Ghent - Belgium - April 2nd 2014

SCIENCE FOR THE NEW REGULATION

Abstract book

BENELUX conference on invasive species

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Programme: Science for the new regulation

8.00-9.00: Registration + coffee

9.00-9.10: Introduction by organising committee

Session 1: Pathway analysis and spread of invasive species (session chair: Olivier Honnay)

9.10-9.40: Hot spots and highways for dispersal of aquatic invasive species in the European network of inland waterways – Rob Leuven

9.40-9.55: Identifying and assessing vectors for the dispersal of invasive species in the Shetland Islands - Rachel Shucksmith

9.55-10.10: Invasion of Western Europe by *Dreissena rostriformis bugensis*: phylogeography, population genetics and potential impact assessments - Jonathan Marescaux

10.10-10.25: The invasive round goby *Neogobius melanostomus* and tubenose goby *Proterorhinus semilunar*is: two introduction routes into Belgium - Tine Huyse

10.25-10.40: Are invasive populations more phenotypically plastic than native ones? An experimental study on *Impatiens glandulifera* – Elst Evelyne

10.40-11.00: coffee break

Pitching poster presentations (Session chair: Peter Goethals)

11.00-11.05: Entry pathways for Non-Indigenous Marine Species in the Azores Islands – Joana Micael

11.05-11.10: Weeds in the networks of the horticultural trade: *Oxalis* and Mediterranean container plants – Ivan Hoste

11.10-11.15: Monitoring of alien species escaping from collections in a botanic garden – Anne Ronse

11.15-11.20: U.S. Response to Biofouled Marine Debris Produced by the 2011 Japan Tsunami – Peg Brady

11.20-11.25: Invasive Alien Species in the Belgian part of the North Sea - Ann-Katrien Lescrauwaet

11.25-11.30: Exotic species in the Dutch delta waters – Sander Wijnhoven

11.30-11.35: The invasive ctenophore *Mnemiopsis leidyi* can adapt to low salinities - Helga Van der Jagt

11.35-11.40: Rapid adaptive evolution during plant invasions – Katrien Vandepitte

11.40-11.45: Using LIFE funding to address the challenge of invasive alien species – Lucie Trokanova

11.45-11.50: Weir management as a tool for mitigating the effects of invasive freshwater mussels in impounded river sections - Remon Koopman

11.50-11.55: Harmonia+ : a first-line screening tool for potentially invasive organisms - Bram D'hondt

12.00-13.15: Lunch and poster session

Session 2: Impact and risk assessment of invasive species (session chair: Gregory Mahy)

13.15-13.45: Advancing impact prediction in invasion ecology with a functional response approach – Jaimie Dick

13.45-14.00: A new Belgian template for invasive species risk analysis: a support for decision makers - Etienne Branquart

14.00-14.15: Observation and risk assessment analysis of the invasive *Mnemiopsis leidyi* in the North Sea – Sabrine Derveaux

14.15-14.30: Concerns regarding the scientific evidence informing impact risk assessment and management recommendations for invasive birds – Diederik Strubbe

14.30-14.45: Evaluating the potential of ecological niche modelling as a component in invasive species risk assessments – Sonja Leidenberger

14.45-15.15: coffee break

Session 3: Control, management and mitigation of invasive species (session chair: Tim Adriaens)

15.15-15.45: Control and Management of Freshwater Invasive Species in Ireland - Joe Caffrey

15.45-16.00: Catching invasive Egyptian geese (*Alopochen aegyptiacus*): evaluation of the optimal deployment season for a floating Larsen trap – Frank Huysentruyt

16.00-16.15: Capacity, capability and cross-border challenges associated with marine eradication programmes in Europe: the attempted eradication of an invasive non-native ascidian, *Didemnum vexillum* in Wales, Great Britain - Katie Sambrook

16.15-16.30: Preventing mass development of invasive macrophytes during the initial colonization phase in an artificially created urban lake – Sebastian Meis

16.30-16.45: Native pike *Esox lucius* can suppress invasive topmouth gudgeon *Pseudorasbora parva* in ponds and leaves the indigenous fish community intact – Pieter Lemmens

16.45-16.55: Human-centered Speculative Design for a future with invasive – Lisa Ma

16.55-17.00: Closing of the day

17.00-18.00: Reception

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Session 1: Pathway analysis and spread of invasive species

Due to increased worldwide trade and human activities, species are transported around the globe. Deliberate and accidental introductions of alien invasive species via shipping, pet trade, stockings and escapes are considered the most important causes of the observed exponential increase in alien species worldwide. Once alien species are introduced it is very hard and costly to eradicate them. Therefore, it is important to determine a priori which species can establish and what impact they have on the ecosystem via for example horizon scanning.

In this session we welcome talks addressing the following questions: What are the main vectors of species introductions outside their native geographic area and what are the mechanisms behind successful introductions? Are the initial environmental and biological conditions determining the success of the species? How do these species spread once they are introduced and what facilitates or hampers their dispersal? Can we develop an early detection system that helps us to prevent new introductions or to avoid the further dispersal of already established ones?

Keynote: Hot spots and highways for dispersal of aquatic invasive species in the European network of inland waterways

Rob S. E. W. Leuven[1], Jon Matthews[1] & Gerard van der Velde[1]

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The presence of several primary hot spots for arrival (e.g., large sea harbours) and the extensive network of inland waterways have allowed many non-native aquatic species from different bio-geographical regions to colonize the rivers of north-western Europe and to mix with native biodiversity, changing communities and affecting the functioning of ecosystems. Six principal invasion corridors have been identified that allow the colonisation of these rivers by aquatic species: (1) The Northern corridor, connecting the catchments of the Black, Azov and Caspian seas via the Volga–Don Canal, and the Baltic and White seas via the Volga-Baltic Canal and White Sea–Baltic Sea Canal and the rivers Rhine, Meuse and Scheldt via sea shipping; (2) The Central corridor, connecting the Black Sea basin with the Baltic Sea region via the Dnieper and Bug-Pripyat Canal and with the North Sea basin via an extensive network of waterways; (3) The Southern corridor, linking the Black Sea basin with the North Sea basin via the Danube-Main-Rhine waterway; (4) The South-western corridor, linking the rivers Loire and Seine; (5) The Mediterranean corridor, linking the Mediterranean basin with the North Sea basin via the Rhone and the Rhine-Rhone Canal; (6) The transatlantic and North Sea shipping routes to various sea harbours in the Rhine-Meuse-Scheldt deltas. In particular, the river Rhine functions as a global highway for the dispersal of non-native species to other rivers in north-western Europe. Over the last two centuries, the total surface area of river catchments connected to the river Rhine via canals has been increased by a factor of circa twenty. From the eighteenth century onwards, in the freshwater sections of the river Rhine, a total of 45 non-native macroinvertebrate species have been recorded. The average number of new invaders shows a sharp increase from 1 to more than ten species per decade. Currently, the contribution of non-native species to the total species richness of macroinvertebrates in the river Rhine is more than 10%. At several locations, the relative abundance of non-natives is up to 90% of the total number of individuals. The Delta Rhine and Upper Rhine exhibit higher numbers of non-native species than other river sections. This is a consequence of an invasion gateway created by the combination of large sea ports and the Main-Danube canal that was opened in 1992. Many non-native species that colonize the rivers Meuse and Scheldt are recorded several years earlier in the river Rhine. Moreover, the year of first arrival of non-native species in the river Rhine appears to be a suitable proxy for their time of arrival in the inland waters of the United Kingdom and Ireland. Important source locations are the Ponto-Caspian area and North America (44.4 and 26.7% of the non-native species, respectively). Transport via shipping and spread via man made waterways are the most important dispersal vectors. The cumulative number of non-native species in time is significantly correlated with the increase in total surface area of other river catchments connected to the river Rhine by means of networks of canals. The frequency of intentional and unintentional introductions is highest for the period 1950–1992. The species richness of non-native macroinvertebrates is strongly dominated by crustaceans and molluscs. Species sensitivity distributions for environmental factors show that invasive species tolerate higher salinity, nutrient content, temperature and current flow than native species. Spatiotemporal analyses of distribution

patterns reveal that average and maximum dispersal rates of six invasive species vary between 44–112 and 137–461 km per year, respectively. Most species showed higher downstream dispersal rates than upstream dispersal rates. Temporal analyses of macroinvertebrate assemblages in the littoral zones indicate that native species are displaced by non-native species. However, established invaders are also displaced by more recent invaders. Recently, the potentially disappeared fraction of native freshwater species in the rivers Rhine and Danube has been estimated and integrated over space and time per volume of goods transported across the Rhine-Main-Danube waterway. The relative importance of non-native species introduction to species disappearance was compared to relative contributions of other anthropogenic stressors in the freshwater environment (i.e., eutrophication, ecotoxicity, greenhouse gases, and water consumption). The introduction of non-native fish species contributed to 70−85% of the total freshwater biodiversity impact, depending on the distance that goods were transported. Therefore, it is sensible to include the introduction, dispersal and effects of non-native species in assessment frameworks for the inter-basin shipping transport of goods.

Identifying and assessing vectors for the dispersal of invasive species in the Shetland Islands.

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The Shetland Islands are highly dependent upon the marine environment, with marine industries currently contributing over 40% of Shetland's economic output. The Shetland Marine Spatial Plan (SMSP) was initiated in 2006 to guide development around the Shetland coast. The SMSP contains spatial data on the marine and coastal environment and its uses and establishes an overarching policy framework. As part of the SMSP a number of approaches to address the potential introduction and spread of 'invasive non-native species' (INNS) have been developed. This includes an INNS monitoring programme and policy development. As part of this process the potential vectors which could contribute to the spread of invasive species to and within Shetland have been assessed. An assessment has also been made on the presence of man-made structures and their potential to act as 'stepping stones', aiding the spread of INNS. The outputs of this analysis have been used to guide biosecurity planning within the SMSP.

