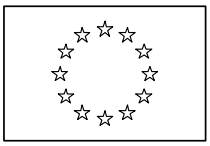

COMMISSION OF THE EUROPEAN COMMUNITIES

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COMMISSION STAFF WORKING DOCUMENT

Annex to the

COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

TOWARDS AN EU STRATEGY ON INVASIVE SPECIES

IMPACT ASSESSMENT

{COM(2008) 789 final}
{SEC(2008) 2886}

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IMPACT ASSESSMENT

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Policy context

Invasive Species (IS) present a serious threat to biodiversity which needs to be addressed if the EU is to attain its target "to halt the decline of biodiversity by 2010"[1]. The Sixth Environmental Action Programme (6th EAP) has identified IS as a priority area for action. The Communication on Halting the Loss of Biodiversity by 2010 and Beyond[2] and its associated Action Plan highlight action on IS as a priority objective and identify the need for the Community to develop a comprehensive strategy to address the IS threat.

In relevant conclusions, the Environment Council "calls upon the Commission to assess gaps in the current legal, policy and economic framework for the prevention of introduction and for the control and eradication of invasive alien species; invites the Commission, in cooperation with the Member States, to prepare an EU strategy and an effective early warning system, taking into account biogeographical regions, on the basis of the CBD Guiding Principles on Invasive Alien Species, taking into account the Bern Convention European Strategy on Invasive Alien Species and recognising the efforts made by relevant Conventions and Organisations such as the IPPC and the EPPO"[3]. The European Parliament "urges the development of a comprehensive Community response to the problem of IS, including an early warning system, and filling gaps in the legislative framework, including the development of an EU Strategy on IS"[4]. The Committee of the Regions[5] and the European Economic and Social Committee[6] have also expressed support for the Communication and its priorities, including those on IS.

Furthermore the Environment Council conclusions of 3 March 2008 note the increasing threat to biodiversity from IS and supports action at EU level.

1.2. Legal context

The existing EU legislation[7] (e.g. Council Regulation 338/97 (Wildlife Trade Regulation), Directive 2000/29/EC (Plant Health Directive), Veterinary Legislation, Council Regulation 708/2007 (concerning use of alien and locally absent species in aquaculture) covering

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1 Presidency Conclusions, Goteborg European Council, 15-16 June 2001

2 COM(2006) 216

3 Council conclusions on Halting the Loss of Biodiversity (COM(2006) 216), 18 December 2006

4 Report on Halting the Loss of Biodiversity by 2010, the Committee on the Environment, Public Health and Food Safety, European Parliament, 28.3.2007

5 Opinion of the Committee of the Regions of 6 December 2006 on the Communication from the Commission: Halting the loss of biodiversity by 2010 – and beyond (COM(2006) 216 final), CdR 159/2006 fin

6 Opinion of the European Economic and Social Committee of 15 February 2007 on the Communication from the Commission on Halting the loss of biodiversity by 2010 - and beyond (COM(2006) 216 final), NAT/334 - CESE 205/2007 fin DE/Ho/hn

7 For detailed information see report "Scope options for EU Action on IS" see http://ec.europa.eu/environment/nature/invasivealien/docs/2006_06_IS_scope_options.pdf

partially some different aspects of IS makes coordinated implementation difficult. The table below gives an overview of these four instruments and their applicability to the IS issue.

	Council Regulation 338/97	**Directive 2000/29/EC**	**Veterinary Legislation**	**Council Regulation 708/2007**
Legal basis	Article 130 S	Article 37	Article 37	Article 37
Ecological impact	////////////////[8]			X
Economic impact				X
Health (plant)		X		
Health (animal)			X	
Health (human)			////////////////////	
Special species group				X
Legal trade	X	X	X	X
Illegal trade				
Hitchhikers				
Border control measures in place	X	X	X	X
Assessment procedure established		X	X	

The dark zones represent the gaps which are not covered by current legislation. The /// zones show areas of partial coverage. A wider definition of harmful in the context of the Plant Health Directive might extend its coverage to ecological, economical and human health aspects. It should be noted that Council Decision 90/424/EEC on expenditure in the veterinary field provides for economic support to control certain animal diseases, and the veterinary legislation dealing with food safety and zoonoses covers certain human health risks. In the framework of the Community Animal Health Policy (CAHP) the animal health legislation may be broadened to cover certain animal diseases potentially transmitted by animals that could be identified as invasive species after a sound risk assessment and in full compliance with OIE/SPS rules and that are not already covered by veterinary legislation.

