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Invasive alien species indicators in Europe

A review of streamlining European biodiversity (SEBI) Indicator 10

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Contents

Acronyms and abbreviations

ADNS	Animal Disease Notification System
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AHTEG	Ad Hoc Technical Expert Group
ALARM	Assessing Large Scale Risks for Biodiversity with Tested Methods
AMAP	Arctic Monitoring and Assessment Programme
BIP	Biodiversity Indicators Partnership
BPL	Biopollution Level
CABI	Centre for Agricultural Bioscience International
CBD	Convention on Biological Diversity
CIESM	Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties
CORDIS	Community Research and Development Information Service
COST	European Cooperation in Science and Technology
DG	Directorate-General
DAISIE	Delivering Alien Invasive Species Inventories for Europe
DPSIR	Driving Forces-Pressures-State-Impacts-Responses
EASIN	European Alien Species Information Network
EEA	European Environment Agency
Eionet	European Environment Information and Observation Network
EPPO	European and Mediterranean Plant Protection Organization
EQSD	Environmental Quality Standards Directive
ESENIAS	East and South European Network for Invasive Alien Species
ETC/CCA	European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation
ETC/IMC	European Topic Centre on Inland, Coastal and Marine Waters
EU	European Union
FP6, FP7	Sixth Framework Programme, Seventh Framework Programme
GBO	Global Biodiversity Outlook

GDP	gross domestic product
GISP/GISD	Global Invasive Species Programme/Global Invasive Species Database
GMO	genetically modified organism
HCMR	Hellenic Centre for Marine Research
HELCOM	Helsinki Commission
IAS	invasive alien species
IBA	Important Bird Areas
IBPR	Integrated Biological Pollution Risk
IEEP	Institute for European Environmental Policy
IPA	Important Plant Areas
ISC	Invasive Species Compendium
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre
LIFE/LIFE+	L'Instrument Financier pour l'Environnement
MA	Millennium Ecosystem Assessment
MSFD	Marine Strategy Framework Directive
NOBANIS	European Network on Invasive Alien Species
OCTs	overseas countries and territories
OECD	Organisation for Economic Co-operation and Development
OMR(s)	outermost region(s)
RLI	Red List Index
ROD	Reporting Obligations Database
RTD	Research and Technological Development
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SEBI 2010	Streamlining European 2010 Biodiversity Indicators
STREP(s)	Specific targeted research project(s)
TRACES	Trade Control and Expert System
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
WFD	Water Framework Directive

Authors and acknowledgements

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Other contributors

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1 Introduction

Invasive alien species (IAS) are plants, animals, fungi and microorganisms whose introduction and/or spread outside their natural past or present ranges pose a risk to biodiversity or have other unforeseen negative consequences. According to the most recent global analysis of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, IAS constitute the fifth most severe threat to amphibians, the fourth to reptiles, the third to birds and mammals, and the second to freshwater fish species (Vié et al., 2009). Previously, IAS have also been recognised as the second most important threat to biodiversity at the global level (after direct habitat loss or destruction) (CBD, 2001; MA, 2005). They also represent a serious impediment to conservation and the sustainable use of biodiversity, and have significant adverse impacts on the goods and services provided by ecosystems, both globally and in the European Union (EU) (Vilà et al., 2010; Vilà et al., 2011).

Moreover, invasive alien species have detrimental effects on animal and human health, with considerable consequences on the well-being of people, including fatalities, but also cause personal and economic costs due to medical treatment and sickness absences. Furthermore, IAS have negative impacts on different economic sectors by reducing productivity (e.g. agriculture, forestry, fisheries), blocking waterways and hindering navigation and may reduce the recreational and aesthetic value of areas (e.g. Kettunen et al., 2009 and Vilà et al., 2010). Even the crudest estimate of monetary impact of alien species in Europe (costs of damage and control) exceeds EUR 12 billion annually (Kettunen et al., 2009), but this is an underestimate, as potential economic and environmental impacts are unknown for most of the alien species present in Europe (Vilà et al., 2010).

The continent-wide assessment of the scale and impact of biological invasions in the 'Delivering Alien Invasive Species Inventories for Europe' (DAISIE) project (DAISIE, 2012) ([1]) revealed that more than 11 000 alien species occur in Europe; more than half of these are terrestrial plants. One clear message of recent scientific research is the increasing and accelerating trend of new introductions of alien species into Europe across all taxonomic groups and environments (DAISIE, 2009). This corresponds to a global pattern (Butchart et al., 2010; McGeoch et al., 2010),

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([1]) The main geographic area covered by the DAISIE European Alien Species Database is the continent of Europe. For terrestrial species, this includes all countries (including islands) within the continent of Europe, as well as Greenland. For coastal aquatic groups, coastlines of all European countries are included, as well as countries on the Mediterranean Sea (e.g. countries of western Asia and north Africa).

indicating that in the foreseeable future, the numbers of alien species as well as their impact will increase. This trend is predicted to continue, along with the further spread of already established species and the establishment of not-yet-established species (Essl et al., 2011). However, due to certain constraints and methodological difficulties (e.g. limited data availability, definition of terms and delimitation ambiguities), robust and sound 'alien indicators' have only recently become available or come under scrutiny.

One major constraint is the definition of invasiveness, because to date, experts have been unable to concur on the terminology (e.g. Genovesi et al. (2012)). Ricciardi and Cohen (2007) summarised the situation: 'The term "invasive" has been used to describe inter alia: (1) any introduced non-indigenous species; (2) introduced species that spread rapidly in a new region; and (3) introduced species that have harmful environmental impacts, particularly on native species. The second definition in various forms is more commonly used by ecologists, while the third definition is pervasive in policy papers and legislation.'

To support the 'Streamlining European 2010 Biodiversity Indicators' (SEBI 2010) process, the European Environment Agency (EEA) commissioned a study to revisit and further develop the indicator 'Invasive alien species in Europe'. The aim of the current project is to critically review and improve this indicator, and propose an updated methodology. Further, options for methodologies of new indicators, which monitor IAS over time across Europe, will be discussed. Particular attention is given to closely linking the indicator(s) to recent biodiversity policy goals and developments.

2 The SEBI 2010 process and indicator 10

2.1 The SEBI 2010 process

The SEBI 2010 process is a pan-European initiative, launched in 2005. The aim was to develop a set of biodiversity indicators (both existing and new), corresponding to the 'Driving Forces-Pressures-State-Impacts-Responses Framework' (DPSIR) (McGeoch et al., 2010), that are able to offer information on progress towards the 2010 target 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth'. Technical specifications of the proposed indicators were published in 2007 (EEA, 2007). At the end of the first phase of the process in 2008, 26 indicators were sufficiently developed (including methodological fact-sheets (EC, 2008)) and 22 were filled with data. These indicators were presented at several occasions, e.g. as an annex to the Communication *A mid-term assessment of implementing the EC Biodiversity Action Plan* (EC, 2012b). The indicators were published as the first indicator-based assessment of progress towards the European target of halting biodiversity loss by 2010 by the EEA in 2009 (EEA, 2009) and their importance has been highlighted recently (EEA, 2012).

With the adoption of the European and global biodiversity targets 2020 (see Chapter 3), it became necessary to review the existing SEBI indicators in the light of new indicator developments, data and discussions. In particular, the question of whether the indicators are able to indicate any progress towards the new biodiversity targets needs careful evaluation. The SEBI coordination team expressed its views recently in a document ([2]) directed to the Ad Hoc Technical Expert Group (AHTEG) on Indicators for the Strategic Plan for Biodiversity 2011–2020 (CBD, 2011a). They emphasised the further development of the indicators in a global context and SEBI's willingness to take a coordinating role for identification of a coherent and transparent set of pan-European indicators to measure progress towards both the Aichi biodiversity targets ([3]), and the targets adopted in Europe with the European Biodiversity Strategy (EC, 2011a).

It is necessary to critically ask how and if indicators are able to answer the posed policy questions. But it is also necessary to ask how the basic functions of an indicator (simplification, quantification, standardisation, communication) are achieved, or what is needed to better achieve them. These fundamental questions were therefore considered in the discussion of existing and suggested 'new' indicators throughout this report.

2.2 Indicator 10 — Invasive alien species in Europe

The expert group on IAS first met in May 2005 at the EEA. The meeting was chaired by Snorri Baldursson and Tor-Björn Larsson, and the group subsequently met repeatedly to discuss and develop the indicators on IAS described below.

Several options for possible indicators were discussed, and subsequently rejected for different reasons (data availability, indicator value, etc.). Five indicators or 'elements of an indicator' were submitted to the SEBI coordination team:

- cumulative numbers of alien species in Europe since 1900;
- the worst IAS threatening biodiversity in Europe;
- impacts/abundance of IAS;
- awareness of IAS;
- cost of IAS.

([2]) http://www.cbd.int/doc/meetings/ind/ahteg-sp-ind-01/information/ahteg-sp-ind-01-inf-07-en.pdf.
([3]) See the Strategic Plan for Biodiversity 2011–2020, adopted during the 10th meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD COP 10) which took place in Nagoya, Aichi Prefecture, Japan, in October 2010.

A fair evaluation of their weaknesses and uncertainties led to the further rejection of three indicators. As a consequence, two indicators were selected for further processing: 'Cumulative number of alien species in Europe since 1900' and the 'Worst invasive alien species threatening biodiversity in Europe'. These two indicators have been selected on the basis of specific criteria, and are currently considered the best available. However, within the strategy outlined for indicator development, the SEBI 2010 Expert Group on IAS strongly emphasised the need to collect and analyse comprehensive information on the issue of EU funding directed towards IAS (EEA, 2007). For this purpose, the EEA commissioned a study aimed at demonstrating trends of EU funding towards IAS, and at further contributing to the development of the methodology for collecting such information to support the work of the SEBI 2010 process (Scalera, 2008).

2.2.1 *Cumulative numbers of alien species in Europe since 1900*

Description: The cumulative number of alien species established in Europe since 1900, illustrated in decades, and given separately for major environments (terrestrial, freshwater, marine) and taxonomic groups (plants, vertebrates, invertebrates).

Method: Data of the first record in the wild of an alien species in the region under study (no multiple counts from different countries) were assigned to decades; data were verified by national experts (including taxonomy); only established species with self-sustaining populations were included.

Data: For the terrestrial and freshwater environments, data were taken from the European Network on Invasive Alien Species (NOBANIS) database, which at that time included data for 11 north European countries. Data for the marine environment covering all European marine waters (Map 2.1 and Figure 2.1) were collated in an expert-based consultation process, including a dedicated workshop.

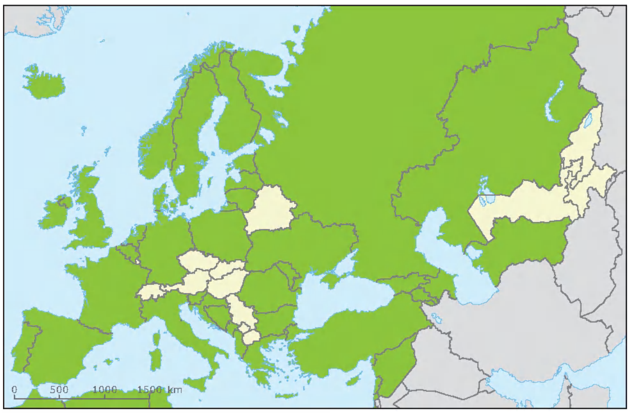
Results: Presentation as histograms without statistical analyses on relationships, trends, and significances. The cumulative decadal bars clearly show that there is a steady increase in numbers of alien species in Europe (Figure 2.1).

Uncertainties: No methodological and data set uncertainties were specified. The main disadvantages of the indicator, however, were recognised as follows:

- Invasive alien species are not distinguished;
- there is limited geographical coverage for the terrestrial and freshwater data set.

Conclusion: The cumulative number of alien species established in Europe served well for the posed key

Map 2.1 **Geographical coverage of the 'Cumulative number of alien species established in Europe since 1900' indicator**



Geographical coverage

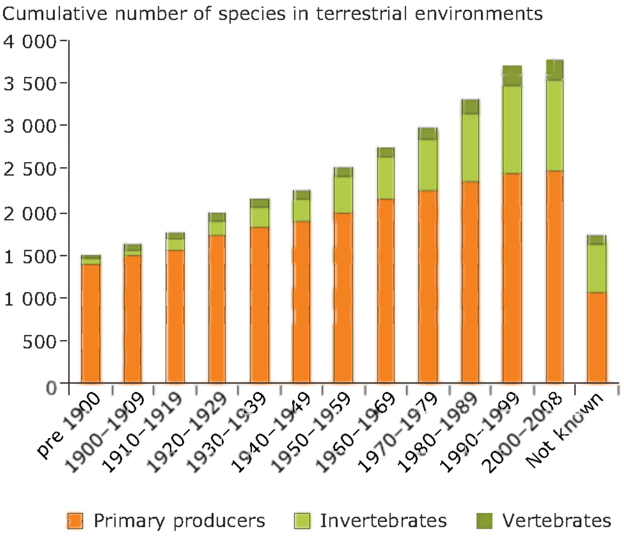
- Marine species
- Outside data coverage

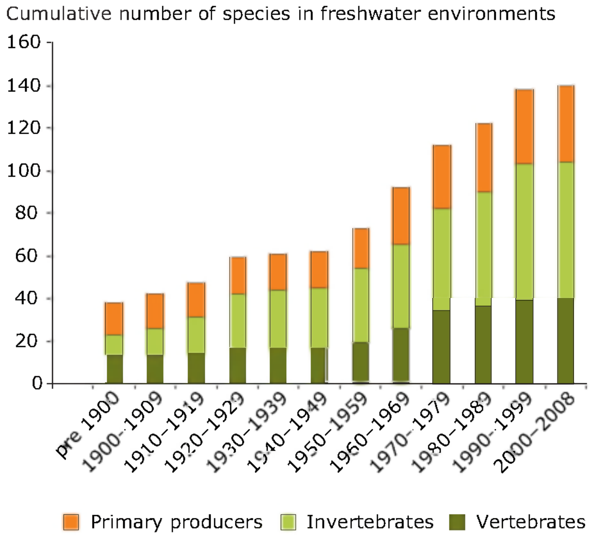
Geographical coverage

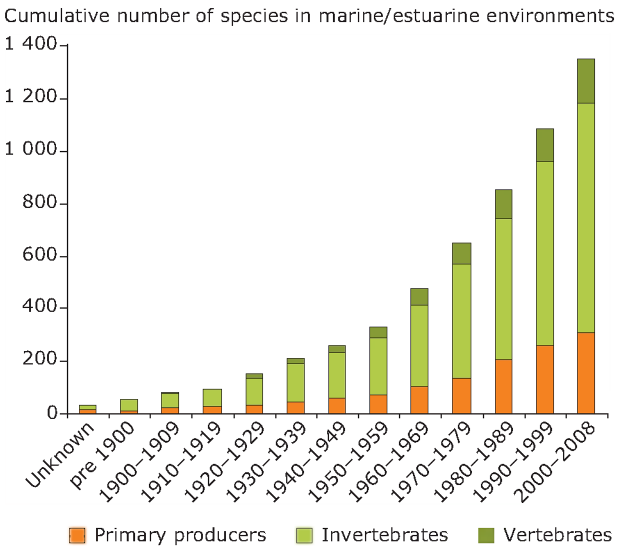
- Terrestrial and freshwater species
- Outside data coverage

Source: EEA-SEBI 2010.