Invasion of Western Europe by Dreissena rostriformis bugensis: phylogeography, population genetics and potential impact assessments

Jonathan Marescaux[1] and Karine Van Doninck[1]

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River basins are conducive to invasions because they form corridors that facilitate rapid spread of introduced species. The reinforced river banks and the whole river bed are disturbed habitats considered as most favorable to invasion. Western European Rivers are particularly vulnerable to invasive species because they have been highly altered by anthropogenic pressures (e.g. artificial banks, construction of weirs, dense navigation). Biofouling invaders constitute one of the major threats to freshwater biodiversity not only because they have an impact on both aquatic ecosystems and biodiversity but also because they negatively influence industrial activities. The best-known example is the invasion of Western Europe and North America by the zebra mussel (*Dreissena polymorpha*, Pallas 1771). In the meantime, a second dreissenid species, the quagga mussel (*Dreissena rostriformis bugensis*, Andrusov 1897) recently became invasive in both the Old and New World. Both species are native from the Ponto-Caspian area. The quagga mussel is native to the entire Dnieper-Bug estuary system, including the Dnieper River delta and the lower Inguletz River. Since 1930, the species extended its distribution range, first into the Ponto-Azov basin and Volga River and then into Eastern European Rivers. The species apparently reached the Danube River in 2004, the Rhine River in 2006 and was found in its tributaries, the Main River in 2007 and the Moselle River in 2010. Furthermore, the quagga mussel was found in Lake Erie in the US in 1989 and rapidly spread across all the Great Lakes, the Finger Lakes and the rivers St. Lawrence, Ohio and Mississippi. Then the species reached the Western United States in 2007. The first observation of the quagga mussel in Western Europe was made in 2006 in the Hollands Diep. Outside the Rhine basin, the quagga mussel was recently found in the Albert Canal (2010) and the Meuse River (2012).
Here, we propose to present our latest results on the invasion of Europe by the quagga mussel. First, we take stock of its invasion in the Meuse River. Second, using both mitochondrial and microsatellite markers, we tried to elucidate the invasion pathways of the species *D.r. bugensis* in Western Europe in order to establish a phylogeography study. Finally, we assessed the impacts of the two invasive *Dreissena* species by determining densities, native mussel perturbation and filtration rate.

The invasive round goby Neogobius melanostomus and tubenose goby Proterorhinus semilunaris: two introduction routes into Belgium.

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Non-native species often have negative impacts on the native fauna as they compete for food and habitat, but they can also introduce alien parasites, a crucial factor that has been mostly overlooked. In 2010, the tubenose goby (*Proterorhinus semilunaris*) and round goby (*Neogobius melanostomus*) were observed in Belgium for the first time. To gain insight in the introduction pathways in Belgium and to identify potential source populations, a phylogeographical and parasitological study was initiated on both species. The cytochrome *b* gene was sequenced and used to calculate haplotype diversity and to build a statistical parsimony haplotype network. Both species showed a low haplotype diversity compared to native and other non-native populations. The network revealed potential source locations in the Northern Black Sea for the round goby and in the Danube at the Serbian-Romanian border for the tubenose goby. Fins, gills and body were examined for the presence of ectoparasites. Two *Gyrodactylus* species were encountered, which have not been recorded in Belgium before. Prevalence, abundance and infection intensity was much higher in tubenose goby, which might be a consequence of a different introduction pathway. Our data provides evidence that tubenose goby entered Belgium through active dispersal. The round goby, however, was most likely introduced with ballast water. Strict regulations are needed to prevent more introductions or further spread of these invasive gobies and their parasites.

Are invasive populations more phenotypically plastic than native ones? An experimental study on Impatiens glandulifera

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Biological invasion is often linked with high phenotypic plasticity. However, it remains unclear whether this plasticity is already present in native populations (pre-adaptation hypothesis) or evolves after invasion (genetic shift hypothesis). This study compares seven vegetative and reproductive traits of *Impatiens glandulifera,* from two invasive (Norway) and two native (India) populations, exposed to three treatments. We tested whether phenotypic plasticity was higher in invasive than native populations and whether populations differ in their level of genetic variation for plasticity. In six traits the reaction norms' slope did not differ between native and invasive populations, confirming the pre-adaptation hypothesis. Only the number of nodes was more plastic in invasive than in native populations. In addition, only this trait showed genetic variation for plasticity, suggesting that absence of genetic variation may explain equal plasticity between ranges in the other traits. Consequently, evolution of phenotypic plasticity during invasion might be trait specific.

Pitching poster presentations

Entry pathways for Non-Indigenous Marine Species in the Azores Islands

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Vulnerability of species from oceanic islands to disruptive ecological agents (e.g. competitors, predators, pathogens and parasites from other areas) is a reflex of evolutionary processes connected to the grade of geographical isolation. The biotic resistance of these ecosystems to introduced invasive species is therefore limited and subject to significant ecological impacts. At least 16 introduction pathways of non-indigenous species have been identified in the marine environment worldwide. Nevertheless, on the Azores archipelago, recreational boating seems to play a crucial role in the spread of these species. Moreover, the examination of hull fouling communities identified Bryozoa (7 *taxa*) and Chordata (6 *taxa*) as the most successful invertebrate's taxa introduced on the Azores *via* recreational boating. The 13 identified species have a global historical invasive potential. The history of hull maintenance, mooring ports and user habits were also identified as being fundamental to the likelihood of non-indigenous species introduction on the Archipelago *via* this pathway. Understanding the risks from human-mediated spread of non-indigenous species is a critical component in the coastal marine management programs and the preservation of the natural heritage.

Weeds in the networks of the horticultural trade: Oxalis and Mediterranean container plants

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In recent decades the opportunities for long-distance travel and exchange of goods and services have led to the concept of the Global Village. Even the remotest settlements on earth are being connected through the global networks of trade and communication. Ornamental plants and their weeds and pests follow the same trend. As a result, increasing numbers of exotics reach Western Europe, including an unknown number of potentially invasive plants and animals. Their success or failure as invaders is not only determined by their ecological traits, but also by economic and technological factors, landscape infrastructure and the whims of gardening fashions. Studying exotics therefore implies that both anthropological and natural factors are taken into account. As a result, prediction is difficult and 'rules' or 'laws' are few.

Case studies based on careful observations in 'the real world' allow the reconstruction of pathways through the networks of the Global Village. The organization of these networks changes all the time, either facilitating or impeding the dispersion of propagules. Vectors responsible for the introduction of exotics may be replaced with altogether new ones over time. It is therefore important to understand how the current network differs from the historical structure. An example of a network is the trade in Mediterranean container plants, particularly olive trees and palm trees that are exported in large numbers from Spain and Italy. Along with these intentionally transported plants are numerous weedy and non-weedy plant species, often not even indigenous to the Mediterranean area.

In order to find out how plants travel through the networks of global trade and transportation one needs to distinguish several different geographical scales. (1) – Some container plants are not indigenous to the Mediterranean and are imported from other continents. (2) – Mediterranean plant nurseries interact with their surrounding habitats. This leads to the exchange of plants between these habitats. (3) – Container plants are imported into North-western Europe through numerous garden centres. These garden centres represent a large number of gateways for exotics to enter gardens.

Only *Oxalis acetosella* is indigenous to Belgium. However, a recent survey has shown that 13 *Oxalis* species have been recorded in the wild. Although some are very rare, the dispersion history of all these species is linked with nurseries and garden centres. Nine species have been recorded as weeds; the remaining four are sold as ornamentals. The introduction of at least three species, which have only recently been added to the Belgian list of exotics, is clearly linked with the importation of Mediterranean container plants. A fifth species, *O. exilis*, has almost certainly been imported from Great Britain as a stowaway amongst rock garden plants, even though it originates from New Zealand.

Monitoring of alien species escaping from collections in a botanic garden

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A large proportion of invasive plant species worldwide consists of garden escapes. They originate from private and public gardens, but several species have also been known to escape from botanical gardens. They are sometimes called collection escapes. The botanical collections which are present in botanical gardens can contain a lot of species that are not available in commerce (yet), but may display an invasive tendency. The monitoring of the escapes from botanic gardens may therefore be important to obtain information about the invasive potential of species in a certain area and climate.

The collections of the botanic garden in Meise, near Brussels, contain about 18000 taxa of which 8000 are grown in the open. The garden is located in an old castle domain of 92.3 ha, that also contains (semi-)natural areas with a high conservation status such as *Cratoneurion* (habitat type H7220). A nine-year vegetation survey of the domain from 2002 to 2010 revealed the presence of 586 species of vascular plants, of which 27% were neophytes that had probably escaped from the collections. In total 156 species were considered to be escapes from the collections, of which 38 species were recorded for the first time as a neophyte in Belgium. Some species survive as escapes long after the plants in the collections have disappeared, such as *Mentha pulegium* that is increasingly found in lawns and *Ranunculus parviflorus* that is present as a weed.

From 2012 on, a systematic monitoring of the escaped neophytes was initiated, with the aim to visit all sectors of the domain in 4 years. All plant species were noted, and for the escapes additionally several parameters were recorded in order to characterize their invasive potential: the number of the plants, their age (persistence as escapes), their distance from the mother plants in collection, as well as the habitat type where they are found. For each species the means of dispersal is also considered. Indeed, escapes are introduced and established deliberately by man into areas outside their original distribution area, but they need to be able to subsequently spread into new areas in order to become invasive.

Since 2010 several new species of escapes have been found, and their amount still increases with every monitoring visit of a sector; however, the preliminary results seem to confirm some former observations and conclusions. First of all, the species with the highest persistence are those that grow in woodlands. This is quite logical, as these are the less disturbed areas in the domain of the garden, since other areas are regularly weeded or mown. Secondly, the species that spread over the longest distances are those that have fruits or seeds that are eaten and dispersed by birds, often berries. The combination of both characters yields the escapes that are most invasive in the domain, such as the Date-plum *Diospyros lotus*, of which several hundreds of seedlings have already been found spread over the domain. Another alarming example is *Cornus sericea*, which spreads in the most valuable habitats of the domain and displaces the natural vegetation. Some newly discovered taxa will also be presented.