In addition, the Nature Directives (Directives 92/43/EEC and 79/409/EEC, Habitats and Birds Directives) explicitly tackle IS issues, as they affect the natural environment. Article 22 of the Habitats Directive provides that Member States shall *ensure that deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice the local fauna and flora and, if they consider it necessary, prohibit their introduction.* Article

[8] Annex B of Regulation 338/97 currently lists 4 invasive alien species

11 of the Birds Directive provides that Member States shall *see that any introduction of species of bird which do not occur naturally in the wild state in the European territory of the Member States does not prejudice the local flora and fauna.* Article 6 of the Habitats Directive sets out Member State obligations in relation to Special Areas of Conservation (SACs) that make up the Natura 2000 protected sites network established under the Directive. These obligations include avoiding deterioration of natural habitats and disturbance of species, both of which could be driven by IS in specific circumstances.

1.3. Stakeholder Consultation and expert input

In preparing this Communication, the Commission sought the views of stakeholders and the general public. Four consultation meetings were held with representatives of Member States and with stakeholder organisations. To facilitate dialogue and exchanges, a discussion paper "Developing an EU Framework for Invasive Alien Species"[9] was prepared and posted on the DG Environment website, as a background document for the online consultation (see below).

From 3 March until 5 May 2008 the Commission carried out a web-based consultation. This public consultation attracted 880 replies which came from 24 EU Member States, overseas territories and international contributions. About a quarter of the replies came from organisations and three quarters from individuals. The results of the consultation indicate that the public is in favour of action at EU level, i.e. an EU Strategy on IS. Furthermore, the results suggest that the public supports strongly the establishment of an Early Warning and Information System. In addition, the public has expressed a need for monitoring and assessment and a need to increase efforts for building up awareness. According to the replies the costs and administrative burden are not perceived as an obstacle, and it is considered that there are alternatives to replace those IS that are currently trade commodities. The need to develop good collaboration with industry is also seen as an important factor. Regulation of trade is considered necessary and acceptable in order to prevent new introductions of IS. A full report on the responses to the questionnaire, detailing the replies received, can be found at http://ec.europa.eu/environment/nature/invasivealien/index_en.htm .

The results of the public consultation, plus the discussion with the Member States' experts and stakeholders, have been taken into account when identifying the available options for developing the Commission's response to the problem of IS. Furthermore, expert input has been used. Expertise has been provided through specialised EU research projects (DAISIE and ALARM, see Annex B), through the European Conference on Invasive Alien Species held in Madrid in January 2008, and through DG ENV service contracts for scoping options for EU action on Invasive Alien Species (terminated in June 2006) and for technical support to an EU strategy on IS (running from January 2008 until June 2009).

1.4. Internal Consultation

A Commission Inter-service Group (ISG) has been established. The group meets before the stakeholder and Member State meetings and the members are invited to attend all the consultation meetings. The group will continue its work during the second phase to pave the way for the EU Strategy on IS.

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[9] See http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

1.5. Impact Assessment Board

A draft Impact Assessment was discussed at the Impact Assessment Board meeting of 9 July 2008. Following the opinion of the Board, the draft version has been updated to take into account the recommendations of the Board, thus the current version of the Impact Assessment contains the improvements sought. More specifically, the policy options have been reworked in such a way as to clarify the difference between the identified options compared to the status quo and business as usual option, but also to take into account the different responses needed depending on how IS enter and spread throughout the EU. The Impact Assessment report shows clearly who needs to bear new responsibilities and costs under each of the examined options, while it indicates the extent to which the options depend on future financing.

The international dimension of IS has been stressed further in the current Impact Assessment. The report looks at possible approaches to tackling issues of extra-EU trade and movement of IS, while the issue of international cooperation has been signalled and addressed. However, more explicit analysis of these points will be done in a subsequent phase.

As indicated, this Impact Assessment report supports the Communication exploring ways to deal with the issue of Invasive Species in the EU including Outermost Regions and Overseas Countries and Territories. A defined policy proposal will be developed during the coming year(s), providing a comprehensive response to the IS problems identified. Further work in the following period has been planned already, aiming to identify the elements that will be part of the comprehensive EU strategy. The work will examine thoroughly the costs to be borne by the various economic and social groups, and it will also help to define the best possible and most cost-efficient way to respond to the IS challenges, while administrative and implementation costs for public administrations and private parties/sectors will also be explored. These analyses will form part of the forthcoming Impact Assessment report that will accompany the future proposal. As financing will be needed for implementing actions to tackle IS, the report will also address thoroughly the financial needs for putting in place and implementing the actions that will be advocated by the Commission proposal.

