Science for Environment Policy
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SPECIAL ISSUE

Invasive Alien Species

Issue 6 June 2008

Editorial

Controlling a key threat to biodiversity

Aggressive non-native species represent a serious threat to biodiversity and are a major cause of extinction globally. In Europe several invasive alien species (IAS) dominate their new environments, threatening native species with extinction. For example, European red squirrel populations are on the brink of extinction in Italy and the UK, following the introduction of the larger American grey squirrel.

Furthermore, IAS come at a high cost. The American grey squirrel damages trees in the UK, with huge consequences for the timber industry. Alien weeds reduce European agricultural yields and Dutch Elm disease – caused by an introduced fungus - has devastated elm trees in the forests of central Europe. The estimated damage and control cost of IAS amounts to nearly Euro 80 billion each year in the U.S. In Europe, costs reach Euro 9.6 billion per year, but extrapolations from this figure suggest that losses are nearer Euro 12.7 billion. And this is without considering costs of major introduced pathogens, such as HIV or influenza (costing Euro 17 and 27 billion/year respectively).[1]

This thematic issue reports recent advances in our understanding of the impacts of IAS and ways that we can prevent their arrival or mitigate their impacts.

Recent research has assessed the impacts of the Japanese knotweed (*Fallopia japonica*). Ousting other plants, it damages habitats and reduces food-supply for insect-eating animals (see: 'Ecosystems threatened by invasive plant species').

Prevention, early-detection and rapid response are the best means of tackling invasive species, but to apply these principles effectively it is crucial to increase our understanding of the patterns of arrival, establishment and spread of alien species (see: 'Which habitats are most at risk from invasive species?', 'Naturalised species may hold key to managing invasive aliens') and to identify the best response strategies (see: 'Cost effective management of invasive predator species').

Another study suggests simplifying the classifications systems for pathways - the routes used by introduced species to colonise new habitats – would facilitate control (see: 'Border control' for alien species: identifying pathways to invasion'). The importance of seawaters and the shipping industry as a route for invasive marine species is discussed in 'Meeting the challenge of invasive species in estuaries and coasts'.

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[1] Kettunen, M., Genovesi, P., Gollasch, S., *et al. In prep.* Technical support to EU strategy on invasive species (IAS) - Assessment of the impacts of IAS in Europe and the EU. Institute for European Environmental Policy (IEEP), Brussels, Belgium. 40 pp. + Annexes.

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Ecosystems threatened by invasive plant species

New research shows that by replacing native vegetation, aggressive plants such as knotweed seriously affect not just plant diversity but whole ecosystems. The study showed that habitats invaded by knotweed supported a lower abundance and richness of insect life, which in turn affects larger insect-eating animals such as frogs and birds.

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"Habitats invaded by knotweed supported a lower abundance and richness of insect life, which in turn affects larger insect-eating animals such as frogs and birds."

Imported in the 19th century from eastern Asia as ornamental plants, knotweed species have rapidly spread, particularly along rivers in the UK and France. River banks are important habitats as they are normally extremely rich in plant and invertebrate life and provide havens for insects and small animals in otherwise intensively used landscapes.

Knotweeds are recognised as among the most aggressive invasive weeds in temperate terrestrial ecosystems. This study compared ten invaded riverbank areas of France, Germany and Switzerland with nearby areas of unaffected native grass and shrub land. It measured the abundance and richness of plants and insect species in the three types of habitat over two years in both spring and summertime and the density levels of the knotweed to find out how far invasive weeds have altered ecosystem patterns and processes.

A greater variety of plant species was found in grassland than in shrub land, but both were more diverse than in knotweed dominated areas. Knotweed invaded habitats had 40 per cent lower insect numbers compared to native grass and shrub land, showing a clear link between replacement of native plant species and the negative impact on insects. However, some native plant species (*Urtica dioica* and *Gallium aparine*) were able to survive inside knotweed areas, and some predatory insects such as spiders were present in equal numbers to native shrubland. However, the authors suggest that predatory insects would have greater difficulty finding food and are thus likely to have lower fitness traits, for example, they may be smaller. At the study sites, there was extremely little evidence of the knotweed being eaten by herbivores, showing that they are probably inedible by European animal species.