U.S. Response to Biofouled Marine Debris Produced by the 2011 Japan Tsunami

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On March 11, 2011 (JST), a magnitude 9.0 (Mw) earthquake struck off the coast of the Oshika Peninsula (Honshu, Japan), creating a devastating tsunami that reached heights of up to 133 feet and inundated 217 square miles. The tsunami sent millions of tons of Japan Tsunami Marine Debris (JTMD) into the ocean, originating both from terrestrial and coastal environments. Then over a year later on June 5, 2012, a 188 metric ton (207-ton) floating dock, confirmed to have been lost from Misawa on Honshu Island during the 2011 tsunami, washed ashore on Agate Beach in Newport, Oregon. Scientists from the Hatfield Marine Science Center in Oregon confirmed that a number of the marine organisms attached to the dock were not native to the Northwest Pacific coasts of North America. These incidents raised awareness of the potential introduction of non-native species, and possible invasive species, to the West Coast of the United States, Hawaii and British Columbia, Canada from JTMD. A Regional Preparedness and Response Workshop to Address Biofouling and Aquatic Invasive Species on JTMD was held July 31 – Aug 1, 2012 at Portland State University, Portland, Oregon. This presentation will provide an overview of that workshop, the steps taken by all the partners to develop the response protocol and on-going collaborative efforts to understand as well as minimize the introductions and impacts from non-native species to Northwest Pacific marine ecosystems.

Invasive Alien Species in the Belgian part of the North Sea

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Flanders Marine Institute (VLIZ) and the VLIZ Alien Species Consortium of experts, conduct since 2008 an ongoing effort to maintain the documented list of alien species that have established populations in the Belgian part of the North Sea (BNS) and its adjacent estuaries. The list strives to include all currently known alien and cryptogenic species registered in marine and brackish environments in the Belgian part of the North Sea, the Belgian coastal zone and its adjacent estuaries (Yser, Scheldt, Ostend Sluicedock). This effort scrutinizes both the intentional and accidental introductions by man or by other vectors. Alien species that do not have established and reproductive populations in the area are not included in the list, neither are species whose distribution is limited to the freshwater environment. Newly registered species as a consequence of (expected) natural migrations are also excluded. To date (July 2013), 72 alien species with established populations have been identified in the study area. The taxa Arthropods (28) and Algae (11), count the highest number of alien species.

Based on literature screening and reported evidence, the alien species reported to be invasive either in the BNS or adjacent waters in the Southern North Sea are identified in the invasive species or 'alert' list. Invasiveness may be defined from an ecological or a (socio)economic perspective. To date, 15 species on the list are reported as 'invasive'. Of these, 7 are Arthropods.

The initiative provides an online source of information on alien species for the BNS, as well as on the network of experts for this study area (since 2008). This includes definitions, information sheets, pictures and a fully documented reference list, by species. Each information sheet describes the life cycle and ecology of the species, the introduction pathways and distribution, the potential effects of the species on its environment – including the impact in case of invasive behavior - and the possible mitigation measures. The list provides up-to-date, scientifically validated and policy-relevant information on, and trends in, the presence of alien and invasive species in the Belgian marine and brackish waters.

Exotic species in the Dutch delta waters

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Analyses of the historic data of the soft sediment macrozoobenthic communities of the Dutch delta waters indicate a continuous 'successful' introduction of exotic species with aquaculture activities during the last century. Since the 1980s ballast water related introductions are of increasing importance. Besides the presence of certain vectors, particularly system related aspects (i.e. environmental characteristics) determine the number of exotic species that succeed to settle. Confined (enclosed) systems seem to be most susceptible to exotic species dominance, where each system has one or two (exotic) species that completely determine the biomass. After arrival the exotic species population development can be described by a typical pattern, existing of 1) a lag-phase after first appearance (during which species can also disappear again), followed by 2) an exponential increase, than 3) populations decline after a few years and 4) populations start to fluctuate as observed for indigenous species (Hummel & Wijnhoven, 2014). This implicates that for water management purposes there is need for a good monitoring and early detection network, as elimination might only be successful during the lag-phase. Dynamic systems are less susceptible for exotic invasions, which means that enlargement of water exchange and dynamics (of enclosed systems) might be a good measure to favor native communities and minimize the chance of new arriving exotic species becoming dominant. Yet, under improving environmental conditions (e.g. more dynamics) also the already present exotic bivalve species may profit (whereas numbers of worms will decrease).

The invasive ctenophore Mnemiopsis leidyi can adapt to low salinities

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One of the most notorious invaders in the marine environment is the ctenophore *Mnemiopsis leidyi,* originating from the American East coast, and famous for its invasion in the Black Sea in the 1980s. The species has a high tolerance to temperature and salinity, and reproduction is strongly related to food availability, temperature and salinity. In the Baltic Sea, low salinity is suggested to be the main factor limiting the spread of *M. leidyi.* Recently, the species has invaded in several European Seas, including the North Sea.

However, also in the brackish North Sea Canal (Amsterdam, upper layer 0-8 psu, stratified) large blooms occur: fykes are clogged and fishing with nets is virtually impossible. At present, there are different explanations of this high abundance of *M. leidyi*: (1) the local population has adapted to the new environment; (2) the local population has not adapted but reproduces and survives in deeper waters where the salinity is higher; or (3) the population solely exists of individuals flushed into the canal from the North Sea.

Therefore, a common garden experiment was designed in which survival, growth and reproduction of individuals captured in Amsterdam was compared to that of individuals from a 'normal' population, originating from the western Wadden Sea. Individuals from both locations were kept on both a low (8 psu) and a high (33 psu) salinity, spawned, and grown under constant food conditions for 32 days.

Low salinity was influencing survival and growth patterns. Mortality was much higher, and growth in the first days was delayed. However, individuals from Amsterdam on the low salinity started egg production earlier, and had a much higher total egg production than individuals originating from the Wadden Sea grown at the low salinity level.

These results show that *M. leidyi* can possibly adapt to lower salinity levels than suggested before and can become a serious threat to other low saline areas, like the Baltic Sea. Also, populations might not show the same phenotypical response to differing environmental conditions. This has to be taken in account when making invasion models, where data from populations all over the world are used to estimate parameters and predict invasion risks for new areas.

Rapid adaptive evolution during plant invasions

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Human activities have increasingly introduced plant species far outside their native ranges under environmental conditions that can strongly differ from those originally met. Therefore, before spreading, and potentially causing ecological and economical damage, non-native species may rapidly evolve. Evidence of genetically based adaptation during the process of becoming invasive is very scant however, which is due to the lack of knowledge regarding the historical genetic makeup of the introduced populations and the lack of genomic resources. We examined frequency shifts in genic SNPs of the Pyrenean Rocket (*Sisymbrium austriacum* subsp. *chrysanthum*), comparing the (i) native, (ii) currently spreading non-native, and (iii) historically introduced gene pool. Results indicated that rapid genetic adaptation preceded the spread of this species. Our findings suggest that invasive species management needs to take into consideration the possibility that rapid genetic adaption can assist introduced plant species to overcome environmental constraints and so facilitate successful invasive spread.

Using LIFE funding to address the challenge of invasive alien species

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The LIFE programme is the European Union's funding instrument for the environment. The latest cycle, LIFE+, came to an end on 31 December 2013. It was composed of three strands (LIFE Nature and Biodiversity, LIFE Environment Policy and Governance, and LIFE Information and Communication)[1].

Since 1992, when the LIFE programme was established, LIFE Nature and Biodiversity (formerly LIFE Nature) has co-financed more than 1 400 projects, providing more than € 1.5 billion in funding, and mobilising a further €1.3 billion in other public and private contributions. This continuous source of targeted financing has radically changed the capacity of many countries and regions to care for and manage Natura 2000 network sites and to support the EU Biodiversity Strategy.

Invasive alien species (IAS) are one of the greatest threats to global biodiversity. LIFE is the main source of EU funding for field activities targeting IAS and the significant number of LIFE projects dedicated to this issue is indicative of the level of concern amongst Europe's conservationists. Indeed, some 140 LIFE projects have directly targeted IAS, with invasive species the primary focus of around 40 of those. The LIFE programme plays an important role in the fight against IAS in Europe, already achieving some outstanding results (especially in eradication and control) and providing important insights into where and how legislation can be effective. The LIFE programme has acted as a testing ground for actions aimed at tackling IAS, and LIFE projects have demonstrated that threats can be successfully addressed, particularly in isolated ecosystems where invasive species often pose the greatest threat. LIFE has been less successful in setting up actions on early warning, prevention and IAS pathways. There is also room for improvement in trans-border cooperation on invasive species management across EU Member States.

This communication will present some examples and best practices from successful projects, with the aim of contributing to their active dissemination. A LIFE Focus publication on invasive species is due to be published by the European Commission in the first half of 2014.

[1] The new LIFE Regulation has been published in the Official Journal of the European on 20 December 2013. It establishes the Environment and Climate Action sub-programmes of the LIFE Programme for the next funding period, 2014–2020. The budget for the period is set at €3.4 billion in current prices.

Weir management as a tool for mitigating the effects of invasive freshwater mussels in impounded river sections

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The biodiversity in the rivers Rhine and Meuse strongly decreased in the past due to river regulation and environmental deterioration. In spite of ecological rehabilitation programmes, riverine biodiversity has only partly recovered. Within impounded river sections, the aquatic invertebrate communities are still impoverished and strongly dominated by non-native invasive species such as Asiatic clams (*Corbicula fluminea*), Zebra mussels (*Dreissena polymorpha*) and Quagga mussels (*Dreissena rostriformis bugensis*). During the severe winter of 2012, a measure to control these non-native invasive mussel species was discovered inadvertently. On February 8th, three weirs in the River Nederrijn were opened to prevent damage to hydraulic infrastructure by drifting ice. This caused a sudden decrease in water level in this river and other connected water bodies. Decreases in water-level ranged from 0.5 to 3.4 m and lasted at least seven days. Elsewhere, in the River Meuse, weirs remained closed because ice drift was less problematic. Data from our fauna monitoring in the River Nederrijn at Lexkesveer (extreme low-water event) and River Meuse at Mook (reference site), allowed us to assess the effects of this extremely low-water event during severe winter conditions on invasive freshwater mussels on hard substrates, using a before-after-control- impact and spatial reference experimental design. The density and size distribution of mussels on groyne stones in the impounded sections of these rivers were determined before (t=0) and two times after (t=1 and 2) the extremely low-water event. In addition, five standardized samples of dead, washed up molluscs at the river banks near Lexkesveer were taken directly after the extremely low-water event (t=1) and 6 months later (t=2) in order to estimate their mortality. The results show that the extreme low-water event had a negative effect on the overall density of Zebra and Quagga mussels in the River Nederrijn. At t=1, the majority of the sampled population was either detached or found dead. In the River Meuse no change in mussel density was recorded. Six months after the low-water event, there was a slight increase in mussel density in the River Nederrijn, indicating that recolonization and full recovery of the mussel population will take several years. This is supported by the significantly smaller size of Quagga mussels found six months after the event in the River Nederrijn opposed to that of specimens collected in the River Meuse. The significantly larger number of dead mussels washed up on the banks directly after the event indicated that other molluscs, including species living in and on sediments, were also affected by the extreme low-water event. However, 99.4% of the washed up individuals sampled directly after the event consisted of non-native species. Based on these results we conclude that: creating extremely low water conditions through the manipulation of weirs during severe winters appears to be a potential tool for the control of non-native invasive freshwater mussel population densities in impounded river sections. After such an extreme mortality event, the full recovery of invasive mussel populations will take several years. Finally, we recommend that the long term effects of weir management on both native and non-native species composition and diversity are assessed.