2. PROBLEM DEFINITION

2.1. IS definition and pathways

"Alien species" are species which are introduced outside their natural past or present distribution area and succeed in surviving and subsequently reproducing. "Invasive (Alien) Species" are species whose introduction and/or spread threatens biological diversity[10]. Invasive species (IS) may arrive and enter a new region through three broad mechanisms: importation as a commodity, introduction via a transport vector, and/or natural spread from a neighbouring region where the species is itself alien. These three mechanisms result in six principal pathways: release, escape, contaminant, stowaway, corridor and unaided.

Figure 3 in Annex A identifies five pathways associated with human activity either as commodities (release and escape), contaminants of commodities, stowaways on modes of transport and opportunists exploiting corridors resulting from transport infrastructures, while a sixth pathway highlights invasive species that may arrive unaided in a region as a result of

[10] CBD Guiding Principles (CBD Decision COP VI/23)

natural spread following a primary human-mediated introduction in a neighbouring region. The different regulatory approaches for each pathway are also illustrated. Invasive species transported as commodities may be introduced as a deliberate release or following an escape from captivity or containment. However, many invasive species are not intentionally transported but arrive as a contaminant of a commodity, for example pathogens and pests. Stowaways (or hitchhikers) are directly associated with human transport but arrive independently of a specific commodity, for example organisms transported in ballast water, cargo and airfreight. The corridor pathway (e.g. highways, railways, canals) highlights the role transport infrastructures play in the introduction of invasive species. The unaided pathway describes situations where natural spread results in an invasive species coming into a new region from a donor region where it is also alien.

The marine environment is well suited to dispersal. This is especially true for those species living in the water column itself, but bottom dwellers may also release propagating units into the water, which then disperse widely with the water currents. The marine environment is relatively poorly monitored, hence the probability of discovering an alien species before it has established a permanent population is small (Ruiz and Carlton, 2003). While only a small fraction of the marine species introduced outside their native range are able to thrive and invade new habitats (Mack *et al*, 2000), their impact can be dramatic (Molnar *et al*, 2008). Figures 4 and 5 in Annex A demonstrate that while there is already a considerable stock of invasive species present in Europe, the problem will grow exponentially due to increased entry via expanding trade activities.

Furthermore, on the one hand side the major economic sectors act as sources of invasive species in Europe and on the other hand invasive species cause significant problems within these sectors (see table 4 in Annex A). The proportions of different taxonomic groups listed in four trade categories are shown in Figures 9-12 in Annex A while Table 6 in the same Annex presents a list of pathways of IS introductions in Europe with descriptions for assessment of pathways.

2.2. IS in Europe, their environmental and economic impact and related costs

2.2.1. General

Biological invasions are recognised as a key component of global environmental change, often resulting in significant damage to the economic value, biological diversity and function of invaded ecosystems (Wittenberg and Cock 2001). Numerous alien species, many introduced only in the last 200 years or so, have become successfully established over large areas of Europe (Hulme 2007). Future global biodiversity scenarios highlight potentially dramatic increases in biological invasions in European ecosystems (Sala et al. 2000). Interacting effects through rising atmospheric CO_2 concentrations, warmer temperatures, greater nitrogen deposition, altered disturbance regimes and increased habitat fragmentation may facilitate further invasions (Vilà et al. 2006).

Overall, the numbers of alien species invading Europe that are known to have an ecological or economic impact are, respectively, 1 089 (11%) and 1 374 (13%). Many species produce multiple impacts; this is a consequence of "cascading" effects at different levels of ecological complexity. Vertebrates are the group with the highest proportion of species having a known

impact, with the greatest regional spread, and one of the taxonomic groups causing more types of impact (see Annex 2 for information about DAISIE[11]). The main identified costs in Europe can be grouped into eradication and control; agricultural and forestry damage; loss of commercial fisheries, damage to infrastructure and, finally, damage to human health.