Figure 2.1 Cumulative numbers of established alien species in Europe







Note: First sentence remains the same, but add the following. The geographic coverage for data from the terrestrial and freshwater environments is: Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia and Sweden. For the marine/estuarine environment, the geographic coverage is all European countries with marine/estuarine waters. Casual records are to some extent included. Casual records < 1920 are excluded, as well as casual records that have later not been found again and therefore assumed extinct.

Source: EEA/SEBI2010; NOBANIS; NEMO database for the Baltic http://www.corpi.ku.lt/nemo/, the Black Sea database http://sfp1.ims.metu.edu.tr/, Hellenic Centre for Marine Research database, ALIENS database https://data.aad.gov.au/aadc/biodiversity/, DAISIE http://www.europe-aliens.org/, and experts from France, Spain and Russia made during a dedicated workshop.

policy question: **Is the number of alien species in Europe increasing?** It further fulfilled the purpose of awareness raising and clearly showed that biological invasions continue to occur in Europe.

The options regarding updating and improving this indicator and its suitability towards the new policy targets are discussed in Section 2.4.1.

2.2.2 *The worst invasive alien species threatening biodiversity in Europe*

Description: A list of the worst IAS threatening biodiversity in Europe across environments and taxonomic groups, illustrated as their numbers per country.

Method: The list was developed by expert opinion based on criteria that the species has a serious adverse impact on biodiversity. In this context, 'serious' is defined as, for example, a severe impact on ecosystem structure and function, replacement of native species, hybridisation with native species, or threats to unique biodiversity (i.e. protected species or habitats, or endemic species). In addition to its impact on biodiversity, it may have negative consequences for human activities, on health and/or economic interests. This means that species mainly posing a threat to human interests were excluded.

Data: Based on existing national inventories and other sources, candidates for a tentative list were selected from all environments and taxonomic groups by the SEBI IAS Expert Group. The list was then subject to informal technical consultation involving the Bern Convention's Group of Experts on IAS, contacts at IUCN/GISP, regional networks (NOBANIS, DAISIE) and other experts. In 2006, the final list was made available; it included 163 species. Based on national inventories and other sources, the presence of these species in the countries of Europe was assessed.

Results: The map shows the number of the worst IAS per country, and presents an approximate estimate of their density (Map 2.2).

Uncertainties: In the report sheets, it was explicitly recognised that the list of species is based on current expert view and is therefore subject to debate. Further, it was suggested that the list be updated every five years. No methodological and data set uncertainties were specified. The main disadvantages of the indicator, however, were recognised as follows:

- subjectivity in selection of species;
- limited measurement of precise impacts of IAS.

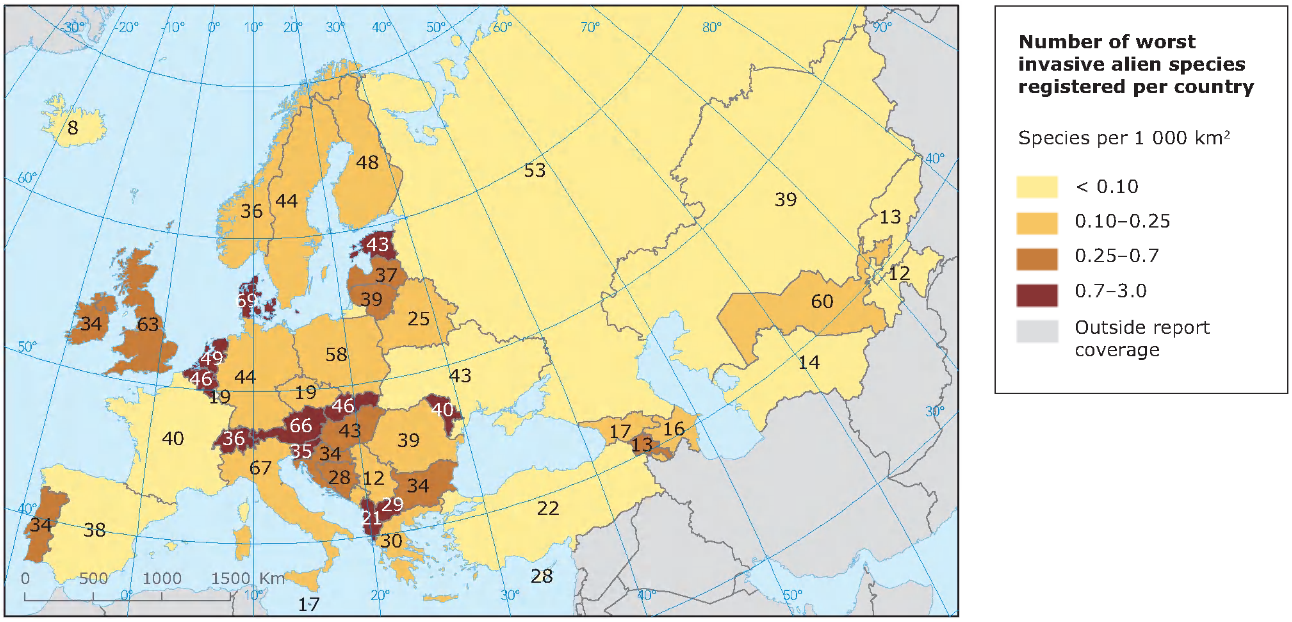
Conclusion: The indicator failed to answer the posed key policy question: **Which IAS should be targeted by management actions?** This is not surprising, because addressing this issue calls for more detailed data, including abundances, impacts, and management options for the species under question. The simple presence of IAS in a country cannot provide an answer as to if an alien species is harmful to biodiversity. In the final assessment, it was noted that '**the main conclusion to draw from the map is that fairly high numbers of listed species can be found in all European countries**'. While this may be a fact, it is not, as mentioned earlier, an answer. The indicator, however, served well for awareness raising (T.-B. Larsson, personal communication, 2 May 2012), and indicated that there is a geographical pattern in biological invasions in Europe. But this indicator has other problematic areas (see Section 2.4.2).

The options regarding updating and improving this indicator and its suitability towards the new policy targets are discussed in Section 2.4.2.

2.2.3 *Abundance and impacts of IAS in Europe*

The rationale behind this indicator was that the presence of an alien species in a country does not provide much information on its impacts, whereas

Map 2.2 Map of the number of the worst IAS per country, and an approximate estimate of their density, presented as number of species per country, per 1 000 km²



Source: EEA-SEBI 2010.

abundance or distribution at finer resolutions has greater explanatory powers. However, due to a lack of detailed distributional information, this indicator was postponed for further consideration. Meanwhile, data availability has improved (e.g. detailed distributional data for '100 of the worst' alien species within the DAISIE project), allowing reassessment of this indicator (see Section 2.4.3).

2.2.4 *Awareness of IAS in Europe*

The threat from IAS is reflected inter alia in awareness campaigns, management actions and governmental policies. The IAS Expert Group aimed to count policy measures by European countries starting from the baseline year 1979, when the Bern Convention was adopted. However, several difficulties precluded complete development of this indicator. A reassessment of the indicator is provided in Section 2.4.4.

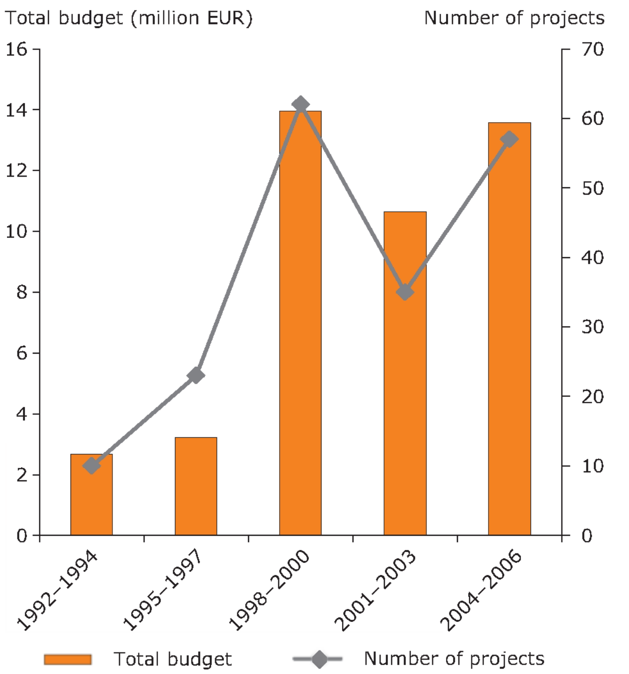
2.2.5 *Cost of IAS in Europe*

Invasion biologists have been asked to put price tags on the impact of alien species. This has prompted a recent surge in analyses and discussions across disciplines, and resulted in many new insights, but has also revealed that this is complex terrain that does not deliver simple answers.

Description: The measures of the budget spent for management and research activities for IAS in Europe since 1992 have been through the two main EU financial tools, for which it seems relatively straightforward to compile cost estimates: the LIFE programme and the RTD framework programmes.

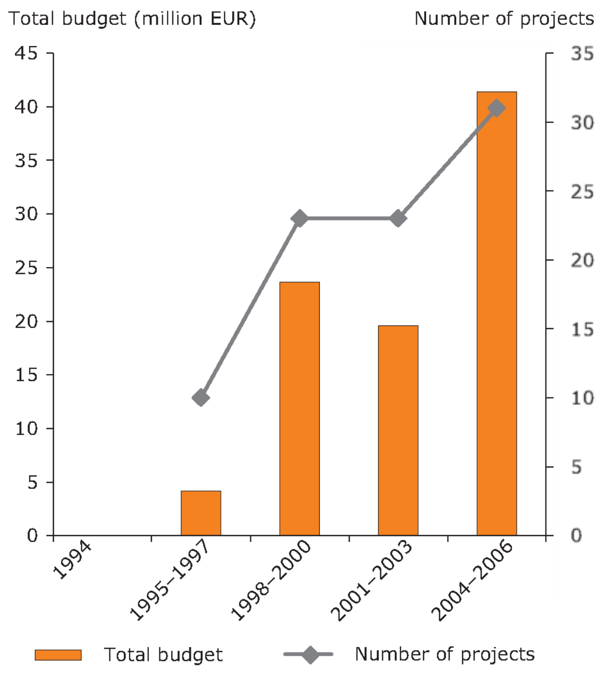
Method: A preliminary data search was carried out through the LIFE and the Community Research and Development Information Service (CORDIS) databases. The data collected in this way have been validated, revised and/or integrated with additional information from the European Commission Directorates-Generals (DGs) for the Environment and Research and Innovation. Additional information has also been collected through direct enquiries to project beneficiaries and, in the case of the LIFE programme, through the European Commission external teams that monitor the implementation of projects on behalf of the European Commission.

Figure 2.2 Number of projects, and budget spent by LIFE for projects dealing with IAS since 1992



Source: Scalera, 2008.

Figure 2.3 Number of projects that include measures dealing with IAS, and relative budget spent by RTD framework programmes since 1994



Source: Scalera, 2008.

Data: The projects were considered as entirely aimed at IAS, either when this issue represented their core activities, or when other associated activities were merely marginal actions or essential accompanying measures (e.g. since the ultimate goal of managing IAS is to ensure the conservation of native habitats and species, in some cases, habitat restoration actions and reintroduction of indigenous species were considered an inherent part of the management of IAS). In the case of projects characterised by a wider spectrum of activities, with IAS constituting a minor part, only the exact cost for the actions specifically directed at IAS (duly extrapolated) was considered.

Results: Presentation as histograms of trends of number of projects and total cost estimates over the years. Aggregating the data into three-year periods suggests an overall positive trend for both the LIFE programme and the RTD framework programmes (Figures 2.2 and 2.3).

Uncertainties: No methodological and data set uncertainties were specified, although it is necessary to take into account the fact that the two financial programmes used for the development of the indicator differ greatly, and therefore it is not possible to extrapolate any definitive conclusion from such analyses. However, the figures regarding the minimum number of projects and the minimum budget spent are derived from simple arithmetical exercises, and for this reason, they are likely to offer a reliable indication of the attention paid to the topic of IAS by resource managers, researchers and public institutions.

Conclusion: As for other response indicators — whose role is primarily to track the measures being implemented to mitigate pressures and improve the state of biodiversity — this indicator shows that the trends concerning both the number of projects funded and the cost estimates are markedly positive. Such trends could be interpreted in the following ways:

- the positive trend regarding the number of projects funded over the years under both the LIFE and the RTD framework programmes could indicate an increasing awareness of the problem, for wildlife managers and scientific institutions, respectively;
- the positive trend regarding the budget spent over the years could indicate an increasing willingness of EU institutions and citizens to pay;
- the positive trend regarding either the number of projects funded or the level of budget spent over the years could indicate that within the EU, the problem with IAS is increasing.

The options regarding updating and improving this indicator, and its suitability towards the new policy targets, are discussed in Section 2.4.5.

2.3 Data sources

2.3.1 NOBANIS

The European Network on Invasive Alien Species (NOBANIS) (NOBANIS, 2012a) is a gateway to information on alien and invasive species in north and central Europe. It covers marine, freshwater and terrestrial environments, and provides a distributed but integrated database on introduced species in the region. As of November 2011, 20 countries and territories participate in NOBANIS: Austria, Belarus, Belgium, Czech Republic, Denmark, Estonia, the Faeroe Islands, Finland, Germany, Greenland, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, the European part of Russia, Slovakia and Sweden. The number of countries participating in NOBANIS has grown over time, and is likely to rise further. Naturally, because of the history of its origin, NOBANIS can only provide a regional picture of biological invasions in Europe.

NOBANIS has a coordinating team, supported by national focal points and a secretary for daily work. This steering committee meets regularly once a year. The distributed national databases are maintained and updated by the participating countries, while the portal is maintained and updated by the secretariat. The costs for the secretariat and for IT support have been allocated initially by the Nordic Council of Ministers and since 2008 by the Danish, Finnish, Norwegian, Swedish, and Dutch governments, and project work, but there is no long-term secured funding or budget for NOBANIS. The contributions of the participating countries, e.g. updating data, participation in meetings, and working time, are usually covered by national funds. Aside from the database, several products are provided, such as a newsletter, species alerts, a marine identification key and comprehensive fact-sheets on selected species. NOBANIS contributes to projects funded by the Nordic Council of Ministers ('Risk mapping for 100 non-native alien species in Europe', NOBANIS, 2012b ([4])) and DG Environment ('A comparative

([4]) http://www.nobanis.org/files/Riskmapping_report.pdf.

assessment of existing policies on invasive species in the EU Member States and in selected OECD countries', EC, 2011c ([5])).

Current (i.e. November 2011) data coverage in NOBANIS is biased. The number of alien species per country ranges from 0 to 2 682. Some countries have uploaded their complete national alien species inventories, while others have included only IAS (according to the country-specific definitions of invasiveness), or have not yet uploaded any data. There is also a bias concerning how current the data are. Whereas some countries regularly update their data, others do not. The dates of the last update range from 2006 to 2012.

The portal provides different query functions, such as searching for scientific and common names, and the possibility to restrict the advanced search to selected taxonomic groups, habitats, pathways, status or invasiveness. The country statistics query produces online pie and bar charts with different filters, e.g. number of alien species, number of alien species by pathway of introduction, or trends in introduction of alien species (= cumulative number of alien species) (see Section 2.4.1). The latter is partitioned into environments (terrestrial, freshwater and marine) and higher taxonomic groups (plants, vertebrates and invertebrates), but includes **all** alien species, whereas the SEBI indicator reports only **established** species. Therefore, queried data do not correspond exactly to the SEBI indicator, although the general pattern does not change.

