like some trematodes. If compared with infections in its native range in north America, the studies say also that the German raccoon population is not a threat by transmitting the raccoon endemic roundworm *Baylisascaris procyonis* that can cause severe human health problems. This statement comes despite that the occurrence of the worm was testified since a while already to be present in the western German population (that is infected by up to 70 %). Recent investigations have shown that with the merger of the raccoon populations across Germany the infection has spread onto the former non-infected east German populations also, causing an overall infection rate of around 40 % now.

Raccoons are agile climbers and use all types of shelters provided by human settlements, hence disturbing citizens in their houses by living, caging and breeding under the roof top, as well as their associated destruction of all types of sealings, isolation constructions and so on, is the most reported problem so far in Germany. This has caused a drop of property value in affected areas in the city of Kassel and in turn led to substantial efforts to raccoon-proof houses and their associated structures. A business has been developed, to support affected citizens, as there are no public support programs existing.

Accidents with aggressive raccoons or incidents when apparently "tame" animals are touched and people, especially children, get bitten or scratched are happening and likely to occur more often than recorded.

In 2013 a canine distemper rush had affected the city's raccoons and around 120 raccoons are found to have died as a result. This is surely an underestimation and given that the official number of raccoons in Berlin is 600 according to the city authorities, the vulnerability and risk of sudden disease transmission by raccoons (to dogs etc.) cannot be neglected and rather seems to be not fully recognised.

Scope and size of impact

Apart from biodiversity loss, there is also no data on impact and damage levels for other fields. This is either because of the complex legal situation that prevents central data collection by a single authority in Berlin, but also public health damage attributed to raccoons is not quantified or the data are not accessible to third parties. In general the issue is considered of little importance and hence neglected.

Approach and activities

Although the invasion of raccoons has been closely monitored all over its invasion period by mostly hunting associations, this had not lead to

appropriate control measures since the interaction between governmental and NGOs did not exist in the time when the invasion started and in fact due to the federal system is in fact still not in place everywhere. The potentially growing problem was ignored, no prevention measures taken, apart from calls among hunters to kill raccoons where ever they are seen. The closure of fur farms was not a result of prevention attempts, but solely caused by the collapse of the fur market.

Almost all work on early detection was entirely attributed to random and anecdotal reports, mostly by interested people, hunters, pest controllers or house owners that increasingly suffered from problems with raccoons. Sometimes the media too covered the theme but not in depth nor continuity, thereby missing the chance to support a change of perception among public by the targeted broadcasting of facts.

This situation of "doing nothing" went on till roughly the turn of the millennium, when it became in general more fashionable to study non-native species. However, studies on raccoons did not focus on finding measurements to prevent their overall establishment, nor control or management. The latter became partially relevant over the last years in response to changing priorities for long term research funding. The need to understand non- native species in-depth, lacks efforts to investigate new forms of control or making mitigation trials etc.

While in the affected area of Kassel a new service branch has developed that serves troubled customers by advising on raccoon protection around their houses and proofing of buildings against raccoon intrusion, such activities do not really exist in Berlin. No organized way for information exchange exists between cities.

The existing research projects mainly deal with local populations that are partially very specific (e.g. in a national park) and do not always link up with each other. Hence often the studies are done in different places without further cooperation and the results do not necessarily lead to generally applicable information or the development of management scenarios.

Hunting associations and individual hunters are those implementing the only existing control measure, which is based on lethal techniques like shooting or trapping. The annual hunting of raccoons in Germany is around 45,000 at the moment. This still has not lead to a significant reduction of the raccoons, nor has it stopped further invasion into unpopulated territories like cities. The reason might be that there is no central program in place and control of raccoons by hunting is hard and intensive labour that not everyone likes to do, and is not considered necessary by the public.

Considering a raccoon population of 500,000 individuals in Germany, and the species existence in all neighbouring countries (although in different densities and numbers), an eradication based on hunting alone, seems insufficient. For urban areas, an estimation of 1 animal per hectare is given in some studies but not really estimated to be so for Berlin. Official authorities in the city speak about between 500 to 1,000 raccoons, but the population is increasing quickly, no census data do exist, the raccoons are nocturnal and shy and are not easily spotted, hence it might be twice or three times this number.

Constraints and obstacles

The currently existing methods to control raccoons, permitted by the federal hunting laws in Germany whose federal authorities in the 16 federal countries mostly added the raccoon meanwhile to their lists of possibly "hunted wildlife", are limited. One main issue is, that not everywhere hunting is permitted (and especially large tracks of urban areas are exempted from regular hunting activities). The situation in Berlin is complicated by the fact that no trapping of any wildlife is permitted in the city and the federal country, thus a very useful tool for reduction of problem animals is non-existing. The city has a few dozens of "city hunters" that are in duty for wildlife control measures in the urban areas. Due to their different abilities and interests and the fact that no consistent management exists, their effectiveness is to be questioned and they rather operate as an emergency brigade when called for action.

Hunting is not possible to suppress the population to an extent that avoids further spread and allows raccoon free areas. Alternative measures like poisoning etc. are not permitted in Berlin and highly unlikely to get implemented ever, since the public will oppose. People in urban areas are often uninformed about the situation, or influenced by an artificial "nature affinity" preventing objective discussions. Berlin would face strong resistance by their citizens, leading to a growing and rather ignored problem.

As part of its PR work, Berlin runs a program to educate the citizens about wildlife and has developed brochures and media activities about certain species, also the raccoon. However more attention is given to the wild boar since this is of interest to the media

and public safety. Often raccoons are not referred to in campaigns and media in a 'neutral way' but are rather presented with affixed terms like 'charming, funny, clever, another foreigner' combined with astonishing news where they already occurred ("… in the garden of the chancellor office, at the Egyptian museum…"). This all leads to a clear misconception about the species real status (still not fully established but advancing invasive species in Berlin) and ignores all possible treats as well. This has lead to a perception of "a species that now clearly belongs to Berlin and Germany" despite being a non-native species originally. Comparisons of non-native species with people "that move from other countries to Berlin too" are not only contra-productive but also prohibiting discussing the IAS issue, in light of criticism not to behave politically correctly.

A final main constraint is that under German environmental law each species that survives without human help in the wild and lives there for a few generations is by law considered a "native species", making wider control or eradication measures more problematic and complex than they are already. The law sometimes provides additional protection to such species and does not help to educate the public about the relevance of invasive species.

Regarding proposals for new investigations on possible control effects or management solutions, the city and federal country of Berlin has no funding available.

Social dimension

Due to the non-existence of a central and city wide program the issue of invasive species, including the raccoons is not deeply in the mind of Berlin citizens. Furthermore, the picture that arose about the raccoon is clearly influenced by grey stories and positive attributions. It goes so far that raccoons, being unhealthy stray animals and attempting to bite children were defended against the attempts of catching them by the very same parents whose children were under threat to become bitten or infected by diseases.

Despite a number of raccoons killed in Berlin that were since a while reportedly infected with mange disease (likely exchanged with the large number of red foxes in the city) and the reported canine distemper virus outbreak 2013, the city's veterinary authorities have not yet attempted to make a large scale investigation or establish control. Such investigation could help to form a neutral image of raccoons as non-native wildlife in the city that should not be supported by feeding etc. and seen with caution if encountered, as they can have diseases or parasites.

In individual cases the authorities in charge (i.e. two local city veterinary offices) have declared not responsible if not a proven case of infection exists in an animal. The sole suspicion of a sick animal is not enough to take action, they said, which further repels concerned citizens from getting active a next time. The unclear situation of responsibility is hampering all efforts to establish clear lines of communication. Together with the police and fire brigade all of Berlin's veterinary and interior offices are on duty, leaving a number of 20+ offices that due to unclear guidance act as they think is correct. Confusion and non-reaction is often the main outcome.

Results and lessons learned

No clear attempt for the management of raccoons exists in Berlin, rather the situation is left to itself widely. Media coverage is at best passive and reactive, as the public is not interested in the topic. The few existing legal instruments are not implemented, likely due to fear of the public opposing the authorities.

Enough information and advice for dealing with IAS is available, but despite that not much experience with the practical aspects exists in German, even though current possibilities for communication and information exchange allow quick exchange with experts from elsewhere.

Not only for the federal country of Berlin, but all of Germany, the establishment of a central office for non-native species aspects, would be useful, especially with regards to the economic importance of IAS. Other European countries have established such authorities already and have also written their own Invasive Species strategies, which is not the case in Germany. The current authority dealing with this issue of invasive is clearly not capable of covering all the necessary aspects as was visible in recent examples like the failed attempt to create overdue management guidelines for the worst IAS, despite such information is demanded by German environmental law.

Germany is currently in the process of implementing its ambitious National Biodiversity Strategy till the year 2020 and millions of Euros are assigned for that. Notwithstanding that IAS are covered in this strategy and their treats described, no project is so far planned to deliver advanced steps to tackle it in order to fulfill the national biodiversity aims in this respect.

Invasion of Silverstripe blaasop in Rhodes Island, Greece

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Location: Rhodes Island

Country: Greece

Background

Lagocephalus sceleratus (Gmelin, 1789) is a tropical non-indigenous species (NIS) that entered the eastern Mediterranean Sea through the Suez Canal. Only nine years after its first detection in the Mediterranean Sea (Feliz and Er, 2004; Akyol et al., 2005), the large-sized invasive species Lagocephalus sceleratus (Silverstripe Blaasop) rapidly spread along the Levantine coasts and all over the Aegean Sea. Invading in just a few years all habitats (Posidonia ocenica meadows, sandy and rocky habitats) between 0-50 meters, it has showed a rapid expansion throughout the eastern Mediterranean Sea, reaching the northernmost parts of the Aegean Sea and south-west to Tunis, but has to date neither been observed in the western Mediterranean Sea nor reached Italy (Kalogirou, 2013).

In an earlier study, L. sceleratus was classified as a seagrass resident with intermediate affinity to P. oceanica meadows ranking among the five most dominant species in terms of biomass (Kalogirou et al., 2010). Later on, in a comparison of fish assemblages between seagrass meadows and sandy habitats, twenty fish species explained 90% of the difference in fish assemblage structure, based on biomass, between habitats (Kalogirou et al., 2012). Among these, L. sceleratus ranked third in terms of biomass in P. oceanica, being the only NIS among the 10 most dominant species. In sandy habitats, L. sceleratus ranked second in terms of biomass and fifth in terms of density respectively (Kalogirou et al., 2012).

Small-sized individuals (<30 cm) were mainly observed in sandy habitats, while larger individuals (30 to 40 cm) inhabited Posidonia oceanica meadows, indicating a possible habitat shift with increased body size (Kalogirou, 2013). In sandy bottoms, the small size range (5-6 cm) of L. sceleratus individuals observed during the Summer, suggests that the fish recruit into this habitat. During the

summer, larger reproductive individuals were caught over P. oceanica meadows, thus confirming that Summer is the main reproductive season for L. sceleratus, as has been previously shown by Sabrah et al. (2006) in the Gulf of Suez. It is an invertebrate and fish feeder and it has been shown that with increased body size, a diet shift to a molluscivore diet occurs, possibly explaining a habitat shift due to changed prey availability/demands or preferences (Kalogirou, 2013).

The counter-clockwise circulation in the Levantine basin, the evolution of the European Mediterranean region and the increase of the Aegean seawater temperature (Raitsos et al., 2010) could have contributed to the enhancement of the introduction, establishment and quick propagation of L. sceleratus, favouring the dispersion of its pelagic eggs and larvae (Golani et al., 2006 updated 2009). The Silverstripe blaasop showed an exceptional ability to occupy all the Aegean coastal waters between the isotherm of 16.25oC and 15oC (Corsini-Foka, 2010), and to enter also the region limited by the isotherm of 14oC (Bianchi, 2007). The population explosion of the species during summer 2007 may be associated with the anomalous high temperature observed in that period throughout Greece and the consequent production of unusual deeper warm water conditions (Pancucci-Papadopoulou et al., 2012), similarly to those observed for Rhodes Island (Corsini-Foka, 2010). Contrary to predictions of an accelerating number of aliens following increased water temperatures, hotter summers in this region may prevent the establishment of many alien species (Belmaker et al., 2013). It was discovered that ecological trait diversity of alien species is substantially more evenly spaced and more divergent than random samples from the pool of Red Sea species, pointing at additional processes, such as competition and promotion of ecological diversity among alien species. Ecological traits of the species and environmental affinity might explain the successful establishment of this species. Migration to deeper and warmer waters may also be considered for the possible establishment of immigrants in various Mediterranean areas, as assessed by Mavruk and Avsar (2008). Furthermore, its anti-predator adaptations such as inflation of the body and toxicity (Golani et al., 2006 updated 2009), the absence of strong confamilial and interspecific competitors and predators in the invaded coastal habitats (Corsini-Foka, 2010), probable high survival of eggs (due to toxicity and unpalatability) have to be considered as factors contributing to the successful invasion and abundance of the silverstripe blaasop in the area (Pancucci-Papadopoulou et al., 2012).

Lagocephalus sceleratus is listed among the 100 Invasive Alien Species (IAS) in the Mediterranean Sea with profound social and ecological impacts due to the presence of tetrodotoxin, a source of food poisoning (Streftaris and Zenetos, 2006). Besides the serious danger for public health, a negative impact on fisheries is evident, and an impact on biodiversity can also be foreseen, as the species has occupied all shallow coastal waters of the area. From an ecological point of view, a rearrangement of the food chain is to be expected, due to the large consumption of native invertebrates (mainly cephalopods and crustaceans) and fish (Aydin, 2011; Kalogirou, 2013).

Problems and challenges

Lagocephalus sceleratus possess one of the strongest paralytic toxins known today, namely, tetrodotoxin (Sabrah *et al.*, 2006). The most important aspect from a social point of view is undoubtedly the risk involved in consuming the fish, due to its toxicity. In the eastern Mediterranean, many cases of tetrodotoxin poisoning have been reported (Bentur *et al.*, 2008). Studies from the Mediterranean Sea also show that there is a significant positive correlation between toxicity levels and fish size (Katikou *et al.*, 2009; El sayed Ali *et al.*, 2011; Rodriguez *et al.*, 2012). According to the results of Katikou *et al.* (2009), the toxicity levels of

individuals smaller than 16 cm in length are not lethal. This reduces the risks connected with misidentification, since commercial *S. smaris*, *B. boops* and *A. boyeri* rarely exceed this size.

In Rhodes area, a negative socio-economic impact of *L. sceleratus* is also evident: (1) a large number of hauls are not productive since a large quantity of the biomass is represented by *L. sceleratus* and has to be discarded, with consequent loss of working hours, fuels, etc; and (2) native commercially important stocks of invertebrates (mainly cuttlefish, squid and octopus) are subject to intense predation, thus a loss in resources is becoming day by day more evident, resulting in higher market prices. However, it is difficult to quantify the predation impact of the puffer fish due to the lack of quantitative studies on local invertebrate communities but also of the digested state of prey items. Interestingly, burrowing and venomous species were among preys, thus showing the ability of *L. sceleratus* to actively search for prey and possible resistance to venom (Kalogirou, 2013).

Complaints of fishermen included destruction of gill nets due to entangling or predation on already captured fish, reduction of local commercial catches of *Sepia officinalis* and *Octopus vulgaris*, cut-off of long-line hooks and worrying fish consumers due to false alerts regarding the difficulties in distinguishing small-sized individuals of *L. sceleratus* from other important commercial fishes of the same size (e.g. *Spicara smaris*, *Atherina boyeri* and *Boops boops*) (Katikou *et al.*, 2009; El sayed Ali *et al.*, 2011; Nader *et al.*, 2012; Rodriguez *et al.*, 2012; Kalogirou, 2013).

Scope and size of impact

In the study area, *L. sceleratus* was found to rank among the 10 most dominant fish species in terms of biomass in *Posidonia oceanica* habitats (Kalogirou *et al.*, 2010) and among the ten most dominant species, both in terms of biomass and number of individuals, on sandy bottoms (Kalogirou *et al.*, 2012). This undoubtedly shows its significant ability to colonise new areas rapidly and establish populations. Its large size was considered the main reason for this species to be marketed in some fishing ports, leading to several cases of poisoning (Bentur *et al.*, 2008; Golani, 2010; Nader *et al.*, 2012).

Approach and activities

The high numbers of *L. sceleratus* that have been caught by coastal fishermen in the area surrounding Rhodes Island, has initiated major national efforts to alert fishermen and the public about the toxicity of this fish. These efforts have included posters warning the public about the lethal effects if consumed. Moreover, fishermen have been warned by the Greek ministry of health that small individuals could be misidentified with other small commercial edible species, such as such as *S. smaris*, *B. boops* and *A. boyeri*. Following the current European legislative requirements (EU Regulation 853/2004/EC, 2004a; EU Regulation 854/2004/EC, 2004b), the species has been declared as not marketable by Greek authorities.

Constraints and obstacles

There is a general inability to control fish species entering the Mediterranean through the Suez Canal, especially after the observed warming of the sea water in the area.

Social dimension

Since 2007, a network of experts has been established at the Hellenic Centre for Marine Research (HCMR). To date, the Hellenic network for Aquatic alien species (ELNAIS: http://elnais.ath.hcmr.gr/) includes more than 50 experts carrying out relevant research, who are based in 11 research centres/Universities across the country. ELNAIS is an open information system providing on line information on the state of art in aquatic alien species in Greece. There are more than 230 marine and freshwater alien species recorded in ELNAIS, accompanied by photographs and distribution maps within Greece. ELNAIS, though without any financial support, is continually updated and aims to be a powerful tool for scientists and stakeholders.