2.2.2. Environmental impact

Invasive species may have profound environmental consequences, exacting a significant toll on ecosystems (European Commission, 2004) (Box 1). These range from wholesale ecosystem changes, e.g. colonisation of sand dunes by *Acacia* spp. and extinction of native species or threats to endemic coastal plants following expansion of iceplant (*Carpobrotus edulis*), to more subtle ecological changes and increased biological homogeneity. For example, rhododendron (*Rhododendron ponticum*) reduces the biodiversity of Atlantic oakwoods and the American mink (*Mustela vison*) is held partially responsible for the decline in water vole (*Arvicola terrestris*) populations in the UK. The freshwater Asiatic clam (*Corbicula fluminea*) is a phytoplankton feeder, its dense populations may affect the structure of planktonic communities, competing with native clams, reducing fish stocks, and shifting primary production to benthic communities. A subtler but potentially more serious impact of invasive species is the possibility of hybridisation with native species. Hybridisation has occurred between alien sika (*Cervus nippon*) and native red (*C. elaphus*) deer, the alien ruddy (*Oxyura jamaicensis*) and native white-headed (*O. leucephala*) ducks as well as between native and alien oaks (*Quercus* spp). Hybridisation may introduce maladaptive genes to wild populations or result in a vigorous and invasive hybrid.

Box 1. List of IS main negative ecological impacts

- **Competing with other organisms**: plants like Japanese knotweed (*Fallopia japonica)* or Giant hogweed (*Hercleum mantegazzianum*) compete with native plants, causing changes to habitat structure
- **Predating** on native organisms: Predation by American mink (*Mustela vision*) has caused significant population declines of ground nesting birds and small mammals
- **Hybridising** with a related species or variety, such as the North American grass *Spartina alterniflora* which hybridised with the European *Spartina maritima* and produced the very invasive hybrid *Spartina anglica*, which has radically changed coastal mudflat habitats in Great Britain, Denmark and Germany
- **Causing extinction** of native species: crayfish plague (*Aphanomyces astaci*) is known to threaten local populations of native crayfish with extinction
- Being **toxic**: toxic algae blooms are caused by alien phytoplankton such as *Chattonella verruculosa*
- Being a reservoir for **parasites** or a **vector** for pathogens: rainbow trout is a host for the salmon parasite *Gyrodactylus salaris*

[11] DAISIE, Delivering Alien Species Inventory for Europe see http://www.europe-aliens.org/index.jsp

- **Disrupting pollination** : *Impatiens glandulifera* competes for pollinators such as bumblebees with the native riverbank species, and so reduces seed set in these other plants
- **Altering energy and nutrient flows**: alien plants, such as *Robinia pseudacacia*, alter nutrient availability via nitrogen-fixing
- **Altering the local food web**: when appearing in large densities the Asian date mussel (*Musculista senhousia*) can shift the community from suspension-feeding to primarily deposit-feeding
- **Altering the composition and functioning of habitats and ecosystems**: Water hyacinth (*Eichhornia crassipes*) changes water flow by overgrowing and blocking water bodies.

Source: Braat L. & P. ten Brink et al. 2008. Cost of Policy Inaction (COPI): The case of not meeting the 2010 biodiversity target, a study for the European Commission (Annex III by ten Brink, Kettunen & Peralta Bezerra on IS)

2.2.3. Economic impact

There are plenty of examples where IS have caused significant damage to economic activity and where their control or eradication has entailed significant costs (see examples in box 2 and in table 2 in Annex A). In general, the recorded economic impact occurs when ecosystem services, i.e. ecosystems' capacity to maintain material flows and processes that are beneficial to human wellbeing, are disrupted by IS. The table below indicates the main IS taxa impacting on different ecosystem services.

Table 1: Main IS taxa impacting on different ecosystem services in Europe

Type of ecosystem service (ES) affected by IS	Main IS taxa causing impact
Provisioning Services	
Food and fibre	Invertebrates (terrestrial & marine); plants (terrestrial); vertebrates (terrestrial); fungi
Fresh water	Invertebrates (marine & freshwater); plants (marine & freshwater)
Regulating services	
Water regulation (e.g. flood prevention, timing and magnitude of runoff, aquifer recharge)	Invertebrates (marine & freshwater); plants (marine & freshwater); vertebrates (terrestrial)
Erosion control	Vertebrates (terrestrial), plants (terrestrial), invertebrates (freshwater)
Water purification / quality maintenance and waste management	Invertebrates (marine & freshwater), plants (marine & freshwater)
Regulation of human diseases (i.e. IS as a vector for disease)	Invertebrates & vertebrates (terrestrial)