The authors point out that large-scale invasions of river banks by knotweed endangers the value of these ecosystems for birds, amphibians, reptiles, mammals and other insect-eating wildlife. However, completely removing knotweed has a high economic cost and is a very difficult operation that needs to be followed up over several years and can also cause undesired effects on native vegetation. The authors suggest low-input management schemes to lower the density of invasive plants may partially reduce the negative impact of the weed.

Source: Gerber, E., Krebs, C., Murrell, C. *et al.* (2008). Exotic knotweeds (*Fallopia spp*) negatively affect native plant and invertebrate assemblages in European riparian habitats. *Biological Conservation*. 141(3): 646-654.

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Which habitats are most at risk from invasive species?

Alien plant invasions are threatening natural ecosystems around the globe, but some habitats are naturally more vulnerable to invasion than others. A recent Europe-wide analysis[1] shows that plant invasions are most common in man-made environments, such as urban landscapes and farmland.

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"In harsh climatic conditions and nutrient-poor habitats, invasion levels are low. Alien plants tend to thrive in nutrient-rich and man-made habitats."

Many conservationists and land managers use the features of the invasive plant itself to predict invasions. However, the new study shows that local habitat characteristics, such as climate, soil nutrients, existing flora and human impact, are better at predicting the risk of biological invasions.

To find out whether particular habitats are more susceptible to invasion by alien species, research teams in the Czech Republic, Spain and the United Kingdom gathered information from the three different European regions. They compiled a database of 52480 vegetation plots spread throughout contrasting climatic conditions and containing a wide range of flora. Catalonia, in north-eastern Spain is a region with predominantly Mediterranean-sub-Mediterranean climate, the Czech Republic located in central Europe has a subcontinental climate while the UK is a region with an oceanic climate.

The teams classified alien species according to whether they arrived before or after AD 1500. This distinction allowed the scientists to compare the proportion of new arrivals in vegetation plots from Mediterranean-sub-Mediterranean, subcontinental and oceanic regions of Europe.

Despite large differences in species, the patterns of habitat invasion were consistent among regions. The study revealed a general trend: in harsh climatic conditions and nutrient-poor habitats, invasion levels are low. Alien plants tend to thrive in nutrient-rich and man-made habitats.

Mountains, cliffs, bogs, dry grasslands and coniferous woodlands tend to resist alien invasion, while coastal and riverine habitats, where nutrient availability and disturbance can be high, are more prone to invasion by alien plants. Human-made habitats such as farmland and urban landscapes also facilitate the spread of alien plants. Besides these, the most invaded habitats include broadleaved deciduous forestry plantations, forest clearings or riverside willow scrub habitats. In the UK, coniferous woodland has a high proportion of invading species because the trees themselves are not native (native conifer plantations outside the UK are normally at low risk of invasion). In the Czech Republic, the study found a high proportion of aliens on urban walls.

Nature conservationists and land managers can combine the robust patterns identified in this analysis with landcover maps currently available in Europe to project the risk of invasion to other European regions. The study's findings can also make a considerable contribution to modelling future scenarios of land-use and climate change to help identify those areas at highest risk of invasion.

Source: Chytrý, M., Maskell, L.C., Pino, J. *et al.* (2008). Habitat invasions by alien plants: a quantitative comparison among Mediterranean, subcontinental and oceanic regions of Europe. *Journal of Applied Ecology*. 45: 448-458.

[1] This work was supported by the European Commission's Sixth Framework Programme, under the Integrated Assessing LArge-scale Risks for biodiversity with tested Methods (ALARM) project: www.alarmproject.net.

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Naturalised species may hold key to managing invasive aliens

Alien species, introduced outside their natural range, can become invasive with the potential to cause damage to the ecosystem of the invaded area. Researchers have suggested that more intercontinental collaboration and funding could provide needed research on under-studied countries and 'naturalised' species across the world.

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"Further investigations should be carried out on naturalised species, as these can potentially reveal the mechanisms required for the transition from introduced species to naturalisation to invasive status."

Invasion biologists are particularly concerned with understanding the common principles that determine how introduced species turn into invasive species. Such information could be used to develop more effective policies to control invasions. However, researchers suggest that there are important knowledge gaps, as not all invasive species have been thoroughly studied and some geographic areas have received little research attention.