In conclusion, NOBANIS provides a valuable and almost ready-to-use portal for updating the existing SEBI indicator, but existing data biases should be taken into account when conclusions are drawn from these data at the pan-European scale.

2.3.2 *DAISIE*

'Delivering Alien Invasive Species Inventories for Europe' (DAISIE) (DAISIE, 2012) was a FP6 STREP funded by the European Commission. It aimed to provide a 'one-stop shop' for information on biological invasions in Europe and had to begin from almost nothing, or from widely dispersed data sources for many taxonomic groups. The collation of data, executed by the joint efforts of 83 partners and 99 collaborators, resulted in approximately 11 000 alien species being documented for Europe. The geographical coverage is extensive and includes 94 terrestrial and marine countries/regions (including islands). All taxonomic groups (except most microorganisms) and environments were considered. Access to the data is provided via the Internet portal, which also provides different query functions, such as searching for scientific (not common) names, and lists of alien species, per country/region. Besides the database, other products are provided, such as a searchable expert registry, and short fact-sheets for '100 of the worst' alien species.

Work within DAISIE was organised in five taxonomic/environment subgroups (plants, terrestrial vertebrates, terrestrial invertebrates, freshwater and marine). While useful during the project period, the consolidation of these different subgroups turned out to be an obstacle for the 'one-stop shop'. This is due to the fact that these subgroups encountered different difficulties in data collation and what kind of analyses were possible to do with the available data. In other words, these subgroups proceeded and still work at different paces. DAISIE lacks a stringent organisational structure and decision-taking criteria.

The available online data still include factual (wrong or missing entries) and technical (synonyms) errors that need to be corrected. Coverage in DAISIE is biased to some extent, although no information is available on the degree of this bias.

A major update was launched in September 2012. With the end of the project in 2008, funding ceased, and although work continued within other projects (e.g. for the marine environment in the 2011-to-2015 project 'Vectors of change in oceans and seas marine life, impact on economic sectors' (VECTORS) (VECTORS, 2012) or small grants, there is yet no overarching strategy for further developing/updating DAISIE, either from the European Commission or from the former consortium partners.

An attempt was recently made to apply for a COST Action ('Towards a European information platform for alien species') that aims to integrate existing databases (DAISIE and other national and regional ones) into a European-wide information network. To achieve this, the proposal's main objective is to increase interoperability of the current databases. Towards this goal, a work programme is proposed to contribute to the harmonisation of the

([5]) http://ec.europa.eu/environment/nature/invasivealien/docs/BIO_IASPolicies2011.pdf.

information in existing alien species databases, and to explore undiscovered sources of information, and identify the needs and formats for alien species information by different user groups and for the implementation of an Early Warning and Rapid Response System. This, however, does not necessarily provide continuing support to deliver robust data needed to develop an indicator on alien species.

The criteria for selecting '100 of the worst' alien species by DAISIE were largely based on awareness raising. First, an equal balance between aquatic (48 species) and terrestrial (52 species) environments was agreed upon, then subgroups were allocated more or less equal numbers of species (marine 32, freshwater 16, fungi 3, plants 18, invertebrates 16 and vertebrates 15). The selection of the 'worst' species was designed to cover a broad spectrum of life forms, and to represent some of the impacts on biodiversity, economy, and health.

In conclusion, DAISIE provides a valuable source of information for updating the existing SEBI indicators, but data are not readily available online, and they require careful consideration to suit the purpose.

2.3.3 *Other potential data sources*

In a recent study, Vandekerkhove and Cardoso (2011) compared and assessed coverage of 30 online databases that include alien species occurrences within the territory of the EU. Some of these databases are global in scope (e.g. the Global Invasive Species Database (GISD), FishBase and AviBase), whereas others are regional (e.g. Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée (CIESM) and the European Network on Invasive Alien Species (NOBANIS) or national. Hulme and Weser (2011) compared DAISIE and NOBANIS data across 13 European countries for trends in alien species' richness and correlations among taxonomic groups. Both studies found considerable differences in data and consequently results were database dependent. Hulme and Weser (2011) call for considerable caution in applying collated data from different sources and conclude that Europe should opt for a central pan-European database as soon as possible. Aside from the advantages and disadvantages of national and regional systems that collate data on alien species, clearly, more effort in streamlining these activities is recommended, to prevent existing knowledge from disappearing or becoming unavailable and to avoid the pitfalls of different definitions and criteria, which lead to incomparability of data. Such an effort is currently put forward by the Joint Research Centre (JRC) through its European Alien Species Information Network (EASIN) (EASIN, 2012) initiative. EASIN aims at increasing access to data and information on alien species in Europe by facilitating the exploration of existing alien species information from distributed resources through a network of interoperable web services, following internationally recognised standards and protocols. At present, EASIN covers IAS in marine and freshwater environments. Most of EASIN's functionalities will be operational and open to the public in 2012.

A new regional network that currently is under development is the East and South European Network for Invasive Alien Species (ESENIAS) (ESENIAS, 2012). Its establishment was supported by the EEA and it is expected to provide data similar to that of the NOBANIS network. Currently participating countries are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the former Yugoslav Republic of Macedonia, Greece, Kosovo ([6]), Montenegro, Serbia, Romania (invited country) and Turkey.

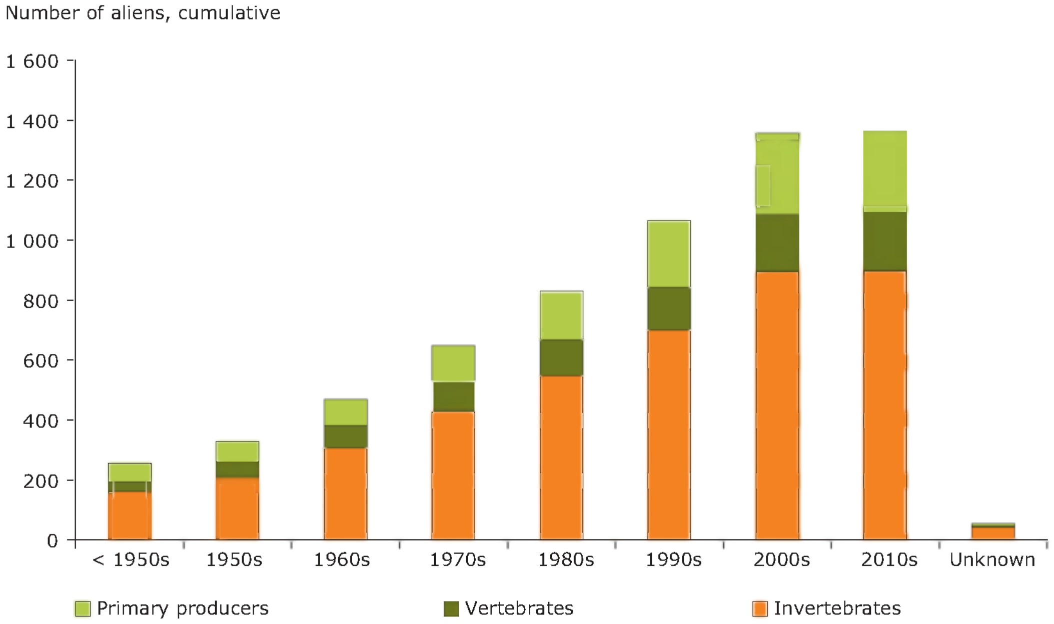
For the marine environment, the pan-European database managed by A. Zenetos (developed within the Hellenic Centre for Marine Research (HCMR) on behalf of the ETC/IMC) currently includes approximately 2 400 species (including freshwater taxa) and 7 300 species records at the country level. The cumulative number of alien species in all European seas (Figure 2.4) can be broken down for countries and MSFD levels.

A potentially new important source of information is the Centre for Agricultural Bioscience International (CABI) Invasive Species Compendium (ISC) (CABI, 2012), which is an encyclopaedic online resource compiling information on all aspects of invasive species. It presents detailed data sheets on more than 1 500 alien species globally, including references, and — according to CABI — it undergoes constant further development and is regularly updated.

The European and Mediterranean Plant Protection Organization (EPPO) website (EPPO, 2012) provides information on quarantine pest organisms and pest risk assessment including an alert list, data on invasive alien plants, and a regular reporting service

([6]) Under UNSCR 1244/99.

Figure 2.4 Cumulative number of alien species in all European seas



Source: A. Zenetos, N. Steftaris and S. Kavadas, unpublished data.

with recent information on new occurrences of organisms within the EPPO region.

Another important source of information, particularly with respect to the monitoring of trends in alien species, is the obligatory reporting requirements of signatory countries to different bodies. Table 2.1 provides an overview of existing reporting obligations in the 'Biodiversity Change and Nature' sector. Although most instruments do not yet explicitly consider alien species in their assessments (with some exceptions ([7]), it may be well worth working towards inclusion of alien species into at least some of these programmes in the future, e.g. as currently under discussion within the Water Framework Directive (WFD) (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy). Vandekerkhove and Cardoso (2010) provided an overview of how Member States deal with alien species in their national assessments; they found a wide range of approaches in use. They concluded that a pan-European index is not currently feasible owing to these different approaches, but found support from Member States for a supplementary biopollution index that does not affect WFD classification (see Section 4.2). However, Atalah et al. (2010) demonstrated that alien species can influence ecological quality assessments, and suggest that ecological metrics may be developed separately for invaded and non-invaded systems. Similarly, the question of how to define and relate alien species to maintain the good ecological/environmental status is pertinent also within the Marine Strategy Framework Directive, and the Habitats Directive (Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora) and Birds Directive, although currently not reflected in the corresponding reporting formats (Article 17 of the Habitats Directive and Article 12 of the Birds Directive). Without doubt, if alien species were to be included in a standardised monitoring programme, the development of a robust alien indicator would be much easier.

In addition, all existing European legal instruments that include reporting obligations should be thoroughly analysed for options to extract standardised information on alien species. For example, the Arctic Monitoring and Assessment Programme (AMAP) (AMAP, 2012) currently has six thematic data centres that 'provide reliable … information on the status of, and threats to, the

([7]) For example in the Bern Convention (1979), the Ramsar Convention (1971), the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds), the Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy).

Arctic environment' in relation to 'anthropogenic pollutants in all compartments of the Arctic environment'. Biological invasions, which can be seen as 'biological pollutants', are not included in this programme, but may affect Arctic environments and indigenous people to a large extent; monitoring these changes may help governments to counteract such threats accordingly. Another example is provided by Eurostat, to which a variety of environmental data (e.g. environmental protection expenditure and revenues, wildlife and forest data), are already reported by Member States: questionnaires may be slightly modified to help address questions related to biological invasion.

This also includes reporting obligations outside the biodiversity/nature-related fields that deal with alien species, particularly in the animal and plant health and aquaculture sectors. For example, Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (EC, 2000) establishes protective measures against the introduction, into the EU (and intra-EU), of organisms harmful to plants or plant products. The Animal Disease Notification System (ADNS) provides detailed information on outbreaks of infectious diseases in animals (under Directive 82/894/EC of 21 December 1982 on the notification of animal diseases within the Community; and Decision 2008/650/EC of 30 July 2008 amending Council Directive 82/894/EEC on the notification of animal diseases within the Community to include certain diseases in the list of notifiable diseases and to delete porcine enterovirus encephalomyelitis from that list). The Trade Control and Expert System (TRACES) is a trans-European network for veterinary health, which notifies and monitors imports, exports, and trade in animals and animal products (under Decision 2002/459/EC of 4 June 2002 listing the units in the animo computer network and repealing Decision 2000/287/EC). Although these instruments are designed and intended to fit other purposes, a simple 'emerging diseases' indicator for awareness-raising purposes may be developed from these data (see Section 5.7), which also is needed to fulfil Aichi Target 9 (see Table 4.1). The Aquaculture Regulation (Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture) established a framework to assess and minimise possible impacts of alien and locally absent species used in aquaculture, including procedures for risk assessment, to ensure adequate protection of aquatic habitats from the use of non-native species.

Table 2.1 Overview (not intended to be exhaustive) of reporting obligations of countries in the 'Biodiversity Change and Nature' sector that are directly or indirectly related to (invasive) alien species)

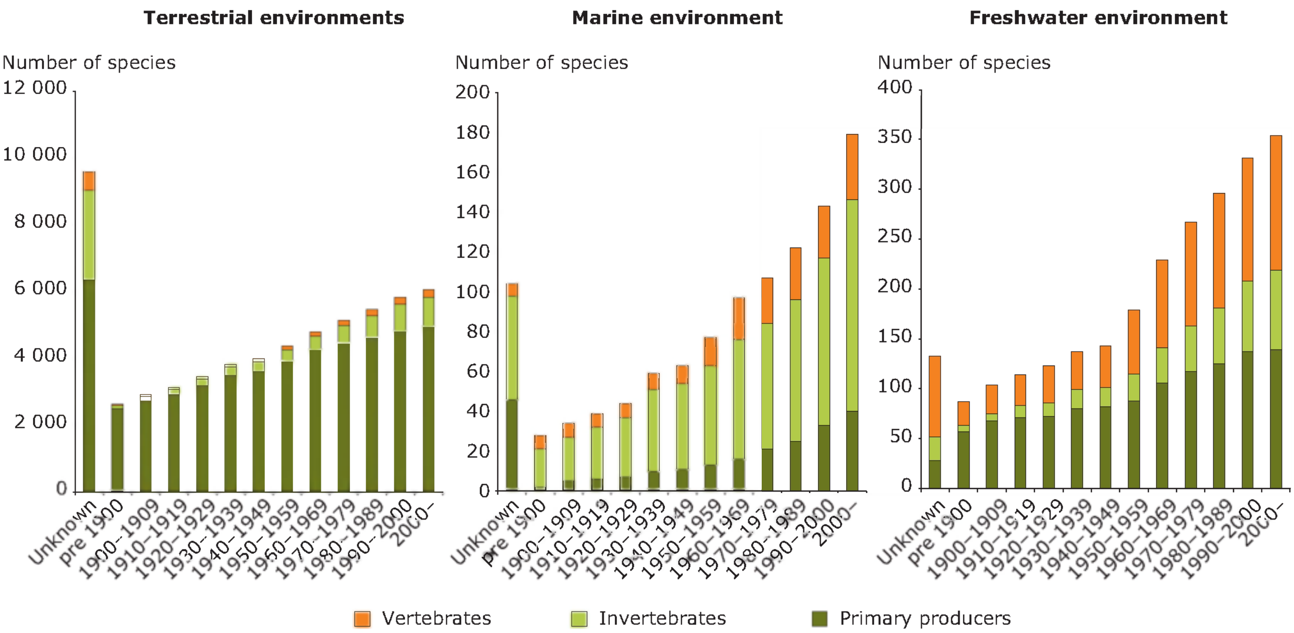
Policy question	Headline indicator	Operational indicator	Aichi target	Other relevant Aichi target
Pressures and underlying causes: Why are we losing biodiversity?	Trends in pressures from habitat conversion, pollution, invasive species, climate change, overexploitation and underlying drivers	Trends in the impact of invasive alien species on extinction risk trends (A)	9	12
		Trends in the economic impacts of selected invasive alien species (B)	9	2, 10
		Trends in number of invasive alien species (B) (decisions VII/30 and VIII/15)	9	10
		Trends in incidence of wildlife diseases caused by invasive alien species (C)	9	12
Responses: What do we do about biodiversity loss?	Trends in integration of biodiversity, ecosystem services and benefits sharing into planning, policy formulation and implementation and incentives	Trends in policy responses, legislation and management plans to control and prevent spread of invasive alien species (B)	9	2, 3, 17
		Trends in invasive alien species pathways management (C)	9	10

Note: Applicability according to CBD terminology (A = Priority and ready for use globally; B = Priority to be developed at global level; C = For consideration at sub-global level) and modified to the SEBI process (A = Priority and ready for use; B = Priority to be developed; C = For consideration).