Fire resistance (change of vegetation cover leading to increased fire susceptibility)	Terrestrial plants
Other: human health other than diseases (e.g. allergies and injuries)	Invertebrates (terrestrial & marine); plants (terrestrial)
Other: destruction of infrastructure	Invertebrates (marine & freshwater)
Cultural services	
Cultural / natural heritage values, aesthetic / cultural value, recreation and ecotourism	Plants (terrestrial, freshwater, marine); invertebrates (terrestrial, freshwater, marine); vertebrates (terrestrial, freshwater, marine); fungi
Supporting services	
Primary production	Plants (terrestrial, freshwater, marine); invertebrates (marine & freshwater)
Nutrient cycling	Plants (terrestrial, freshwater, marine); invertebrates (marine & freshwater)
Soil / sediment formation	Invertebrates (marine & freshwater)
Other: changes in species dynamics and/or ecosystem's food web	Invertebrates (marine & freshwater)

Source: Kettunen M. et al 2008. Technical Support to EU Strategy on IS; Report "Assessment of the impacts of IS in Europe and the EU".

The recent analysis by Kettunen et al. (2008) of cases where there is evidence of significant environmental, social and economic impact in Europe from 125 IS, including the 100 worst IS identified in DAISIE, revealed a total of 57 IS species that are known to negatively affect ecosystems' provisioning services, i.e. the ability of ecosystems to provide different goods and products (e.g. food, fibre and water) that benefit human wellbeing. The vast majority of these impacts (impact of 54 species) are caused by IS having adverse effects on **provisioning of food**, for example IS causing decline in fish catch, aquaculture, crop and wood production or IS with negative effects on livestock (e.g. livestock health). In addition, in some cases (3 species), decline in **provisioning of water** due to blocking waterways has been recorded (i.e. some aquatic exotic plants, such as water hyacinth (*E. crassipes*) and New Zealand pigmyweed (*C. halmsii*)).

The above analysis of IS' impact on ecosystem services also shows that IS are known to have a negative impact on regulating services such as **erosion control, water quality and resistance of ecosystems to wild fires**. For example, invasive mammals can cause erosion by burrowing in river banks whilst invasive plants may overtake completely native plants that play an important role in binding soil with their roots (borrowing: e.g. Louisiana crayfish (*P. clarkii*) and European rabbit (*O. cuniculus*); competition: Himalayan balsam (*I. glandulifera*)). Finally, IS can also **damage infrastructure** due to burrowing (invertebrates & vertebrates) or via their root systems (plants).

According to the same report, most of the identified instances where IS have a negative impact on cultural services, i.e. different cultural, social, recreational and educational values of ecosystems, relate to the **reduction of recreational use and/or tourism** due to invasion of non-native species (40 species). This can happen for a number of reasons, including decreased

aesthetic value caused by IS invasion, nuisance to humans and/or recreational activities, and impact of IS on human health (see section 4.2.2 above). For example, a number of non-native aquatic plants are known to reduce recreational use of water bodies by blocking access to open water (e.g. *Azola* sp. and water hyacinth, *E. crassipes*). Thick vegetative growth of aquatic IS can also hinder fishing and angling activities. In general, the assessment of IS' impact on cultural services, such as the aesthetic value of landscape, is highly subjective. This means that any view about the impact of non-native species on these services can be either positive or negative, depending on the perspective of the person or organisation concerned.

On the other hand a high number of much-appreciated pets, game species and ornamental plants and animals in Europe are non-native. These include, for example, common cat (*F. cattus*), rhododendron (*R. ponticum*), Japanese deer (*C. nippon*), and ornamental fish used in private and public aquaria (Kettunen et al., 2008).

Box 2: Examples of recorded economic impact resulting from IS and cost of controlling them

Instances of recorded direct economic impact include the damage caused by Japanese knotweed (*Fallopia japonica*) to masonry, pavements, walls, drainage works and native riparian communities, increased flood risk and increased cost of land clearance for development (where the plant occurs on a development site it can cost tens of thousands of pounds to adequately control). In Germany, estimated costs are €5.9-6.6 million/year (plant control), €12.3-21.2 million/year (stabilisation of river banks), €2-7.7 million/year (clearance of railways) and €3.5-10.5 million/year (repair of foundations). The Czech Republic spends €0.2 million/year on control/containment. In the UK, a 2003 estimate put the cost of removal from Britain at £1.56 billion. Specific control costs cover attempted eradication (over €1 078 million/year) and research on biocontrol (€0.11 million/year). In Wales (UK), the estimated annual control costs for one county council were £300 000 (in 1994).