Harmonia^{+}: a first-line screening tool for potentially invasive organisms

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The sooner invasive alien species become tackled during invasion, the more cost-effective measures against them will be. But before such prevention or early eradication measures can take place, it is essential to have first identified those species posing the highest risks. Given the huge and still-increasing number of species that become transported and may become problematic, such a prioritization must allow for a high number of species from different taxonomic groups to be assessed in a relatively short time.

For Belgium, Branquart (2007) launched a scheme that allowed for a quick screening of species' capacity to spread and impacts on the environment (ISEIA protocol). Yet, during the years, this scheme was found to unsatisfactorily cover several issues, and the challenge was therefore to refine this scheme further yet retain its simplicity.

We therefore constructed *Harmonia^{+}*, which -compared to its predecessor- is more complete with regard to the invasion stages covered, with the different kinds of impacts included, and with the consideration of pathogens, among other improvements.

More specifically, *Harmonia^{+}* presents about 30 key questions on a particular organism, the answers of which need to be provided by one or more assessors. These questions refer to the species' risks on (1) introduction, (2) establishment, (3) spread and (4) impacts, the latter of which are further subdivided into impacts on (4a) environmental, (4b) plant, (4c) animal and (4d) human health. The answers are ordinally scaled, and this allows to put the (separate and combined) risks into scores, which in turn, allows to rank species and prioritize actions against them.

Harmonia^{+} has come about through the collaboration of eight Belgian scientific institutes, each providing their expertise on different components of the protocol. A first version was tested by an international panel of risk analysis experts, and later versions have been applied to test cases by national experts as a means of validation

<u>Session 2:</u> Impact and risk assessment of invasive species (session chair: Gregory Mahy)

Several alien invasive species are known to have an effect on ecosystem structure and functioning. Although there is often an impact observed, the mechanisms behind the impact are often not quantified or fully understood.

Assessing and predicting the impact and risk of potential alien invasive species is essential since it can help to determine which species might cause problems once they are introduced into the new environment. In this way, targeted actions can be undertaken to prevent further environmental degradation due to species introductions. Talks on experiments, field data analyses as well as conceptual work related to impact and risk assessment of alien invasive species are welcomed in this session.

Keynote: Advancing impact prediction in invasion ecology with a functional response approach

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Invasion ecology urgently requires predictive methodologies that can forecast the ecological impacts of existing, emerging and potential invasive species. Ideally, such methods should be applicable across taxonomic and trophic groups, be rapid, reliable and inexpensive, as well as amenable to testing the well-known context-dependencies of invader impacts (eg impact differences over temperature ranges). We argue that many ecologically damaging invaders are characterised by their more efficient use of resources. Consequently, comparison of the classical 'functional response' (relationship between resource use and availability) between invasive and trophically analogous native species may allow prediction of invader ecological impact. Indeed, this method has a sound basis in classical population and community ecology and has been applied to problems of biological control for decades, yet remains largely ignored in invasion ecology. Functional response analyses, by describing the resource use of species over a range of resource availabilities, avoids many pitfalls of 'snapshot' assessments of resource use. The framework developed here demonstrates how comparisons of invader and native functional responses, within and between Type II and III functional responses, allow testing of the likely population-level outcomes of invasions for affected species. Recent studies support the predictive capacity of this method; for example, the invasive 'bloody red shrimp' *Hemimysis anomala* shows higher Type II functional responses than native mysids and this corroborates, and could have predicted, actual invader impacts in the field. The comparative functional response method can also be used to examine differences in the impact of two or more invaders, two or more populations of the same invader, and the abiotic (e.g. temperature) and biotic (e.g. parasitism) context-dependencies of invader impacts. The framework may also address the previous lack of rigour in testing major hypotheses in invasion ecology, such as the 'enemy release' and 'biotic resistance' hypotheses, as the approach explicitly considers demographic consequences for impacted resources, such as native and invasive prey species. Finally, I discuss a number of challenges in developing this approach, such as incorporating indirect effects (eg trait-mediated indirect interactions), deriving functional responses by methods other than laboratory experiments, the generation of sufficient case studies to test the overall hypothesis that functional responses can indeed predict invader impacts, and the inclusion of the methodology in risk assessment frameworks.

A new Belgian template for invasive species risk analysis: a support for decision makers

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An increasing number of regulatory tools aiming to impose preventive and control actions against invasive species are currently being developed in Europe. Both species prioritization and the choice of best preventive and potential control actions to reduce the risk require robust and transparent risk assessment. Two different generic tools, available from http://ias.biodiversity.be, have recently been developed in Belgium to help decision makers reaching these goals, i.e. a quick screening prioritization process (Harmonia+) and a detailed risk assessment scheme. Both tools may be applied to any non-native organism irrespective its taxonomic affiliation and encompass an evaluation of the probability of organism entry, establishment, spread, and of the potential and magnitude of environmental, economic and social consequences including plant, animal and human health.

Harmonia+ is a quick screening tool that may be used for different purposes (D'hondt et al. 2014): (i) the elaboration of priority lists of invasive species that are established or could potentially establish in an area, (ii) the fulfillment of rapid assessment to help conservation managers to prioritize actions when a new non-native organism is found in the wild and (iii) the identification of non-native species with the highest priority for in-depth and time consuming risk analyses and (iv) the scoring of probability and magnitude of the different elements included in those risk analyses.

The detailed scheme for invasive species risk analysis is based on the recommendations of the international standards for pest risk analysis for organisms of quarantine concern produced by the Secretariat of the International Plant Protection Convention. It follows a process defined by two main stages, i.e. the risk assessment stage itself and the risk management stage, which involves identifying options for reducing the identified risks. This detailed analysis is especially valuable to know whether trade restrictions could be considered as adequate and efficient to reduce the risk.

The output of the risk assessments based on these new tools will be presented and discussed for five emerging non-native species in Belgium (water primrose, red swamp crayfish, American bullfrog, sacred ibis and raccoon dog). Different recommendations and priorities for decision making will be provided for the different species based on the outcome of these analyses.

Potential uses for the selection of species of EU concern in the framework of the new EC proposal of Regulation on the prevention and management of the introduction and spread of IAS in Europe will also be discussed.

Observation and risk assessment analysis of the invasive Mnemiopsis leidyi in the North Sea.

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Coming from the other side of the Atlantic Ocean through ship's ballast water, the American comb jelly (*Mnemiopsis leidyi*) was first observed in the North Sea in 2006. Given the worrying history of this invader in the Black Sea, where the species may have contributed to the collapse of the commercial anchovy fisheries, questions arose on a potential population explosion and its consequences in the already stressed North Sea environment. To answer these questions, the MEMO project ("*Mnemiopsis* ecology and modeling: Observation of an invasive comb jelly in the North Sea") was designed by an international consortium of marine research institutes (ILVO, IFREMER, ULCO-LOG, Cefas, Deltares).

As *M. leidyi* adapts easily to different marine environmental conditions, the spatial and temporal distribution of *M. leidyi* was assessed by means of monitoring campaigns at sea and in the harbours. To ensure a uniform procedure for sampling, preservation and identification, a SOP (Standard Operating Protocol) was developed. Analysis of samples from regular seagoing surveys confirmed the presence of the American comb jelly in coastal areas, estuaries and harbors of France, the Netherlands and Belgium. Additionally, several prediction models were developed to predict *M. leidyi* presence under different circumstances and in different areas.

M. leidyi is notorious for its high reproduction rate and the impact it can have on fish eggs and larvae by predation. In the 2Seas region, the trophic position of *M. leidyi* in the local food web was assessed by studying its biology, physiology and feeding behavior. Additionally, experiments were performed to close the life cycle of the species in captivity and to examine its tolerance to changes in environmental conditions. These studies resulted in hypotheses on the reason of the survival success of the species in the study area.

The data on the distribution and potential impact of *M. leidyi* were used to develop several models that assess its survival and reproduction capability. These models showed strong evidence of the importance of temperature in relation to the presence and density of *M. leidyi* and the role of estuarine populations as a year-round source of *M. leidyi* for the wider North Sea. Next to the modelling work, two socio-economic analyses were performed which suggest that the direct impact of the species in case of blooms would be relatively small at present.

An important aspect of the project was scientific outreach of the project results to inform policy, various stakeholders (such as fisheries and tourism), and the general public.

Concerns regarding the scientific evidence informing impact risk assessment and management recommendations for invasive birds

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Invasive species can be a major threat to biodiversity and economy. Given the large number of introduced invasive species and the limited resources available, a rigorous assessment of the potential impact of these species is of vital importance for prioritizing management programs. Often, general scoring systems in which certain criteria are used to assess the impact of an invader along several impact categories are applied to obtain a ranking of troublesome invaders. For example, a recent study provided a first categorization of invasive bird impacts in Europe, and argued that several invasive birds should be eradicated because of the threat they pose to biodiversity.