Source: CBD, 2012.

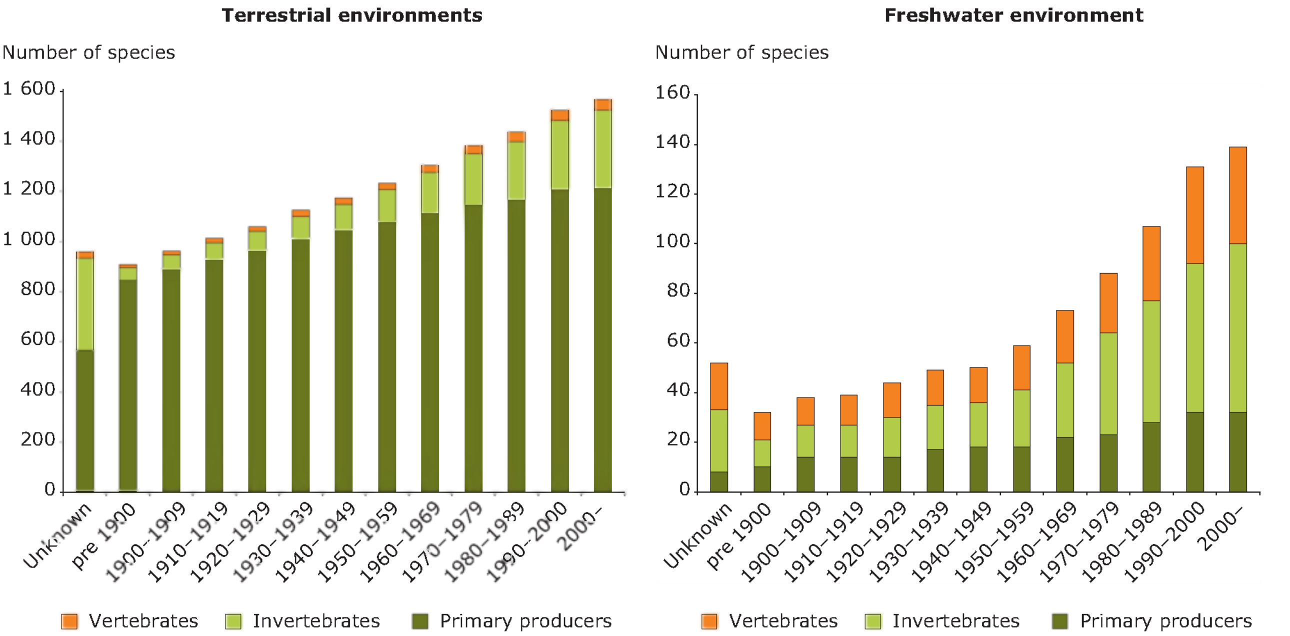
Finally, two important sources of information on IAS at the EU level are the LIFE and the CORDIS databases, which are managed by the European Commission and include detailed information on the projects financed through the LIFE and the RTD framework programmes respectively.

Figure 2.5 Cumulative numbers of all alien species in terrestrial, freshwater and marine environments (data for 17 countries from NOBANIS), automatically produced by the online portal



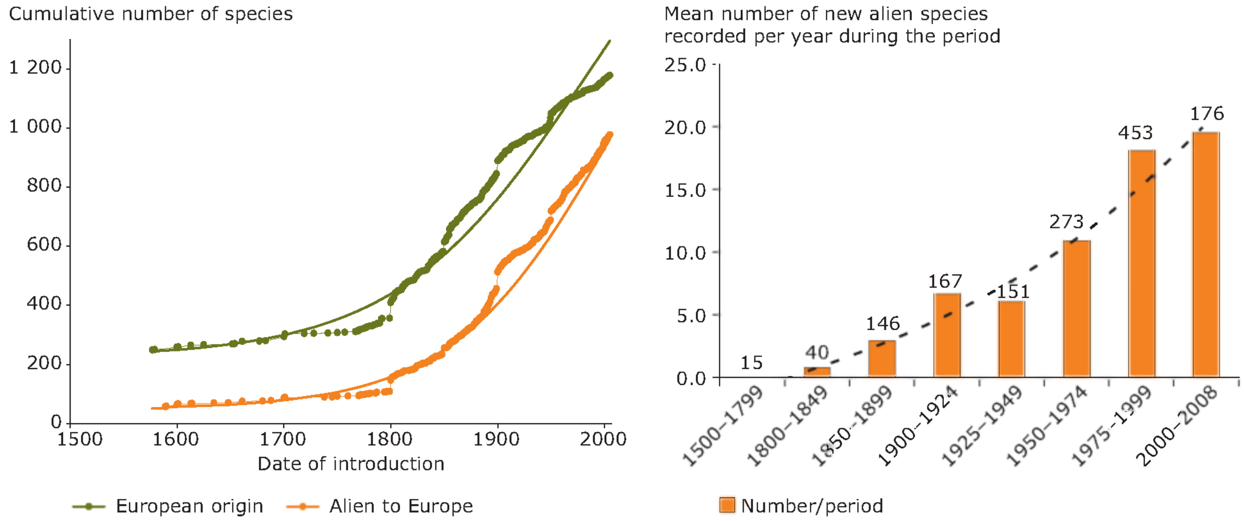
Source: NOBANIS, 2012a.

Figure 2.6 Cumulative numbers of established alien species in terrestrial and freshwater environments, based on original data from NOBANIS



Source: NOBANIS, 2012a.

Figure 2.7 **Cumulative number of introduced alien plant species (left) and mean number of introduced alien arthropod species (right) over time**



Note: In the right figure, the total number of new alien species introduced during the period is given above each column. The line shows the mean number of alien species introduced per year during each period.

Source: Data from DAISIE project, queried August 2012.

2.4 Updating indicator 10

2.4.1 Cumulative numbers of alien species in Europe

Updating this indicator is relatively straightforward, thanks to the availability of new data from the NOBANIS and the DAISIE databases. Based on NOBANIS it is possible to enlarge the geographical coverage from 11 to 16 countries; based on DAISIE it is possible to cover all of Europe (50+ countries and regions). Both databases allow for expansion of the timescale of the indicator from 1900 to 1500, at least for some groups and environments.

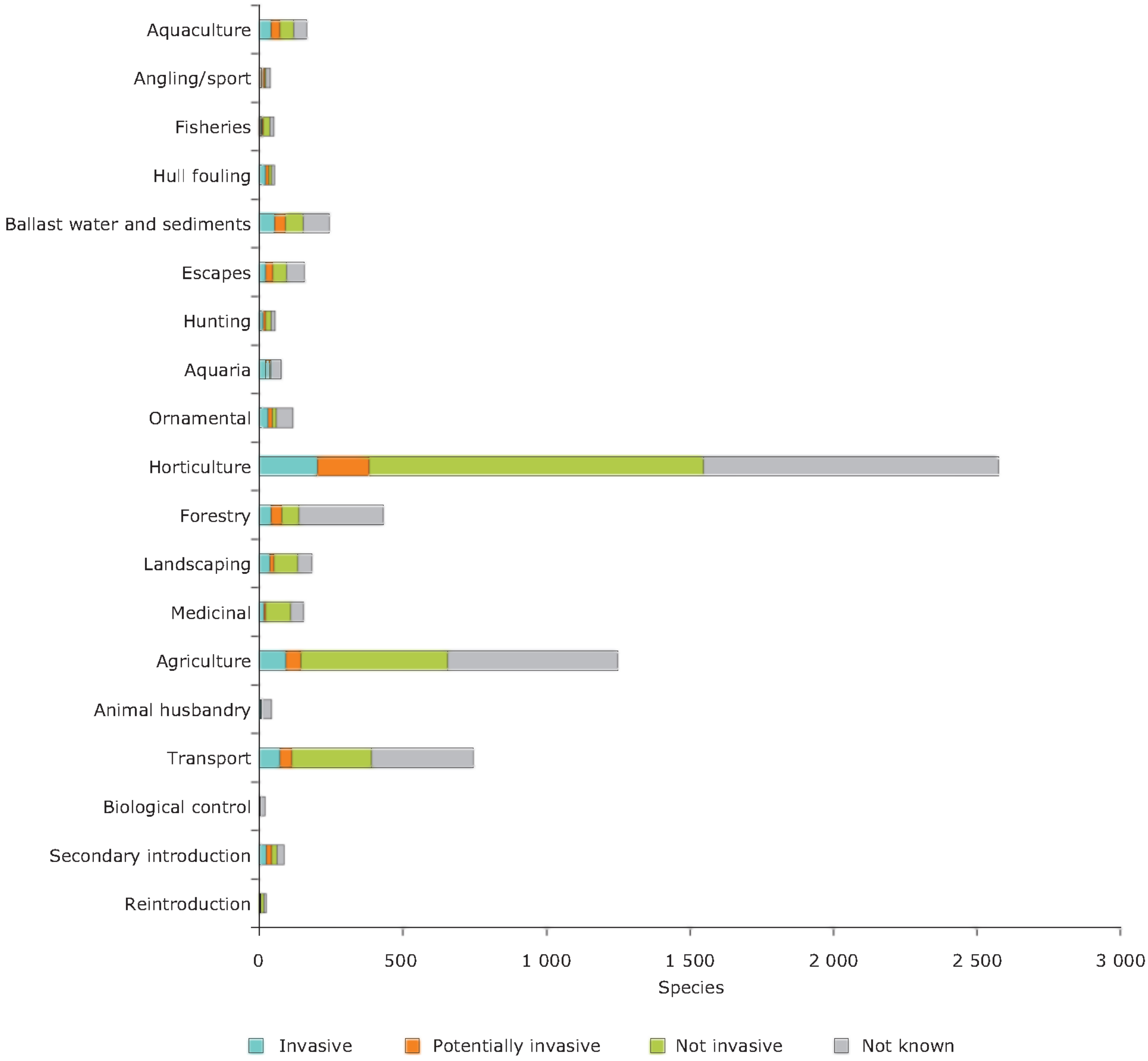
As mentioned above, NOBANIS data are freely available, and figures identical to the SEBI indicator can be generated immediately, whereas DAISIE data are currently more dispersed, although still accessible. The SEBI indicator is constructed separately for the different environments (terrestrial, freshwater and marine) and taxonomic groups (plants, vertebrates and invertebrates) (Figures 2.5, 2.6 and 2.7). Data from both DAISIE and NOBANIS need some preparation (e.g. separating established species, calculation of number of species per decade, different environments and taxonomic groups) (Figure 2.7). Regarding the uncertainties mentioned above, the separation between alien species and IAS is still not included, whereas the geographical coverage is greatly enlarged and now can be considered unquestionably representative for Europe.

The relevance of considering pathways as part of any prevention measure is recognised by explicitly mentioning them in the new biodiversity targets. It is therefore more than advisable to incorporate pathway data within any update of this indicator. NOBANIS and DAISIE both include information on pathways of alien species in their databases, albeit using different terminologies: this information is available, but not harmonised. With the NOBANIS online tools, a query for pathways is a matter of seconds (Figure 2.8), although the connection to decades of introduction may need some work. The latter holds true for the DAISIE data.

The correct assignment of a species to a particular pathway can be difficult, because species have sometimes been introduced by more than one pathway, and different primary and secondary pathways may be relevant as well. The focus for an indicator, however, should be on the primary pathway, to show effects (if any exist) of control or regulative measures.

Following a well-known pattern, pathways have changed over time, usually due to altered consumer behaviours, fashions or economic trends (Hulme et al., 2008). Ideally, such a pattern is related to policy actions and the indicator is sensitive enough to convincingly demonstrate this kind of change. This helps to prioritise pathways and can be executed for all alien species and for a list of selected or 'worst' species. Theoretically, depending on applied pathway categorisations, the cumulative number of

Figure 2.8 **Pathways used by alien species in 17 NOBANIS countries, by different levels of invasiveness (based on countries' criteria) (data for 17 countries from NOBANIS)**



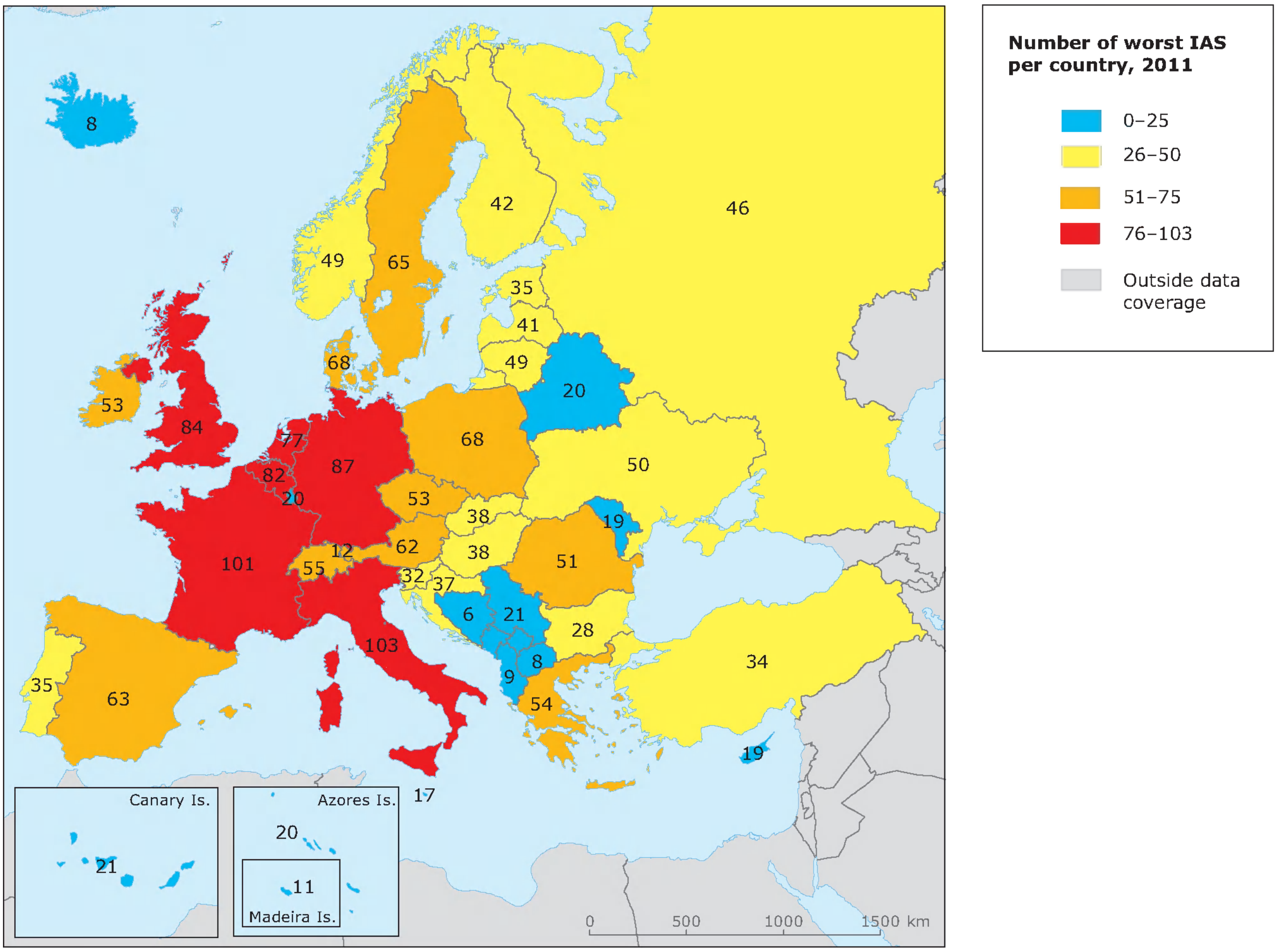
Source: NOBANIS, 2012a.

alien species can be further broken down to specific environments (e.g. number of escaped glasshouse species or alien species in wetlands or urban areas).