Another example is the impact of bark stripping by grey squirrels (*Sciurus carolinensis*) on forestry production. The western corn rootworm (*Diabrotica virgifera*), which was accidentally introduced into Serbia in the 1990s, is a major pest of maize that leads to yield losses. Preliminary studies on the potential for establishment of the western corn rootworm show that this pest is likely to survive and develop wherever maize is grown in Europe. Leaving aside introduced pests and diseases affecting agriculture, alien parasites such as *Gyrodactylus salaris* (an ectoparasite of Atlantic salmon) and *Anguillicola crassus* (swimbladder nematode of eels) have led to dramatic decreases in fisheries sector incomes in several Nordic countries. The American oyster drill (*Urosalpinx cinerea*) is a major gastropod pest of the cultured oyster industry as it feeds preferably on oyster spat and is recorded as consuming more than half the oyster spat in certain European estuaries (Cole 1942). The muskrat (*Ondatra zibethicus*) and coypu (*Myocastor coypus*), both introduced by the European fur industry, damage river banks through digging and have increased the risk and severity of floods in many central and southern European countries. In Italy (1995-2000), the removal of over 220 000 coypus cost €2.614 million whilst riverbank damage exceeded €10 million and agricultural damage was almost €1 million. Current control costs available for EU Member States total €5.02 million/year (Netherlands: prevention/control €0.8 million; East Anglia (UK): eradication €0.45 million; Italy: combined damage/control costs, €3.77 million).

Notorious invasive alien weeds cause major economic harm, e.g. Mexican tea (*Chenopodium ambrosioides*), knotgrass (*Paspalum paspaloides*), Canadian horseweed (*Conyza canadensis*), Bermuda buttercup (*Oxalis pes-caprae*), while other alien plants act as hosts of plant

pathogens e.g. rescuegrass (*Bromus catharticus*) as host for barley yellow dwarf virus and wheat stem rust. Invasive alien species can also affect human health, e.g. phytophotodermatitis through contact with giant hogweed (*Heracleum mantegazzianum*), asthma and hay-fever arising from the pollen of annual ragweed (*Ambrosia artemisiifolia*), poisoning of humans through consumption of toxic fruit, e.g. American pokeweed (*Phytolacca americana*), silverleaf nightshade (*Solanum eleagnifolium*) or leptospirosis spread by the brown rat (*Rattus norvegicus*).

Sources: Kettunen et al. (2008); DAISIE.

2.2.4. Costs occurred

The analysis by Kettunen et al. (2008) reveals that, in general, the existing evidence on IS' economic impact in Europe can be divided into two main categories, i.e. costs of damage and costs of control measures. Information on the cost of damage is the most common cost item for the negative impact on the agricultural, forestry and fisheries sectors resulting from invasions of non-native pests, such as plant diseases (fungi), insects and fouling organisms (marine, freshwater and terrestrial invertebrates). In addition, there are some estimates on the damage caused by IS to human health, e.g. treatment costs for asthma. Information on the monetary resources needed to control IS is available across different IS taxa and invaded ecosystems.

Based on the information on documented (real & estimated) costs, **the total known monetary impact of IS in Europe amounts to €9.6 billion/year** (Kettunen et al. 2008, see Table 2 below). Costs related to the damage caused or control of terrestrial IS (e.g. vertebrates, plants and invertebrates) form a major part of this estimate. This includes, for example, damage caused by pests to agriculture and forestry.

Given the limited availability of documented costs, Kettunen et al. 2008 also carried out an extrapolation of costs to provide a more comprehensive picture of the real magnitude of the potential economic impact of IS in Europe[12]. The extrapolation has been carried out on the basis of information on the area affected by IS and the known range of IS in Europe. The cost estimates from identified study areas have been transferred to cover the full current range of IS in Europe. **As a result the costs of IS can be estimated as €12.7 billion/year.** This should still be seen as an underestimate for it only covers a limited number of IS (e.g. extrapolation of costs was possible only for 25 of 125 IS considered in the analysis). Also, the extrapolation is only based on a subset of real IS costs, i.e. it does not cover the loss of biodiversity-related existence, bequest and option value due to IS invasion.