The ELNAIS webpage has been advertised in newspapers and other public communication channels. An info page encourages the readers (scientists and citizen scientists) to join ELNAIS by: (1) reporting on the occurrence of species, which is after verification published in the news, (2) seeking external expert knowledge on species unknown to them, and (3) contributing new information by sending photos and environmental details of species they consider as new to the Greek biota. Divers, underwater photographers, amateur and professional shell collectors, fishermen and port authorities have been the main data providers for ELNAIS. Invasion stories of *L. sceleratus* are often front-page items in local newspapers (Zenetos *et al.*, 2013).

The magnitude of the social impact since the establishment of *L. sceleratus* in Rhodes has been so vast, that a competition was organized during summer 2011 by the sport and professional fishermen associations. Two winning prizes were awarded, i) to the fisherman who caught the largest individual and ii) to the one who caught the heaviest fish (in kg).

Results and lessons learned

Raising awareness among fishermen and amateurs, with a consequent sharp decrease of *Lagocephalus* landings and increase of market safety is essential.

In the particular case of *L. sceleratus*, the awareness campaign addressed both to professionals and the public resulted in a very efficient response, reducing risks for human health. Moreover, tetrodotoxin (TTX) is a highly valuable toxin that is pharmaceutically used to treat multiple sclerosis (MS) and cancer patients for pain relief. The large amount of individuals (biomass) inhabiting various areas of the South-Eastern Aegean Sea could experimentally be caught, their toxin could be isolated and produced in laboratory conditions. For this reason, the i) Hellenic Centre for Marine Research/ Hydrobiological Station of Rhodes in collaboration with the ii) National Reference Laboratory of Marine Biotoxins, Institute of Food Hygiene, Ministry of Rural Development and the Food and the iii) Department of Fisheries in Cyprus co-submitted without success a proposal in 2012 (in the framework of the Interreg IV call) to explore the above-mentioned study.

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Invasive plant species in aquatic and riparian habitats in the urban Dublin area

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Background

The focus is primarily in the aquatic and riparian habitat associated with the main rivers, canals and standing watercourses in the urban Dublin area. Most of the watercourses have problems with invasive species, the primary culprits being riparian species. The extent of the problem was first assessed in 2008 by Dublin City Council Parks and Landscape Services by way of field surveys and mapping of watercourses. The first Dublin City Council (DCC) Biodiversity Action Plan (2008 – 2012) for the city (http://www.dublincity.ie/) identified threats of invasive species to biodiversity. In 2009, Dublin City Council, with support from the national Heritage Council, engaged consultants to further assess invasive plant species along the city's main watercourses (Ecoserve, 2009). Principally, these are Giant hogweed (Heracleum mantegazzianum), Japanese knotweed (Fallopia japonica), Bohemian knotweed (Fallopia x bohemica) and Himalayan balsam (Impatiens glandulifera). Other highly invasive species that currently present problems in our watercourses include New Zealand pigmyweed (Crassula helmsii) and Curly-leaved waterweed (Lagarosiphon major), the former in one of our major navigation waterways (the Grand Canal) and the latter in a dedicated fishery developed to cater for disadvantaged youths in a Dublin city park (Darndale Park).

The watercourses described are in the administrative area of Dublin City Council and include the River Tolka Valley and the Darndale Fishery.

Tolka Valley

The River Tolka Park Site is the second largest river in Dublin and occupies a catchment area of 14,150 hectares over three counties. It flows through Dublin city for much of its length and discharges directly to an EU Special Protection Area (SPA) under the Birds Directive, the Tolka Estuary SPA. The Tolka Valley is home to a number of resident species designated under the

EU Habitats and Birds Directive, including the Otter (Lutra lutra), Kingfisher (Alcedo atthis), four species of Bat, Salmon (Salmo salar), Trout (Salmo trutta), as a resting area for migratory protected birds such as Brent geese (Branta bernicla), as well as seven species of Butterfly and a number of rare, nationally-protected plants and birds of national conservation importance.

Tolka Valley was first settled during the Norman period and there are archaeological as well as botanical influences to this day from that period. The Valley was somewhat industrialised, with mill races constructed and localised brick manufacturing in the 16th-19th centuries. It remained agricultural until the late 20th century when, during the national construction boom, it was planned to develop the Valley, on the periurban fringe of the city, with a commuter rail station and high-density housing for a population of about 15,000 (Pelletstown Local Area Action Plan, 1999). This was partially realised prior to the collapse of the national banking and construction sectors. The river valley was planned as an amenity resource for this new community. However, habitat management plans were only developed from 2005 onwards, after the main residential and commercial centre had been built.

Giant hogweed has been a major problem along the River Tolka Valley for decades. The Giant hogweed problem in the valley almost certainly originated during the 19th century in an estate garden in the upper reaches of this river and spread downstream via seed dispersal. This is believed to be the origin point for this species nationally. From the late 1970s large areas of the urban river were totally overgrown with this highly invasive and hazardous species. It is not clear how the Himalayan balsam gained access to the River Tolka Valley but it may have been intentionally introduced because of its attractive flowers and the abundance of nectar that they produce. The extensive public access to zones along the river has permitted transfer across sites, as well as dispersal by water of certain species. Management regimes which were designed to clear vegetation from river banks due to antisocial behaviour allowed for further colonisation by non-native species. Traditional grazing practices along the banksides and adjacent areas died out as the river valley became increasingly urbanised, causing changes to the management of former pastures (Ecoserve, 2009). Since the early 2000s the Himalayan balsam has spread aggressively along the riparian zone in this Valley and occupied large sections of river corridor.

Dublin City Council (DCC) Parks and Landscape Services commenced a chemical treatment regime in 2007-2008 for all main river corridors on lands they owned and managed, including the Tolka River. This was refined in 2009 and chemical treatment is now carried out thrice annually, with mapping of progress annually. Since 2011, DCC Parks and Landscape Services have been using the recording system devised by the National Biodiversity Data Centre (NBDC) to standardise monitoring. The data collected is publicly available on their website (www.nbdc.ie). It is noteworthy that no invasive riparian plants were recorded in the upper region of the catchment and that occurrence of invasives, such as Giant hogweed and Himalayan balsam, seem to correlate with urbanised sections of the river channel.

DCC is also including monitoring of invasive species in its reporting procedures under the Water Framework Directive (WFD) and, as lead authority for the Eastern River Basin District, has held workshops for the 12 local authorities of the District on biodiversity. These included presentations on invasive species and their impacts on biodiversity and river function.

Assessment of the habitat of the River Tolka Valley is being undertaken as part of the river development project. The first survey by DCC (with Heritage Council support) was in 1998, to assess habitats prior to major urbanisation planned for the locality. In 2010, DCC produced habitat mapping in GIS of the entire city, as a progression of earlier mapping

undertaken in 2006 for the production of the Biodiversity Action Plan. This is used to correlate habitat changes. Habitat surveys suggested that biodiversity potential is high but that habitat degradation had occurred and needed to be reversed.

Darndale Park

The Darndale Fishery is an artificial lake that was built in Darndale Park in 1999 to provide an amenity feature as part of an urban regeneration project of a disadvantaged area of north Dublin. In 2008 Inland Fisheries Ireland (IFI) introduced Common carp (Carpio carpio) into the lake to provide angling for the local community and to provide an angling learning facility for local youth as a means of biodiversity awareness under the IFI's Dublin Angling Initiative.

In the Darndale Fishery Curly-leaved waterweed (Lagarosiphon major) was intentionally introduced by an angler in about 2009 in the mistaken opinion that it would provide dissolved oxygen for the resident fish. He was unaware of the highly invasive capacity of this weed and did not realise that it would grow to occupy the full depth of the water column in the fishery and the full area of the watercourse – as it did within two years. This illustrates the need for biodiversity awareness-raising activities by government bodies, particularly for urban areas where there can be rapid changes occurring to ecosystems.

Problems and challenges

In the River Tolka Valley the Giant hogweed and Himalayan balsam have caused serious problems for native biodiversity. Where these plants grow in abundance they block light from native herbaceous plants and grasses, ultimately removing them from the banksides. Not only does this reduce biodiversity among the resident flora, it exposes the bare banksides to river scour during the winter months. This has caused river bank subsidence and introduces silt and clay into the river, which can result in the clogging of trout and salmon spawning gravels (Caffrey, 1999). The addition of extraneous material into the river can also result in flooding problems during times of high flow and the River Tolka has flooded with very serious consequences for Dublin city in the past. In addition, Giant hogweed is a hazardous plant whose sap can cause serious burns when it comes into contact with skin, particularly in the presence of bright sunlight (Caffrey, 1994; Caffrey, 1999). Many reported incidents of children and adults being burned by this plant in the River Tolka Valley have been reported over the years.

In the Darndale Fishery Curly-leaved waterweed has totally overgrown the watercourse and rendered it unfishable by anglers. This has removed a valuable local amenity from the local community in an area where general amenities are scarce. It has also removed a prime location that was in constant use by IFI's Dublin Angling Initiative for training young anglers. In addition, the excessive growth of weed resulted in dramatic fluctuations in dissolved oxygen levels in the water, particularly during the summer months, with the resultant death of many resident fish.

Scope and size of impact

DCC monitoring since 2008 indicates that all of the main river catchments in Dublin are impacted by invasive alien plant species, to the extent that in some sections of channel they have become the dominant species. The NBDC website (http://invasives.biodiversityireland.ie/) shows that, for each species, the extent of impact is considerable. The types of ecosystems affected include semi-natural grasslands, riparian woodlands (where regeneration is affected), amenity grasslands and coastal habitats, including Annex 1 SAC habitats in north Dublin Bay. The presence of invasive species in amenity grasslands can have an impact on recreation and also on protected species.

The presence of Giant hogweed is also a concern for public safety and human health in terms of its potential to cause skin burns and eye injuries. This topic was presented by DCC at a national environmental science conference (ENVIRON) in January 2013. While no evaluation of the economic worth of angling on the River Tolka has been undertaken, it is deemed to be substantial based on the large numbers of club and non-club affiliated anglers that utilise the resource each season.

The riparian ecosystems of Dublin City have been given greater focus in the recent City Development Plan (www.dublincity.ie/Planning/DublinCityDevelopmentPlan/), whereby a planned network of green infrastructure is proposed. Such policies are in line with the EU's recent statement on Green Infrastructure in May 2013 (EC, 2013). However, with such increased connectivity planned, the potential for invasive species to mobilise must be considered and addressed. Loss of indigenous species has not been assessed in Dublin City.

DCC Parks and Landscape Services is undertaking Species Action Plans for a number of key sites of highest biodiversity in individual parks. It is planned to prepare a communications strategy, which will include training for the public in conjunction with NGOs to assist with recording/eradication of certain key species. Challenges include public safety issues for volunteers due to the riparian terrain, urban landownership complexities and the need to exercise care when dealing with Giant hogweed. There are 1,400 hectares of public parks and open spaces in Dublin city and, as a consequence, a prioritisation of sites is being prepared. This is being informed by national biodiversity research under the SIMBIOSYS Project coordinated by Trinity College Dublin Biodiversity Research Centre (www.tcd.ie/research/simbiosys). This includes a strategy for the management of invasive species in core areas as well as for outliers, which could be future agents for dispersal.

Approach and activities

Inland Fisheries Ireland (IFI) has assumed responsibility for the control and management of aquatic invasive species in watercourses under its control, nationwide, and has developed an extensive 'war chest' of practical information materials for stakeholders, community groups and the public in general (http://www.fisheriesireland.ie/Invasive-Species/invasive-species.html). IFI also has staff that are trained in both identifying and physically tackling those invasive species that encroach into watercourses. IFI staff regularly conduct training sessions on invasive species identification and provide information to stakeholders and the public on how to make accurate and timely reports if potentially harmful invasive species are found. These informal training sessions also alert participants to invasive or potentially invasive species that have not yet been recorded in Ireland or in Dublin city but which could be introduced. These activities lay the groundwork for good prevention, early detection and rapid response.

Efforts to control Himalayan balsam have focused on the use of herbicides and physical removal by pulling (a method that has become known as 'balsam bashing'). To date, chemical control has been operated by DCC staff and is proving to be quite effective. However, work conducted elsewhere in Ireland has shown that the involvement of local communities and committed stakeholders in coordinated 'balsam bashes' can effectively clear large areas of infested river corridor. It is intended to establish community groups along the River Tolka Valley to conduct extensive 'balsam bashes', under the supervision of DCC and/or IFI staff.

Because of the hazardous nature of Giant hogweed, control has been conducted solely by trained operatives. Spraying or stem injecting with the herbicide glyphosate is permitted 'in or near rivers' and is one of the most effective methods to control this invasive species (Caffrey, 1996). Large-scale spraying of Giant hogweed stands along the Valley has been conducted by DCC since 2007.

The construction of a new public park by DCC along a section of the River Tolka afforded an opportunity to pilot a new approach under Renew4GPP, an EU LIFE Project. The objective is to enhance green public procurement (GPP) by demonstrating to municipal authorities the ecological advantages of high-quality, innovative landscaping products based on 100% renewable resources. These are weed control mats for the landscape industry, but their use for control of invasive species is novel to the project in Europe and Ireland. Previously, it has been used for highway embankment stabilisation and to control common herbaceous weeds. These mats inhibit the growth of weeds for at least 3 years and then fully degrade into compost, which will promote the growth of native riparian plants which are planted to establish natural vegetation cover.

The River Tolka park site possessed a latent seed bank of Giant hogweed and Himalayan balsam. The disturbance of soils during construction exacerbated the problem described above by exposing this seed reserve. The use of the weed control matting on such sites was piloted to determine if non-chemical methods would be effective. Two types of matting were used: the first type is planted through with increased density of native riparian species and the second type seeded with native wildflower/grass mixes. Preliminary results indicate that it is preventing soil loss during flooding, resisting burning and reducing maintenance requirements. Some uplifting of the matting has occurred by germinating Himalayan balsam plants and DCC will continue monitoring until 2015 to inform the LIFE project.

A new and innovative method to control of large infestations of Curly-leaved waterweed was developed by IFI scientific staff in a large lake in the west of Ireland (Caffrey *et al*., 2010). This method involves covering the target weed with large mats of jute (also known as hessian or burlap), which block incident light from reaching the vegetation (see Figure). This material has proved to be easy to handle, relatively cost-effective, environmentally safe and highly efficient at killing Curly-leaved waterweed. An added benefit is that it permits local seed banks of native plant species to germinate and grow though the jute pores once the offending invasive species has been killed. This method was applied to treat the Curly-leaved waterweed in the Darndale Fishery.

Constraints and obstacles

In 2011 Regulations that strengthen the controls on the introduction and dispersal of invasive species into Ireland were signed into Irish law (European Communities Birds and Natural Habitats Regulations 2011 – S.I. No. 477). However, at the time of writing, the Regulation that prohibits the importation, sale or distribution of invasive species (Regulation 50) has not been commenced. This means that harmful invasive species, such as Curly-leaved waterweed, are still being sold in this country. It is hoped and anticipated that this latter Regulation will be commenced before the end of 2013.

Funding to effectively tackle invasive species in Ireland is relatively limited, although Government agencies are applying this limited resource to address significant invasive species problems or problem areas. DCC has invested considerable funding into the redevelopment of the River Tolka Valley, where tackling the invasive species problem was central to the redevelopment programme.

Lack of awareness of the problems posed by invasive species among stakeholders (e.g. anglers, boaters) and the general public can be a major obstacle to progress in the battle against these species. This is currently being addressed, however, through active engagement at meetings and, on site, by practical demonstrations.

Another problem relates specifically to Himalayan balsam because of its attractive flowers, which resemble those of *Impatiens walleriana*, a common annual bedding plant. It is not uncommon for people to collect seeds from this plant and sow them in their gardens or in adjacent habitats. This has contributed to the spread of this plant in Ireland in recent years. A further problem relating to this species is the fact that it is a favourite among bee keepers because of the bountiful supply of nectar provided by the flowers. It will be important to deliver the message to this group that the benefits by way of honey are far outweighed by the negative impacts that the plant has on biodiversity and ecosystem services.

Social dimension

Communicating the message regarding the negative effects of invasive species, particularly those that are perceived to have some appeal or functional value (e.g. oxygenate ponds for fish, provide a nectar source for bees), is vital to the success of any campaign to effectively tackle invasive species. IFI has been to the fore in communicating this message, whether through the national or local media, through information delivery, erection of bankside signage, production of free-to-download invasive species apps for smart 'phones, etc. (http://www.fisheriesireland.ie/Invasive-Species/invasive-species.html).

Attendance at major social and stakeholder events in Dublin city (e.g. the Bloom festival that attracts over 50,000 plant enthusiasts, Irish Angling Expo that attracts over 9,000 angling enthusiasts, etc.) has served well to pass the message on to interest groups, and the results have been very positive. More people are now contacting IFI, DCC and other agencies to report sightings of invasive species and community groups are offering their services to help control these pernicious species.

Work conducted in Dublin city to tackle invasive species has been well received. The hazard that Giant hogweed represented throughout the River Tolka Valley, particularly for children that played there during the summer months, was significant and many were burned by the sap from this plant. In the early days of this infestation people did not know of its dangers and often the cause of the burns went undetermined. This has changed and most people who live adjacent to the Valley or who use it to fish, boat, walk or relax are now informed of the human health that the plant represents. The reaction to DCC's coordinated Giant hogweed control programme was thus greeted with praise and gratitude.

Results and lessons learned

The programmes set in place to control Giant hogweed and Himalayan balsam on the River Tolka Valley have been hugely successful to date. The previously common vista of continuous stands of Giant hogweed along both sides of the river is gone and, while occasional small stands of these invasive species do occur throughout the Valley,

they are registered by ongoing monitoring surveys or reported by concerned members of the public, and immediately treated. Large areas of riparian zone that were occupied by Himalayan balsam have been cleared and plans are in progress to engage local communities in 'balsam bashing' campaigns in coming years. The result of these actions has been to make the Tolka Valley safe for users and has been witnessed in the natural recovery of native bankside herbaceous species and grasses where these light-occluding stands have been removed.