Pros of the indicator: Data are available for updating and expanding the indicator. The indicator has very good geographic coverage (it covers all of Europe), environments (all major environments are included), and taxonomy (all major groups are included, with some minor inaccuracy). It is in line with policy question and targets, and easy to communicate. It also takes into account the precautionary principle and avoids the pitfalls of discussions on 'invasiveness'.

Cons of the indicator: Rejmanek and Randall (2004) have shown that numbers of naturalised and IAS are closely correlated. So, the underlying assumption is that this positive relationship between the total number of alien species and the number of IAS also relates to Europe. It appears a well-justified simplification; however, some data cast doubt on the generality of this approach. The sensitivity of the indicator may be not high enough to detect any rate of change towards the 2020 target, and may underestimate a hypothetical decrease in alien species numbers. The presentation of cumulative numbers is a saturation curve even without any management action or policy decision being taken,

Map 2.3 **Updated (but uncorrected) map of the number of the worst IAS per country**



Note: A few of the worst IAS and some countries are not included in DAISIE, and country distributions are known to be incomplete for several species.

Source: Data from DAISIE, queried November 2011.

leading to maximal homogenisation towards the end. However, considering recent timescales, this theoretical assumption seems to be negligible.

2.4.2 *List of the worst IAS threatening biodiversity in Europe*

The presence of species from the list of the worst IAS per country can be easily updated using the online DAISIE database, resulting in a new map of the worst IAS in Europe (Map 2.3). However, this entails some difficulties, due to the current incompleteness of the online DAISIE data set. Comparing the recent DAISIE numbers (Map 2.3) with the previously published numbers (Map 2.2) produces a decrease in numbers for some countries, clearly is artefact due to data quality. Further deviations result from a different geographic coverage (e.g. Turkey and Macaronesia). Updates of this map need to include more sources (including expert opinions) to provide a realistic picture of the worst alien species distribution in Europe.

An option for further development of this indicator could be to provide rates of change instead of added numbers. If the number of the worst IAS per country in the year 2000 or 2010 is considered as baseline, any change (introduction or eradication of IAS) could be illustrated by green (eradication) or red (introduction) shading and corresponding negative or positive numbers. However, the same disadvantage as for the original indicator also applies here: differences in data quality between countries may deliver a misleading pattern.

The list of the worst species was proposed by the SEBI IAS Expert Group, based on a clear and transparent set of criteria, and finalised following a consultation process including Eionet and EEA member countries.

However, it is possible that the list does not fully reflect the impact of IAS on biodiversity in Europe. In addition, many alien species have negative effects on biodiversity, even when not classified among the 'worst'. A finite list does not reflect the dynamics of biological invasions as new alien species continue to arrive in Europe (e.g. the Yellow-legged hornet *Vespa velutina* and the chytrid fungus *Batrachochytrium dendrobatidis*), may increase in relevance (e.g. the tropical marine algae *Caulerpa racemosa*; the Rose-ringed parakeet *Psittacula krameri*), or may represent other types of impact (e.g. the effect of the Asian tiger mosquito *Aedes albopictus* on human health). The SEBI IAS Expert Group was fully aware of the limitations of this indicator: 'The list of worst invasive alien species threatening biodiversity in Europe is not an indicator by itself, but an important basis for more specific indicators focusing on impacts, awareness and economic cost of IAS and, also, a very powerful awareness tool.' It was further suggested that the list should be updated every 5 or 10 years by a group of experts.

The wording was also criticised as inadequate, because of the negative connotations it contained: it was suggested that the term 'worst' could be replaced by 'selected', 'problematic', or 'high impact', for instance.

Pros of the indicator: Data are available for updating the indicator. The indicator has a very good geographic coverage (it covers all of Europe), environments (all major environments are included), and taxonomy (all major groups are included, with some minor inaccuracy). It is easy to communicate to policymakers, stakeholders, and the public. A list of the 'worst' IAS can be used as starting point for further exploration, e.g. prioritisation of management actions and research, detailed mapping of expanding species and impact (monitoring), selecting species for cost estimates, and national early warning systems.

Cons of the indicator: Although progress in data quality has been achieved in the DAISIE project, some gaps in data quality across regions still remain, and the resulting map needs careful assessment if it is to represent a real pattern of the level of invasions in Europe. This appears to be only partly the case for both existing maps (Maps 2.2 and 2.3).

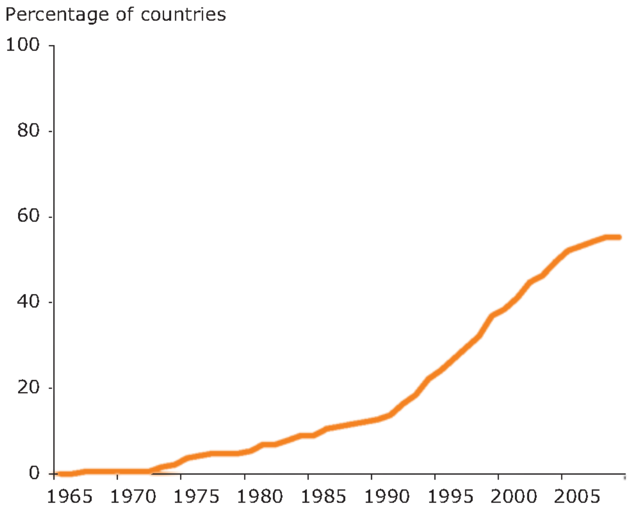
2.4.3 Abundance and impacts of IAS in Europe

The DAISIE project delivered detailed distribution data (50 x 50 km) for some of the '100 of the worst' alien species in Europe. This information could be updated in a concerted action every 5 or 10 years and the change documented, indicating increasing or decreasing impact of IAS in Europe. However, whereas new occurrences are easily documented (depending on the species), the decline or even disappearance/eradication of an alien species within a grid cell of this size is almost impossible to verify. This means that this indicator is biased towards increasing abundances and ultimately does not tell much of a different story than the indicator of cumulative numbers. Furthermore, it is expected that there will be inconsistencies of data quality across countries. In conclusion, considering these inconsistencies of data quality and the problem of subjectivity of species selection, it is recommended to dismiss this indicator for the time being.

2.4.4 Awareness of IAS in Europe

It is evident that raising awareness of IAS is crucial in dealing with alien and IAS (Shine et al., 2010). This can be achieved at different levels, and indeed most indicators fulfilled awareness-raising goals to some extent. For example, the SEBI 2010 IAS indicators, the cumulative numbers of alien species and the distribution of the worst alien species gained public attention (T.-B. Larsson, personal communication, 2 May 2012), indicating that biological invasions are considered relevant

Figure 2.9 Adoption of national legislation relevant to the prevention or control of IAS for 191 countries reporting to the CBD (1967–2008)



Source: McGeoch et al., 2010.

in Europe. However, this reflection of public opinions does not answer posed questions towards achieving biodiversity targets. The same is true for the 'cost indicator' (see Section 2.4.5), which may serve well for awareness purposes, but is directed towards different policy questions (see Section 4.1, Tables 4.1 and 4.2).

In the context of the indicator 'Trends in policy responses, legislation and management plans to control and prevent spread of invasive alien species', the number of governmental policies is considered a useful indicator of awareness at the political level. This was also executed at the global level by McGeoch et al. (2010), showing an increase of national legislation against IAS, particularly after the establishment of the Convention on Biological Diversity (CBD) in 1992 (Figure 2.9). Another option is to analyse the number of countries, stakeholders or organisations that commit to voluntary codes of conduct or follow self-imposed restrictions (e.g. Heywood and Brunel, 2008; Davenport and Collins, 2011).

Pros of the indicator: Data on national legislation directed towards prevention, mitigation, or control of IAS are partly available, although its comparability may need some attention (EC, 2011c).

Cons of the indicator: Governmental policies not always reflect actions taken on the ground.

2.4.5 Cost of IAS in Europe

The results of the EEA study 'EU funding for management and research of invasive alien species in Europe' (Scalera, 2008) offers a clear picture of the response actions of both the main stakeholders and the public authorities. These actions indicate that there is an increased perception of the problem and a more scientifically and technically informed approach to solving it. Such response indicators help measure the extent to which efforts are being made to reduce the rate of biodiversity loss due to the spread of IAS, and help laypeople and policymakers understand the relevance and the meaning of the problems linked to this issue. Therefore, the information on costs for management and research of IAS may be very useful for policy purposes, e.g. by raising awareness of the problem and the importance of such financial instruments in the fight against IAS.

The study also suggested that an indicator on costs of IAS in Europe can easily be updated, analysing trends on funding for management and research with the data relative to the programming period from 2007 to 2013 for both LIFE+ and the FP7. Once the relative data are available, they can be aggregated in three-year periods and compared to those for the years 1992–2006, thus showing the trends in EU response actions over more than 20 years. The same indicator could be further updated in the future, depending on how the LIFE and RTD framework programmes will be organised in subsequent programming periods.

Pros of the indicator: The further development of this indicator, given the 'relatively easy' accessibility of the pertinent information, would avoid detracting from the attention and resources allotted to conservation and management that are needed to achieve the goal of biodiversity conservation. This complies with the need for cost-effectiveness and the important principle of communication simplicity. Another advantage of this indicator is that it succeeded in raising awareness among policymakers and stakeholders on the actual and potential contribution of such financial programmes, and particularly of the LIFE programme, on the management of IAS (Salsi and Scalera, 2010). In addition, the scope of such indicator could be further extended by linking to other initiatives carried out by the EEA in collaboration with the European Commission, e.g. the mapping of LIFE projects in relation to the Natura 2000 network.

Cons of the indicator: Because of the lack of a specific financial instrument directly dedicated to IAS, extensive work is required to select the project dealing entirely or in part with the issue. Many control strategies are known to have failed or to be ineffective, and so the costs and benefits of the funded activities do not necessarily reflect the costs and benefits of IAS. Therefore, the actual figures provided by this indicator do not reflect the environmental costs, and would not convey a true picture of the economic value of the impacts of IAS over the years. Moreover, since the indicator does not consider the resources allocated through financial tools other than the LIFE and RTD framework programmes, the figures should be considered very conservative.

2.4.6 The combined awareness–cost indicator option

The number of policy measures in European countries (e.g. national action plans or legislative texts) is not sufficient to demonstrate awareness 'on the ground' that translates into decided actions. Policy papers that lack executive control, penalisation or compensation for any caused environmental or economic damage do not yet guarantee any action or success. Although policy responses, legislation and management plans to control IAS are important steps forward and can eventually be queried from countries, this information is considered less relevant as an indicator towards the intrinsic goal of halting the loss of biodiversity.

A better choice to overcome this ambiguity and indicate awareness of IAS in Europe would be to count targeted eradication or control programmes, or to compile reports on the amount of money spent against IAS at the national level. Because 'Trends in policy responses, legislation and management plans to control and prevent spread of invasive alien species' and 'Trends in the economic impacts of selected IAS' are operational indicators of the new Strategic Plan for Biodiversity 2011–2020, it is suggested to combine both indicators here. Despite addressing different policy questions (Table 4.1), both are related to Aichi Target 9. Cost estimates are also related to the ecosystem services approach (see Section 5.1). The comprehensive assessment of the economic impact of an alien species is not a trivial calculation; it requires solid data and knowledge of economic mathematics. Current economic analyses of alien species often consider only costs due to yield loss, chemical control, or human working power, but neglect other, indirect and long-term costs, and benefits. It is not to be expected that full cost estimates of the impacts of IAS will become available for many species in the next decade.

However, for a solid indicator, it is not actually necessary to capture the whole picture, but rather to indicate the general trend with high certainty. Scalera (2009) summarised the IAS-related projects within the LIFE and the RTD programmes (almost 300 projects over 15 years) and their expenditures (exceeding EUR 132 million) and suggested that these estimates could be used as both an awareness and a cost indicator for Europe. The overall trend over time was positive, indicating an increase in awareness of the problem among wildlife managers and scientific institutions, an increasing willingness of EU institutions and citizens to pay, and more generally, an increase of the problem with IAS within the EU. Such a combined awareness and cost indicator measures progress being made towards the goal of reducing the loss of biodiversity in Europe. Similar exercises could be carried out focusing on projects funded with other sources and types of funding, available, for example, at national or local levels (e.g. in national parks or in Natura 2000 sites).

In addition, direct costs of pests for agriculture, forestry or human health can be estimated and used for awareness raising, but without considerable efforts in harmonizing, these data cannot be used as an indicator.

Policy measures that are related to pathways (e.g. the 2004 Ballast Water Convention (the International Convention for the Control and Management of Ships' Ballast Water and Sediments); the Aquaculture Directive (Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals); IAS as pets, aquarium and terrarium species, or as live bait and live food), are covered by the extended cumulative numbers of alien species indicator, and (although part of the awareness-raising process) are not included here.

3 Review and state of play of IAS indicator work at global level

The adoption in 2002 by the CBD of Decision VI/26, which included a commitment to achieve, by 2010, a significant reduction of the rate of biodiversity loss, has led to the development of indicators aimed at assessing progress towards these targets. Initially, the CBD identified two potential indicators of the threats to biodiversity, including one on 'numbers and cost of alien invasions'. At the 10th meeting of the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), held in 2005, it was agreed to use 'trends in invasive alien species'. In 2006, the CBD secretariat committed GISP and IUCN to produce a global indicator for biological invasions. Four indicators were prioritised: the number of IAS per country, the Red List Index of impacts of IAS, and two measures of responses to the problem (trends in the number of international agreements relevant to reducing threats to biodiversity from IAS, and trends in the adoption of national legislation relevant to the control of IAS) (McGeoch et al., 2010; Genovesi et al., 2012). In 2011, an indicator based on the cumulative number of alien species was used to identify progress toward the 2010 targets (Butchart et al. 2010), and was included in the third edition of the CBD's *Global Biodiversity Outlook*.

At the tenth meeting of the Conference of the Parties (COP 10) in Nagoya in 2010, the CBD adopted a new Strategic Plan for Biodiversity 2011–2020, and a set of targets (Aichi targets), including Target 9 on alien species: 'By 2020, invasive alien species and pathways are identified and prioritised, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.' Concerning the European context, it must be stressed that at the COP 10 it was agreed that the Strategic Plan would serve as a flexible framework for setting regional targets, and Decision X/2 adopted a timetable for the development and reporting of regional targets to assess progress made towards their targets. Furthermore, with Decision X/2, the COP 10 convened an AHTEG on indicators for the Strategic Plan for Biodiversity 2011–2020, from 20 June to 24 June 2011 in High Wycombe, United Kingdom.