[12] I.e. where information is available on the costs of an IS for a given area (the study area) and where the full European range of this given IS is known (from the DAISIE database), costs numbers can be created for the full range. This is done by applying the costs insights from known case study areas (i.e. costs per unit area of the study area) to the wider area impacts by the IS. These costs numbers assume that the level of impact/costs is similar throughout the known European range of a given IS.

Table 2 Overview of the recorded economic costs (real costs & estimates) due to different IS taxa in Europe[13].

Taxa / biome of IS	SUM of known costs in EU (million EUR / year)	No of cases	SUM of known costs in non-EU[14] (million EUR / year)	No of cases	SUM of known costs in Europe (million EUR / year)	No of cases	TOTAL (million / EUR)
Fungus (freshwater / terrestrial)	1505.00	3	0.16	1	-		1505.16
Freshwater invertebrate	99.38	3	20	1	0.99	3	120.37
Freshwater vertebrate	-		-		-		
Freshwater plant	3.89	2	-		-		3.89
Marine invertebrate	1	1	-		36.68	3	37.68
Marine vertebrate	-		-		-		
Marine plant	-		-		18.56	2	18.56
Terrestrial invertebrate	786.16	10	-		500.00	1	1286.16
Terrestrial vertebrate	4290.13	29	-		-		4290.13
Terrestrial plant	2302.67	23	-		-		2302.67
Known costs	**8988.23**	**71**	**20.16**	**2**	**556.23**	**9**	**9564.62**

Source: Kettunen M. et al 2008. Technical Support to EU Strategy on IS; Report "Assessment of the impacts of IS in Europe and the EU".

Note: This synthesis is based on the available information on documented costs of IS (i.e. without extrapolation of costs). (Kettunen et al, 2008 Annex II)

Table 3 Overview of the recorded economic costs (real costs & estimates) of different IS taxa on different economic sectors in Europe.[15]

Economic sector & pest taxa	Costs of damage (million EUR / year)	Costs of control (million EUR / year)
Agriculture*		
Terrestrial plants (weeds)	1050.00	no info
Terrestrial invertebrates (pests)	735.48	526.72
Freshwater invertebrates	2.21	0.1

13 see Kettunen et al. 2008 Annexes VI and VII.

14 Non EU states included are Andorra, Iceland, Liechtenstein, Moldova, Monaco, Norway, Russia, Switzerland, Ukraine, former Yugoslavian states in the Balkans

15 See Kettunen et al. 2008 Annexes VI and VII for data origin and references.

Terrestrial vertebrates	901.28	no info
Fungi	1500.00	no info
Pests non-specified for taxa		198
Total	**4913.79**	
Fisheries / aquaculture		
Freshwater invertebrates	118.06	no info
Marine invertebrates	25.53	no info
Marine plants	18.56	no info
Fungi	0.16	no info
Total	**162.31**	
Forestry		
Terrestrial plants (weeds)	no info	22.7
Health*		
Terrestrial invertebrates	22.50	1.46
Terrestrial plants	33.15	2.34
Total	**59.45**	
Known costs (million EUR / year)	**5135.55**	

* The table does not include costs of epidemic animal and human diseases

Source: Kettunen M. et al 2008. Technical Support to EU Strategy on IS; report "Assessment of the impacts of IS in Europe and the EU"

Note: This table synthesises the information on documented costs of species (i.e. without extrapolation) as relevant to specific sectors (Kettunen et al. 2008, Annex 2)

Kettunen et al. analysed the documented IS economic impact by sector (i.e. a specific "subset" of the above €9.6 billon), divided into two main categories: (a) cost of damage; (b) cost of management and control measures. According to these calculations, the known documented **costs for the agricultural, fisheries, forestry and health sectors amount to €5.1 billion/year** (excluding the costs of epidemic animal and human diseases). Again this figure is based on the documented data and with no attempt at extrapolation of other gap filling. Like the other aggregate cost estimates above, this figure is likely to be an underestimate of the real situation as the forestry-related costs seem clearly to be underrepresented and no monetary values exist for costs attributable to IS in the tourism sector. The key elements of the breakdown of these costs are given below (for more detail, see the Task 1 report):

– Based on available information, IS costs *(documented costs)* are **highest for the agricultural sector** (€4.9 billion/year, of which €4.19 billion/year relates to damage costs and €725 million/year to control costs);

– **Documented information is very limited for fisheries and aquaculture** (estimate of €162 million/year in damage costs: no information is available on control costs);

– The information available is clearly **underrepresented for forestry** (no estimate of overall damage costs: control measures estimated at €22.7 million/year);

– The IS cost to the **health sector** (excluding cost of epidemic animal and human diseases) **was estimated at €59.45 million/year** (€55.65 million/year in damage costs and €3.8 million/year in control costs).