In the Darndale Fishery early indications are that the jute matting has effectively killed the majority of the Curly-leaved waterweed population in the lake, as no major stands of this canopy-forming plant have been observed since the operation was completed in early 2013.

For engaging the public and relevant stakeholder groups, practical demonstrations are more effective than passing out literature or writing articles in local papers or journals. The practical, preferably on-site demonstration affords the participants the opportunity to view the invasive species at first hand and to engage the tutor or expert directly relating to key ID features, habitat preferences and control methods. Also, the enthusiasm of some of the participants can be 'infectious' and encourage other members of the group to become more actively involved. At such demonstrations, also, it is often possible to point out how the invasive species adversely impact on the native biota or on the functioning of the infested area (e.g. scoured and eroded banksides, clogged instream gravels, deposits of soil inchannel).

The use of technology to make information dissemination, ID and reporting more easy is very important. IFI has recently produced a free-to-download invasive species app for smart 'phones that assists the user in identifying invasive species and provides summary information on their habitat and impacts. It also provides a facility to take a geo-referenced photograph that will be automatically uploaded onto the IFI server for identification by an expert. Feedback is given to the sender and, if the notification requires it, immediate action will be taken against the invasive species.

When encouraging community involvement in control operations, such as 'balsam bashing', it is important to give the participants as much practical and useful information as possible. Towards that end, IFI has produced a simple "How to Balsam Bash" brochure that provides information as to why 'balsam bashing' can be successful and how and when to engage in the exercise for maximum effect. In 2011, IFI and DCC launched Fisheries Awareness Week in the national media with a 'Balsam Bash' on the River Dodder in Dublin city to raise awareness and this was carried out by local anglers, the Irish Wildlife Trust and the Green Communities coordinator of An Taisce, Ireland's 'National Trust'. Next year the Tolka Valley will be the focus of this event.

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Control of Hottentot Fig (*Carpobrotus edulis*) on Howth Head, Dublin

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Background

Hottentot Fig (Carpobrotus edulis) is a popular and widely planted ornamental garden plant from South Africa. It is also an aggressive invader of coastal habitats throughout Europe. It forms vast mats to the exclusion of all other plants. In Northern Europe on the Gower peninsula of Wales and along the Cornish and Devon coasts of Great Britain, it has formed extensive colonies smothering many kilometres of coastal cliffs. On the drier eastern coasts of Ireland, especially on Howth Head, a Special Area of Conservation (SAC) it poses a serious ecological threat to EU protected habitat – Sea Vegetated Cliffs (EU1230). Its presence encourages rats, which feed and gnaw on the seedpods and these also predate on sea bird eggs and are a nuisance to humans. The first record for Hottentot Fig (Carpobrotus edulis) in the wild in Ireland is from Howth Head, Dublin in 1962. Many garden owners in the area illegally dump their garden waste and clippings along the top of the cliffs and this presumably is how it has taken hold. A further 14 records occur on the island of Ireland in counties Cork, Waterford, Wexford, Wicklow and Down. The largest colonies (>150 x 50 m) known in the Republic of Ireland are those found on Howth Head, Dublin.

Problems and challenges

Hottentot Fig (*Carpobrotus edulis*) has a very dense fibrous root system concentrated in the upper 50cm of the soil, with new roots forming at each node as the plant spreads outward (D'Antonio & Mahall, 1991) and forming *impenetrable* mats over 50cm deep, which compete aggressively with native species (D'Antonio & Mahall 1991 and D'Antonio, 1993). Once it becomes established, it shows a high vegetative reproductive rate, and its growth does not appear to be affected by herbivores or competition in California where it is also invasive (D'Antonio, 1993). On the Cliffs at Howth Head Dublin the species had begun to engulf parts of the sea cliffs which act as a refuge for much of the coastal biodiversity of Dublin city and the "soft" muddy cliffs are also more susceptible to erosion with Hottentot Fig (*Carpobrotus edulis*) growing instead of the native vegetation.

Scope and size of impact

In Howth Head ((Special Area of Conservation - SAC) it poses a serious ecological threat to EU protected habitat – Sea Vegetated Cliffs (EU1230). Hottentot Fig (*Carpobrotus edulis*) smoothers out native vegetation so the percentage loss of indigenous species and habitats is one hundred per cent with a severe infestation. Its presence encourages rats, which feed and gnaw on the seedpods and they also predate on sea bird eggs and are a nuisance to humans.

Approach and activities

As Hottentot fig (*Carpobrotus edulis*) on Howth Head in Ireland lies within Howth Head (SAC) no experimental chemical treatments could be carried out initially during the nesting season March – September. The pilot chemical treatment and native species recruitment experiments planned were carried out at an alternative coastal site in the nearby county of Wicklow which is not a Special Area of Conservation. Once positive results of experimental control work were obtained, special permissions was sought from the Minister and the Commissioner on Irish Lights to carry out control of the species at the Howth Head site (SAC and Lighthouse).

Constraints and obstacles

Funds were sought and obtained from a small funding body, the Heritage Council (http://www.heritagecouncil.ie/grants/grants/). This source of funding was cancelled for 2013 and beyond, which means that smaller projects with aim to eradicate well known invasive species before they become too problematic are not now funded. Special Licenses had to be obtained from the Environment Minister and the Commissioner of Irish Lights to carry out control work on the species in the SAC and near the Bailey Lighthouse at Howth, a large lighthouse near the busy port of Dublin.

Social dimension

Information posters and leaflets were provided to all the local libraries and contact was made with the local committees and local and national press. Landowners were very generous with access to the sites and provision of water for the chemical sprayers. One site to which we were not allowed access to in 2010 is particularly worrying, as Hottentot fig at this site has the potential to reinvade the cliff areas from which it has been treated. Project Manager Dr. Noeleen Smyth (National Botanic Gardens of Ireland) made visits to Howth with interested groups during Heritage Weeks events after presentations on the effects of invasive species in general at the National Botanic Gardens. Public attendees to the talks were very interested in the invasive species issue and the groups who traveled to Howth Head to view the invaded sites were made more aware of the issues of invasive species as mainly garden escapes, providing new awareness among the gardening general public of the danger of invasive species to the Irish natural landscape. Teams of local, national and international Volunteers also worked on the project and visitors to the area as it is a popular amenity close to the city for tourists were supplied with leaflet information during control works.

Results and lessons learned

A 95% mortality/ success rate with the chemical treatment applied to Hottentot fig (*Carpobrotus edulis*) was obtained at Howth Head. For the Hottentot fig (*Carpobrotus edulis)* treated, the leaf litter remaining post treatment was found to vary between 1 – 20cm in depth with an average pH of 6.4 and organic matter content of 16.4%, which differed, though not significantly from the surrounding soil pH 7.5 and organic matter 12.2 %. The depth and pH of the leaf litter remaining was not however, found to adversely affect native species regeneration. In less than a year, which is a rapid vegetation response, native plants were re-establishing themselves from amongst the dead Hottentot fig (*Carpobrotus edulis)* stems. On Howth head, extensive populations of rare species such as *Inula crithmoides* and *Crithmum maritimum* have already developed. Currently some 50% of the all treated sites have been revegetated in this way.

Pilot control experiments were very useful for informing control efforts on cliffs at Howth. Data were obtained from the pilot control experiments and these proved invaluable in discussing the options to control the species on Howth Head, in convincing landowners, the public, government management authorities on the necessary control needed. Evidence from EU projects works in Minorca and work also carried out in California, where the species is also a pest species, were also very useful in explaining why controlling the species at an early stage could save both Irish biodiversity and funds in the long term.

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Invasion of jellyfish in the coastal waters of Israel

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Background

"Invasion of the jellyfish: Mediterranean on alert as hundreds suffer from stings" ran a newspaper title in July 2008 (www.independent.co.uk/environment/nature/); "The great Mediterranean jellyfish invasion" ran another in 2009 (www.time.com/time/magazine/article/0,9171,1931659,00); and yet again "Swarms of jellyfish pose threat to Mediterranean tourism" (www.dailymail.co.uk) in 2011. Periodic increases of indigenous jellyfish outbreaks have long been noted in the Mediterranean (UNEP, 1991; CIESM, 2001). Various anthropogenic perturbations – eutrophication, overfishing, global warming and the increase of man-made marine hard substrates – have been suggested as contributing to the proliferation of jellyfish populations in recent decades (Goy et al., 1989; CIESM, 2001). Boero (2013) proposed that the removal of top predators and the formation of oligotrophic temperature-stable water masses may cause the suppression of the high energy fish and mammal-dominated food web and the re-emergence of a medusozoan-dominated food web. But whereas most recurrent jellyfish outbreaks in the western and central Mediterranean are made up of indigenous species, non-indigenous species (NIS) have taken the lead in the East: the SE Levant is unique in hosting four alien scyphozoan jellyfish concurrently, in addition to two alien ctenophores. The Erythraean scyphozoan Rhopilema nomadica, first noted in the Mediterranean in the early 1970s, is notorious for the huge swarms it has formed each summer since the early 1980s along the SE Levantine coast (Galil et al. 1990).

Problems and challenges

Rhopilema swarms adversely affect tourism, fisheries and coastal installations. The annual swarming results each year in envenomation victims suffering burning sensation, eurythema, papulovesicular and urticaria-like eruptions that may last weeks and even months after the event (Benmeir *et al.* 1990, Silfen *et al.* 2003; Yoffe *and* Baruchin 2004, Sendovski *et al.* 2005). Coastal trawling and purse-seine fishing are disrupted for the duration of the swarming due to net clogging and inability to sort yield (S. Azoulay, pers. com.). Jellyfish-blocked water intake pipes pose a threat to desalination plants, cooling systems of port-bound vessels and coastal power plants: in the summer of 2011 Israel Electric removed tons of jellyfish from its seawater intake pipes at its largest power plants (www.bbc.co.uk/news/world-middle-east-14038729).

Scope and size of impact

Jellyfish prey on fish eggs and larvae as well as competing with the juveniles by preying on the same plankton resources. At high densities, jellyfishes may cause an undesirable ecosystem shift (Boero 2013). Since *R. nomadica* appeared off the SE Levant, the numbers of the indigenous scyphozoan *Rhizostoma pulmo* have dwindled.

The impact of jellyfish outbreaks on fisheries is caused both by the impoverishment of fish populations by recruitment impairing, by clogging trawl nets and by coating the catch with their stinging cells laden mucus leading to loss of fisheries revenues. Jellyfish have also clogged cooling systems of power plants, interrupting energy supply. Because of their painful stings jellyfish constitute health hazards to humans, increasing medical and social costs, cost of illness and loss of earnings. The sting-avoidance behaviour affects recreational activities in areas affected by jellyfish outbreaks. There might also be some socio-cultural loss as seaside recreation is forsaken for swimming pools or other forms of recreation.

Approach and activities

Beginning in 2000, Bella Galil, the National institute of Oceanography (NIO), has been recording the summer swarms of *Rhopilema nomadica* along the Mediterranean coast of Israel and supplying weekly updates to the media (radio, tv, print) and through the trilingual (Hebrew, Arabic, English) institutional website www.ocean.org.il/meduzot, and recently, through facebook[1]. In 2009 Israel joined the Mediterranean-wide JellyWatch program initiated by Prof. Boero, Italy, and funded by CIESM. The iconic Hebrew language Jellywatch poster is widely distributed and has become a familiar sight. In addition to the media, information is fed directly to coastal power and desalination plants and to beach-side first aid stations.

Constraints and obstacles

The early detection and surveillance system ran by Bella Galil, the NIO, has received encouragement and compliments but no state funding. Since no effective control/eradication tools exist, education and dissemination of timely information are the only way to deal with the impact of the swarms. Israel's highly developed mobile telecoms market, which has one of the highest penetration rates in the world, is ideal for providing the necessary information.

Social dimension

A socio-economic survey, carried out in July 2012 by Paulo A.L.D. Nunes and Bella Galil, captures the welfare impacts of jellyfish outbreak among coastal recreationists in Israel. 270 face to face interviews were conducted at the beachside during the jellyfish swarming season. Econometric estimation shows that an individual beach recreationist, on average, receives a welfare gain of about 92 ILS (equivalent to 25 USD or 19 Euro) a month, as generated by their monthly visits to the beach. Multiplying this value to the coastal population of Israel the annual benefit is worth nearly 100 million dollars per summer month. Since the presence of Jellyfish swarms significantly affects beach recreational behaviour, the monetary value estimate of this impact is great. A quarter of the survey respondents stated that they will return to the same beach once the swarm is gone. Therefore for this population, daily information regarding jellyfish presence at a particular beach will determine beach recreation behaviour. All in all, these figures constitute an important indicator denoting the socio-economic value of public policy/management instrument – based on the supply of information – a public good – to the (potential) beach users, which is the only effective policy instrument (adaptation to jellyfish outbreaks).

Fishermen, Life Guards, beach-goers, coastal police have been supplying information to the NIO database

1 The National Institute of Oceanography, Israel Oceanographic & Limnological Research informs that a large swarm of the Erythraean alien nomadic jellyfish, *Rhopilema nomadica*, is currently present along the Mediterranean coast of Israel from Ashkelon to Akko. Its distance from shore and density differ in different sections, but generally it is at least 100 m away from the shore line, with only few individuals swept ashore. However, the proximity of the swarm means there is high likelihood of stings. Off the southern coast of Israel, another invasive alien jellyfish, *Phylorhiza punctata*, occurs in larger numbers than noted in previous years. (5 July 2013, viewed 7 July 2013).

and are members of an informal e-community that exchanges information on the prevalence of jellyfish and stings along the Israeli coast.

Results and lessons learned

The Israeli public is well aware of the presence jellyfish swarms thanks to wide dissemination of the information in formal and informal media, such as Facebook and Twitter. Information on marine bio-invasions and their ecological and economic impacts is available as well. Since adaptation to jellyfish outbreaks is the only effective policy instrument, timely, scientifically accurate, non-sensational information is essential.

Marine bio-invasions are impossible to eradicate, or even control, once the NIS has been established in the natural environment. As in the case of *Rhopilema nomadica*, the only option is education. However, much should be done to reduce the influx of new arrivals by pathways and vectors.

The influx of NIS entering the Mediterranean through the Suez Canal (half of the multicellular NIS in the Mediterranean) has impacted the already teetering fisheries, mariculture, and tourism through proliferation of alien parasitic, noxious and poisonous species, displacement of commercially-important native species, or through alteration of the food web and by causing a phase shift in coastal ecosystems and changing seascape patterns. There is no another vector of marine bio-invasions that delivers as high a propagule supply for so long to a particular locale. Yet, conspicuously absent among the items enumerated in the SCA's "Vision, Mission and Duties", are references to its environmental responsibility (www.suezcanal.gov.eg). The Suez Canal has undergone major enlargements in order to maintain its market share. The recent expansion, completed in January 2010, increased its depth to allow passage of vessels up to draft of 66 ft, and already the Suez Canal Authority is evaluating the feasibility of increasing the Canal's depth or doubling its width to attract larger vessels (www.suezcanal.gov.eg). The implications of a deeper, wider Canal combined with higher through-current velocities on propagule pressure of NIS are all too clear. The 'business as usual' attitude poses a challenge to the environmental ethics and policies of the Mediterranean countries. As signatories to the Convention on Biological Diversity they are required to prevent the introduction of, control or eradicate alien species which threaten ecosystems, habitats or species (Article 8(h)), and ensure that the environmental consequences of their policies that are likely to have significant adverse effects on biological diversity are taken into account (Article 14.1) (www.cbd.int/convention). No management option to reduce the influx of NIS through the Suez Canal has yet been discussed, leaving the Mediterranean vulnerable to increasing thermophilic bio-invasions.

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Eradicating American Eastern grey squirrels in Genoa Nervi urban park

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Background

The target species for this case study is the Eastern grey squirrel (Sciurus carolinensis) present in an urban park in the city of Genoa.

The population of grey squirrel originated from five specimens introduced from Norfolk (U.S.A.) in 1966 in Genoa Nervi urban park. Today we estimate 200 (150-300) squirrels, nearly all confined in the urban parks system in the eastern outskirts of Genoa. As the park system is surrounded by dense urban fabric, it seems that grey squirrel expansion out of the urban context has until now been prevented. However, some isolated animals are periodically reported in areas not too far from neighbouring forested natural landscapes.

The city of Genoa extends between the Ligurian Sea and the Apennine Mountains and with a population of about 600,000 it is the sixth largest city in Italy, one of Europe's largest cities on the Mediterranean Sea coast and the largest seaport in Italy.

Problems and challenges

The grey squirrel is a North American species that has been introduced to many localities of North America, Australia, South Africa, Great Britain, Ireland and Italy. In Europe, the grey squirrel was introduced to Great Britain, Ireland, and Italy. In these countries the spread of the grey squirrel has been associated with a dramatic decline of the native red squirrel (*Sciurus vulgaris*). This replacement is caused by competition for food resources between the two species that reduces juvenile body growth and recruitment, and female breeding success in red squirrel. The replacement is also (in UK) disease-mediated, as grey squirrels act as a reservoir host to a squirrel poxvirus that causes high mortality in red squirrels.

The presence of the grey squirrel in Britain and Ireland is a serious problem for these islands, but is a local problem, fortunately. In Italy, instead, grey squirrel presence is in fact a serious risk to the survival of the red squirrel, not only in the country but also in the neighbouring countries of France and Switzerland and, in the long term, throughout the European continent. According to statistical prediction models, grey squirrels can, in a few decades, colonize the Alps, the Apennines and other countries such as France and Switzerland.