This is surprising, as recent reviews suggest that there is little evidence that invasive birds strongly impact biodiversity. We therefore re-evaluated this risk assessment. We found that in the majority of cases, the evidence presented to support impact claims is weak, as they are generally not based on direct scientific research but on often anecdotal observations relating to small areas only. Moreover, even if all claims would materialize, this does not necessarily justify a call for eradication. Previous experiences with eradications have learnt that a feasibility study, encompassing all aspects of biological invasions (including public opinion and possible benefits of the invader) is critical for the achievement of any strategy against invasive species. This is essential, as ill-conceived calls for eradication could result in a public backlash, causing funding agencies and managers to shy away from the problems posed by invasive species.

Evaluating the potential of ecological niche modelling as a component in invasive species risk assessments

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Biological invasions have dramatically increased with the development of global trading, causing the homogenization of communities and the decline of biodiversity. Ballast water exchange from shipping and introductions from aquaculture are the two main vectors of invasive species in the marine environment, in which eradication is very difficult. Modelling approaches are invaluable to predict the impact of potentially invasive species before they establish themselves as breeding populations, allowing preventive measures to be put in place.

In this study, we developed a number of workflows for data mobilization, niche modelling and statistical analysis of raster layers. We analysed habitat suitability in the Baltic Sea and the Northeast Atlantic for a 'black species list' of 18 marine species invasive in Northern Europe, divided into four ecological groups: zoobenthos, phytobenthos, zooplankton and phytoplankton. The data refinement workflow was used to mobilize more than 23.000 occurrence records from public databases and integrate them with observations from literature. Suitable habitats were modelled using Ecological niche modelling (ENM) and statistical analysis workflows.

We found several potential risk zones (hotspots) for invasive species in the Skagerrak and the Kattegat, a transitional area for invasive species entering the Baltic Sea. Cold spots showing a low risk of invasive species spread were found in the Bothnian Bay. Our niche modelling results are compared to traditional risk assessment methods based on salinity matching to assess risk of spread along an example shipping route (Gothenburg - St. Petersburg). We discuss the potential of ecological niche modelling methods based on several environmental parameters in providing useful predictive information to policy makers in relation to ballast water management. The study shows the utility of e-science approaches in providing scalable tools for rapid integration of biodiversity data and for producing predictive models that improve the prevention and management of marine invasions.

Session 3: Control, management and mitigation of invasive species (Session chair: Tim Adriaens)

Due to the increasing number of alien invasive species established worldwide, control, management and mitigation are recently put forward on the agenda of policy and decision makers in Europe as well as in the rest of the world. Several measures have been taken such as ballast water control to prevent new introductions or to avoid the spread of already introduced ones. Management actions are, however, complicated because many different stakeholders are involved and the suggested measures and legalisation are not always that effective. Successful eradication actions of invasive species or public awareness campaigns have shown that management of invasive species is necessary. In this session we welcome talks that elaborate on how science can help to contribute to a good policy regarding invasive species management. Besides a good policy it is important to investigate how we can make our ecosystems more resilient to invasions or how restoration actions can contribute to combat invasive species.

Keynote: Control and Management of Freshwater Invasive Species in Ireland

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When the EU Regulation on invasive alien species (IAS) comes into force, it will require Member States (MS) across the EU to dramatically rethink their attitude to IAS. The Regulation will establish a framework for action that strongly targets measures to prevent the introduction and establishment of recognised IAS. However, it is clear that no matter how vigilant MS are at identifying pathways for entry or at operating official controls at borders and elsewhere, IAS will continue to gain entry (probably at a far reduced rate) and pose problems for biodiversity and ecosystem services. This is in addition to those IAS that are already present in the territory of a MS and pose a threat to other MS in the Union. In these circumstances IAS control, management and mitigation are required and the proposed Regulation states that effective management measures must be put in place to tackle these species and their impacts. Effective management for established IAS, however, is both difficult and costly, and regrettably rarely results in successful eradication. The island of Ireland has relatively few IAS, although those that have become established are particularly harmful. The rate of increase of high impact IAS in Ireland since the 1980s is greatest in the freshwater environment, where species such as *Dreissena polymorpha, Lagarosiphon major, Crassula helmsii, Elodea nuttallii* and *Leuciscus leuciscus* have established and caused significant ecological and economic problems. Research to tackle these problems has focused on identifying weak links in the life cycle that can be targeted for specific control and on the development of new or innovative control methods (e.g. light reduction using jute matting). Considerable effort has also been channelled into the area of biosecurity to reduce the spread of established IAS by key stakeholders (anglers and boaters) within the country. The results from a number of these programmes will be described and their influence on IAS policy development in Ireland will be discussed.

Catching invasive Egyptian geese (Alopochen aegyptiacus): evaluation of the optimal deployment season for a floating Larsen trap

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Management of invasive geese is generally done by egg pricking or oiling, shooting and/or trapping. Trapping efforts generally focus on moulting flightless geese, which has proven to be highly effective for capturing large numbers. In Flanders, moult trapping has been very successful for Canada geese, with a total of 7829 caught between 2010 and 2013. Egyptian geese also experience a full primary moult leaving them flightless, but are, due to their excellent diving capacities, not susceptible to the current moult trapping systems. In addition, the species does not generally nest in colonies and regularly uses nest sites in trees, making the nest less accessible for reproduction control. This seriously reduces the amount of eggs that can be found for oiling or pricking, leaving shooting as the only feasible management option to date. However, since numbers of this alien species have been increasing and are continuing to rise, there is a growing demand for effective control measures in addition to shooting. Egyptian geese are known to be highly territorial which opens opportunities for the use of traps with live decoy birds, the so-called Larsen traps. In order to determine the optimal catching month with these traps, we set out a field experiment in which 19 floating Larsen traps were used for one week in each month during one year. Given the large differences in the species behaviour throughout the year we expected to see significant differences in catchment success over the different months. Success was defined as either the number of geese that could be caught per day or the number of days it took to catch the first goose at a given location in a given month. The results showed clear differences between the different months, designating spring months as the optimal season to deploy decoy birds. In addition, elements that further contribute to the observed trapping success are explored, non-target effects (bycatch) and possible improvements and alternative deployment options are identified. This field trial was performed within the framework of the EU co-funded Interreg 2Seas project RINSE (Reducing the Impact of Non-Native Species in Europe) (www.rinse-europe.eu) (2012-2014), which seeks to improve awareness of the threats posed by INNS, and the methods to address them.

Capacity, capability and cross-border challenges associated with marine eradication programmes in Europe: the attempted eradication of an invasive non-native ascidian, Didemnum vexillum in Wales, Great Britain

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Increasing recognition of the threat of invasive non-native species to ecological and economic assets has led to a recent surge in international, regional and national policies. Within the European Union, the cross-border issues associated with invasive non-native species has necessitated the development of a draft EU Regulation on the prevention and management of invasive alien species to ensure comprehensive Member State engagement. The draft Regulation, published in 2013, recommends the creation of a list of invasive alien species of Union concern, wherein any Member State identifying newly establishing populations of these species must implement rapid eradication measures within three months of notifying the Commission. The first official report of the invasive non-native ascidian *Didemnum vexillum* in Wales, Great Britain in 2008, and subsequent eradication efforts, presents a timely opportunity to evaluate the existing capability and capacity in Great Britain to undertake a rapid eradication in the marine environment in light of the draft EU Regulation. In addition, Great Britain comprises of three nations with devolved administrations, providing an opportunity to illustrate some of the cross-border challenges that the EU faces in addressing marine invasive non-native species and highlights the importance of cross-border collaboration to prevent and manage marine incursions. Although Britain is often cited as one of the nations within Europe that has made significant progress in the field of invasion management, the lessons learned from the eradication process in Wales highlight that Britain is currently inadequately prepared to undertake rapid eradication measures in the marine environment and that the lack of a coordinated approach between nations has significant potential to devalue local eradication efforts. In addition, we emphasise the important role the European Union has to provide a centralised source of information on practical solutions and guidance to Member States to support them to meet future obligations.

Preventing mass development of invasive macrophytes during the initial colonization phase in an artificially created urban lake

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In recent years, mass development of invasive aquatic macrophytes in lakes has caused an increasing number of management issues. Sustainable management of aquatic macrophytes following initial establishment in a water-body is often difficult and cost-intensive. Artificially created water-bodies, including urban lakes or gravel pits, offer the opportunity to investigate the efficacy of preventive measures designed to reduce regular maintenance efforts and facilitate the use of a water-body for recreational purposes (e.g. boating, water sports) following creation.

Lake PHOENIX is an artificially created shallow, urban lake with an area of 24 ha and a mean and maximum depth of 2,8 m and 4,0 m, respectively. The lake is situated on a former steel works compound in the city of Dortmund (Germany). Lake PHOENIX was created between 2005-2010 and filling was completed by Mai 2011. The development of the lake was accompanied by the development of a lake management concept aiming to prevent mass development of invasive macrophytes (particularly *Elodea nuttallii*) during the initial colonization phase of the lake after filling. In order to achieve this aim the concept was based on a role model of natural, nutrient poor lakes with low growing macrophyte species (stoneworts), which would facilitate the recreational use of the lake (boating). The concept was implemented by managing on-site nutrient availability and by influencing the initial colonization potential of stoneworts. The sediment bed which consisted of nutrient rich clay was therefore covered with a nutrient poor sand-layer of around 0.2 m thickness and a phosphorus stripping facility was installed. In addition, stoneworts collected from a nearby site (in total 525 buckets with a volume of 5 L) were planted in 2010 and 2011. Furthermore, sediment containing stonewort oospores were collected from a nearby site (in total 510 m^3) and applied to Lake PHOENIX in 2010 and 2011 to enhance the colonisation of the lake bed with stoneworts. The presentation will outline the preventive measures and their ecological background. Furthermore, macrophyte community composition and spatial distribution of macrophyte groups during the first two years following completion of Lake PHOENIX (i.e. during 2012 and 2013) will be presented.