The report of the AHTEG, submitted to SBSTTA 14 in November 2011 (CBD, 2011b), included a technical review and recommendation for the establishment of indicators on the following aspects: Trends in number/extent of IAS; Trends in impact of IAS; Trends in responses to IAS; Trends in the impact of IAS on extinction risk trends; Trends in the economic impacts of selected IAS; Trends in incidence of wildlife diseases caused by IAS; Trends in policy responses, legislation and management plans to control and prevent spread of IAS; Trends in IAS pathways management; and Trends in policy responses, legislation and management plans to control and prevent spread of IAS (Table 4.1). The fourth edition of *Global Biodiversity Outlook* will provide a mid-term review of the implementation of the Strategic Plan in conjunction with the evaluation of the Millennium Development Goals (Decision X/4). It must be stressed that the AHTEG recognised the significant effort already invested in the indicator suite for the previous strategic plan, and agreed that these indicators brought together by the Biodiversity Indicator Partnership (BIP) should be retained.

3.1 IUCN Red List Index of impacts of IAS

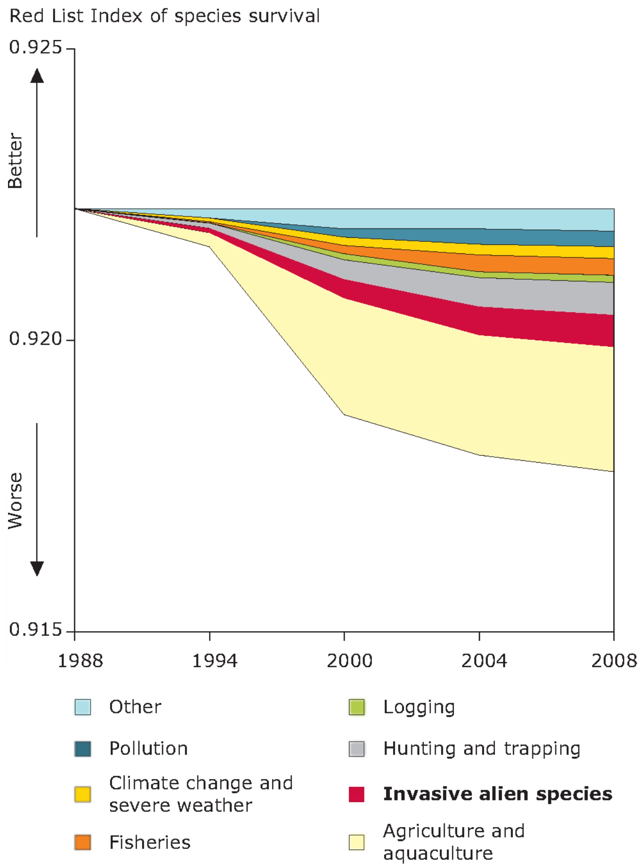
The IUCN Red List Index (RLI) measures the overall rate at which species move through the IUCN Red List categories, and allows assessment of the role of specific threats — such as invasive species — in these movements, providing a measure of the pressures IAS place on biodiversity. The RLI shows changes in the overall extinction risk of species; it is calculated from the number of species in each category, and the number changing categories between assessments as a result of genuine improvement or deterioration in status. An application of the RLI relevant for IAS is the calculation of the effects of the impacts of IAS on species included in Red Lists, also allowing a comparison of the relative role of this with other pressures (Figure 3.1).

Genovesi et al. (2012) provides more details on the calculation of the RLI: 'The Red List Index applied to invasive species, permits to calculate overall rates at which species are moving towards or away from extinction, owing to the balance between the negative impacts of IAS on species and the positive impacts of conservation actions tackling IAS. The index is based on repeated assessments of species for the IUCN Red List. Red List categories are assigned to species based on application of quantitative date (relating to the size, structure and trend of both the population and distributional range) to explicit criteria with quantitative thresholds. Assessments require parameter estimates to be fully documented with sources and explicit estimates of uncertainty. Only those changes to Red List categorisations resulting from genuine improvement or deterioration are included in the RLI (category changes driven by improved knowledge or revised taxonomy are excluded). For all genuine category changes, the primary driver (i.e. threat leading to deterioration in status, or threat overcome by conservation action leading to improvement in status) is identified, and the overall decline in the RLI is then apportioned to different primary drivers, with the thickness of the slice indicating the importance of each particular driver. Determining the primary driver of category changes is facilitated by the fact that the magnitude of each threat to each species on the Red List is calculated according to its estimated scope (i.e. proportion of the population affected by the threat) and severity (rate of population decline over three generations driven by the threat within the scope), plus the fact that detailed documentation is associated with each genuine status change.'

Repeated calculation of the RLI of impacts of IAS (RL-IAS) requires repeated assessments conducted at the scale of interest (i.e. Europe). The reliability of the index also depends on the taxonomic coverage of the Red List, that can be deficient for several groups including many IAS such as insects and fungi. McGeoch et al. (2010) have shown that the RL-IAS on birds, mammals and amphibians has increased globally over time, i.e. their overall status has deteriorated as a consequence of the impacts of IAS.

There are several options for applying the RL-IAS to the European context. In fact, the IUCN global Red List permits the selection of species threatened by region (including Europe). Furthermore, for several taxonomic groups (mammals, reptiles, amphibians, freshwater fishes, butterflies, dragonflies, and selected groups of beetles, molluscs and vascular plants), European Red Lists have been already developed. Therefore, it must be stressed that an application of the RL-IAS to the European context could provide detailed

Figure 3.1 RLI for birds showing trends driven by the impacts of IAS compared with trends driven by other factors, for the proportion of species expected to remain extant in the near future without additional conservation action



Note: Index number = 9 785, non-Data Deficient extant bird species at start of period.
An RLI value of 1.0 equates with all species categorised as 'Least concern' (not expected to become extinct in the near future).
An RLI value of zero indicates that all species have become extinct.
The shaded sections show the contribution of different drivers to the overall deterioration in the status of species over the time period.

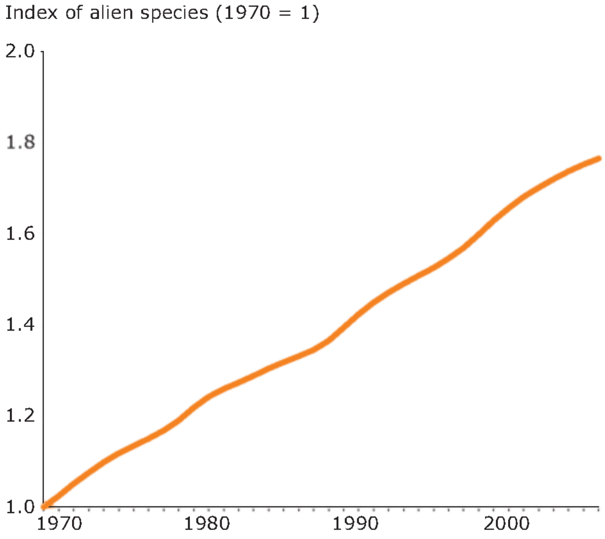
Source: BirdLife International, 2010.

information on the trends of this threat in the region, also allowing testing of the effectiveness of applied conservation measures.

3.2 Combined index of invasion trends

Butchart et al. (2010) proposed a combined index of invasion trends, based on the DAISIE data set, that has been included in the Global Biodiversity Outlook 3 (Figure 3.2). The index is based on the number and distribution of 542 alien species

Figure 3.2 The combined index of trends in numbers of alien species in Europe between 1970 and 2007



Note: The figure shows that the numbers of alien species in Europe increased 76 % from 1970 to 2007.

Source: Butchart et al., 2010, Science 328: 1 164 (2010).

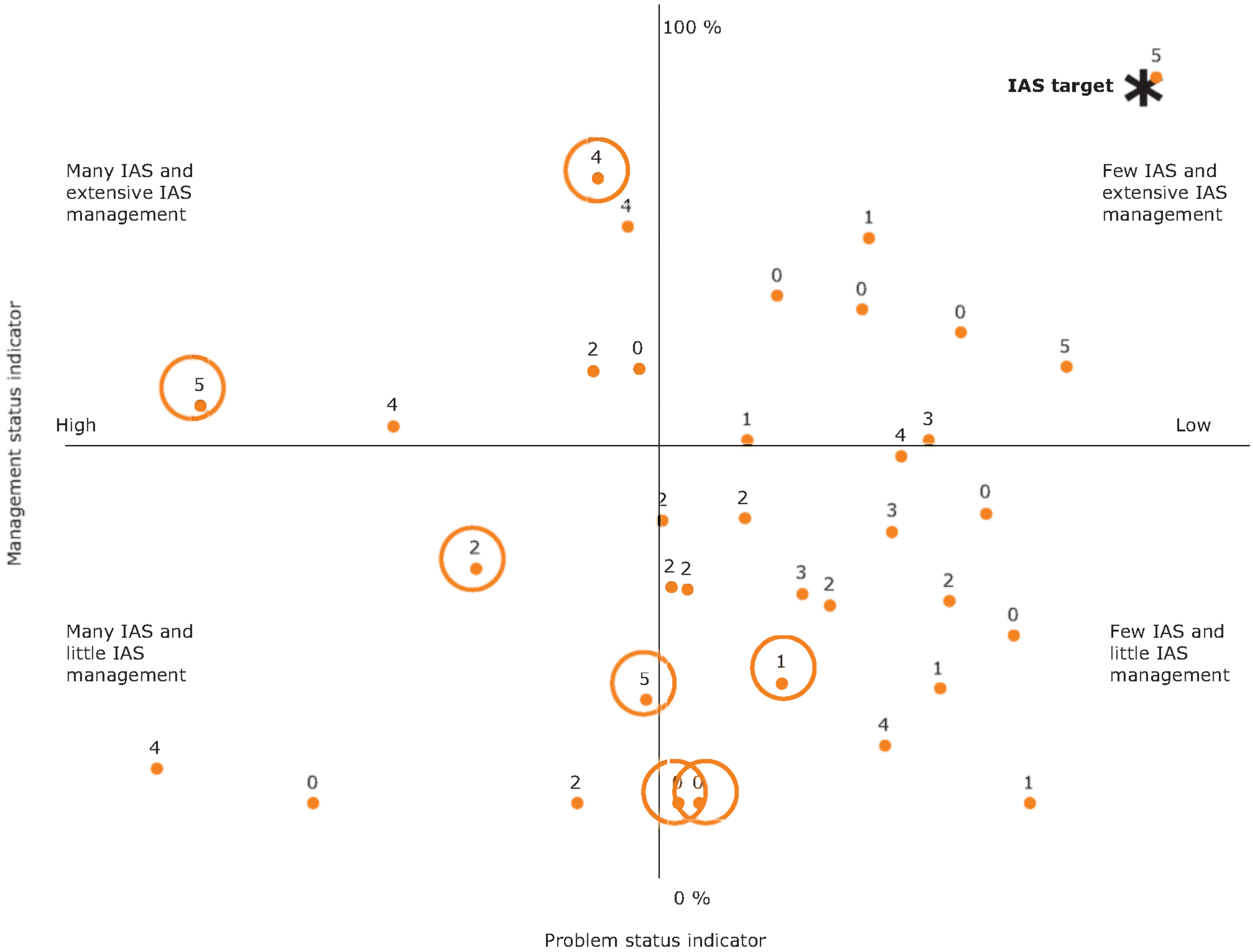
and 2 871 species-country records, in a stratified random selection of 57 European countries/regions representative of different climates, continents, country sizes and development status. Based on this data set, a European trend was calculated as the geometric mean of indices for the number of alien species of metazoans in the Mediterranean, freshwater animals and mammals across all European countries (27 EU Member States, plus Andorra, Iceland, Liechtenstein, Moldova, Monaco, Norway, Russia, Switzerland, Ukraine, and former Yugoslavian states). In the calculation, no species was considered in more than one data set.

It must be stressed that the combined index proposed by Butchart et al. (2010) was based on the European data set, because of the particularly comprehensive information available in this region as compared to other regions of the world. Based on DAISIE and NOBANIS data sets, it would be possible to apply the combined indicator with a much more detailed and comprehensive approach than that proposed by Butchart et al. (2010), and with a much longer temporal coverage than the period 1970–2010. To the contrary, since a bias of unknown magnitude is inherent in historic data, due to unbalanced sampling efforts over time and space, for example, the combined index may also be considered as a baseline indicator, starting with 2000 and applied in subsequent decades.

3.3 Composite indicator of invasion trends

Another relevant attempt to combine data from different sources has been proposed by McGeoch et al. (2006), who suggest single and composite indicators that include problem-status and management-status measures that are designed to be flexible, readily disaggregated, and to draw on existing data as far as possible. The proposed composite indicator was calculated at the national scale, and contained information that is aggregated across three single indicators (N–number and status of IAS; E–number of IAS with operational management plans; P–number of IAS introduction pathways covered by operational management plans) (Figure 3.3). The proposed global indicator thus represents a minimum information set that most directly addresses the indicator objective and simultaneously aims to maximise national participation. The aim of the composite indicator is to benchmark country performance. Appropriate weighting for area or productive energy availability, or for gross domestic product (GDP), could be applied to facilitate the comparison. This global indicator still requires testing to assess its accuracy, sensitivity, and tractability.

Figure 3.3 **Composite indicator of global trends in IAS showing the relative positions of countries with respect to their numbers of IAS and their operational management plans**



Note: Circled countries (*left to right*): Australia, South Africa, New Zealand, Canada, Swaziland, Namibia, United Kingdom; uncircled countries are simulated country data.

Source: McGeoch et al., 2006.

4 The policy context

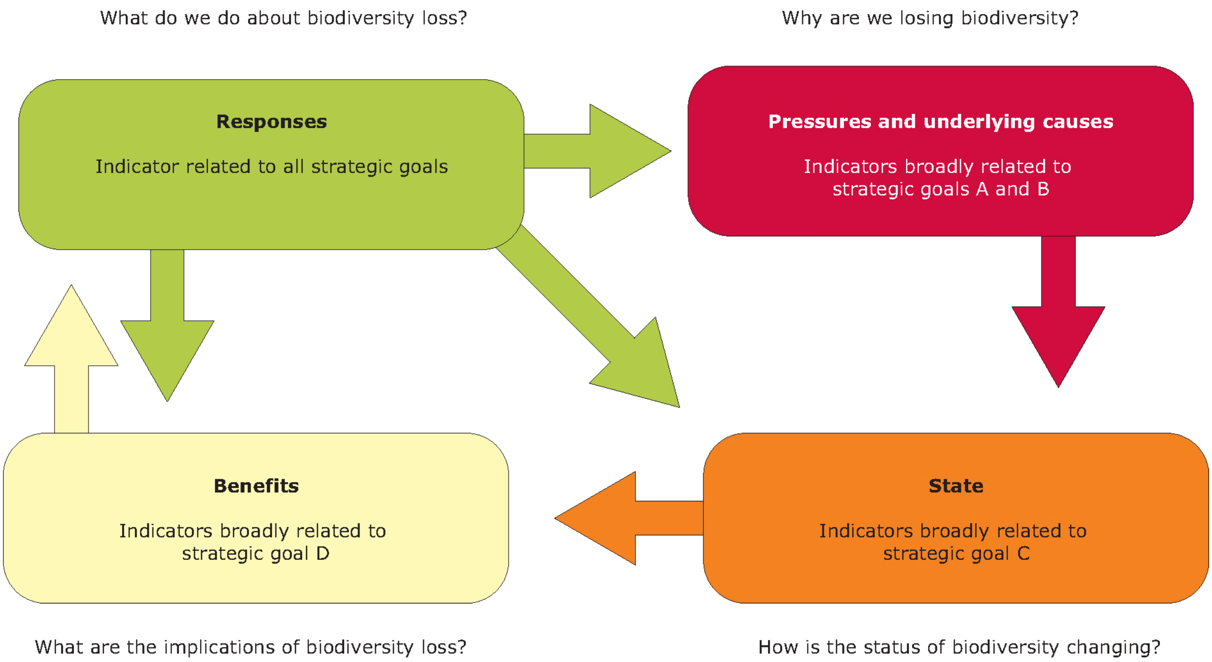
The SEBI process aims to be closely connected to global and EU biodiversity policies. The usefulness of this approach is beyond question. This section explains the connections between the CBD, EU post-2010 strategies and IAS indicators.