In 2010 a LIFE + project (*EC-SQUARE: Eradication and control of grey squirrel: actions for preservation of biodiversity in forest ecosystems*) started, with the aim to control or eradicate the grey squirrel in Northern Italy. In EC-SQUARE we are developing methods to control and eradicate grey squirrels in different socio-ecological contexts. These will be integrated with public opinion assessments to investigate and shape public perceptions of the general problems posed by alien species and, in particular, the grey squirrel. Developing and carrying out specific control methods linked to local public perception of the alien species will allow us to test the efficacy of innovative methods under different local contexts and to introduce new alien species management strategies which will be made available to policy makers at different administrative levels.

The main objective of EC-SQUARE is to eliminate or, where eradication will be judged impracticable, to control the risks posed by the introduced alien species, the Eastern grey squirrel, to biodiversity, and in particular to the conservation of the native red squirrel in Italy. A major challenge for a successful eradication and/or control campaign is to obtain a wide consensus of the civil society for control measures, suitable in different socio-ecological situations. This is especially the case when one needs to intervene on a species whose presence is not considered a menace by the general public, but which even has a positive appeal in some contexts like (sub) urban parks.

In planning eradication/control strategies, particular attention should be given to the conflicts, which could arise when implementing the project, and methods for managing these conflicts should be identified and used. In particular situations, such as Genoa Nervi park, inside urban areas, where the public is accustomed to see and feed grey squirrels, a removal method that implies killing the animals may not be accepted, leading to a strong opposition to the whole project. In these situations, with small populations, the eradication with surgical sterilisation should be considered a possible alternative.

Scope and size of impact

The presence of the grey squirrel in Italy constitutes a serious threat to the survival of the red squirrel in the country and throughout Europe. The two species are, in fact, in competition and in areas of introduction of the grey squirrel, extinction of red squirrel occurs.

In Great Britain the grey squirrel has colonised much of England and Wales and is expanding in Scotland. In the meantime, the red squirrel has become one of the species most at risk of extinction. The same replacement is occurring in Ireland as well as in Italy.

The European authorities are very concerned about the possibility that the grey squirrel can colonise much of Europe, putting at risk the survival of the red squirrel. For this reason, the Standing Committee of the Bern Convention has repeatedly sent recommendations to Italy, asking to take prompt actions to remove the grey squirrel. In November 2008, the Standing Committee has opened a "case file", a sort of infringement procedure, against Italy for failing to act in limiting the spread of the grey squirrel. The LIFE project wants to answer to the demands of Europe, tackling the problem in a coordinated manner across the different regions to arrive at an effective reduction of the spread of the grey squirrel.

Grey squirrels in the urban park in Genoa Nervi are the only population in Liguria. Spreading outside the city, the American squirrels will invade the Apennines and could easily reach France moving along the coast.

Approach and activities

Existing legislation asks to quantify the distribution and number of animals of populations before carrying out control programs. We voluntarily provide other actions

to increase knowledge on populations and tackle the human dimension aspect of the problem.

In the preliminary actions, we determined the size and distribution of grey squirrel populations at each site where the alien species occurred. To understand public perception of red and grey squirrels, essential to plan and implement grey squirrels management strategies, we assessed general public and stakeholders knowledge about red squirrel conservation problems and the role of the species in forest ecosystems, and their attitudes towards grey squirrels and its management, using a targeted questionnaire. In the next step, we developed a General Management Plan (GMP) for grey squirrel populations in each region (Liguria, Piedmont and Lombardy).

The GMP analyzes, on a per site basis, the actual population status, taking into account both grey squirrel population dynamics and site landscape characteristics, as well as a characterization of social drivers and pressures. It defines a series of indicators of both population status and socio-economical background to define the management actions.

To avoid future introductions, the Task Force of the LIFE Project collaborated with different Italian ministries involved in animal trade and management to make a grey squirrel risk assessment as necessary input to enforce a grey squirrel trade ban. The squirrels' trade ban was approved on the 24th December 2012.

EC-SQUARE will eradicate or control grey squirrels in most of the sites with live-trapping followed by euthanasia. In Liguria, because of high public appeal of grey squirrel at Genoa Nervi Park and surroundings, the GMP for Liguria supported eradication by live-trapping grey squirrels, with subsequent sterilisation and detention in captivity of the animals.

The possibility to (re)introduce red squirrels in the park after the removal of the grey squirrel was also considered as a sort of 'social compensation' for the citizen: we remove a population of an invasive squirrel and provide a new population of the native red squirrel. This foreseen release of red squirrels inside a city takes place in an area where the species was never reported before. Thus, the operation could not be considered a reintroduction or a management option with a 'direct' conservation value for the red squirrel. It is, however, a tool that can be adopted as a means to achieve social consensus for the removal of grey squirrels from Nervi Park to prevent them from having future impact on the red squirrel in the Apennines. This would potentially increase the link between citizens and the native squirrel species, providing evidence that native species could live in urban areas without the need to introduce exotic animals.

Constraints and obstacles

The project is funded through a European LIFE project with support of the territorially competent government agencies, the University of Genoa and the project task force. The main obstacles are related to the difficulty to have scientifically correct media coverage. Newspapers, television, online media, prefer to emphasize the removal of 'cute' grey squirrels, not reporting or even denying the risks for red squirrels.

People are not used to evaluate management options that involve removing animals (with euthanasia or sterilisation) with a science-based approach. If they are 'a priori' against these options, they deny any scientific evidence, arguing that it is not true without the need to bring any evidence in their favour.

Social dimension

The first version of the GMP for Liguria included the capture, sterilisation and maintenance in captivity of the sterilised animals. The start of the trapping activity was delayed by the strong opposition of some local associations and groups of citizens. When the project reached the media, it was presented as a '*massacre of squirrels in Genoa Nervi'*. With interviews and press releases, the Regional Authority has made it clear that the project involved the sterilisation of animals and not suppressing them.

Part of the citizens and local NGOs were convinced by the proposal of the sterilisations, but argued that it is not fair that animals born 'free' in the park end up living in captivity 'behind bars'. After these complaints from associations and groups of citizens, the GMP Liguria was changed and now it is foreseen that the sterilised animals will be maintained free in some urban parks in the city of Genoa. In this way, people could also continue to see them, at least for some years till they die.

To increase the support to the project and deal with critical situations, usually caused by articles in newspapers, reporting approximate information or by local groups who were demonstrating, we activated different modes of negotiation with stakeholders: through the media, through meetings with selected stakeholders, public meetings, face to face meetings.

However, despite continuing meetings with associations and citizens and a willingness to change the management plan, providing for the release of sterilised squirrels in other parks of Genoa, a small

group of citizens is still opposing the project. They consider the grey squirrels in the park as 'their squirrels', a sort of pets that they are used to feed and take care of. They would not be convinced by any evidence of the risk the American squirrels pose to the native red squirrels. Despite these difficulties, the project is going on, with a veterinary clinic in charge of sterilisations. The start of the trapping activity is scheduled in September 2013.

The position of different stakeholders on the possibility to reintroduce red squirrels in the park after the removal of grey squirrels is not univocal. Some consider this as an interesting option to have in any case squirrels in the park and to improve the link between citizens and the red squirrel. Others do not accept that wild animals will be released in urban environment.

Results and lessons learned

We expect to eradicate the grey squirrel from Genoa Nervi through live-trapping, surgical sterilisation and release of the animals in other urban parks. This would be the only way to manage the situation: a 'cute animal' introduced in an urban park where it becomes the 'darling' of the people visiting the park. When acting in urban areas, taking into account the human dimension is fundamental. In addition, the project provides a number of lessons learned:

- There is a need to communicate in advance to the general public the objectives and the rationale of the project.
- Prepare a management plan, but consider also some alternative options if the initial position is too strongly fought.
- Evaluate different options and consider consultations of main stakeholders, this includes any organized group with interests in the area of the project, but also citizens that could organise themselves to provide contrasting views to the project.
- Try to discuss with the strongest opponents, but be aware that you can fail to convince them.
- The political support is fundamental. Politicians are sensitive to attacks from the media, and the opponents know this. They will use the media to convince politicians responsible for the activity that 'moving the project forward only causes problems and is not worth it'. It should be considered that the media, at least in Italy, prefer to support positions that protect animals, especially in urban areas, without any distinction between native and alien species.
- Finally, one of the problems we encountered was the ease with which scientific data supported by several lines of evidence, such as the replacement of the red squirrel by the grey squirrel, are denied in the newspapers simply saying '*it is not true*', without having to provide any evidence to support this statement.

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Eastern grey squirrels in Perugia, Umbria

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Background

The Eastern grey squirrel is one of the 100 world's worst invasive species listed by IUCN and in the DAISIE database. In Italy it is present in four regions: Piedmont, Lombardy, Liguria and Umbria. Umbria is the most recent area in which the species has been reported.

The release of the grey squirrel in Umbria occurred in the early 2000s. Seven squirrels accidentally escaped in a private wildlife park nearby the city of Perugia (Umbria, Central Italy). The squirrels had been purchased in 1999 by the owners from a dealer of northern Italy probably as a result of illegal catches in Piedmont area. In fact with a recent DNA analysis (Signorile et al*, 2013* in review*) we have observed that these squirrels have a high genetic similarity with the Piedmont ones. Unfortunately, until 2009 the presence of non-native species remained unknown to the scientific community and other public bodies.*

In this gap the species has been spreading, nowadays, in an area of at least 50 km^2, which covers a huge part of the city of Perugia and the Site of Community Importance (SCI) IT5210021 "Monte Malbe" (located to the west of city). The SCI is characterized by a continuous woodland cover with a prevalence of Holm oak and deciduous trees with the presence of the chestnut. Instead, the sub-urban area of Perugia is characterised by scattered settlements with important semi-natural patches. In urban areas there are many public parks that may support a healthy population of grey squirrel.

Problems and challenges

The introduction of grey squirrel in Europe is one of the best known cases of biological invasion. The invasive species tends to replace, through a specific competition process, defined "competitive exclusion", the native red squirrel (Wauters et al 2002 a,b). Well-documented examples are those in the British Islands and northern Italy (Gurnell and Pepper, 1993; Wauters *et al,* 1997; Bertolino and Genovesi, 2003; Bertolino *et al*, in press). Several studies have shown that the competition between the two species originated from the semi-complete overlapping of ecological niches: in conditions of limited resources the red squirrel is unable to compete with the grey one.

Probably in Umbria, according to preliminary trapping action, the estimated population would be of about 2,000-3,000 grey squirrels. Within the SIC "Monte Malbe" and in its surroundings it can be assumed there is replacement between the two squirrels with the subsequent disappearance of the native species.

Umbria is commonly known as the “green heart of Italy”, the region has seven Special Protection Areas and 97 Sites of Community Importance, in addition to Monti Sibillini National Park and six Regional Parks. The biodiversity of these areas could be put in jeopardy by the grey squirrel presence. Many of these areas (Parks, SPAs and SCIs) are located along the Apennines, considered an important biodiversity hotspot in Europe.

The presence of *Sciurus carolinensis* in Umbria represents a potential threat to the forest biodiversity of the entire Italian peninsula. Umbria has the following geographic and ecological features: a wide spread of natural vegetation with a high component of woodland (60% of the entire surface of the region), a high degree of ecological connectivity, lack of ecological barriers and a core position within the Italian peninsula.

Also, in Umbria, grey squirrel impacts might in the mid-long term affect important local agricultural fields, such as vineyards, orchards, olive groves, chestnuts. Thus alien squirrel will threaten niche economies with a high local importance, causing potential socio-economic issues. Bark-stripping activities can cause damages to the woodland of the Italian peninsula in the long term period.

A specific threat linked to the presence in urban areas is the potential role of grey squirrel in public health issues.

Scope and size of impact

The first consequence of the expansion of the grey squirrel in urban environments is the disappearance of many populations of native red squirrel. Nowadays, the area from which the native species has disappeared is about 20 square kilometers, while several other isolated populations are at risk of replacement. The process of replacing between the two squirrels appears to be reversible but it is necessary to take rapid and effective action to halt alien species.

Another consequence of the spread in urban areas is the potential health issue. A preliminary mycological survey carried out during 2012 revealed a potential role of carrier of zoonotic agents by the grey squirrel (Crotti S, Technical report). We have isolated in two symptomatic grey squirrels with evident skin lesions, the dermatophyte *T. interdigitale* that may be responsible for human *tinea*. The presence of non-native squirrel in high attendance areas (like urban and sub-urban parks) and its confident behaviour towards humans are critical aspects in public health issues. Health surveys should inform a support decision system to identify potential sources of sanitary public problems in urban areas. Management plans should take into account the sanitary outputs to manage the non-native squirrel. Moreover, it is necessary to raise awareness in public opinion about the risk posed by the grey squirrel, not just from a conservation point of view but also from a healthcare perspective.

Approach and activities

Since 2010 the first research program, which allowed a preliminary definition of the alien squirrel range has been carried out. In 2011, a Management Plan written by the Province of Perugia and approved by the Italian Institute of Protection and Environmental Research and the Ministry of Environment permitted the legal capture, removal and handling of squirrels. Researchers in the Department of Cell and Environmental Biology of the University of Perugia collected squirrel population range data and samples with financial support from the Hunting and Fishing Service of the Region of Umbria. 77 grey squirrels were trapped and euthanised in respect of animal welfare. The overall density estimated with this removal method in 7 trapping areas is about 10 squirrels/hectare, with maximum values of about 30 nearby the release site. Nowadays we have collected 244 records of alien squirrel, including 11 roadkills, all in urban areas.

This preliminary research project was funded independently with 15.000 Euros per year from the

Umbria Region as a result of a voluntary approach. However this project was inadequate to solve the problem, so the Institute for Environmental Protection and Research with the support of local partners submitted a LIFE+ Biodiversity proposal for the 2013 call.

Constraints and obstacles

We can list at least four constraints and obstacles:

1. Intercepting new *foci* of IAS in the shortest possible time has a great importance. If a non-native species is detected in the early stages of the introduction, the response management will have a greater chance of success in species eradication. However, the delay in discovering new incursion makes the removal (or control) much more difficult, causing high economic costs. The introduction of grey squirrel in Piedmont is a typical example: between the first releases in 1948 and the first warnings for conservation of red squirrel 30-40 years have passed. Also in Umbria, soon after the release of the alien squirrel there was no early warning system able to intercept the new incursion. This has allowed to grey squirrel to spread over the SCI and in urban areas.

2. In Italy there is a legal framework vacuum: public bodies have no obligation in the management of non-native species. This is a key problem: politicians may choose to do nothing. Trapping and euthanasia of squirrels, which have so high appeal in public opinion, does not pay in terms of consensus.

3. In this economically constrained period, local governments do not have enough funds for projects that need so many resources. Furthermore there are no central agencies that can fund and lead projects on alien species.

4. Given the presence of the grey squirrel in urban areas, the opposition of animal welfare groups is a huge constraint to carry out the trapping and suppression.

Social dimension

The grey squirrel has an innate appeal and often features in childhood culture or is sold/kept as a pet. Therefore there is a considerable risk for conflicts between wildlife conservation, animal rights and welfare, public perception of scientifically based control methods and management policies that aim to reduce ecological damage (extinction of the native red squirrel) caused by grey squirrels. This nexus of issues is occurring in a period in which decision-making appears particularly sensitive to popular and populist views and less to scientifically based management programmes of species. As a result of these conflicts already in the past, grey squirrel management strategies in Piedmont (northern Italy) have been influenced and even stopped by actions of animal welfare groups. Considering that in Umbria the alien species is linked to several types of human settlements, like high population density in sub-urban areas and in the city centre, a primary goal is to obtain a wide consensus (hopefully active, or at least not preventing) by the public opinion for management actions.

Results and lessons learned

We have obtained preliminary data on grey squirrel distribution and local population densities. However, with these few financial resources we can't accomplish any management strategies for reducing grey squirrel population nor start an effective communication plan.

For this reason the Institute for Environmental Protection and Research together with other partners, such as Umbria Region, Municipality of Perugia, Zooprophylactic Institute of Umbria and Marche, Legambiente Umbria, Agency Regional Parks of Lazio and Istituto OIKOS srl, have submitted a LIFE+ Biodiversity proposal trying to achieve the following results:

Management:

- Removal of at least 80% of the estimated grey squirrel population in Umbria. If it will not be feasible to complete eradication of the grey squirrel population we will produce an adaptive management strategy that allows keeping the population within a given size.

- Restore at least two sub-urban red squirrel populations and increase the local density in the areas where the species is disappearing due to the presence of the non-native one.

- Creation of a dynamic map that explains the trend of removal operations. This map will be available in the LIFE+ Project website.

- Remove a potential source of public health issues posed by grey squirrel. Direct and indirect contact can create diseases in people with depressed immune systems (e.g. dermatomycosis).

Awareness and communication:

- Increasing in the public opinion the role of native red squirrel in the forest ecosystems and the threats posed by the alien grey squirrel to biodiversity.
- Raising awareness of the pet trade issue.

Dissemination:

- Produce a best practice tool for an Early Warning System and Rapid Response to new incursions by IAS.
- Providing technical alternatives to the use of non-selective systems for the control of rodents (toxic bait dispenser) in urban areas, thus reducing the impact on non-target species, and the environmental contamination.
- The Alien Squirrel Emergency Team, on the basis of communication and management experiences gained in U-SAVEREDS, will create the appropriate background to cope rapidly with possible new foci of non-native squirrels in Italy.
- Creation of advanced communication and management strategies, which can be applied to other Invasive Alien Species at local and national scale.

There are three main recommendations in relation to the "grey squirrel in Umbria":

1. It is necessary to prevent the IAS introduction, or at least develop an efficient early warning and rapid response system. If the Public Authorities had acted immediately after the release, the species would not have been expanded within the city of Perugia and in its sub-urban areas. The spread in urban areas has meant that citizens adopted a positive attitude towards non-native squirrel. In addition, from a technical point of view the implementation of catches in the urban environment will require more effort in time and funds.