The study[1] found a clear bias towards research on North American and European species. Almost half of all invasive species studied were in North America. Fewer studies have been conducted in Australasia and on oceanic islands, although these areas contain high numbers of naturalised species. An alien species may become naturalised if it forms populations that can survive without human-help. However, it may not yet be 'invasive'. To be classified as invasive, a species must adapt to overcome barriers in the new environment, such as, for example, a lack of its natural food source or dispersal agents. Naturalisation is therefore an important intermediary stage in the invasion process.

Except in South Africa, relatively few detailed studies have been conducted in Asia and Africa, although these regions have many naturalised species. The researchers suggest that thorough studies from a wide variety of habitats around the world are important, because different processes may determine whether species become naturalised in different regions.

Besides identifying a geographical bias in the study of naturalised species, the research also suggests that the number of studies conducted on individual species was weighted towards species that have already become highly invasive. The researchers suggest that further investigations should be carried out on naturalised species, as these can potentially reveal the mechanisms required for the transition from introduced species to naturalisation to invasive status, even though the impact of naturalised species is less than that of invasive species.

Important developments are taking place, however. The DAISIE[2] project delivered an inventory on invasive species found across Europe. The international partners in the ALARM[3] project assess large scale risks for biodiversity, including those from biological invaders.

As a direct consequence of globalisation, the spread of invasive species is set to rise. Developed nations probably have the highest proportion of invasive species, because they have a long history of international trade which facilitates the spread of alien organisms. Further research is needed, particularly in many developing nations as they become part of the international trading network.

Source: Pyšek, P., Richardson, D.M., Pergl, J. *et al.* (2008). Geographical and taxonomic biases in invasion ecology. *Trends in Ecology & Evolution*. Doi:10.1016/j.tree.2008.02.002.

[1] This study is supported by the European Commission's Sixth Framework Programme, under the projects Delivering Alien Invasive Species Inventories for Europe (DAISIE) and Assessing LArge-scale Risks for biodiversity with tested Methods (ALARM).

[2] For more information on the DAISIE project see: www.europe-aliens.org

[3] For more information on the ALARM project see: www.alarmproject.net

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Cost-effective management of invasive predator species

Predators, which have been introduced to an area intentionally or by accident, can threaten native prey-species with extinction. A recent study found that immediate eradication is the most successful strategy for controlling non-native predators. However, in cases where this is not possible, keeping predator numbers below a predetermined upper limit is the most cost-effective method of control.

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"It is easiest to reduce predator numbers when the population is high because it is easier to find individuals than in low density situations."

Using a modelling approach, researchers compared the pros and cons of five different management strategies designed to eliminate or control introduced predators. The strategies were evaluated to explore their ability to reduce the threat to native species and to assess their cost-effectiveness. In addition, the success of each strategy was examined under ideal conditions (when removal targets are achieved) and also when management was only partially successful in meeting the intended removal targets.

The five strategies were:

- **immediate eradication** - this aims to completely remove the predators as soon as possible
- **fixed-number control** - this is the removal of a set number of predators, and is often chosen when finances are limited; it may eradicate predators if numbers are small
- **fixed-rate control** - this is the annual removal of a fixed percentage of predators which limits the growth in population
- **upper-trigger harvest** - occurs when the predator numbers rise above a certain level and is used to keep predator populations at an acceptable level
- **lower-trigger harvest** - occurs when the predator numbers fall below a predefined level and is used to eradicate small populations of predators

Overall, the researchers found that, with sufficient funding, the immediate eradication of predators was the most effective strategy for reducing the threat to prey-species, even if the predator was not completely eradicated.

In situations where complete removal of predators is not possible and there are limited funds available for conservation efforts, the research suggests that the upper-trigger harvest method is preferred from both a cost and efficacy point of view. This is because high density predator populations have the greatest impact on native species. At the same time, it is easiest to reduce predator numbers when the population is high because it is easier to find individuals than in low density situations. This suggests that targets for reduction in predator population size can be more easily met and that reductions in predator numbers will have a greater benefit for native species.

Source: Baxter, P. Sabo, J.L., Wilcox, C. *et al.* (2008). Cost-Effective Suppression and Eradication of Invasive Predators. *Conservation Biology.* 22(1): 89-98.

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'Border control' for alien species: identifying pathways to invasion

Invasive Alien Species (IAS) pose a serious threat to biodiversity which needs to be addressed at both global and EU level. New research suggests new classifications of pathways for invasion that may help develop policies to tackle IAS.