4.1 The CBD context

The history of discussions and decisions regarding IAS at previous COP meetings was partly summarised by Shine et al. (2009 and 2010), and is not repeated here. In October 2010, at the COP 10 in Nagoya, Parties approved the Aichi Target 9 under the CBD Strategic Plan 2011–2020: 'By 2020, invasive alien species and pathways are identified and prioritised, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.' This target is part of Strategic Goal A: 'Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society.' It was further agreed to establish an AHTEG to give advice and guidance on possible developments of standards by appropriate bodies (animal and plant health, introduction of IAS as pets, aquarium and terrarium species, as live bait and live food) and to address possible gaps in these systems.

At SBSTTA 15 (Montreal, Canada, 7–11 November 2011) indicators for achieving the Aichi biodiversity targets 2011–2020 were discussed, based on a AHTEG report on Indicators for the Strategic Plan for Biodiversity 2011–2020 (CBD, 2011c). The conceptual model for the proposed indicator framework is based on four policy questions, headline indicators and operational indicators (Figure 4.1). Six operational indicators regarding IAS

Figure 4.1 Conceptual model communicating the different types of indicators for assessing progress towards the Strategic Plan for Biodiversity 2011–2020



Source: CBD, 2011c.

are mentioned in the document; these relate to the policy questions and headline indicators (Table 4.1). The relation of these indicators to the SEBI indicator process is summarised in Table 4.2.

Table 4.1 Operational IAS indicators and their relations within the indicator framework, for assessing progress towards the implementation of the Strategic Plan for Biodiversity 2011–2020 and achievement of the Aichi biodiversity targets

Policy question	Headline indicator	Operational indicator	Aichi target	Other relevant Aichi target
Pressures and underlying causes: Why are we losing biodiversity?	Trends in pressures from habitat conversion, pollution, invasive species, climate change, overexploitation and underlying drivers	Trends in the impact of invasive alien species on extinction risk (A)	9	12
		Trends in number of invasive alien species (B) (decisions VII/30 and VIII/15)	9	10
		Trends in the economic impacts of selected invasive alien species (B)	9	2, 10
		Trends in incidence of wildlife diseases caused by invasive alien species (C)	9	12
Responses: What do we do about biodiversity loss?	Trends in integration of biodiversity, ecosystem services and benefits sharing into planning, policy formulation and implementation and incentives	Trends in invasive alien species pathways management (C)	9	10
		Trends in policy responses, legislation and management plans to control and prevent spread of invasive alien species (B)	9	2, 3, 17

Note: Operational indicators are classified as follows: A = Priority and ready for use globally; B = Priority to be developed at global level; C = For consideration at sub-global level.

Source: CBD, 2011c.

Table 4.2 Relationship between the operational CBD IAS indicators and the SEBI indicator process

Operational CBD Indicator	SEBI 2010 Indicator	SEBI 2020 Indicator
Trends in the impact of IAS on extinction risk (A)	Indicator on impacts/ abundance of IAS (B-C)	**The Red List Index (A)**
Trends in number of IAS (B) (decisions VII/30 and VIII/15)	**Cumulative number of alien species (A-B)** Worst IAS threatening biodiversity in Europe (B)	**The combined index of invasion trends (A-B)**
Trends in the economic impacts of selected IAS (B)	Indicator on cost of IAS (C)	**Cost of IAS in Europe (B)**
Trends in incidence of wildlife diseases caused by IAS (C)	–	Not yet developed (C), see Section 5.7
Trends in IAS pathways management (C)	–	**Amendment to the Cumulative number of alien species (A-B)**
Trends in policy responses, legislation and management plans to control and prevent spread of IAS (B)	Indicator on awareness of IAS (B-C)	**Number of national governmental policies (B)**

Note: Applicability according to CBD terminology (A = Priority and ready for use globally; B = Priority to be developed at global level; C = For consideration at sub-global level) and modified to the SEBI process (A = Priority and ready for use; B = Priority to be developed; C = For consideration). Recommended indicators are in bold.

4.2 The EU context

4.2.1 The EU Biodiversity Strategy 2020 and the EU vision 2050

The ambitious goal of halting the loss of biodiversity by 2010 set in 2001 has not been met. This is confirmed by several data and indicators that were used to measure progress or failure towards this target. In 2010, the International Year of Biodiversity, global and European biodiversity targets were reassessed and newly formulated. Again, the verification of any change will be built upon existing or new data and indicators. The further development and critical re-evaluation of existing indicators, therefore, is of high political relevance. At the COP 10 in Nagoya, new biodiversity targets were developed at the global level (CBD) and adopted together with a new vision for the post-2010 period by the EU.

The 'EU vision 2050' states that 'by 2050 European Union biodiversity and the ecosystem services it provides — its natural capital — are protected, valued and appropriately restored for biodiversity's intrinsic value and for their essential contribution to human wellbeing and economic prosperity, and so that catastrophic changes caused by the loss of biodiversity are avoided'.

Grey squirrel © Bertolino Sandro

The 'EU Biodiversity Strategy 2020' (EC, 2011a) aims to help integrate biodiversity needs into the development and implementation of sectoral policies. In its headline target, it states to 'halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.' This strategy includes 6 main targets and 20 actions for achieving this goal. One of the six targets and two actions explicitly address IAS, as set out below.

- **Target 5: Combat Invasive Alien Species**: 'By 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS.'

- **Action 15: Strengthen the EU Plant and Animal Health Regimes**. The Commission will integrate additional biodiversity concerns into the Plant and Animal Health regimes by 2012.

- **Action 16: Establish a dedicated instrument on Invasive Alien Species**. The Commission will fill policy gaps in combating IAS by developing a dedicated legislative instrument by 2012.

The strategy acknowledges the significant threat to biodiversity already posed by IAS in the EU and states that 'this threat is likely to increase in the future unless robust action is taken at all levels to control the introduction and establishment of these species'. The development of a robust indicator to show IAS trends in Europe, and their impact on biodiversity and ecosystem services, is therefore directly related to achieving the goals of the strategy.

The accompanying impact assessment (EC, 2011b) elaborates further on the topic, briefly discusses two options and stresses the necessary link between EU objectives and global targets. For the same reason, it is useful to consider global IAS indicators (see Chapter 3) and, ideally, develop an EU indicator that can be 'ready-to-go' in a global indicator setting. Explicitly highlighting the relevance of pathway analyses for preventing future invasions, there is a need to integrate pathway data into the SEBI IAS indicator set.

There are two options discussed in the impact assessment: (1) prioritisation of species to be tackled; or (2) broaden the scope of species to be tackled. Option (1) includes species posing threats to biodiversity, the economy, society and health (e.g. a blacklist system tied to trade restrictions). The advantage is that the number of species (and therefore the necessary actions and costs) are likely to be limited and proportionate. Option (2) does not include a prioritisation of species, and a broader approach may indeed be helpful in some respects (e.g. eradication of some well-known established IAS in Europe is impossible; some IAS are native elsewhere within Europe; public awareness). However, due to the sheer number of known alien species in Europe (more than 11 000 according to DAISIE) and expected costs, option (1) was preferred. Regarding the SEBI IAS indicator, this is in line with the development of an indicator on the 'worst IAS' or some related indicator.

4.2.2 Environment Directorate-General activities

The Council of the European Union adopted conclusions on the EU 2020 Biodiversity Strategy at its meeting on 21 June 2011 (Council of the European Union, 2011). Therein, 'deep concern' was expressed that Europe's biodiversity remains under severe threat from (among others) IAS, and it 'welcomes' the Commission's commitment to develop an EU strategy on IAS, including a dedicated legislative instrument on IAS by 2012, following a risk-based approach.

DG Environment has launched an interservice consultation process and is currently working towards the dedicated legislative instrument, which aims to fill gaps not covered by existing instruments within the animal and plant health sector. Member State and public consultation processes are foreseen for 2012.

5 Necessity, options and possibilities for 'new' IAS indicators

5.1 IAS and Ecosystem Services

The necessity and usefulness of connecting biodiversity data to the concept of ecosystem services is widely but not generally accepted (e.g. Norgaard (2010), and Spangenberg and Settele (2010)). The AHTEG on indicators for the Strategic Plan for Biodiversity 2011–2020 noted the current lack of agreed indicators for ecosystem services (CBD, 2011c). The UNEP-WCMC (2011) proposed four possible IAS indicators tailored to Aichi Target 9 that relate to ecosystem services (Table 5.1), while admitting that this list is not intended to be exhaustive and should rather be seen as a resource for further discussion.

Based on DAISIE data, Vilà et al. (2010) provided a review of financial costs of selected alien species across all taxa and environments for Europe and an assessment of the impacts of the '100 of the worst' IAS on ecosystem services. This kind of analysis could be enlarged to include — depending on data availability — the (existing or updated) '163 SEBI worst' IAS or, theoretically, all the 1 094 species with documented ecological impact and the 1 347 species with economic impact. Based on time-series data of introductions, it is possible to analyse these data over time and hence develop an indicator. Alien species interfere with all kinds of ecosystem services (Figure 5.1) and considering the increasing appeal of this political instrument to nature conservation policies, it seems advisable to continue work in this direction. However, detailed knowledge of IAS impacts and their multiple effects may complicate or limit the approach. Clearly, a better understanding and a more in-depth analysis of the relation between IAS and ecosystem services is needed.

5.2 Biopollution indexes

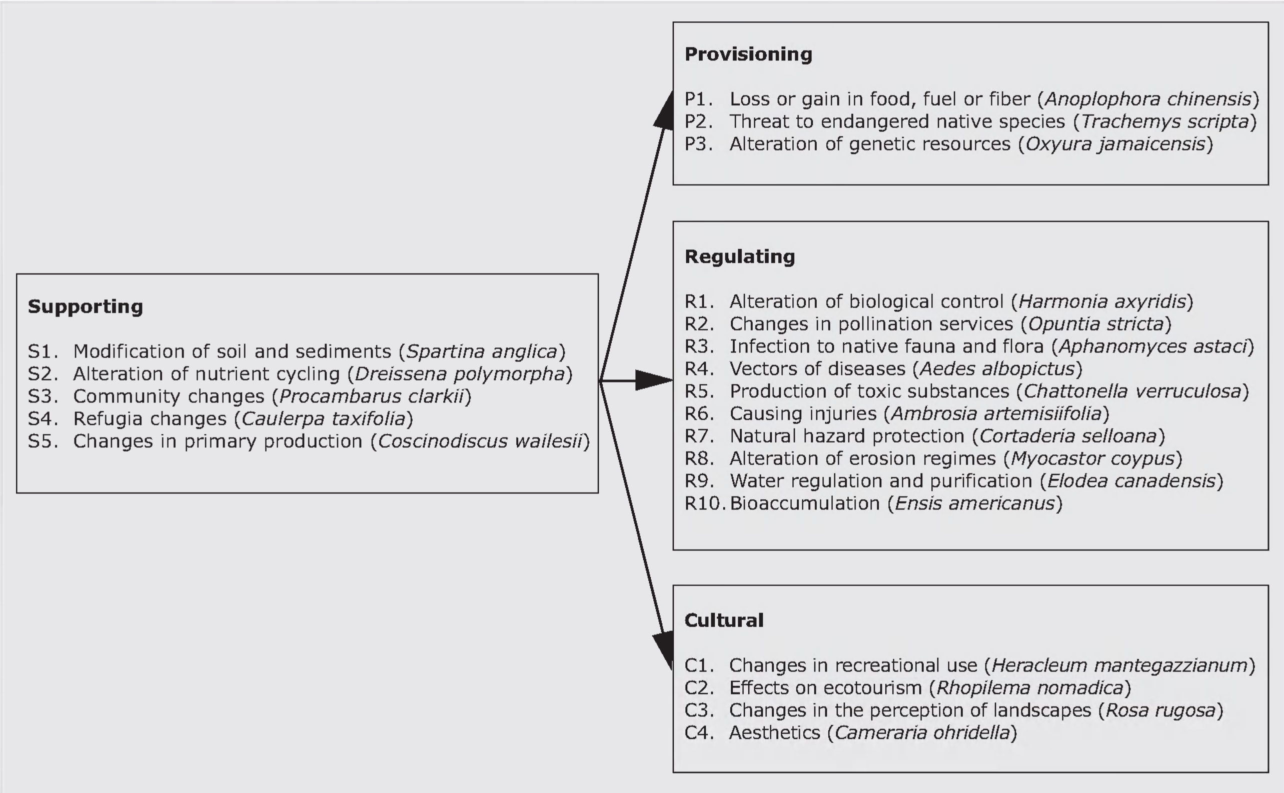
Biopollution describes the negative impacts of IAS on environments. Different biopollution indexes are available, such as the Integrated Biological Pollution Risk (IBPR) index, developed within the FP6 ALARM project (Panov et al., 2009). This index is based on the DPSIR framework and takes into account the number of alien species relative to the number of native species (presence/absence) in a waterbody as well as their impact and spread (based on a blacklist risk assessment). It is currently used under the WFD by five Member States. The Biopollution Level (BPL) index (Olenin et al., 2007) uses semi-quantitative data on abundance and distribution range, and differentiates impacts at different levels (on the community, the habitat and the ecosystem levels). It has been proposed for describing good ecological status within the MSFD (Olenin et al., 2010).

Table 5.1 IAS Indicators related to Aichi Target 9, suggested by workshop participants (November 2010)

Indicator	Ecosystem Service Group	Notes
Dollar value impact of IAS on crops (pests/disease/pollinators) or % yield	Regulating	Linked to loss of an ecosystem service
Fish and wildlife production	Provisioning	Trends in production (implementation possible for 2011 and 2020; cost-effectiveness available at the national scale)
Dollar value of impacts of IAS on water availability	Provisioning	Implementation possible for 2020
Daily impacts of IAS on human health	Multiple	Implementation possible for 2020

Source: UNEP-WCMC, 2011.

Figure 5.1 IAS impacts on ecosystem services: examples



Source: Vilà et al., 2010, © Ecological Society of America.

Currently, these (and related) indicators are continually being tested and further developed, which limits their immediate applicability as an indicator towards the 2020 target.