2. In Italy an update of the National law 157/92 ***"Norme per la protezione della fauna selvatica omeoterma e per il prelievo venatorio"*** is unavoidable. The law makes no distinction between native and non-native species, this creates a legal chaos: grey and red squirrel are protected in the same way.

3. Biological invasions occupy a position between 'nature' and 'culture', as they have both biological and social aspects. The response to incursions therefore needs to take into account the human dimension. Especially in urban areas if the invader is a "pretty" species it is necessary to adopt a multidisciplinary approach that involves wildlife biologists and communications experts.

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Pallas's squirrels in the city of Weert

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Background

About 15 years ago, a few Pallas's squirrels (Callosciurus erythraeus) escaped from an animal trading company near the vicinity of the City of Weert. About 10 years later, people started noticing and reporting these squirrels. The population started to build-up and reached an estimated size of 275 – 300 Pallas's squirrels. The Pallas's squirrels established in the city of Weert and the forests and areas with patches of (mainly broadleaved trees) surrounding Weert.

Problems and challenges

A risk assessment was carried out. The conclusion was that Pallas's squirrels are likely to outcompete the native red squirrel (*Sciurus vulgaris*) and cause significant damage to buildings, (fruit) trees and pipes etc. made of plastic.

Scope and size of impact

There are no scientific data available on the quantity of impact. However, since the population of the Pallas's squirrels started growing, local residents mention that they don't observe the native red squirrel anymore in and around their gardens. Also damage to houses, trees, etc has already been observed in the establishment area of the Pallas's squirrel.

Approach and activities

A risk assessment was carried out. Furthermore, a monitoring project was launched to determine the establishment area of the Pallas's squirrel and to get a rough idea on the number of squirrels present in the area. This monitoring project was carried out by using hair-traps, camera's and by involving local people who were asked to report any sightings.

Based on the risk-assessment and the monitoring project the Minister of Economic Affairs, Agriculture and Innovation and the Province of Limburg decided to start a joint project to remove the Pallas's squirrel population. This project, funded by both the national government and the Province of Limburg, started in late 2011. The project is divided in several phases and is still running.

The trade and possession of Pallas's squirrels was prohibited by law (Flora and Fauna Act) along with two other alien squirrel species (Grey squirrel, *Sciurus carolinensis* and Fox squirrel, *Sciurus niger*).

Constraints and obstacles

Monitoring effectiveness

One of the difficulties in this project is the (lack of) effectiveness of regular monitoring techniques. By using tree holes and as it seems, even holes in ground, the Pallas's squirrel is behaving differently from other squirrel species, such as the native red squirrel, and can remain invisible during 'regular monitoring'. Based on current knowledge, it is believed that monitoring for signs of fresh tree damage is the best monitoring method.

Public support

(The lack of) public support is always a major issue in any alien animal management action, but even more when dealing with highly likable squirrels. This was one of the reasons for deciding to capture the animals alive, to sterilise them and find alternative housing in zoos throughout Europe. It is believed that without this decision the management action would have failed or become much harder to carry out. Support is crucial, also because local residents' gardens are used for trapping.

Trapping effectiveness

Although trapping Pallas's squirrels is effective, it sometimes takes weeks to capture a squirrel on a single site. It may prove very difficult and time-consuming to capture the last animals in the area.

Social dimension

Local citizens are asked to report any sightings of the Pallas's squirrel and are asked permission to place traps in their gardens. Communication actions are mainly focused on a local and regional scale and local townships and land managing organizations are involved in the preparation and execution of the project.

Results and lessons learned

In the period of late 2011 – May 2013 around 250 Pallas's squirrels have been caught. It is estimated that only a few dozens of Pallas's squirrels are still present in the area. The project continues to capture the last squirrels.

People are reporting red squirrels again in areas where they only spotted Pallas's squirrels in the previous years.

Regarding communication it is much more effective to ask people face-to-face about sightings and cooperation compared to asking for support in newspapers on the radio, etc.

Regarding monitoring, based on current knowledge, it is believed that identifying signs of fresh tree damage is the best monitoring method. The involvement of local people is also a crucial factor, both for monitoring and placement of traps in private gardens, and therefore it is important to seek public support, starting at the local level.

Management actions against any alien species should be based on solid scientific knowledge / expert judgment. A management option that is (cost) effective and feasible may fail if public support is lacking. This may require choosing an option other than killing animals.

If the aim is to eliminate a population, then start preparing for a long-term project. The hardest part is to catch the last individuals.

Additional information

- www.vwa.nl/txmpub/files/?p_file_id=2201576
- www.zoogdiervereniging.nl/pallaseekhoorn

Removal of invasive plant species in Vila Nova de Gaia

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Background

Four invasive plant species have been the object of our control in Vila Nova de Gaia:

- *The Ice plant, (Carpobrotus edulis), native to South Africa. It was introduced in Europe in the seventeenth century for ornamental purposes;*
- *The River Spiderwort (Tradescantia fluminensis) native to South America;*
- *The Pampas grass (Cortaderia selloana), native to southern South America, both introduced some decades ago for ornamental purposes. The last "escaped" into the wild about two decades ago;*
- *The Montbretia, (Crocosmia x crocosmiiflora), obtained in Europe from the crossing of two species native of south Africa (C. aurea x C. pottsii).*

We also control the turtles of the genus Trachemys, native to the Americas, ranging from the United States to northern Argentina, which were introduced as a pet.

Problems and challenges

The plants referred to fully occupy the spaces where they are established preventing the presence of the local flora. Turtles settle in wetlands and compete with native wildlife.

Scope and size of impact

Ice plant, *Carpobrotus edulis* forms impenetrable mats that occupy large areas of dunes, including Natura 2000 Habitats. The habitats 2130* ("Fixed dunes with herbaceous vegetation (grey dunes)") and 2150* ("Atlantic decalcified fixed dunes (Calluno-Ulicetea)"), coastal habitat types occurring on sandy coasts of the Atlantic and Mediterranean environmental zones of Europe are also the primary habitat of endemic plants such as *Jasione lusitanica* (Annex II of the Habitats Directive) and *Coincya johnstonii* (a narrow endemic plant exclusive of coastal dunes in the Porto district). Both habitats are being invaded by *Cortaderia selloana* at high rates from the heavily invaded neighbouring areas. This threat is further exacerbating the effects of other invasive plants (e.g. *Carpobrotus edulis*) as well as of other pressures characteristic for a densely urbanised coastal region.

Cortaderia selloana is a vigorous plant invader that threatens valuable habitats (amongst many others) in several EU countries/islands, including Spain, France, Italy, UK, Canary Islands, Madeira and Azores.

River Spiderwort (*Tradescantia fluminensis)* is a persistent species that forms continuous carpets, preventing the development of native vegetation (mostly herbaceous), especially in riparian corridors.

Pampas grass (*Cortaderia selloana)* grows vigorously and forms dense clusters that dominate the herbaceous and shrubby areas, create barriers to wildlife movement and uses the resources available to other species. It rapidly occupies soils resulting from excavations or embankments and may cause allergies and sharp leaves can cause personal injury.

Montbretia, (*Crocosmia* x *crocosmiiflora)*, this species is not very harmful, but appears in tufts Local Nature Reserve in the Douro Estuary.

Turtles of the genus (*Trachemys)* begin to be present in many urban lakes and wetlands where the owners drop out when they grow up. They are voracious, destroying many amphibians and fish, and even nesting waterfowl. There are reported cases of bites on people and they can transmit Salmonella, an enterobacteria.

Approach and activities

Ice plant, *Carpobrotus edulis:* Manual removal has taken place in 63.63 hectares of coastal dunes and 18.8 hectares of Local Nature Reserve of the Douro River estuary, resulting in almost complete eradication.

River Spiderwort (*Tradescantia fluminensis):* Manual removal in 35 hectares of Gaia Biological Park, especially in the riparian corridor of the Rio Febros. The eradication can only be achieved by repeating regular removal.

Pampas grass (*Cortaderia selloana)*: Manual removal in 35 hectares of Gaia Biological Park of all new plants produced by airborne seeds. The eradication can only be achieved with a permanent surveillance.

Montbretia, (*Crocosmia* x *crocosmiiflora)*, Manual removal in 18.8 hectares of Local Nature Reserve of the Douro River estuary, the result being that the almost complete eradication.

Turtles of the genus (*Trachemys):* Trapping in wetlands and subsequent euthanasia and conservation in enclosures. In the case of Trachemuys we edited a book (bilingual Portuguese and Spanish) raising awareness of the danger that this kind of turtles brings for native fauna.

Although Portuguese law stipulates that the State should control invasive species, there is no national plan; our actions are voluntary, at the municipal level.

Constraints and obstacles

The main obstacle is economic because the eradication of invasive species requires a lot of manpower. Right now we use unemployed people, with the support of the Portuguese Institute of Employment that pays them.

For Green Turtles (*Trachemys*) the problem is that the import is not prohibited, and sale and possession of all species, only for a few. Another serious problem is presented by the "animal lovers" who have a "loving" relationship with the turtles and by releasing turtles in nature. We have current environmental education campaigns to resolve this.

Social dimension

In the case of green turtles (*Trachemys*) is important the voluntary delivery for citizens of about 400 animals per year, only in our Wildlife Recovery Centre in Vila Nova de Gaia.

Results and lessons learned

In our intervention area (municipality of Vila Nova de Gaia – North Portugal) we are getting very positive results in the dunes estuary of the River Douro and Gaia Biological Park.

The best strategy is to promote awareness campaigns towards the population, for permanent removal of invasive species.

Additional information

- LIFE Trachemys:
- http://www.cma.gva.es/web/indice.aspx?nodo=72095andidioma=P,
- https://www.facebook.com/GVA.LIFETrachemys
- https://www.facebook.com/lifecagados
- Parque Biológico de Gaia
  http://www.parquebiologico.pt

Fighting Common ragweed (*Ambrosia artemisiifolia*) and other invasive plant species in Geneva State

© Emmanuelle Favre

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Background

In Geneva there is a long botanical tradition, managing and looking at what species are entering the state of Geneva. There have been some invasive species since 1970s, but most of them were not a problem until 1990. The curve was until this moment quite flat. After 1990 the situation became worse. The State started eradicating invasive species in 2000. There is a plan and a strategy for invasive species and their eradication only takes place in natural ecosystems, such as nature reserves. In other areas, outside nature reserves, the State follows a policy of confinement. There are actually no systematic eradication actions taken for most of the IAS. We, however, try to eradicate Ambrosia artemisiifolia (Common ragweed) outside of natural areas, as it causes health problems, mainly allergic reactions. For this species there is a coordinating team including different partners (the agriculture office, the road office, health professionals, etc.) that works together. Every year these plants are being destroyed by professionals and volunteers. That means we have every year a control check of the places where we eradicated plants the past years and a control check of the new places declared at Info Flora (the national center of flora observations in Switzerland),

For Ambrosia the work over the past years is effective. The amount of pollen is reducing every year. The local pollen is decreasing as a result of the action. But the wind spreads the seeds over far distances and therefore action has to be continued every year.

Problems and challenges

Generally speaking for IAS, the biggest challenge is that Geneva is at the lower area of the water basin. Mountain rivers carry invasive species to Geneva. To fight the problem, coordination with neighbours in other cantons in Switzerland or in France is of high importance. It is very difficult to bring everyone around the table to fight together, especially because we have neither the same laws nor do we have the required funds available for this. Grand Genève is an organization across the border (http://www.grand-geneve.org/enjeux-strategie/nature-paysage), with French and Swiss participation, that plans activities to take action on both sides of the border. Their mission is to coordinate action for nature conservation and especially for fighting invasive alien species. This is in a beginning phase and will take time to develop.

There is no real strategy to control entry of invasive species in the State of Geneva even if Switzerland disposes of a federal law that should help to control the circulation of IAS (see the annex 2 of the "Ordonnance sur l'utilisation d'organismes dans l'environnement"). The State of Geneva completed this federal law with a cantonal law, based on a blacklist and a watchlist available on this web site: http://www.infoflora.ch/fr/flore/neophytes/listes-et-fiches.html.

At the airport, customs monitoring should take place if someone carries plants on the list. However, it is difficult with seeds to have good control. The difficulty to ensure IAS entry control is the lack of customs staff to have effective control at the borders.

Scope and size of impact

No precise data is available on the scope and size of the impacts of invasive species. In nature reserves it is not so bad, no valuable ecosystems have been lost because of invasive species.

In cultivation for example, the fields should not have more than a certain % of Solidago or Senecio per hectare. Farmers have to fight it. In the legislation this has been included in 2010. However, the legislation is not that effective for the moment, colleagues of the agriculture office cannot watch every year the results, as they cannot check every field. The monitoring is not possible at the moment because of limited human resources.

Only one impact has been measured, namely the economic impact of *Ambrosia artemisiifolia* for health care. An evaluation in France (Région Rhône Alpes) estimates it between 14 and 19 million Euros. This includes allergens, medical consultations, specific tests, asthma attack treatment or short sick leave.

Approach and activities

Education on the problem of invasive species is limited due to financial constraints and a lack of human resources. It is difficult to provide information directly to the key actors concerned. We spend some days every year with groups that take voluntary action against invasive species.

Concretely, the state of Geneva is not able to develop efficient prevention measures, because of the lack of human resources.

Constraints and obstacles

It is most difficult to maintain funds in place, as it requires explaining to politicians that funds are needed every year without ending. For Ambrosia, the wind dissemination continues. Action has to be taken every year, even though the result is good now, the pollen will spread. Also with our partners, citizens, colleagues in other offices it remains difficult to explain that continuous efforts are needed.

For the moment there is a fixed fund for IAS eradication in nature reserves. It is for fighting against the invasive species solidago, reynoutria, buddleia or ambrosia for example. If we try to develop new projects it is hard to justify the increase of the costs (especially for reynoutria, because the costs are very high). The main aim at the moment is to keep the actual quality of the nature reserves in place.

In addition, as mentioned before, another difficulty is to have human resources to work on this (border control, control of the plants sale in garden centers, communication and education, etc.).

Social dimension

To fight invasive species, the role of nature associations is very important. They are our partners and help us to communicate the issue and raise public awareness. The biggest one is Pro Natura. La Libellule, is an NGO working on nature education and also talks about this topic. They are helping us in working with citizens. We should be more present to connect with persons who have a garden. That is missing at the moment.

In addition, associations of house owners also contribute to the information dissemination. They are especially helpful with garden owners.

Results and lessons learned

The lesson learned is to take action at the moment when we have the suspicion of a species that looks invasive. We have many botanic experts in Geneva. If they see invasives they inform us. We should take measures at the beginning and do not give invasive species the time to spread. Always keep an eye on what is happening. Don't think twice about taking action. As an example, *Ludwigia grandiflora* appeared in a natural pond, and the State took action as soon as they knew about its existence. This IAS is now eradicated.

On the other hand, we had discovered a moss species with our specialists and we decided to keep it as an experiment to see how it reacts and how fast it develops. This was an exception. The species was located on a stone and does not disseminate quickly. That is a test but under strong control measures.

Additional information

- The website of the state of Geneva: http://etat.geneve.ch/dt/nature/neophytes-274-2001-12193.html
- The federal law (http://www.admin.ch/opc/fr/classified-compilation/20062651/201206010000/814.911.pdf)
- The cantonal law (http://www.geneve.ch/legislation/rsg/f/s/rsg_L4_05p11.html)
- The website of the Grand Geneve http://www.grand-geneve.org/
- Etat de Genève (2013), stratégie de lute contre les planters exotiques envahissantes 2012-2023.

London Invasive Species Initiative – a case study

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Background

London has a long history of human movement both in and out of the capital, which in turn has facilitated the transport of plants and animals within this area. As this has been an ongoing disturbance for thousands of years, a wide range of non-natives have become entrenched in the environment. With traces of their possible negative effects lost to time many of these species are now imbedded into what is considered a naturalized landscape.

Unfortunately the transport of species continues while distances travelled have grown and the time taken to make these trips shortened considerably. This has led to new waves of non-native species entering the Greater London area, although not all becoming invasive. This increased movement and London's function as a major international port are key drivers facilitating new species introductions.

Through trade and travel we intentionally and unintentionally transport species from and into Greater London. This highlights one of the reasons that urban areas are known hotspots for new invasive incursions. Other factors that contribute include the variety of available habitat niches and abundance of critical resources i.e. food, water and shelter. In addition, urban areas also have a variety of different habitats available, increasing a species chance of finding its required habitat.

All of these factors, along with the United Kingdom's relative isolation from mainland Europe mean that London is at a high risk of invasive species. Together with the many millions of people, the demands on space, the environment and our resources has been the driving factor behind the development of the London Invasive Species Initiative (LISI) which is the topic of this case study.

Much of what the London Invasive Species Initiative (LISI) is and how LISI operates is demonstrates an innovative way to address the unique issues that arise from managing invasive non-native species in a highly urbanised and culturally diverse world city. In short LISI brings together organisations to deliver practical action to prevent, control and eradicate invasive non-native species while encouraging co-ordination and partnership working to prevent, reduce and eliminate the impacts of invasive non-native species across Greater London.

Problems and challenges

The *London Invasive Species Initiative* (LISI) addresses a range of invasive non-native species throughout the Greater London area and therefore it is difficult to list all the specific environmental, social and economic problems and challenges that are a result of these species. Below we have listed the main concerns that are the result of invasive non-native species listed in our *species of concern* list. This list was specifically created by LISI in response to a need to clarify which invasive non-native species posed a genuine threat to the Greater London area.

The major problems resulting from invasive non-native species within the London area include:

- Significant outcompeting of desirable species for both habitat and resources (Defra, 2007).
- Increased pressure on desirable species through direct predation.
- Compromised human health from species such as the Oak Processionary Moth (*Thaumetopoea processionea*) and Giant Hogweed (*Heracleum mantegazzianum*).
- Elevated flood risk, due to overgrowth along and within waterways.
- Creation of navigation hazards by blocking canals and other waterways.
- Direct and indirect effects on industry, both horticultural and agriculture through lower yields and stock death i.e. ash dieback (CABI, 2010; Defra, 2011).