Native pike Esox lucius can suppress invasive topmouth gudgeon Pseudorasbora parva in ponds and leaves the indigenous fish community intact

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Asian topmouth gudgeon *Pseudorasbora parva* has been recognized as a highly invasive cyprinid fish species in Europe that might present risk to native fish communities. The present study aimed to investigate whether a native piscivorous fish, pike *Esox lucius*, is able to reduce the establishment success and invasiveness of topmouth gudgeon *Pseudorasbora parva* in shallow ponds. We performed a large scale, replicated whole-pond experiment in which experimental native fish communities were spontaneously colonized by topmouth gudgeon and exposed to treatments with and without pike. Our results provide evidence for strong negative effects of pike stocking on the abundance and biomass of topmouth gudgeon, while we found no effects on native fish species. The present study indicates that the presence of native pike can dramatically enhance the biotic resistance of fish communities against invasion by topmouth gudgeon. We argue that the resistance of fish communities against invasion by exotic species may in some cases be enhanced by management strategies that reinforce the presence and abundance of naturally occurring and indigenous piscivorous fish.

POSTERS

Re-visiting Vila do Porto marina (Santa Maria, Azores archipelago)

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Harbours and marinas are important places of introduction and spread of non-native organisms, due to local, regional and international shipping activities, both commercial and recreational. Moreover, marina infrastructures are an increasingly common form of artificial habitat, which is likely to increase the recruitment of organisms relative to natural shores. The association of marine wildlife with artificial structures represents, generally, a preliminary indicator of the colonization status of invasive species. Santa Maria island is located in the Eastern Group of the Azores and is the southernmost island of the archipelago. A survey for non-indigenous species was done by scuba-diving at the marina of Vila do Porto, located on the south coast of the island, during August 2013, five years after its construction and four years on from its first non-indigenous species characterization (2009). An increase of 4 fold percentage of NIS was detected, with Bryozoa showing the highest diversity among taxa. Although there are no known records of adverse impacts on the indigenous local fauna, as the potential of invasion increases, it becomes strongly important the development of a narrower control and specific monitoring programs supported by an effective regulation to prevent the possible adverse introductions.

Alien roadside species more easily invade alpine than lowland plant communities in a subarctic mountain ecosystem

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Effects of roads on plant communities and alien plant invasions are not well known in cold-climate mountain ecosystems, where road building and development are expected to increase in future decades. Knowledge of the sensitivity of mountain plant communities to disturbance by roads is however important for future conservation purposes.

We examine whether mountain roads promote the introduction and invasion of alien plant species from the lowlands to the alpine zone, along three elevational gradients in a subarctic mountain ecosystem. We also investigate the effects of roads on species richness and composition, including the plant strategies that are most affected. Observations of plant community composition were made together with abiotic, biotic and anthropogenic factors in 60 T-shaped transects.

Alpine plant communities reacted differently to road disturbances than their lowland counterparts. On high elevations, the roadside species composition was more similar to that of the local natural communities. Less competitive and ruderal species were present at high compared with lower elevation roadsides.

While the effects of roads thus seem to be mitigated in the alpine environment for plant species in general, mountain plant communities are more invasible than lowland communities. More precisely, relatively more alien species present in the roadside were found to invade into the surrounding natural community at high compared to low elevations. We conclude that effects of roads and introduction of alien species in lowlands cannot simply be extrapolated to the alpine and subarctic environment and that higher vulnerability for future invasion can be expected on high elevations.

Effects of desiccation on native and non-native mollusc species in the rivers Rhine and Meuse

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Fluctuations in river discharge are becoming more extreme due to climate change, land use changes in catchments, river regulations and water management changes. Low discharges result in desiccation of littoral zones of rivers as well as water bodies in the river floodplains. Thereby decreasing both the native and non-native mollusc species assemblages. Therefore, the spatial and temporal effects of desiccation on both the native and non-native mollusc assemblages have been assessed in a free flowing section of the River Rhine and an impounded section of River Meuse. Desiccation tolerance data derived at 20 oC of sixteen freshwater mollusc species occurring in the rivers Rhine and Meuse were used to calculate the time (in hours) until 99% mortality (LT99). Using these LT99 values a log-logistic species sensitivity distribution (SSD) of mollusc species to desiccation was constructed. Parameters of the acquired SSD were then used to analyse both the spatial and temporal trends of desiccation on mollusc species in a groyne field of the rivers Rhine and Meuse. For native species LT99 values varied between 17.2 and 434.2 hours and between 36.7 and 561.6 among non-native species. However, between groups of native and non-native species no significant difference in desiccation tolerance was found. Our model calculations show that desiccation events will frequently occur during average discharge years of the River Rhine in habitats up to 1.5 m below the average water level. During extremely low discharge years this effect will be more pronounced and is expected to occur at a depth up to 3.5 m. During average discharge years of the River Meuse no desiccation events will occur. However, when the water level cannot be maintained in the impounded sections of the River Meuse during years with extremely low discharges, desiccation events will also have profound effects in this river. Though, re-establishment time between events is longer in impounded river sections since the frequency of desiccation events is lower.

Phytosociolical study of Oxalis corniculata and O. latifolia weed community in Kampala (Uganda, East Africa)

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A phytosociological study of a community dominated by *Oxalis corniculata and O. latifolia* was studied in Kampala. These two species are introduced in Uganda long ago and are now considered invasive and difficult to eradicate. These two species are aliens and were introduced in Uganda long ago. They are established there since then and are now known as invasive weeds because of their negative impact on the environment and are to eradicate. In Kampala, they occur in ruderal/disturbed areas and croplands in association with many other widespread species forming important weed communities. The main objective of this study was to investigate the species composition, life forms, geographical distribution and dispersal means, and to determine the phytosociological status of the community. Sixteen phytosociological relevés were performed throughout Kampala following the Zurich-Montpellier School of Phytosociology method (Braun-Blanquet 1932; Mueller-Dombois & Ellenberg 1974). 57 species were recorded and among these, *Oxalis latifolia* and *O. corniculata* appear as the most important because of their highest coefficients of abundance dominance, 36.36 and 13.61 % respectively. The community is characterized by one stratum of 10-15 cm high. Therophytes, annual species, are the largest life form in terms of number of species (43.9%). However they have a lower average cover (32.1%) than hemicryptophytes, geophytes and chamaephytes which together represent 67.9% of total. Most species are sclerochorous (42.1% of total) and mainly dispersed by wind (anemochory) but they have a lower average cover (25.7%) compared to the ballochorours species (67.1%), those that are dispersed mechanically by themselves. On the other hand, the desmochorous and sarcochorous species, those whose dissemination is carried by animals (zoochorie) are relatively abundant (35.09%) but have the least average cover (7.21%). The majority of species are widespread: pantropical, palaeotrpical or cosmopolitan. In contrary, species of African origin are less abundant. *Oxalis corniculata, O. latifolia, Commelina africana* and *Digitaria abyssinica* are identified as character species of the community. This has been described as a new association*, Oxaletum corniculato-latifoliae ass. nova.* It is ascribed to the alliance *Eleusinion indicae* Léonard (1950) 1952 and the class *Ruderali Manihotetea* Léonard in Taton 1949.

Current status and management of American bullfrog Lithobates catesbeianus in Flanders

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American bullfrog *Lithobates catesbeianus* is one of the world's worst invasive species and suspected to cause substantial ecological damage around the globe through predation, competition and pathogen transmission. The species has been introduced in Flanders at the end of the 1990s, with first observations in nature in 1996. The first proof of reproduction in Flanders dates back to 2001 at several places in the Grote Nete Valley. Since then the population has been expanding its distribution area, and now holds an area of occupancy of 17 km^2 occurring in more than 70 km^2 grid cells. The largest stronghold of bullfrog is a big (meta)population in the valley of the Grote Nete where the species is now established for more than a decade. Here, the pond-rich valley of the Grote Nete river hosts a large reproducing population in a complex of several hundreds of - largely private - ponds used for recreational fishing and gardening. In the north of the province of Antwerp, smaller isolated populations (less than 10 water bodies with reproduction) are present (municipalities of Hoogstraten, Arendonk and Kasterlee). To halt the spread, and reduce its impact (predation, competition and spread of diseases) on native biota, regional and local authorities, ngo's, conservation managers, a social economy company and scientists worked together in the cross-border EU co-funded Interreg project Invexo (www.invexo.be). Attempts were undertaken to eradicate the smaller populations, using a variety of active trapping techniques (double fyke netting, pond drawdown, filling of ponds and habitat reconversion, seine netting, electrofishing, hand netting and nightlighting). Research was performed into cost-effectiveness of double fyke nets. This catching gear is relatively cheap, easy to handle and know has documented catchability for both larval and adult stages, thereby offering some perspectives for integrated control of populations. Management followed a holistic approach, integrating active removal with habitat management by introduction of native predatory fish, which has been shown to increase the general quality of the aquatic habitats involved. After Invexo (2009-2012), the Agency for Nature and Forest (ANB) funded a follow-up project (2013) with further research into the catchability of adult bullfrogs, detailed inventory of the population and follow-up of managed populations. As a consequence, after 4 years of active trapping and destruction of one core population in the cluster of ponds, the population in Hoogstraten is depleted and presumably eradicated. In the pond complex in Arendonk, the situation is less clear. Here, several ponds are still infected and there are indications that the situation is worsening. Inventory also shows that the Grote Nete population is still under westward expansion. Meanwhile, risk analysis was performed for bullfrog in Belgium in order to underpin legislative action to prevent new incursions. Tackling bullfrog would require a dedicated management plan and would entail consolidating the partnership of authorities, volunteer networks and social economy companies.

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Order on nature conservation (1/03/2012) : a legal frame of reference for nature policy in the Brussels-Capital Region.

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Order on Nature Conservation, adopted on 1 March 2012 and published on 16 March 2012 in the Belgian Official Journal, established a new and progressive legal framework for nature policy in Brussels. It constitutes quite a unique and specific tool as it addresses nature conservation in an urban context. Following a large part of the order dealing with regional environmental policy, article 67 specifically addresses the issue of species. Indigenous and European species are strictly protected in the Brussels-Capital Region, except for the brown rat (*Rattus norvegicus*), house mouse (*Mus domesticus*), domestic farming species and domestic pets. Besides the protection regime, a new important pillar introduced by the order covers management of exotic (invasive) species. In that regard, Order on Nature Conservation constitutes an ambitious and strong instrument for the purpose of reducing the impact of exotic species on nature, economy and human health.