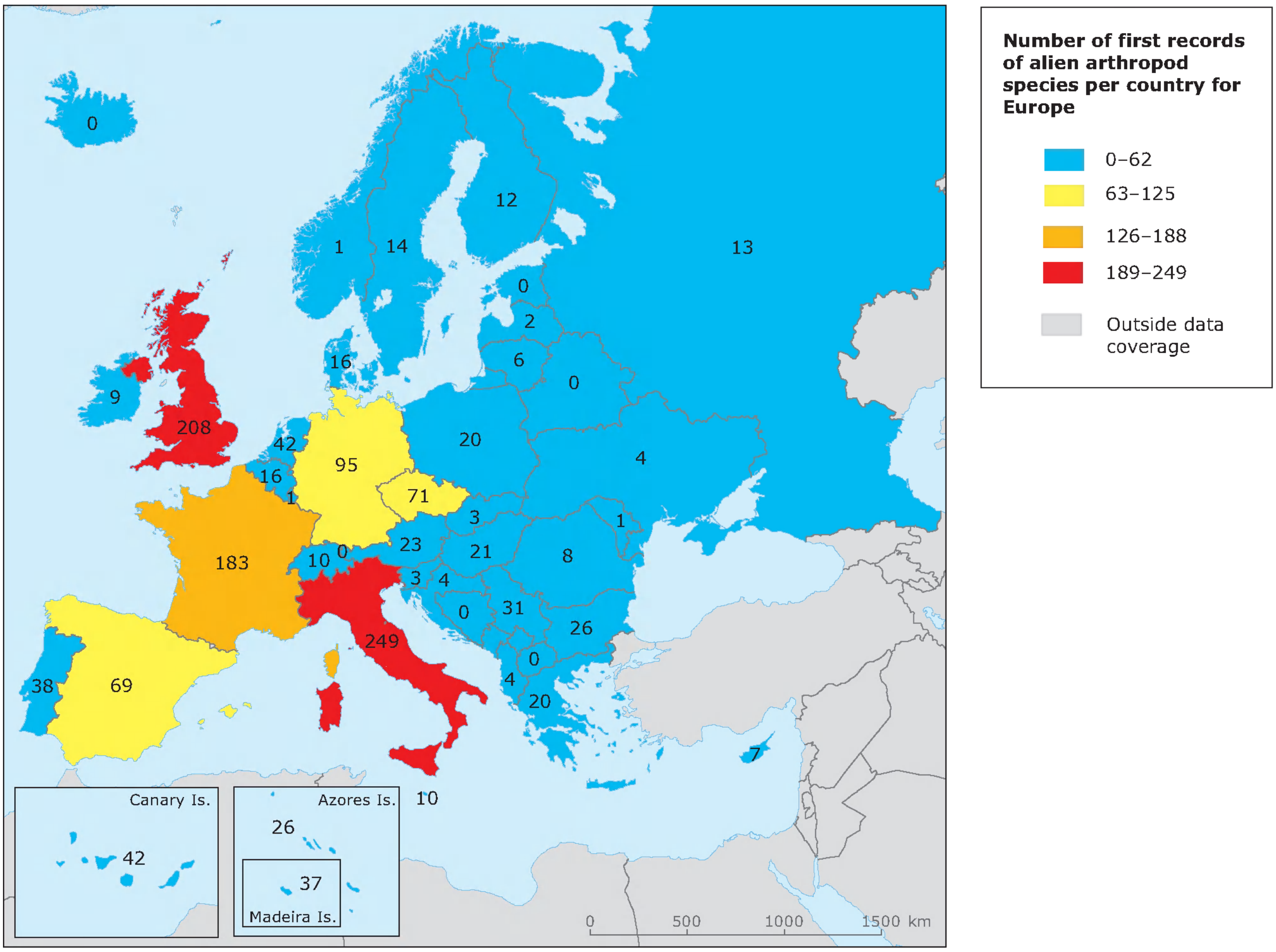
5.3 Hotspot indicator

Biological invasions are not uniformly distributed across Europe. Biogeographic, environmental and socio-economic constraints produce a geographically structured pattern that should be reflected in appropriate policy responses. For example, some regions or European islands (including the outermost regions (Azores, Canary Islands, French overseas departments, Madeira, Saint Martin) and overseas countries and territories (British overseas territories, French overseas collectivities, Dutch overseas territories, Greenland) are well-known focuses of IAS and deserve the utmost attention in invasion management. To provide a picture of these hotspots of invasion in Europe or in the EU/EEA areas, a map showing the number of first occurrences of IAS per country can illustrate this geographic pattern (Map 5.1). Taking into account the known year of introduction, such a map can be developed for different time periods and can be used to construct an indicator showing the increase or decrease of first occurrences per country over time. This pattern deviates from the cumulative or worst number of alien species per country; it reflects, rather, socio-economic drivers or importance of pathways, but also variability in research efforts and availability of information in each country.

5.4 Single group indicator

Although Vandekerkhove and Cardoso (2010) demonstrated that the WFD currently does not allow for development of a pan-European index on IAS in freshwater (due to significant methodological inconsistencies and differences in available baseline data between countries), monitoring obligations within EU directives may provide leverage for developing several taxon-specific indicators in future (see Section 2.3.3). It would be most cost-efficient to modify reporting formats according to, for example, an invasive alien bird index (based on the Birds Directive) or an invasive alien fish index (based on the WFD). However, the required harmonisation process between countries would take some time, so such indicators do not appear realisable in the short term, towards the 2020 targets.

Map 5.1 Number of first records of alien arthropod species per country for Europe



Source: Roques, 2010.

5.5 Single species indicator

Although not applicable as a trend indicator, the fast and often spectacular expansion of alien species may serve as an awareness-raising tool that partly fulfils the requirements of a response indicator on awareness. Cooperation with traditional (but still powerful) media and consideration of new, social media (e.g. 'Eye on Earth') can be used to get the message across and inform a wider audience.

5.6 Alien species and climate change

The combination of two accelerating pressures on biodiversity (biological invasions and climate change) poses new challenges to nature conservation and biodiversity policies (Burgiel and Muir, 2010). Climate change has profound impacts on biological invasions, for example, on pathways and motivation of introductions, establishment and reproduction rates of alien species, changes of distribution ranges in latitude and altitude, and the invasibility of habitats (Walther et al., 2009).

The forthcoming ETC/CCA report on climate change impacts, vulnerability, and adaptation will briefly address alien species. Different statistical modelling techniques are available for predicting the possible future distribution of species under climate change. Uncertainty in these models is still great, often due to limited knowledge of input variables (biological attributes of species, resolution of distributional data), but also due to the inherent natural variability of biotic and abiotic factors. However, most models indicate that IAS will continue to spread, because they are often opportunistic and generalist species that on average, outperform native species under changed environmental conditions. The number, establishment, or spread of alien species, whose presence is (more or less) directly related to temperature (e.g. palms, cacti, parakeets or the red-eared slider), may serve well as 'surrogate indicators' of the effects of climate change on alien species. However, usually these patterns are driven by multiple factors and simple causal relationships are rarely observed.

5.7 Animal and plant health

According to Aichi Target 9, an indicator on 'Trends in incidence of wildlife diseases caused by invasive alien species' should be developed. Such an indicator is currently not available, but may be developed based on existing reporting obligations within the animal and plant health sectors, e.g. by using data reported to the Animal Disease Notification System (ADNS). The ADNS is a notification system to ensure rapid exchange of information between national authorities responsible for animal health. However, only diseases listed in Annex I of Directive 82/894/EC are reported, which means that new and emerging diseases are not automatically reported. A regularly updated summary for the current (EC, 2012a) and past years is available online. Within the Animal Health Strategy, several supporting instruments are available, such as TRACES (a unified database including information on all veterinary matters), improved border biosecurity (revision of import legislation, and risk management) and surveillance (including training support). The situation is similar in the plant health sector, with reporting obligations of species being listed in annexes and regular updates being carried out. In conclusion, designing an indicator on wildlife diseases is a high priority, and existing data may be used, but a stringent methodology needs to be developed.

5.8 Important alien areas

Important Bird Areas (IBAs) are globally important sites for bird species identified at the national scale, that ideally will be monitored regularly for measures of threat, including IAS. If executed regularly, these data may be used to indicate or track trends in the impact of IAS at a smaller, regional scale. The process of developing Important Plant Areas (IPAs) is under way, and may result in a similarly useful data set in future. In such areas, the impact of IAS may be studied, and the trends documented and translated into an indicator, and extrapolated to larger scales. The same holds true for national monitoring activities within protected areas, e.g. national parks, that may be used to indicate trends of change of IAS at the regional level.

By contrast, the idea of designating 'Important Alien Areas' would involve identifying regions or areas that are especially rich in alien species and that require particular attention in terms of monitoring or management. Such areas could be selected, for example, in connection with pathways (e.g. import hubs such as airports or ship harbours) or ecosystems (e.g. lagoons, gardens and parks in cities, or forest plantations).

5.9 Summary

In Chapter 5, eight 'new' indicators are briefly discussed. Table 5.2 summarises their applicability in terms of data availability and policy relevance. The development of an indicator showing 'Trends in incidence of wildlife diseases caused by invasive alien species' has the highest priority and policy relevance.

Table 5.2 Overview of possible 'new' IAS Indicators, their operability, relation to policy questions and to operational indicators

Indicator	OP	PQ	Operational indicator
IAS and Ecosystem Services	B-C	P	Trends in the economic impacts of selected IAS
Biopollution Indexes	B-C	P	Trends in number of IAS
Hotspot Indicator	B-C	P, R	Trends in number of IAS; Trends in IAS pathways management
Single Group Indicator	C	P	Trends in number of IAS
Single Species Indicator	n/a	R	
Alien Species and Climate Change	C	P	Trends in number of IAS
Animal and Plant Health	B	P, R	Trends in incidence of wildlife diseases caused by IAS; Trends in IAS pathways management
Important Alien Areas	C	P	Trends in number of IAS

Note: Operability (OP): A = Priority and ready for use; B = Priority to be developed; C = For consideration; n/a = not applicable. Policy questions (PQ): P = Pressures; R = Responses. All indicators relate to Aichi Target 9.

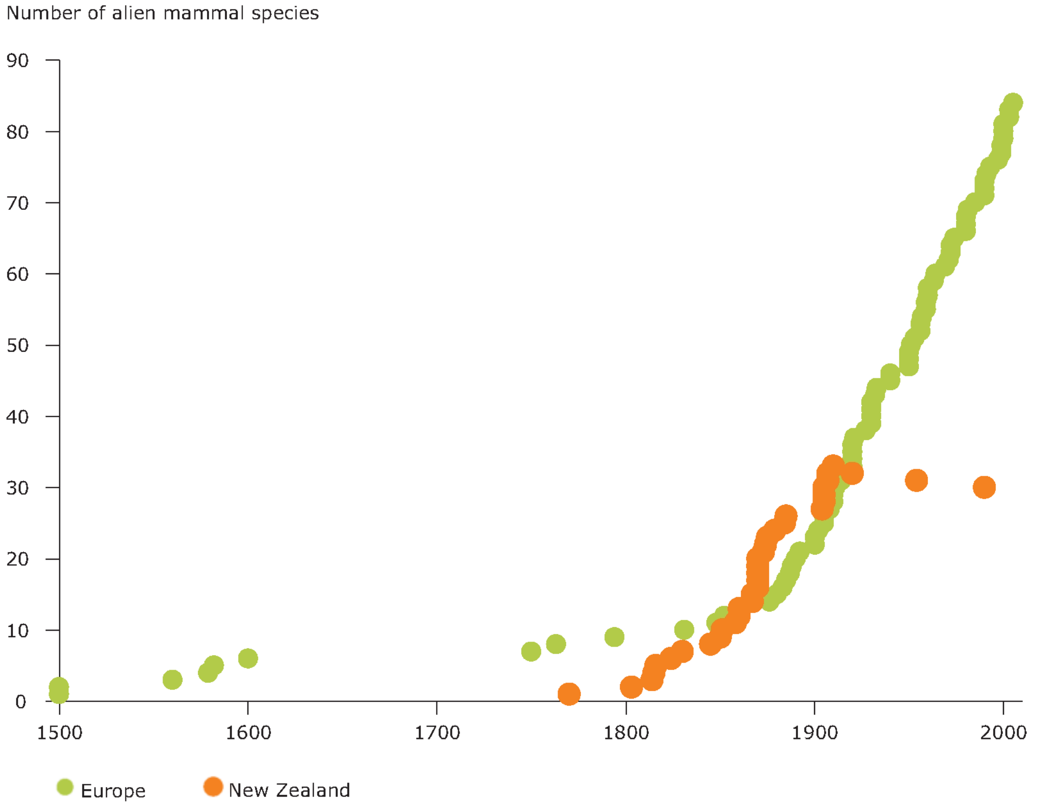
6 General difficulties

There are many difficulties involved in developing a robust and meaningful indicator for any change, which cannot be addressed in full detail in this report. However, selected general and specific difficulties related to IAS are briefly discussed.

A general problem of indicating biological phenomena is that of the timeline. Whereas policy needs measurements within a few years (the 2020 target), biological processes and biological invasion patterns in particular emerge and develop only within decades or even centuries. There is a well-known time lag in biological invasions that can mask incidence and magnitude of impacts. This so-called invasion debt (Essl et al., 2011) implies that legacies of past socio-economic activities are still manifest in current levels of invasions, and that decisions to avoid future invasions with possible negative impacts on biodiversity need to be taken now. This emphasises the usefulness of the precautionary principle, and the connection of any IAS indicator to prevailing pathways.

Spectacular single species invasions, which can be useful for raising public or political awareness, particularly regarding specific pathways or sectors, can occur over much shorter periods of time. However, the methodological backbone of a robust

Figure 6.1 **Number of introduced alien mammal species to Europe and New Zealand since the year 1500**



Note: Introductions to New Zealand ceased once strict biosecurity policies were enforced.
Source: P. Genovesi, unpublished data.

indicator is (or should be) standardised time-series data that cover long enough periods to buffer natural stochasticity.

It is useful, for public acceptance, that one of the indicators is able to reflect the success or otherwise of actions taken. If measures are taken seriously, this will be achieved automatically with any indicator over time. However, due to the sheer number of alien species and the sensitivity required to show any effects, this is not possible with most indicators. One possible option to address this is to connect implementation of regulations towards specific IAS pathways with the subsequent decrease in numbers of IAS (Figure 6.1).

Another general critique is that uncertainties of many indicators are often not adequately reported. As with recent climate change indicators, where uncertainties are high, a compulsory uncertainty statement should be included in assessments of IAS indicators. It must be stressed, however, that an uncertainty statement already accompanied the existing SEBI indicators, and that pros and cons were mentioned in a transparent way.

Despite lying outside the remit of this report, it should be emphasised that the ultimate goal of halting the loss of biodiversity in the next decades as a consequence of the introduction of IAS can only be achieved if decision-makers of all involved sectors act in concert. Solid science-based information and public awareness are key to changing our habits and influencing political developments in the near future.

7 Recommendations

1. Following a review of indicator 10 — Invasive alien species (IAS) in Europe, we conclude that both existing indicators can be improved. Updates to include new data and to broaden the geographical coverage have become available in recent years.

2. Regarding the indicator cumulative numbers of alien species in Europe, we recommend expanding the temporal coverage to 1 500 or 1 800, depending on quality and availability of data, and including pathways of alien species into the indicator. This helps to prioritise pathways, supports the precautionary principle, and is in line with the new 2020 policy targets.

3. Regarding the indicator the worst IAS threatening biodiversity in Europe, although the list may be useful as a starting point for several subsequent analyses within this indicator process, we believe the list itself and maps showing numbers of the 'worst' IAS per country may be misleading and do not answer the posed policy questions. We recommend that this indicator should be dismissed for the present.

4. Regarding the indicator on costs of IAS in Europe, we recommend continuing to update the figures on trends on number of projects and the budget spent within both the LIFE+ programme and the FP7, and to include this indicator for further processing.

5. New indicators need to be developed to answer the posed policy questions. A suite of such possible new indicators is presented and discussed. Regarding the policy questions that need to be addressed, and considering the pros and cons, we recommend further elaborating on the following new indicators within the SEBI process:

   (a) the Red List Index;

   (b) the combined index of invasion trends.

6. The opportunities provided by obligatory reporting requirements from Member States within existing instruments such as the Habitats and Birds Directives, the Water Frame Directive, and the Marines Strategic Framework Directive, should be further elaborated towards an alien indicator based on repeated and standardised monitoring data.

7. Ultimately, the development and execution of IAS indicators in Europe above all depends on the realisation of a dedicated EU strategy for IAS.

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