Scope and size of impact

Due to the scale and size of the area included in our remit it is difficult to collect reliable and complete data on all the species that are of concern. To enable collection, storage and interpretation of data LISI is partnered with *Greenspace Information for Greater London* (GiGL). GiGL is London's environmental record centre which collects and stores a range of greenspace, biological and associated data. Although GiGL has the largest collection of this type of data for the London region it is only able to report on the data that is provided voluntarily through its partners, volunteers and researchers.

The most current data held by GiGL shows that there are over 34,200 LISI records which represent 2% of individual species records in the GiGL data base. There are also over 100 species/sub-species recorded which interestingly only contributes 0.7% to the total number of species and subspecies listed on the GiGL database. This data stored by GiGL is a representation of that which is collected for a range of reasons from planning requirements to volunteer interests. As this is collected for specific projects rather than a systematic London wide search it is hard to analyse this data as a true mirror of what exists in the environment. It does however provide an insight into the number of invasives collected as part of completed surveys which can then be used to investigate data deficiencies.

Therefore to increase data holding, get a fuller picture of base line data and in time increase the effectiveness of LISI we work in partnership with and are hosted by GiGL. This enables LISI to promote one of its main aims which is to facilitate cooperation and information and resource sharing between existing organisations, charities and NGOs. GiGL is able to support LISI in pursuing necessary invasive non-native species data collection and storage as part of our remit while benefiting from the wealth of knowledge from a data collation and storage specialist groups.

Approach and activities

As stated previously a main aim of LISI is to facilitate joint working and information and resource sharing. This is only made possible by increasing communication between all the relevant stakeholders. This communication allows for awareness raising of information, available resources and joint working opportunities. It also facilitates relationship building which can in itself progress invasive non-native species management. At present there are ten organisations represented on the LISI steering group and many other organisations that are part of existing invasive non-native species information networks. Building in partnership has been the backbone of ensuring the projects' success.

This range of partners is required to reflect how environmental management has developed in London, which in turn has come from competing demands on land use. This range of demands plus a large existing non-native species population created the need to clarify what species were considered 'invasive' non-natives. From this LISI have put together a list of species in conjunction with relevant land managers and industry and species experts (UK Technical Advisory Group, 2008). This *species of concern* list is available to help provide direction for land managers and is constantly updated to represent changes to both knowledge and our natural environment.

In general we have tried to provide a means to address a range of issues present regarding invasive non-native species within London. To help achieve this LISI has recently completed the *London Invasive Species Plan* (LISP) which provides coherent direction and a coordinated approach to those interested in addressing invasive non-native species. It combines expert species knowledge with current best practice to provide the most appropriate management options available. The *London Invasive Species Plan* links national strategies to local action and provides a coordinated approach which will increase the effectiveness and sustainability of our current management practices (Defra, 2008).

A coordinated approach developed from this plan has already seen the development of the *data recording format.* The aim of this element of the project is to address existing data deficiencies as well as encourage stakeholders, community groups and organisations to collect and share data in a format that creates comparable data. The result of this will be a holistic picture of invasives data across London regardless of which stakeholder, community group or organisations have collected it.

Other work completed includes individual species management, although as there are a lot of areas that require work this needs to be prioritised, for this we created a prioritising system. In general it runs in order of importance from: 1) areas where eradication is possible, 2) where there are isolate populations that will result in localized eradications, 3) areas where invasive non-native species are seriously adversely affecting a native species population or ecological community where minimum work required. It is important to note that invasive non-native species are limited to those on our *species of concern* list, as this is able to change to reflect current science and priorities.

LISI also completes a range of other projects, including general activities/communications to facilitate and create partnerships to encourage information sharing and economies of scale in regards to management works. Information is also shared through workshops and information sheets etc.

Constraints and obstacles

Although London is in a unique situation, constraints and obstacles which limit invasive species management and LISI will be familiar to anyone running similar initiatives. These come in different categories that can generally be summarised to include limited resources, a lack information – on species location and density, effective management and pathways, and 'alternate priorities' for land use and resources available.

These restraints are largely self-explanatory and again are familiar to those managing invasive non-native species. Although there are a range of other limitations which might be less known. These include limited access to land which can be difficult to gain if owners do not perceive invasive species to be a concern. It also can be difficult due to the history of London to identifying the owner of land which can hinder efforts to manage invasive species. This is further confused by the range of stakeholders present in the London area.

Overall these issues might be easier to overcome if there was stronger and more effective legislation in regards to invasive non-native species within United Kingdom (Law Commission, 2012). This also highlights the need to complete research on the economic impacts of specific invasive non-native species within London, as this would allow organisations and decision makers to see the cost of no management. This would also help address an undercurrent within the United Kingdom which is accepting of the movement of species, as this has been part of the culture since exploration of the globe started.

Social dimension

The people that live, work and travel in and through the city are in a unique position as they define how invasive non-native species are perceived and how action is to be communicated, carried out and portrayed within the urban environment (GLA, 2002). London is a cultural centre and has a highly cosmopolitan population and with this comes a range of ideas, thoughts and relationships with and about nature. These circumstances mean that people's connection to the environment is likely to be different to those of us that manage and work within the environmental sector, which must be kept in mind.

In general LISI has limited communication directly with community members and local citizens as they tend to communicate directly with our partner organisations. This is beneficial for several reasons, including the size of Greater London and its 8,174 million or so residents being a difficult number for LISI to liaise with, as well as capitalizing on the long established networks between existing organisations. Instead of communicating directly with the community we liaise directly with the organisations and NGOs already in place. This enables us to ensure information provided throughout London

is consistent. LISI also aims to save resources by allowing them not to have to 'recreate' any resources that have already been produced in regards to community education and engagement.

This is also crucial in terms of encouraging volunteer action which in turn is needed for effective invasive non-native species management. As currently there is little legal requirement to manage these we depend on volunteers to assist in their removal and therefore effective communication through a range of partners is essential.

Results and lessons learned

It is difficult to provide results for this style of programme as it is not a typical scientific study. It is also difficult as there is not one standard way to measure the success of this project. We aim to continue to facilitate information sharing and relevant projects, therefore as they are still being completed there are positive actions coming from the project. More time would be needed to thoroughly evaluate the project, although with its ever evolving remit it would be hard to define.

To allow for results to be collected and evaluated we attempt to evaluate each project that is completed through LISI, which operates as a way to evaluate the entire LISI project. We currently kept a record of all the projects finished – a range of which have been mentioned in the '*approach and activities'* section.

Overall many of the lessons learned from LISI so far have confirmed the need for many of the programmes that are being created by the initiative. So far we have been able to see the benefit of joint working and information sharing but there have been some unexpected outcomes. Many have been highlighted in the problems and challenges sections, which has allowed a better understanding of the direction that needs to be taken to insure effective invasive non-native species management.

LISI has highlighted some of the issues with larger scale joint working, such as limited time for information sharing due to the demands on land managers' time. Although not unexpected it has certainly been more of a notable setback than initially anticipated. With everyone's dedication it can been seen how something that is initially harder can improve on the overall results. It has also highlighted how far resources can be stretched where there are many people willing to work together.

Overall we have certainly learnt a lot about organisations priorities, which is understandable in these tough economic times.

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Monk Parakeet control in London

© Dave Parrott

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Background

In England, the present feral population of introduced monk parakeets (Myiopsitta monachus) has been present in the wild since at least 1989 as a result of accidental and/or deliberate releases from captivity. Presently, there are small breeding populations in three locations across London (sites in the north, west and east of the city) separated by sufficient distances to represent three separate introduction and establishment events. More recently (2013) a fourth location has been identified with a single nesting pair outside of London. Further transient colonies have previously existed in locations elsewhere in England (outside of London).

The population of Monk parakeets in north London has shown a sustained overall growth over the years. Unlike the previous other smaller transient colonies which died out (outside London), the north London population has proved very resilient. Information suggests that the source of the present north London population was six birds that escaped/released in 1989. The population is reported to have increased to 15 birds by 1995, 24 birds by 1999, a minimum of 45 birds by 2003.

In 2008 the Monk parakeet was identified by the GB Non-native species Programme Board as one of six priority species for rapid reaction. As agreed by parties to the Convention on Biological Diversity (CBD), the GB invasive species strategy adopts a precautionary approach towards invasive species and advocates priority being given to prevention and early response/eradication. Since being identified as a priority for rapid reaction a series of field trials have been undertaken investigating the feasibility of control and the efficacy of removal techniques.

In January 2010, Natural England (an Executive Non-departmental Public Body responsible for a broad remit towards the environment including the licensing of wildlife management) added the Monk parakeet to three general licences enabling landowners/occupiers to carry out control activities that would otherwise be unlawful under the Wildlife and Countryside Act, 1981. These general licences allow landowners/occupiers to kill or take monk parakeets to prevent serious damage to crops; to protect public health and safety problems; and to protect native flora and fauna. This measure had the potential to help address local issues but did not amount to a strategic approach and therefore there was still risk of further establishment and expansion of the population.

In late 2010, ministerial permission was granted for an attempted full eradication.

Problems and challenges

The decision to remove Monk parakeets from the wild in England was taken after considering all the evidence on the threat they pose to economic interests (primarily utilities and agriculture both in their native range and areas where they have been introduced) and taking a precautionary approach to any potential threat to biodiversity. The evidence base for the decision included advice from key agencies and principally, a peer-reviewed Risk Assessment for the species. The Risk Assessment made clear that this species is capable of causing severe local damage to crops and of causing damage to artificial structures as a result of colonial nest building.

Monk parakeets are an agricultural pest in their native range; they can carry diseases; and they have the potential to cause biodiversity impacts through competition for resources. They nest communally, often on man-made structures such as electrical utility structures (e.g. pylons and substations) where they can cause power outages. In the USA, where they have also been introduced, the cost of nest removal alone to reduce the risk of power outages was estimated to be $1.3m to $4.7m over a 5 year period.

In England, Monk parakeets have been present in the wild previously. A number of the parakeets were kept at liberty in Whipsnade Park, Bedfordshire, for some time before 1958 but had to be recaptured due to them causing "…so much damage in orchards for some distance around…". Although the number of birds at this time has not been specified, there is a record of thirty-one Monk parakeets being released at Whipsnade in 1936.

Scope and size of impact

Estimates of the size of the feral population prior (2008) to the field trials of removal techniques were around 100 birds in three locations across London. Later, estimates prior to the initiation of the attempted eradication (February 2011) indicated around 80-90 birds distributed in the three areas of London.

The parakeets nest sites were in a variety of urban habitats and include atop a mobile phone mast and the birds were causing a significant nuisance to a number of householders through noise and fouling.

Approach and activities

Activities to remove the feral monk parakeet population have involved two main stages: (i) feasibility trials of removal techniques (2008-2010), (ii) a ministerial approved attempted eradication (2011-ongoing).

(i) Feasibility trials (2008-2010)

Field trials of control techniques involved the evaluation of trapping (cage traps and whoosh nets), nest removal and shooting.

Trapping attempted in residential gardens was ineffective. No Monk parakeets were observed to approach a ladder/crow trap when it was provisioned with either food baits, playback of recorded monk parakeet vocalisations, live decoys or nest material. Similarly, no parakeets approached a baited (food or nest material) whoosh net. Subsequent removal activity, however, included successful trapping using both a cage trap and whoosh net (see below).

Nest removal was successfully achieved using two different methods ('cherry-picker' and free-climbing). Birds either built new nests in the same tree or relocated to nearby occupied trees.

Shooting proved relatively successful with 15 birds killed using an air rifle in one location and two birds killed using a shotgun and bespoke cartridges in a second location, with no apparent significant dispersal of remaining birds.

(ii) Attempted eradication (2011-ongoing)

A ministerial approved programme to attempt the removal of all feral monk parakeets was initiated in February 2011. Prior to the commencement of the removal programme the total number of feral monk parakeets was estimated to be around 80-90 birds.

As of June 2013, a total of 33 adult monk parakeets have been removed using cage traps, whoosh nets and hand nets. Twenty-eight of these birds were transferred to temporary holding flight pens with 21 birds re-homed. In addition to the removal of 33 adult birds, nests, eggs and nestlings have been removed across all three sites; with recruitment into the populations minimised as far as possible.

Since February 2011, the overall adult population has been reduced by around 40% and almost all known breeding attempts have been disrupted for two consecutive seasons minimizing recruitment of young into the population.

Constraints and obstacles

The parakeets and/or their nests sites inhabit a wide variety of urban habitat – residential property, industrial property, woodland, parkland and city farm. These different habitats are associated with a variety of purposes and associated human activities and attitudes toward the presence of the parakeets. The proposed removal of the parakeets, therefore, involved numerous uncertainties in respect, for example,

to permission to access land to undertake control activities. The successful complete eradication of the species from the wild, therefore, is dependent on cooperation from numerous authorities, organisations and individuals. In the event that access to sites or the utilisation of specific control techniques (e.g. shooting) is prevented then the management of the feral population would be forced to move from a strategy of full eradication to one of population reduction and containment.

Social dimension

Since the start of the removal programme campaigns by residents opposed to the removal in two of the locations have resulted in the Local Councils imposing restrictions on which control techniques can be used. One council has banned all lethal control on council-owned land; a second council has banned lethal control but will allow egg control and the capture of adults that do not have dependent young.

In two of the three main nesting locations (these are in residential areas; the third main site is located on an industrial property) the majority of citizens who are directly affected by the parakeets (i.e. those with nesting parakeets on their property) are in favour of the removal of the parakeets. However, other citizens in the neighbourhood are against the removal. Councils appear to be more influenced by those against the removal – these groups have organized petitions and local media coverage.

Results and lessons learned

Taking the feasibility trials and attempted eradication together, a total of 48 adult birds have been removed from the feral population. It is estimated that there are currently <50 birds left in the wild.

Despite the significant reduction in the feral population achieved, the level of success and the rate of delivery of the overall project has been restricted by persistent constraints on access to land on which some parakeets nest and feed and/or constraints on the control methods that landowners have been willing to sanction.

Trapping:

- Following unsuccessful attempts through the immediate complete construction of the cage trap at a site, subsequent trapping attempts involved the incremental construction (and baiting) of the trap over a number of weeks. The response of the birds was monitored using remote cameras. Further construction of the trap was only undertaken once parakeets had accepted the previous alteration and resumed visiting the site.
- When birds were successfully trapped, the cage was covered with a tarpaulin and birds were not removed until it was dark. This prevented the remaining birds from observing the removal.
- At one site, the parakeets were reluctant to enter a passive cage trap through the narrow ladder entrance. The trap was converted to a wireless-operated cage trap with a much larger entrance. A group of parakeets were subsequently captured.

Shooting:

- Although relatively effective the use of an air-rifle resulted in a number of parakeets being shot but not immediately killed or brought down. A special shotgun cartridge was developed for use with a sound-moderated shotgun in urban areas.

Social dimension:

The removal of the feral population has raised a number of issues in respect to the perceptions of citizens towards invasive species and their potential influence on the management of introduced populations. There appears to be a lack of understanding, or resistance, to the concept of the precautionary principle – certainly in the case of colourful and charismatic species such as parakeets.

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Japanese knotweed (*Fallopia japonica*) in Swansea in the City and County of Swansea – a local authority perspective

© Sean Hathaway

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Background

Japanese knotweed (Fallopia japonica) was first recorded in the wild in the UK in 1886 on a cinder tip in south Wales, about 23km east of Swansea. The first record in Glamorganshire was 1902 and the first record of a complaint to the council in Swansea was received in 1972.

Swansea has probably the biggest problem with knotweed in the UK. During the Industrial Revolution, Swansea was the world centre of the copper industry but in the early 20th century the industry declined leaving a legacy of post-industrial blight in the Lower Swansea Valley. Post war regeneration from the 1960s with construction and movement of contaminated material would have spread the plant and as knotweed is tolerant of ground contamination the inhospitable conditions at the time would not have been a constraint.

Most land types are affected by knotweed in urban Swansea including sand dunes, wetlands woodlands, heath land, grassland and parks. Rural areas have a smaller problem with outbreaks mainly confined to hedges or riparian zones etc.

Spread has been documented by a number of surveys throughout the City and County of Swansea area as follows:

1992 urban survey = 47.7ha of knotweed

1998 urban survey = 61.9ha of knotweed - an increase of 14.2ha (30%)

1998 county survey = 99.9ha of knotweed

Problems and challenges

Biodiversity
Most species and habitat action plans in the Swansea Local Biodiversity Action Plan include knotweed and/or other INNS of flora as a negative factor affecting the habitat or species.

Ecosystem services
Supporting services:
- Reduces nutrient cycle due to thick mulch layer, heavy shade and rain interception.
- Seed dispersal-dense and dominant growth reduce native flora seed dispersal.
- Primary production-reduction at a local level.

Provisioning services:
- Food, crops, wild foods-less area for food production, reduced species diversity.
- Water-causes access problems and physical damage to drainage, pumping stations, services etc. and easily spread downstream during construction and maintenance.
- Minerals-can interfere with extraction.

Regulating services:
- Carbon sequestration and climate regulation-alters local climate adversely affecting flora.
- Waste decomposition-reduction due to thick layer of mulch and deep rhizome system.
- Pest and disease control-no natural predators in the UK so can put all energy into growth and reproduction.

Cultural services:
- Cultural, intellectual and spiritual inspiration-physical damage to ancient monuments, historic landscapes, landscaping, parks and listed buildings.
- Recreational experiences (including ecotourism)-loss of views, uncared for appearance, loss/reduction of access, litter.