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"The most common route of invasion by vertebrates is deliberate release, while most invasive invertebrates arrive as the result of contamination."

Pathways are the processes by which alien species are introduced from one location to another. The researchers designed a new framework[1] that analyses invasion pathways used by a wide range of species – vertebrates (e.g. mammals, reptiles and birds), invertebrates (e.g. insects), plants and micro-organisms – in both land and aquatic environments. Their simplified framework reduces the variety of pathways down to a manageable six classifications. These are:

- Deliberate release – game animals, biocontrol agents or plants used to shape landscapes
- Escape – from gardens, aquaculture or zoos
- Contamination – plants, pathogens and pests that are unintentionally transported
- Stowaway – in ballast water, cargo and airfreight
- Corridor– (e.g. roads, canals) which highlights the role transport infrastructures play
- Unaided – the natural spread of an alien species from another region where it is not native

The most common route of invasion by vertebrates is deliberate release, while most invasive invertebrates arrive as the result of contamination. Plants are most likely to spread due to escape from gardens and parks. Micro-organisms, diseases and fungi tend to arrive as contaminants of their hosts, such as grain or timber imports. Invasions through transport corridors such as canals, bridges, tunnels and roadsides are important pathways that are often underestimated.

The Convention for Biological Diversity has identified a number of pathways that are currently not subject to legislation. These include hull-fouling, air transport, scientific research, tourism and the pet trade. However, developing legislation for each one of these pathways is a challenge. A simpler means of regulation would be to categorise each pathway into one of the six classes proposed by this study. The researchers suggest that overarching legislation could then be developed based on the shared properties of the pathways. This would account for the type of invasion pathway and means of transport, as well as identifying who is responsible for the species introduction (exporters, carriers, or infrastructure developers) and effects of the introduction.

The proposed framework positions scientific findings on invasive species and the six main pathways within the context of current regulations such as the Convention on Biological Diversity, International Codes of Conduct on Fisheries and Biocontrol and EU Directives on Birds and Habitats. The researchers point out that legislation designed to cope with past invasion scenarios may not be effective in addressing future threats since historically most invasions arose from releases, escapes and contaminants, but now an increasing proportion arrive as stowaways, along corridors or unaided from neighbouring countries.

[1] This research was supported by the European Commission's Sixth Framework Programme, under the Assessing LArge-scale Risks for biodiversity with tested Methods (ALARM) project. For more information visit http://www.alarmproject.net/alarm/ .

Additional information: A helpful review of alien invasions in Europe was published in 2007. Entitled 'Biological Invasions in Europe: Drivers, Pressures, States, Impacts and Responses', it can be downloaded from here (third chapter): http://www.springer.com/life+sci/ecology/book/978-0-85404-251-7?detailsPage=toc.

Source: Hulme, P., Bacher, S., Kenis, M. (2008). Grasping at the routes of biological invasions: a framework for integrating pathways into policy. *Journal of Applied Ecology*. 45(2):403-414.

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Meeting the challenge of invasive species in estuaries and coasts

Invasive alien species pose a significant threat to estuaries and coasts where they cause both ecological and economic damage. New analysis identifies significant knowledge gaps in both science and policy and argues that current policies for managing such invasions are ineffective.

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"The best way to tackle invasive species is through prevention, early detection and rapid response. Only if these fail should the emphasis shift to eradication and control."

Estuaries and coasts are particularly susceptible to invasion from non-native, or alien, species, because they are centres for activities which facilitate the spread of non-native species. For example, shipping may spread non-native species when ballast water (stabilising water in a ship's hull) is emptied into the marine environment, often thousands of miles from where it was first taken into the ship. There is also a risk of non-native invasions from species attached to the hulls of ships as well as accidental releases from fish farming, the aquarium trade and the live seafood and bait industries.

A new analysis combining scientific information, policy and cost analysis suggests that invasive alien species are not receiving the attention they deserve from scientists, policy-makers and managers alike. The researchers argue that the best way to tackle invasive species is through prevention, early detection and rapid response. Only if these fail should the emphasis shift to eradication and control, which are usually more costly.