Invasive species (Articles 77 and 78) are listed in a separate annex (IV). It covers 28 animal species and 46 vegetal species, identified on the ground of scientific evidence collected by the Belgian Biodiversity Platform, including the Egyptian Goose (*Alopochen aegyptiacus),* Rose-ringed Parakeet (*Psittacula krameri),* Summer Lilac *(Buddleja davidii)* and Common Rhododendron (*Rhododendron ponticum*). Currently, the deliberate introduction or reintroduction into the wild of invasive animal or vegetal species mentioned in Annex IV is prohibited. In addition, it is forbidden to buy, to sell, to exchange and to assign for a consideration or free of charge invasive species, without prejudice of the federal competence on import, export and transit of non-indigenous species in conformity with Special Act of 8 August 1980. Article 78 allows the government to adopt preventive measures, such as measures aiming at preventing invasive species from developing on the territory of the Region of Brussels-Capitale, or measures aiming at reducing the impact of invasive species already existing in the wild (including eradication measures). The deliberate introduction into the wild of non-indigenous animal and vegetal species (in other terms, exotic species which are not listed in annex VI) is subject to a permit. Applications for permits must be submitted to Brussels-Environment and must include a risk assessment. The measure must however not harm the conservation status of natural habitats and indigenous fauna and flora.

A number of other implementing decrees - among others – in relation to management of invasive species (defining methods and means of capture and killing of mammals, birds and fish) and to the criteria applicable to animals born and kept in captivity, are in the pipeline. The timeframe for adoption of those texts depends on the priorities defined in the Nature plan, which was at the time of writing subject to public inquiry. Following the adoption of the European regulation on the prevention and management of the introduction and spread of invasive alien species, the order on nature conservation will undeniably be examined for the purpose of ensuring consistency in terms of content. You can obtain a copy of the order via the Belgian Official Journal, of via email (obeck@leefmilieu.irisnet.be).

Reconstruction of the colonization dynamics of the invasion of the North American raccoon (*Procyon lotor L.*, 1758) in Germany

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Biological invasions provide excellent study systems to understand evolutionary, genetic and ecological processes during range expansions. A major challenge lies in determining factors causing the spread of alien species. This knowledge is needed to develop management plans and a framework to predict and to prevent further invasions. We investigated the dispersal of the common raccoon (*Procyon lotor*) in the invasive range in Germany, where two separate founding events have been documented in the 1930s and 1940s (Lutz 1984; Stubbe 1975). We reconstructed the population history and dispersal pathways by genotyping raccoon samples at 20 microsatellite loci and analyzing the hunting statistics on the administrative district level over the last decade. According to the hunting bags, which were gathered up by German Wildlife Information System database (WILD), the abundance of the species increased from 9,064 harvested individuals in 2000 to around 71,000 individuals in 2011. Even in the core of the invasive range the yearly harvest continuously increases and new records at the range edge indicate ongoing range expansion. Contrary to the literature, our results indicate that at least four introduction events have occurred in Germany, which constituted genetically differentiated subpopulations in the status of incipient contact. The genetic diversity in Germany was relatively high and it is likely that a larger number of founders have built the populations than suggested by the historic record assuming a fundamental influence of recent accidental or deliberate releases on the invasion process. The invasion success is possibly positively affected by the high genetic diversity caused by admixture from multiple source populations. Hence, the raccoon invasion does not represent an example of a genetically depauperate species becoming invasive.

Lutz, W. (1984). Die Verbreitung des Waschbären (Procyon lotor, Linné 1758) im mitteleuropäischen Raum. Zeitschrift für Jagdwissenschaft, 30(4), 218-228.

Stubbe, M. (1975). Der Waschbär Procyon lotor (L., 1758) in der DDR. – Hercynia N.F. 12 (1): 80-91.

Parasite spill-over, spill-back and dilution effects of invasive oysters – is there evidence from field data?

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Invaders are able to affect native parasite-host dynamics via a variety of ways. New established hosts can act as reservoirs by co-introducing a parasite that also infects native hosts (*spill-over effect*). In addition, invaders may act as an alternative host for native parasites, thus increasing the parasites' population sizes and subsequently intensifying parasite burdens in native hosts (*spill-back effect*). Alternatively, invasive species can reduce the disease risk for native hosts, e.g. by preying on infective stages *(dilution effect).* We explored field evidence for these three effects in the intertidal of the Wadden Sea, in which the Pacific oyster, *Crassostrea gigas*, is one of the most prominent invaders that interacts with native blue mussels, *Mytilus edulis*. In autumn 2012, a nested sampling scheme was conducted where individual mussels and oysters were sampled on four plots on eight different mixed (oyster and mussel) beds throughout the entire Wadden Sea. On each spatial scale abundances of both native and invasive hosts and candidate parasites were quantified. We found evidence for a spill-over effect of the parasitic copepod *Mytilicola orientalis* from oyster to mussels, however evidence for spill-back and dilution effects on shell-boring polychaetes and trematodes were less apparent. In addition, we found the infection levels of parasites in both mussel and oyster hosts to be more similar within beds than among beds, indicating that the effect of the invader on native-parasite host systems mainly acts on local spatial scales.

Attempts to control aquatic Crassula helmsii at Huis ter Heide (Tilburg, The Netherlands), with special reference to dye treatment

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Several methods were deployed simultaneously to control, if not eradicate, the highly invasive *Crassula helmsii* (Australian swamp stonecrop, New Zealand pigmy weed) in a newly created shallow pond adjoining the heath and moorland pools of the Dutch nature reserve Huis ter Heide. Measures included mechanical removal of top soil after draining, followed by extensive covering of pond margins with non-transparent foil, regular manual removal of washed-up plants, and addition of non-toxic dyes. The latter aimed to reduce compensation depth sufficiently to prevent submerged growth below the foil-covered area. Treatment with a mixture of soluble red and black dyes (DyoFix®), commercialized for the control of aquatic weeds and phytoplankton, started in January 2013. Five further additions followed in the course of this year to make up for losses and (starting from July) to increase concentration.

Biomass of submerged vegetation was recorded prior to dye treatment (October 2012) and again in October 2013. Total biomass was substantially higher on the second occasion, mainly due to the continued increase of *Crassula* which became dominant throughout the pond. The abundance of *Eleocharis acicularis* did not change markedly, whilst *Potamogeton pusillus* decreased. Vegetation height increased slightly and the number of macrophyte taxa remained similar. Measurement of photosynthetically active radiation at different water depths showed that prolonged light limitation was unlikely to have occurred even in the deepest part of the pond, despite the use of considerably higher doses of dye than recommended. Consequently, the lack of a negative response was no surprise.

Although pond morphology and water-level changes complicated application in this particular case, effective control of *Crassula helmsii* by 'shading' with dyes appears unlikely given the extreme growth plasticity of this species.

The Huis ter Heide demonstration project is part of the EU co-funded Interreg 2Seas project RINSE (Reducing the Impact of Non-Native Species in Europe; www.rinse-europe.eu), which seeks to improve awareness of the threats posed by INNS, and the methods to address them.

ALIEN Challenge: Pan European Collaboration on Alien Invasive Species

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ALIEN Challenge is a four year EU funded project to facilitate coordination of nationally-funded research on a European level. It is part of the COST intergovernmental framework for European Cooperation in Science and Technology. Amongst other things the project will coordinate interchange of data between members by develop exchange and quality standards. It will make policy recommendations and coordinate research between member states. It is composed of four working groups that include stakeholders such as invasion ecologists, socio-economists, data analysts, data-providers, data-consumers, monitoring agencies, database managers, journal editors and policy makers.

Working Group One: Early Warning and Rapid Response

WG1 will systematically review past trends relevant to early warning and rapid response. Recommendations will be developed for rapid dissemination of invasive species notifications within and between countries.

Working Group Two: Trends and analyses on pathways and priority species

The project will bring expertise together to develop innovative approaches to the analysis of population trends and invasion pathways. It will aim to identify ways of controlling introductions and prioritising species for rapid response.

Working Group Three: Trends and analyses on impacts of priority species

To efficiently target early warning and rapid response it is essential to be able to predict the environmental and socio-economic impact of invasive or potentially invasive species. The assessment of impacts has often been done on an ad hoc basis, with unstandardized methods and a local scope. WG3 will review invasive species impacts in Europe and harmonize methods and protocols among countries and categories of species.

Working Group Four: Data standardisation and harmonisation

Guidelines will be developed for the exchange of alien species information. Identifying minimum and desirable data requirements and agreeing ontologies.

RINSE management trials and demonstrations for an invasive evergreen shrub in coastal dunes

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Coastal dunes are a unique ecosystem and home to a large number of red list species. Embryonic dunes, shifting white or fixed grey dunes, humid and wet dune slacks, dune grasslands and moss dunes are high conservation value habitats of European importance. However, many of the dune areas are small and fragmented, making them very susceptible to external influences. Surveys have shown that the surrounding gardens are an important source of invasive plant species occurring in these natural areas. Some of these plants, such as black cherry *Prunus serotina*, *Ribes aureum, Cotoneaster* spp*.* and exotic *Populus* spp. are starting to cause problems for native biodiversity. Detailed monitoring shows that some of these species are starting to display invasive behaviour. Therefore, there is an urgent need amongst conservation managers for detailed data on efficiency of potential management measures. The non-native North American Oregon grape (*Mahonia aquifolium*) is such a species. This evergreen shrub is a very popular garden plant in the area. It grows vigorously on sandy soil along the coast and with its yellow flowers has great ornamental value. However, with its strong clonal growth it can strongly proliferate and overgrow native vegetation. Furthermore, its blue berries are easily spread by birds. Little is known about management of this invasive species. Therefore, within RINSE, an experiment was set up in three heavily infested dune reserves. Individual *Mahonia* shrubs were located with GPS and received different management treatments. Some were manually removed with shovels, some were treated with a glyphosate Roundup Max 5 % formula on the leafs, others were cut and paint with glyphosate or with a saturated salt solution as an environmentally friendly alternative. The direct effect of these treatments in terms of kill rate and vital regrowth will be compared so that a clear advice can be given to the manager of these areas. Besides this field trial, which targets individual plants and small infestations in sensitive areas, a demonstration was held (November 2013) in highly infested areas on mechanical removal using a heavy excavator. Here, invasive shrub (Oregon grape *Mahonia aquifolium* and Japanese rose *Rosa rugosa*) removal was combined with large scale landscape restoration. The effort will be documented (cost, effort, aftercare) and the outcome monitored in terms of regrowth from different depths. This work is performed in cooperation with the Agency for Nature and Forest (ANB). The trials and demonstrations are performed within the framework of the EU co-funded Interreg 2Seas project RINSE (Reducing the Impact of Non-Native Species in Europe) (www.rinse-europe.eu) (2012-2014), which seeks to improve awareness of the threats posed by INNS, and the methods to address them. RINSE also engaged in networking with local stakeholder forums to set up preventive actions towards garden centers, public bodies and private owners. The first comprehensive results of the *Mahonia* field trial are expected in spring 2014.