Economic activities:
- Unable to secure mortgage and/or buy sell properties due to presence of knotweed.
- Additional costs for dealing with land for development due to knotweed.
- If removal off site is an option then costs for taking to landfill are extremely high.
- Less local spending if knotweed prevents access or prevents recreational activity eg fishing.
- Costs of dealing with knotweed on nature conservation sites reduces funding for other habitat and species management.

Human health
- Knotweed is not a health hazard but can cause extreme stress and anxiety if people are unable to secure mortgage and/or buy sell properties due to its presence.
- It can cause a lot of arguments and disagreements between neighbours and land owners that may result in legal action.

Scope and size of impact

Due to thick mulch layer, heavy shade and rain/sun light interception, the diversity of flora within a stand on knotweed is reduced. Climbers such as bramble and cleavers are able to reach sun light by scrambling to the top of the plant but underneath only a few shade tolerant species can survive. Diversity does increase at the edge of the knotweed stand.

In Swansea knotweed is present in most habitats both natural and 'man made' as follows;
sand dunes (back and fore dune), sandy beach, wetlands (reed bed, lake edge, wet woodland), woodlands (all types but not in the centre of a thick conifer block), heath land (dry, wet, acid), grassland (dry, wet, pasture, natural), parks (formal and informal), hedges, riparian zones, land to be developed and gardens.

Knotweed does not cause a health hazard but can cause extreme stress and anxiety if people are unable to secure mortgage and/or buy sell properties due to its presence.

Economic damages:
Between 1993 and 2006/7, the City and County of Swansea spent £368,000 on knotweed control. In 2012 the Housing Department of City and County of Swansea spent £22,000 on knotweed control. Each year the Highways Department of City and County of Swansea spends approximately £7000 on knotweed control.

Approach and activities

Voluntary control:
In 1997 the City and County of Swansea adopted a Knotweed Action Plan to:

1. Promote and encourage a co-ordinated approach. E.g. funding from different departments in the Council

2. Identify and treat sites. E.g. Surveys carried out

3. Prevent spread into unaffected areas. E.g. Control undertaken in nature reserves and wildlife sites and encourage control in the Gower Area of Outstanding Natural Beauty

4. Raise awareness and offer advice. E.g. give public control advice, disseminate advice to universities, developers, professional bodies and work with local and central government.

In the mid 1990s the City and County of Swansea introduced a knotweed planning condition on all planning applications where knotweed is present. This ensured knotweed on these sites was dealt with by the developer.

Between 2000 – 20/10/09:

- there were 23,272 planning applications in Swansea, an average of 2,366 applications per year;

- there were on average 2.95% planning applications per year with the knotweed planning condition;

- there were on average 6 planning applications per month with the knotweed planning condition.

There is now a planning condition for other invasive non native flora.

Natural Control:
The City and County of Swansea has been involved with the Natural Control of Japanese knotweed project for many years and is part of the field trials in Wales and England. This research is led by CABI http://www.cabi.org/japaneseknotweedalliance/default.aspx?site=139*and*page=50

The City and County of Swansea work with the Non Native Species Secretariat (NNSS) and are part of the Wales Biodiversity Partnership INNS working group.

Mandatory control:
In some cases the council can take enforcement action against the landowner. For example, the Highways Act if knotweed is causing a highways obstruction or the Prevention of Damage by Pests Act if knotweed is encouraging vermin. Other organisations may have different powers of enforcement.

Constraints and obstacles

- Limited funds – lack of funding for knotweed as other INNS need to be controlled as well as managing species and habitats.

- No/ineffective mechanism of early detection in place – not such a problem in Swansea as awareness raising over the years has enabled to public to become fully aware of the plant and related issues.

- No/ineffective legal tools to prohibit import – it is illegal to cause the plant to spread in the wild only (but what is the wild?).

- Lack of clarity on roles/responsibilities – if on council land then the land holding department is responsible for control. On private land there is little enforcement action local authorities can take as it not illegal to have knotweed growing on your land. Private individuals may have to take private legal action against another private land owner.

- No competent agency for control/eradication – if on council land then the land holding department is responsible for control. Otherwise the landowner is responsible although they do not have to control it as it is not illegal to have knotweed on your land.

- No/ineffective legal tools to prohibit trade/possession – it is not illegal to have knotweed on your land. The Wildlife and Countryside Act 1981 (as amended) only deals with not causing the plant to be spread in the wild i.e. not in gardens or urban areas. Is agricultural land the wild? It is not a noxious weed so is not included in the Weed Act 1959.

- Limited ability to detect new invasions – not such a problem in Swansea as awareness raising over the years has enabled to public to become fully aware of the plant and related issues.

- Technical constraints and/or lack of expertise – There are several techniques to control the plant,

that are divided into to two main categories; chemical (persistent and non-persistent) and non-chemical (removal to landfill, burial on site, use of liners etc.). For the public there are shop bought herbicides available. The main problem are the costs, time scale, choosing the correct technique and lack of awareness. What should treatment aim to do, control or eradication. It is difficult to prove the knotweed has been eradicated as it can lie dormant for several years.

- Legal obstacles to control/eradication – it is not illegal to have knotweed on your land. As mentioned before, the Wildlife and Countryside Act 1981 (as amended) only deals with not causing the plant to be spread in the wild i.e. not in gardens or urban areas. Is agricultural land the wild? It is not a noxious weed so is not included in the Weed Act 1959. Knotweed on private land is a big concern.

Social dimension

In Swansea awareness raising over the years has enabled to public to become fully aware of the plant and related issues. The public here are very active in identifying new sites, reporting illegal movement of the plant and highlighting where they think treatment is not being carried out correctly.

A number of voluntary groups have taken part in knotweed surveys and other INNS of flora.

The City and County of Swansea deals with several enquiries per day, relating to knotweed issues, often due to being unable to buy/sell a property. However as there is little action local authorities can take when the plant is growing on private land, the public are understandably frustrated when it appears that nothing can be done.

Results and lessons learned

Awareness raising over the years has been very successful in enabling the public to understand the issues with knotweed and how to deal with it. For example in 2012 there were: 336 email knotweed queries, 157 telephone/written knotweed queries, 38 knotweed planning applications. All of these had to be responded to.

For treatment the most effective approach is to coordinate action and funding to increase economies of scale and to reduce duplication.

Long term monitoring of treatment is essential to ensure treatment carries on if required several years into the future as knotweed can lie dormant for several years.

Carrying out a lot of awareness raising, asking people to help with surveys and advising them how to control the plant can raise hopes and expectations with the public. They may think that all knotweed will be controlled or that there is funding available to deal with it.

Data from Swansea's previous treatment costs and knotweed planning application condition has been used in a number of INNS reports including.

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New Zealand flatworms (*Arthurdendyus triangulatu*) in Scotland

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Background

First discovered in the early 1963 in Northern Ireland, thereafter in 1965 in Scotland and England, Arthurdendyus triangulatus (commonly known as the New Zealand flatworm) is now found throughout the British Isles and the Faroe Islands, but is more common in Scotland and Northern Ireland. In Scotland it was first discovered in Edinburgh botanic garden and it is thought to have spread from there to other botanic gardens, then to plant nurseries and garden centers. Dissemination continued via domestic gardens and finally to agricultural land. It was originally considered a curiosity until in the early 1990s it was correlated with the disappearance of native earthworms in Northern Ireland. During the last two decades, large numbers of NZ flatworm records have been reported from domestic gardens in Scotland where reports often associate it with loss of earthworms and damp areas. Subsequent movement into agricultural land has so far been limited but when it occurs it is associated with close proximity to an infested domestic garden. Introduction of A. triangulatus from New Zealand and subsequent spread is suspected to have occurred in soil around containerised plants. Once in the UK, A. triangulatus needs cool damp conditions to survive and become established.

Problems and challenges

Earthworms are known to have a beneficial effect on soil structure, drainage, agricultural productivity and are a food source for many forms of wildlife. It has been established that *A. triangulatus* is a predator of indigenous earthworm species. Removal of earthworms leads to degradation in soil structure, reduced fertility, drainage capability and aeration. In urban areas, a reduction of earthworms can lead to a reduction in the quality of green space which in turn may have a small but deleterious impact on human

well-being. Earthworms are an important dietary component to wildlife and 21 bird and 7 mammal species are considered at severe or moderate risk thus reducing urban biodiversity. To date, there is no known control strategy to manage the alien flatworm once it has become established. The challenge in the mid-term is to slow down its geographic spread and in the long term to develop a control strategy, which would remove *A. triangulatus* from infested land.

Scope and size of impact

No objective attempt has been undertaken to investigate the detrimental impact of the presence of *A. triangulatus* on urban biodiversity. Apart from its presence being associated with the disappearance of moles in agricultural land we do not know the (in)direct impact on urban wildlife which feed on earthworms e.g. badgers, shrews, hedgehogs and fox as well as many bird species such as Blackbird, Mistle and Song Thrush.

It has been estimated that the possible potential impact on Scottish Agriculture is *c.* £10,000,000 due to loss of agricultural production. The impact on ecosystems is unknown but waterlogging and a changing flora such as the establishment of rushes in infested land has been reported. It has been well established in numerous EU studies that urban green space provides cultural ecosystem services and has a positive impact on human well-being. A significant reduction in the quality of green space has the potential to have a negative impact on human well-being although the financial cost to national health services is currently not quantified.

The impact on ecosystem service loss such as reduction in surface drainage due to reduction in earthworm numbers (lack of burrows/drainage channels) as a consequence of *A. triangulatus* has not been quantified in the context of urban surface sealing and climate change (rainfall events). This is a missed opportunity given the propensity for urban planners to build houses on flood plains.

Approach and activities

At present there is no way of eradicating *A. triangulatus* from infested areas so all effort must focus on preventing its geographic spread. To facilitate this, *A. triangulatus* was declared a scheduled organism making it an offence to knowingly move it from one location to another. However, no punitive measures were levied on garden centres who present the assumed conduit of spread.

However, in Scotland, once garden centres and nurseries were made aware of the issues surrounding *A. triangulatus* they knew their reputations were at stake and they voluntarily tried to eradicate it. The percentage of infested nurseries subsequently decreased.

Through articles published in trade press and hobbyist magazines, knowledgeable gardeners became aware of the potential problems and inspected bought in containerised plants for the presence of *A. triangulatus.* Furthermore, responsible gardeners exchanged only cuttings, seed or bare rooted plants re-potted in flatworm free soil/medium. Urban allotment societies ran information courses for members highlighting the issues associated with *A. triangulatus.*

Constraints and obstacles

The lack of good comprehensive biosecurity at borders between countries and the lack of initial public knowledge of the potential problems associated with *A. triangulatus* have been the two main problems. This has been underpinned by an ambivalent attitude from policymakers towards *A. triangulatus* and with few exceptions the lack of research funding.

Social dimension

Once provided with the necessary information, the majority of responsible individual gardeners, gardening and allotment societies, and trade associations have operated as voluntary stewards of the urban garden environment being where possible vigilant to the potential introduction of *A. triangulatus.*

A media campaign with the involvement of television and newspapers helped to initially raise the profile of *A. triangulates,* however, on the whole this had a short-term effect and in general with the urban gardening fraternity, members of the general public were ignorant of the potential impact of *A. triangulatus*.

Overall, the general public requires education to identify *A. triangulatus* and similar alien flatworm species to prevent future introductions. This is lacking and already in addition to *A. triangulatus*, the UK has had introductions of further alien invasive flatworms, namely *Arthurdendyus testacea* and *Australoplana sanguinea*.

Results and lessons learned

We have conducted a number of surveys including a detailed study of domestic gardens in Edinburgh.

In addition, as a consequence of the initial media campaign and the occasional articles in the gardening press, we continue to receive voluntary citizen science records of *A. triangulatus*. As a result we have mapped the distribution of *A. triangulatus* at a national level from 1963 and demonstrated a continual geographic spread from the highly urbanised areas of Scotland.

We believe that *A. triangulatus* continues to spread in Scotland (and the UK?) albeit probably at a slower rate than would otherwise be the case if it had not been publicised over the years. However, there is a need to continue to educate the public, undertake research into possible control strategies and maintain efficient biosecurity to prevent further introductions of *A. triangulatus* and/or other alien invasive flatworms.

In New Zealand, there are a number of predatory terrestrial flatworms belonging to the same genus e.g *Arthurdendyus testacea,* which also feed on European earthworms and may be better suited to warmer conditions i.e. are from the North Island of New Zealand (*A. triangulatus* is confined to the South Island of New Zealand). If these are introduced and become established then the potential problems, which now seem to be currently confined to Scotland, Ireland and the Faroe Islands may be relevant to the wider European Community. Of the total number of terrestrial flatworms in Britain (14 species), ten species are considered aliens. Biosecurity at our borders would appear to be very poor.

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House crow (*Corvus splendens*) – an invasive bird travels to European cities

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Location: All coastal areas and cities as well as major ports with associated urban and industrial areas are vulnerable

Country: Nearly 30 countries all over Africa, Middle East and South-East Asia, in Europe: Cyprus, Ireland, Netherlands

Background

The House crow (Corvus splendens) is a native species to south Asian countries, from eastern Iran through Afghanistan and India to Bangladesh, Myanmar and Thailand by its native range.

In the second half of the 19th century the species was introduced by the British colonial authorities to East Africa (Zanzibar in Tanzania), the Arabian Peninsula (Aden in Yemen,) as well as South east Asia (West-Malaysia near Kelang), merely in an attempt to support street cleaning and implementation of rodent control. Being a highly adaptable species, the House crow will always manage to settle on locations where it is introduced and start breeding when possible. The birds are very adaptable and resist harsh climates as well as early competition with native Corvids for example. House crow especially benefits from introductions to urban areas, ports and associated landscapes and the species is in its native range closely associated with humans as can be seen all over India. Due to its impact, in many places where House crow was introduced it became declared a pest species soon after.

Starting persecution, growing breeding colonies, competition for food, but in particular the overall development of shipping routes and traffic among countries not connected by such routes before, made the species spread further in the second half of the 20th century and it was documented that House crows traveled with ships as far as Taiwan and Japan, the Caribbean but also Europe's South and North. The origin of birds using these human-assisted path ways are both, from native regions as well as from introduced populations.

The species established in these new locations, and is found all along the East coast of Africa, Indian ocean islands, Hong Kong and Singapore, as well as all coasts of the Arabian countries. Colonies also have established on the edges of the invasion like in South Africa, The Netherlands and Israel, spreading the clear risk of being further transported to new and adjacent areas not affected before. Single birds also showed up multiple times in Western Australia in the first decade of the 21st century. In 2010 the species was recorded the first time in Namibia and in 2011 in Benin as the first West African record.

House crows also have an ongoing history in Europe: a first single bird was recorded at Gibraltar 20 years ago. A single bird is now also detected for each country, Cyprus and Ireland. The port of Rotterdam, Hoek van Holland, in the Netherlands even harbours a small breeding colony since more than two decades.

Problems and challenges

The problems of House crows are manifold, affecting: biodiversity, public health and urban development, as well as tourism, transport, agriculture, farming and social issues.

Scope and size of impact

Mostly the impact of invasive species on society and economy is investigated instead of their effect on biodiversity. This is also the case for the impact of the House crow where dwindling tourism bookings, power cuts, losses of crops, or transmission of diseases can be more directly attributed to monetary values, than the slow disappearance of birds, reptiles and butterflies or the loss of breeding space or habitat viability for native species.

Some studies have tried to quantify losses of biodiversity that occurred as a result of House crow invasion. House crows are in their native environment controlled by natural predators and other factors (e.g. in India a specialized cuckoo affects breeding significantly). This is not the case in places where the crow is an alien species, as a slow but constant loss of all small animal fauna, from insects to small mammals, occurs in these areas. This is due to competition for food resources, water or breeding sites, but also by direct predation. In the vicinity of House crow populations often not many other passerines exist, creating a disturbed environment. Formerly reported native species are chased away to other areas.

Reports show that House crows enter seabird breeding sites on islands where no invasive predators existed before and the native colonies quickly lost breeding pairs. This can affect threatened species but also the status of protected areas. Larger species (e.g. Corvids, vultures, owls, storks, herons, gulls, birds of prey) are often constantly harassed by House crows, affecting their survival over long. Also migrating birds of prey are attacked as reported from some sites. This had lead to the disappearance of e.g. Black kites from areas in East Africa.

Since invasive House crows seek for the least demanding way of energy supply, the species is also a predator of mice or rats, eats garbage or carcasses, steals food and attacks people to gain such. These issues and the House crow created problems in agriculture are the main reason for activities against this invasive species. In agricultural areas, House crows are known robbers of fruits and crops, being able to significantly reduce the harvest. Larger flocks of House crows can destroy the harvest or demand costly protection measures. The invasive crow hunts chickens and is predating poultry eggs, making free ranging poultry keeping impossible in areas with House crows. The birds are reported to attack young born goats and all sorts of domestic animals. House crows on domestic animals are not beneficial in collecting ecto-parasites, but rather hurting domestic sheep, goat or cattle while hacking for parasites and making the open wounds prone to infections afterwards.

Fish is stolen by House crow from fish farms, either directly from the surface or after harvest and in ponds and other urban settings, causing economic loss. Former fish drying areas in some East African and Arabian coastal cities are completely abandoned because of the invasive species' presence. Reports of House crows robbing food from children, elderly people, as well as from open area markets, can be found everywhere this invasive crow has become established.

House crows can cause power cuts, especially in urban areas in developing nations where the disconnection of a few wires – that the crows regularly preferably use for nest constructions – can lead to larger power cuts. Where breeding takes place in corners of buildings or garden trees, people are often directly attacked. Also tourism is affected, as House crows have a strong habit of stealing food from dishes and buffets in open area restaurants and hotel food areas. Also golf courses are vulnerable to House crow presence, as the birds search for insects destroying the green lawn but also stealing commodities and food from gulf cars. Golf courses are also places where the birds roost and breed.