Although the analysis notes that the Convention on Biological Diversity (CBD) and the Codes of Practice on the Introductions and transfers of Marine Organisms set by the International Council for Exploration of the Seas[1] are among the most comprehensive codes of practice, it is also highlighted that these instruments are not binding and carry no penalties for non-compliance. Furthermore, the analysis highlights that when countries seek to regulate introductions, they must do so without hindering trade. Lobbying from trade groups has also been effective in stopping legislation designed to reduce the risk of invasion. In the USA for example, attempts to ban an entire group of seaweeds failed as a result of lobbying by the aquarium industry.

The absence of effective prevention strategies means that in many cases the only options available are eradication and control. The researchers suggest that for invasive species, eradication is usually less expensive than prolonged control programmes, provided the invasion is in the early stages. Examples of successful eradications include the seaweed *Macrocystis pyrifera* in the USA and the mussel *Mytilopsis sallei* in Australia.

Moving forward, the researchers note that the current species by species approach to prevention is not very effective. Further research is needed to improve prevention strategies, such as trait-based approaches, which use previous invasion history in the world to predict species which could pose an invasion threat. Another approach is habitat matching, which screens undesirable species based on how closely their native habitat matches the habitat under threat. New technologies that allow early and rapid detection of invasive species combined with regular monitoring would also increase the chances of successful eradication.

[1] To read the code of practice, download: http://www.ices.dk/reports/general/2004/ICESCOP2004.pdf

Source: Williams, S. L., Grosholz, E.D. (2008). The Invasive Species Challenge in Estuarine and Coastal Environments: Marrying Management and Science. *Estuaries and Coasts*. 31: 3-20.

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A selection of articles on Invasive Alien Species from the *Science for Environment Policy* News Alert

Microwaves could stop alien invaders (12/6/08)

Invasive alien species (IAS) represent a serious threat to biodiversity both in Europe and worldwide, with associated economic impacts. One important EU goal is to halt the decline of biodiversity by 2010. Now scientists have developed and tested a new, inexpensive system to kill unwelcome plant and animal species that get a free ride in merchant ships.

Controlled forest fires could kill invasive tree disease (15/5/08)

In a new study, researchers examined the potential influence of human-driven changes in land-use on disease establishment in forests. The research suggests that changes in forest management, which encourage greater and more dense forest cover, are creating environmental conditions that promote disease.

Invasive species pose global threat to marine biodiversity (24/4/08)

Invasive marine species, whether accidentally or deliberately introduced, have transformed coastal marine habitats around the world. Once introduced, they are almost impossible to eliminate. A global assessment of the impact of invasive species on marine diversity found that interception and removal of routes used for colonisation by invasive species are the most effective strategies for reducing future impacts.

Public Awareness and Policy Effectiveness: the Case of Alien Species (06/12/07)

Non-controlled invasive alien species are posing a major threat to ecosystem balance. Scientists have recently determined that socio-demographics factors, as well as the kind of species and the method used, are significant criteria to take into account when designing alien species control and eradication policies. Raising awareness and educating the general public should then become a priority in order to enhance the acceptance and success of such policies.

To view any of these articles in full, please visit: http://ec.europa.eu/environment/integration/research/newsalert/chronological_en.html, and search according to article publication date.

Additional information

LIFE projects combat invasive alien species

The LIFE programme has made an important contribution to the management of invasive alien species (IAS), in terms of both the number of projects and the overall expenditure, as highlighted in a recent report from the EEA. From 1992-2006, the EC co-financed on average 12 IAS-related LIFE projects per year, at an average cost of Euro 230,000 each, corresponding to a budget of almost Euro 3 million per year. The LIFE-Focus brochure 'Alien species and nature conservation in the EU: The role of the LIFE programme' describes these innovative projects and highlights successful strategies on how to deal with IAS. Download the LIFE brochure at: http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/nat.htm#alien EEA report: http://ec.europa.eu/environment/life/news/newsarchive2008/may/index.htm#alien And find a IAS-related compilation of LIFE projects here: http://ec.europa.eu/environment/life/themes/animalandplants/lists/alienspecies.htm

A pan-European inventory of invasive alien species

The Delivering Alien Invasive Species In Europe (DAISIE) project, funded under the European Commission's Sixth Framework Programme, provides a 'one-stop-shop' for information on biological invasions in Europe on its website: www.europe-aliens.org. Delivered via an international team of leading experts and an extensive network of European collaborators and stakeholders in the field, the site hosts an inventory of invasive species that threaten European terrestrial, fresh-water and marine environments. Continually being updated, users can search for information on any one of the 8996 alien species currently occurring in Europe.