Integrated management of invasive geese populations in an international context: a case study

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Impact scoring for established non-native birds in Europe has shown Canada goose (*Branta canadensis*) to have the highest environmental, economic (agricultural damage) and social impact. Among the ecological effects are overgrazing, fouling, trampling of vegetation such as reed beds and meadows, bioturbiation of oligitrophic fens and pathogen transmission. Management of invasive geese in the region (western Flanders, eastern Flanders, Zeeuws-Vlaanderen) was, until recently, mainly done by egg pricking and hunting. Within the framework of the EU co-funded Interreg projects Invexo and RINSE, the coordination of egg pricking and hunting was enhanced and additional moult captures (n=131) were performed on a larger cross-border scale. Moult captures were very successful for Canada geese, with a total of 7829 caught between 2010 and 2013. Greylag geese (*Anser anser*), although comparable in density, tended to move away from catching sites during the moulting season. In relation to density, catch success for feral goose (*Anser anser* f. *domestica*) was high. Barnacle geese (*Branta leucopsis*) moult later and were therefore only caught in very low numbers. The reported numbers of Canada geese culled by hunters also increased in the same period with over 7000 birds shot per season. The overall impact of the combined management efforts was assessed by annual simultaneous counts of the geese populations in the region using a fixed sample of counting areas. Trends in the average number of geese per municipality and per year were modelled using gee-GLMs. This showed a significant decrease in the number of Canada and feral goose since the beginning of the project. In east-Flanders, where moult captures were applied most intensively, a significant yearly decrease was noted. Here, the modelled decline was in line with the trend in the absolute numbers of Canada geese which showed a 40 % reduction since 2010. For the species caught in high numbers, the impact was significant over four years, and related to catch effort. Although this approach suggests a link between moult captures and population numbers it also assumes other management efforts to be evenly applied over the project area, which was not the case. When analysed on a larger geographical scale, the number of geese in the entire area hardly decreased in the last year. Recent research indicates that Canada geese disperse over large distances within Europe, blurring effects of a local action over the years. Goose captures were performed within the EU co-funded Interreg Invexo (www.invexo.eu) (2010-2012) and the Interreg 2Seas project RINSE (www.rinse-europe.eu) (2012-2014), which seeks to improve awareness of the threats posed by INNS, and the methods to address them. Future work will be to upscale management and implement adaptive management backed by population models and thorough monitoring. This requires continued investment in prevention, awareness raising and generating public support. At short term, if the result of these actions is to be maintained after the Interreg project RINSE finishes, there is an urgent need for institutional coordination, formalised cooperation between stakeholders and structural funding of this initiative.

Mapping the risk of emerging alien species in the Benelux territory

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Predicting the potential range of emerging alien taxa is essential for assessing the risk of them becoming invasive. Techniques in ecological niche modelling, or species distribution modelling, are instrumental in making such predictions.

We conducted a risk mapping for a selection of emerging alien species in the Benelux. Observation records were collected from a variety of sources. Maximum Entropy (Maxent) was used to model the distribution of each species with presence-only data. A combination of climatic and vegetation predictors were used to construct the species' niches (notably from the MODIS, WorldClim and CRU datasets).

Species for which (1) current distribution maps had not been constructed before, (2) sufficient good-quality observation records were collected by us, and (3) the predictive performance of the models proved 'excellent' (AUC statistic > 0.90) were: *Aedes japonicus* (East Asian bush mosquito), *Carpobrotus edulis* (ice plant), *Diabrotica virgifera* (Western corn rootworm), *Procambarus clarkii* (red swamp crawfish) and *Rhipicephalus sanguineus* (brown dog tick).

The modelled maps for these species are shown on the poster. All species show a medium to high predicted presence in at least some parts of the Benelux. However, while the predicted range appears to be wide for a species like *P. clarkii* (all major rivers from Flanders and The Netherlands), the predicted range for other species seems to be more confined. This may represent clear natural (*C. edulis*, along the entire Belgian and Dutch coast) or human environments (*R. sanguineus*, mostly confined to cities), or represent rather diffuse distributions (*Ae. japonicus*, scattered among the entire Benelux).

Preliminary observations about the incipient invasion of Alternanthera philoxeroides (Mart.) Griseb. (Amaranthaceae) in Europe

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Abstract. Wetlands are particularly threatened ecosystems and the importance of their conservation has been emphasized internationally. The low endurance and resilience of wetlands cause a faster degradation and biodiversity loss than in other ecosystems. The factors of degradation and loss include infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overexploitation and the introduction of invasive alien species. The Amaranthaceae family is one of the groups with a high incidence of alien taxa in Europe in terms of species richness and invasiveness. Among these, *Alternanthera philoxeroides* (Mart.) Griseb. was recently considered by the European and Mediterranean Plant Protection Organization (EPPO) one of the European alien species that represents management priorities for actions in the Mediterranean Basin since it negatively affects biodiversity in the temporary and permanent wetlands. As part of the study of the genus *Alternanthera* Forssk. in Europe (new edition of the Flora of Italy, and Euro+Med Plantbase projects by D. Iamonico, and alien flora of Belgium project by F. Verloove) we here present some preliminary results concerning the morphology of the species, its ecological preferences (including phenology, preferential habitat, vegetation communities in which the species occurs, etc.), chorology and frequency in Europe, degree of naturalization and impacts.

Development and application of an integrated model to assess the potential distribution of an invasive amphipod species

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Ecological models have been recently used as a new and powerful tool to perform risk assessment of invasive species. Because of the complexity of biological invasions, an integrated and interdisciplinary approach is required to support the risk assessment and understanding of the processes involved. In this study, we used an integrated modelling approach in order to assess the future distribution of *Dikerogammarus villosus*, a highly invasive species, under changing environmental conditions. First, a habitat suitability model was constructed based on a regression tree model, to determine the preferred chemical water quality conditions. Secondly, this habitat suitability model was combined with a chemical water quality model, because it was expected that the suitable habitat would increase with improving water quality. Finally, migration speed, based on a network analysis, was taken into account, to model the spatio-temporal spread of *D. villosus*. According to our model simulations, the species is primarily present in large rivers and canals with a hard bank structure and a moderate to good chemical water quality. With improving water quality due to a decrease in nitrogen and orthophosphate concentration, the species will be able to colonise new habitats rapidly. Based on its calculated average migration speed of 5 km per year, it is expected that within 15 years the species will be able to colonise all main watercourses in Flanders, where the water quality is sufficient and the habitat is suitable. A validation based on the observed presence shows that the model accurately predicts areas with a high suitability for *D. villosus*. Our integrated modelling approach is useful as a practical method to perform risk assessment for areas vulnerable to invasion.

Detection of invasive plant species and assessment of their impact on ecosystem properties through remote sensing (DIARS)

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The biodiversity conservation policy of the European Commission includes the development of warning and rapid response systems for biological invasions and urges further investigations of their impacts on ecosystem function and services. However, solely field-based approaches to mapping invasive plant species distribution and their impact across landscapes is a time consuming process and potentially subject to observation bias. Remote sensing provides a systematic, objective, and synoptic view on Earth cover. This technique hence offers a great opportunity to target biological invasion and their impact across various spatial and temporal scales. Despite a handful studies, all of them outside Europe, that have followed a remote sensing approach, the use of remote sensing for studying biological invasions is largely underexplored and underused by invasion biologists.
In response to this research need, the DIARS project (funded under the FP7, ERA-NET, BiodivERsA programme) was recently started up bringing together European specialists from both remote sensing as well as ecology. The objectives of this three-year project are twofold. The first objective is to demonstrate and to characterize the ecosystem impact of invasive plant species through the combined use of field data and remotely sensed data. The second task is to support monitoring, prediction of spread and risk assessment of invasive plant species as preconditions for management measures and mitigation. The more specific research objectives are to (i) quantify, study and better understand the effects of biological invasion on ecosystem properties, through methods of remote sensing ; (ii) develop and validate an approach to create accurate fine scale baseline maps and predictive models of the distribution of invasive plant species at the landscape scale; (iii) assess possibilities and constraints for generalization across ecosystems and invasive species; (iv) develop and disseminate a toolbox for the detection, mapping and prediction of the distribution of invasive plant species at the landscape scale, and to assess their impact on ecosystem properties; and (v) provide knowledge transfer and a hands-on training for ecologists, conservation biologists, policy makers and landscape managers across Europe.

Pathogen Dilution In The Wadden Sea: How Invasive Species Release Natives From Pathogen Pressure

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It has increasingly been recognized that organisms can interfere with parasitic free-living stages, preventing them from infecting their specified host and thus reducing infection levels. This common phenomenon in freshwater and terrestrial systems has been termed the 'dilution effect'. Here we show that non-host invasive species found in the Wadden Sea can remove free-living parasitic cercariae stages of the digenean trematode *Himasthla elongate* without becoming infected. The species tested resulted in a significant reduction in cercariae over a 3hr time period with the invasive sea weed, *Sargassum muticum*; the Pacific oyster, Crassostrea gigas; and the crab *Hemigrapsus takanoi* resulting in reduction in free-living cercariae by < 87%. The consequences of this reduction mean that there are fewer parasitic stages available to infect the native downstream host, the blue mussel *Mytilus edulis*.