Large flocks of crows roosting close to airports are posing a well known risk for bird collisions with airplanes, especially due to their active and sometimes erratic behaviour patterns, leading to a potential risk for the tourism industry in particular in tropical countries.

In Europe no large colony of House crow exists so far, despite a breeding colony of around 40 birds continuously stays in the port of Rotterdam , remaining relatively stable in size. Because of this no loss to biodiversity or economy can be yet attributed to House crow in Europe.

A final issue that makes House crows a problematic invasive species is their likelihood to carry diseases and parasites, and their transmission to humans. The bird is known to host a dozen of animal intestinal parasites, as well as at least eight reported human diseases. Due to their behaviour of being close to humans, the possibility for transmission of diseases

are manifold and places, such as hospital garbage sites or outdoor hotel restaurants and swimming pools make unpredictable infection routes a real threat. The H5N1 bird flu virus had also been found in dead House crows in Hong Kong and China during the latest outbreaks there.

Approach and activities

Despite availability of information on the House crow, like the IUCN's Invasive Species Specialist Group (ISSG) Global Invasive Species Database (GISD), it is unclear how many managers and authorities concerned do use such resources. Not all of the affected countries have measures against the House crow in place, and those that act do that with different approaches, reasons and strategies.

No country or region yet started a project or program aimed at eradicating House crow from their national territory, but some countries have prevented the species to become established by successfully eliminating every House crow individual that appears. This depends on availability of resources. However, no cross-border project has become operational, despite the desire to cooperate to deal with this problem. This all needs to be done on voluntarily basis, as no internationally binding law exists.

Provision of information is one of the most important steps, as first the situation needs to be assessed correctly to decide on a plan for action. InGrip-Consulting has therefore done surveys to areas affected by House crows and results were shared with the authorities concerned with planning.

The first line of control–prevention and early detection – comes too late for those countries facing the problem of invasive House. All the Indian Ocean and West African countries are especially threatened by House crows traveling with ships from East Africa or across the Cape to their cities and ports. Early detection (i.e. active surveillance of ports and coastal cities) followed by rapid response (i.e. immediate elimination of any arriving House crow) is required. Such approach has proven to be successful in Benin and Namibia.

The arrival of a single House crow in the port of Cork, Ireland, three years ago, is not considered a reason for concern by the authorities, rather a welcomed addition to the local fauna and birding tours. The colony in the port of Rotterdam that also started with a single bird and slowly developed is not closely monitored, indicating a limited understanding of the threat by decision makers and the public.

Constraints and obstacles

Lack of resources, knowledge and the willingness to act hamper work against invasive species, including House crows.

The introduction via undetected arrivals with ships is seen as a real threat and the major pathway into new territories. Countries that have not experienced this bird before are not necessary vigilant, but fortunately birds are more visible than amphibians or weeds, and large groups of active bird watchers are one of the primary resources for new House crow detections.

A few countries have an early warning and rapid response regime in place that immediate take lethal action against any newly arriving House crows. Such system has been implemented for the island of Socotra, Yemen, where a project partnership of the Socotra Environmental Protection Agency (EPA) and InGrip-Consulting had eradicated the small but persistent population of House crows in 2009, with funding of UNEP / GEF-SGF in Yemen. Well trained local EPA staff is now on the watch and newly arriving crows are dealt with immediately. For control or eradication only a few methods exist (catching, poisoning, shooting). Experience shows that shooting and trapping by inexperienced staff can quickly lead to an avoidance strategy by the crows. This may lead to the misconception that these methods are not effective and that it is impossible to achieve eradication. In addition, the killing of birds is considered controversial.

Some large internationally funded eradication projects have not resulted to effective control due to massive gaps in risk assessment, reporting or checks on the professionalism of local partners and validity of sources of information used. This surely will reduce the willingness to fund new action. More attention to these aspects by donors is strongly encouraged to avoid repeating situations like the recent loss of up to 1.5 M Euro from European countries development funds for failed and intransparent activities to combat House crow in Tanzania and Zanzibar.

No special legislation exists for the House crow in Europe although the species has been declared a pest in some other countries outside of Europe. Most countries concerned have signed up to the Global Convention on Biodiversity and would at least under this framework have an obligation to act on halting the invasion of House crows in their nations and regions.

Social dimension

Social dimensions can be divided into two groups:

1. Those that are affected by House crow invasions welcome any kind of control and as a result locally self imposed control measures lead to cruel circumstances without sustainable outcomes. No official program was opposed by local people except if religious or mythological motives played a role, like in the uncontrolled invasion in the Indian Andaman and Nicobar islands, a former isolated and House crow free state.

2. Those opposing any harm to House crows by large scale control operations or eradication attempts are merely found in Europe and the northern hemisphere. It looks like loss of nature, urbanization and the feeling of losing natural identity creates an affinity for literally all animals (at least those attributed to be charming, clever, including birds) regardless whether they are invasive or not. It must be stressed that observing animal welfare issues is a very important factor to be observed in any invasive animal control project.

Successful projects can serve to inform the wider public about the issue of invasive species control measures, especially if the message can be spread locally the effect will be strong. Educated people and responsible organizations or authorities often turn out to be strong partners in assuring adequate and necessary follow up work, for example in relation to early detection or public support. Spreading achievements and learning experiences, as well as providing the key findings to international databases like the Global Invasive Species Database is hence of utmost importance.

Results and lessons learned

Due to the voluntary work InGrip funded from its own resources entirely, the House crow has received more attention and new projects and initiatives have startedin some countries. In a few cases new international alliances were established and the exchange of information started. On Socotra the first eradication project on a large island was achieved, securing a biodiversity hotspot and UNESCO heritage site.

The species became more popular as subject to be studied and lead to some useful investigations on impact and biology. The attention for House crows among the donor community varies from no support, to funding large projects that did not lead to effective measures. Europe has so far fully failed to address the House crow issue on the continent, and assist other countries in a useful manner. The support for the matter of House crow within the IUCN's ISSG and the sensibility of the Western Australian government to this issue had led to a very useful conference on Invasive bird species in Perth in 2008, allowing the establishment of new alliances and partially effective co-operation. The work against the species in various countries is mostly an individual achievement that requires interlinking with neighboring nations or cities and ports that are connected by transport channels.

Taking on a challenging task and not giving up is the greatest lesson learned for engaged activists like our company during the past six years of trying to halt the invasion of House crow around the globe. The gratefulness of people and those citizens that suffering in daily life of the crows presence, and the chance to restore native wildlife in urban settings and coastal areas is a very rewarding and motivating work.

It showed that Europe is not leading the fight against House crow invasions, whereas the encouraging work in South Africa and the shooting of the first detected House crow in Namibia has so far halted the invasion of West Africa. To identify the most vulnerable places for new invasions and implementing vigilance and rapid response measures in those locations will buy the time to find ways of reducing the invasion of House crow in general and tackle the source populations.

Once this can be achieved all other populations shall be eradicated if a global restoration of the natural situation regarding House crow is the target. As the spread and establishment of the species in large urban areas like Cairo (Egypt), Lagos (Nigeria), Rio de Janeiro (Brasil) or Shanghai (China) will bring the situation out of control and will be impossible to reverse, this situation must be prevented by any means.

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Japanese knotweed and other exotic invasive knotweeds (*Fallopia spp.*) in Europe

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Background

The Japanese knotweed (Fallopia japonica) was imported into a Dutch nursery as a garden ornamental from Japan in 1849 and was spread to gardeners throughout Europe quickly thereafter. Although initially prized as a garden plant, it has since developed into one of the world's worst weeds. Giant knotweed (F. sachalinensis) originates from eastern Russia and Japan and the hybrid of the two species, Bohemian knotweed (Fallopia x bohemica) are also known as invasive species in various parts of the world.

The perennial plants grow in tall, dense stands (up to 4-5m in height) from rhizomes that are the main propagative organ in Europe. Japanese knotweed is infamous for being able to grow into invasive stands from tiny rhizome fractions, which can be spread in contaminated soil, on machines or through water. Seed is currently probably a less important means of spread, but in continental Europe the occurrence of viable seeds has been reported and seedlings are known to be able to establish in natural conditions. Moreover, genetic analyses have revealed high genetic diversity within the hybrid (Fallopia x bohemica) in central Europe. This strongly suggests that sexual reproduction occurs in Europe and contributes to the invasion success of exotic knotweeds.

Feeding trials with native herbivores revealed that, in general, exotic knotweeds showed higher levels of resistance than native plant species tested, suggesting that both parental species and hybrids largely escape from herbivory in Europe. Reduced pressure by natural enemies might well contribute to the invasion success of exotic knotweeds in Europe.

Naturally occurring disturbances, such as flooding, facilitate the transportation of rhizome and stem fragments that can lead to the spread of the species throughout catchment areas. Hence, alien knotweeds are particularly a problem along rivers and in wetlands. The species are however not restricted to moist sites and can grow in a multitude of different habitats such as waste places, along roads and railways, on coal mines, on fallows and in other disturbed areas. Human activity, in particular transport and dumping of garden waste and top soil contaminated with rhizome fragments, has aided the distribution of this species throughout Europe. Consequently, it is a classical weed of urban and peri-urban areas. Various countries have declared invasive alien knotweed as noxious weeds. In Switzerland, the handling of invasive knotweeds in the environment is prohibited.

Problems and challenges

Exotic knotweeds are considered among the most aggressive invasive weeds in temperate Europe. The species form dense stands, at times even monocultures, leaving literally no space for native plants. Invaded areas do however not only support lower numbers of plant species, also diversity and abundance of invertebrates is lower compared to native habitats. Large-scale invasion by exotic knotweeds species is therefore likely to seriously affect biodiversity and reduce the quality of invaded ecosystems for amphibians, reptiles, birds and mammals whose diets are largely composed of arthropods.

Efforts to control knotweeds are being undertaken throughout Europe, but exotic knotweeds are vigorous plants with high regeneration, and once established at a site, control, let alone eradication, is difficult to achieve. Considering the substantial amount of money that is already invested in the control of exotic knotweeds, the need for solid data from adequately replicated studies on the effectiveness of control measures has been recognized (e.g. Kabat *et al*. 2006). In cases where knotweed management is also aiming at restoration, data on re-establishment of native flora and fauna in formerly invaded sites is required.

Scope and size of impact

Japanese knotweed forms dense stands that largely replace native flora and fauna, for example due to shading, allelopathy and the fast accumulation of litter. Habitats invaded by knotweeds support up to 90% lower number of plant species compared to native habitats. Native plant species growing in exotic knotweed stands also suffer from reduced propagule availability inside invaded areas. For example, seed set by *Silene dioica* was found to be 93% lower inside than outside knotweed patches.

The loss of native vegetation within exotic knotweed stands has important consequences for animals. Invertebrate abundance can be as low as 20% and their diversity up to 25 % lower within exotic knotweeds than in native vegetation. Invertebrate biomass recorded within exotic knotweed stands can be up to 60% lower compared to native habitats. Moreover, the identity of the invertebrates can be very different in invaded and natural habitats, as a result of the almost complete absence of insects that feed on knotweed and the increased abundance of litter that shifts the community towards detritivores.

The economic impact can be very large, as a result of structural damage to infrastructure and property, control costs and the loss of housing value. The annual impact in the UK has been estimated as more than £150m (Williams *et al.* 2010).

Approach and activities

Multiple approaches have been tested and applied to control or contain invasive alien knotweeds, but invasive knotweeds remain among the most difficult alien plant species to control worldwide. The most common approach is possibly herbicide treatment, but this is damaging to the environment and expensive if large areas or many plants have to be treated (a rough estimate indicated that treatment of all knotweed in the UK would cost £1.3 bn). Early detection of new knotweed infestations may allow complete eradication by removal of the whole root stock, which can require excavation to 3m depth.

Various experimental studies have been conducted in Europe to control established knotweeds, including chemical control, mowing/hand-pulling, rhizome-crushing and biological control. Among the mechanical treatments investigated by CABI were rhizome-crushing using a screener-crusher, followed by covering of the crushed rhizome with plastic to enhance decomposition of the crushed rhizome, and repeated cutting of knotweed stands to deplete the rhizomes. These studies were carried out in river catchments in Switzerland and adjacent parts of France.

In contrast to chemical control that can be costly, must be repeatedly applied and is not always applicable (ban of pesticides along river banks), classical biological control is relatively cheap / cost effective in the long term. The use of coevolved natural enemies, once successfully established, provides permanent sustainable control of the target plant.

A project for the biological control of Japanese knotweed was initiated in 2000 and laboratory studies started at CABI UK in 2003, funded by a public-private consortium. Surveys in Japan in collaboration with Kyushu University's Institute of Biological Control, revealed that about 200 natural enemies (over 150 arthropods and dozens of plant pathogenic fungi) occur on Japanese knotweed in its native range. However, after selection and preliminary testing, only 2 were specific enough to be further considered as potential biological control agents. The physiological host range of the psyllid *Aphalara itadori* (Homoptera) was tested in the CABI quarantine facility in Egham, UK, with about 90 plant taxa, covering all *Fallopia* spp. and a wide range of the polygonaceae native to the UK, as well as closely

related ornamentals and a selection of crops. These tests indicated that *A. itadori* is a highly specific predator and that the risk to native flora is very low (Shaw *et al.* 2009). Laboratory experiments were also conducted to evaluate the potential impact on some generalist predators (preference and comparison of success on *A. itadori* vs. aphids). In 2009 a petition for the release of the psyllid was submitted to the UK government and approved in 2010 after public consultation. The psyllid was first released in the UK in 2010 on selected field sites and a monitoring programme is currently running to evaluate the potential impact in the field.

In 2012, the Swiss Federal Agency for the Environment (FOEN) approved a 2-year project that aims to assess the risks of potential non-target attack by the psyllid if released in Switzerland. A selection of Polygonaceae native to Switzerland that were not tested in the UK and cultivated local varieties are currently being tested in CABI's quarantine facility in Switzerland.

An additional potential control agent, the leafspot fungus *Mycosphaerella polygoni-cuspidati* (Kurose *et al.* 2009), is still under investigation in the UK.

Constraints and obstacles

A key obstacle is the lack of information and coordination among stakeholders in combating invasive alien knotweeds. A broad dissemination of measures to be taken to prevent further spread of alien knotweeds would be of prime importance.

Furthermore, the very widespread and locally very abundant occurrence in some countries, and particularly its abundance in riparian habitats make it a difficult target for control. The plant's ability to regrow from small fragments can make control difficult or expensive due to the need for repeated control efforts. The EU ban on the use of pesticides close to open water have made chemical control in riparian habitats more difficult and the use of mechanical control methods can pose a risk of spreading the species if applied without caution. Hence the need for effective and affordable management options, such as biological control.

Social dimension

The perception of Japanese knotweed is variable across Europe but is almost universally disliked. The most extreme situation is to be found in the UK, where the plant is famous for its ability to devalue the built environment. It is not uncommon for banks to refuse to lend money for the purchase of a house that has knotweed within a certain distance of its boundary and developers are very wary of sites where there is a suspicion of knotweed presence. Japanese knotweed is often an indicator of a poor social environment and of urban decay, so many groups become involved in eradication / control campaigns. The media have taken a keen interest in the plant and every season this generates hundreds of articles. In the UK local action groups have rallied around the knotweed cause such as the Cornwall Knotweed Forum and various invasive species forums have followed suit.

Results and lessons learned

- Managing exotic knotweed by cutting and removing above ground biomass reduces the vigour of knotweeds and promotes re-colonisation by of knotweed invaded areas by native plants and invertebrates. A regime of six cuts during the growing season was the most successful of the methods tested. Interestingly, regular mechanical control successfully eliminated allelopathic effects of knotweeds on native plant species.

- Crushing knotweed rhizomes in combination with stocking the crushed material under a plastic for twelve months resulted in fast decomposition of the rhizomes. This method is of considerable interest since it provides a technique to locally decontaminate soil infested with exotic knotweed, thereby avoiding high costs incurred by transport of infected material to deposit it safely. The method can also be applied in natural areas, in particular for rapid eradication of small and young infestations at the beginning of an invasion, thereby avoiding further spread of the exotic knotweed in the area.

The biological control of Japanese knotweed in the UK has started with releases of the biological control agent, the psyllid *Aphalara itadori*, first made in 2010. The project is currently limited by the restricted establishment of the agent at the eight release sites. A monitoring programme is aimed at assessing the impact of the control agent on the knotweed, as well as any potential impacts on native plants and invertebrates. This should also allow the identification of recovery of the native biodiversity if the agent is found to successfully reduce the size or abundance of the knotweed.

Capturing the media's interest and attention is the fastest way to reach a good number of people and it helps if your target species is as notorious as knotweed and you live in a country where "an

Englishman's home is his castle" and that castle is under threat.

When applying mechanical control, it is important to train the workers about the risks of knotweeds, especially because of the risk of spreading the species through fragments that can be transported with machinery and tools. Hence, one of the key elements for managing invasive knotweeds is the dissemination of information regarding prevention of contaminated soil, safe disposal of above-ground and below-ground part parts and the risk of spreading fragments with tools or machines. Because of the ease of spread through water courses, management may aim at whole river catchments.

Sites where knotweed control has been initiated should be monitored over a sufficient number of years to record the impact of the treatments on the knotweed, but also to record how the ecosystem has responded to the reduced abundance of the weed. Do native species recover, or is the knotweed replaced by another invasive weed?

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  http://www.eea.europa.eu/publications/streamlining-european-biodiversity-indicators-sebi
- IUCN guidelines for the prevention of biodiversity loss caused by invasive alien species
  http://www.issg.org/pdf/guidelines_iucn.pdf
- Global Invasive Species Database
  http://www.issg.org/database/welcome/

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SSC
Species Survival Commission

ISSG
Invasive Species
Specialist Group

DBU
Deutsche Bundesstiftung Umwelt

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office for the Environment FOEN