These analyses are limited to a number of key sectors where information is available. Although it does not provide a complete picture, it demonstrates that economic damage by invasive species implies significant costs.

2.3. The International Dimension of IS

The EU will need to boost support for the prevention, detection, control and eradication of IS in **third countries**. The Convention on Biological Diversity has inter alia urged donors to provide, as a high priority, funding for the development and implementation, at national and regional levels, of the invasive alien species strategies and action plans and for the application of the CBD Guiding Principles[16]. The Environment for Europe Conference agreed to promote the implementation of the pan-European Strategy on Invasive Alien Species developed under the Bern Convention[17]. The European Community can support third countries and regional or international activities through its Development Cooperation Instrument (in particular the Environment and Natural Resources Thematic Programme), the European Development Fund and the European Neighbourhood Policy Instrument. Member States can provide additional support through their own development cooperation instruments.

2.4. Why Action at EU level?

Several biological invasions now threatening Europe might have been prevented by a higher level of awareness of invasive species issues and a stronger commitment to addressing the matter, e.g. the spread of the killer alga (*Caulerpa taxifolia*). Current inaction by many, though not all countries, is becoming increasingly disastrous for the region's biodiversity, health and economy (Hulme 2007). European states should recognise the risk that activities within their jurisdiction or control may pose to other states as a potential source of invasions and take appropriate individual and cooperative actions to minimise that risk. This is particularly important within Europe as species introduced into the territory of one state can easily spread to neighbouring states, especially with a shared coastline, transboundary mountain ranges and international watercourses. It is also critical with regard to Europe's trading partners.

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16 See inter alia CBD COP decisions VI/23 including the Guiding principles for the prevention, introduction and mitigation of impacts of alien invasive species that threaten ecosystems, habitats or species, VIII/27 and IX/4.

17 Kyiv Resolution on Biodiversity adopted at the 5th Ministerial Environment for Europe Conference.

The heterogeneity in the degree to which different European nations are exposed to biological invasions may limit recognition of the risk that activities within their jurisdiction may pose to other nations. Species prioritised for management differ across Europe, which means that concerted action should be planned at sub-regional levels. Finally, a species that is alien in one European nation may be native in another. This makes for considerable complexity with regard to the development of regulations regarding trade within Europe. Therefore in the current work at EU level the focus is on the invasiveness of the species.

Effective control of invasive species has been hampered in Europe by the lack of: (a) monitoring for alien species at frequent enough intervals in regions of concern; (b) a means to report, verify the identifications, and warn of new sightings; and (c) risk assessments that predict the likelihood of a particular species becoming invasive.

There are several reasons why dealing successfully with IS requires action at EU level:

(1) IS do not respect borders. An IS outbreak, which is ignored in one Member State, may represent a risk for neighbouring countries. Equally, action by one Member State can be annulled by inaction across the border.

(2) IS remain a rapidly increasing threat to European biodiversity. Inaction hinders achievement of the EU target of halting biodiversity loss.

(3) The increasing volume of trade contributes to the spread of IS. Free trade rules are perceived by many Member States as a constraint on regulating introductions of potential IS at the national level. Trade in goods is the exclusive competence of the EC.

(4) The EU dimension is already recognised in the context of existing measures to deal with problems in the field of plant and animal health. In cases where invasive species represent a threat to plant and animal health, there are already overlaps[18].

(5) The EU dimension is clearly demonstrated in Council Regulation 708/2007 concerning the use of alien and locally absent species in aquaculture, adopted in June 2007.

(6) Experts encourage the Commission to implement a cooperative legal framework at EU level to address IS (e.g. Resolution of the NEOBIOTA conference held in September 2006 and attended by some 350 European scientists[19]). The conclusions of the European Conference on Invasive Alien Species[20] and the outcome of the online consultation of the public and stakeholders have also given strong leverage for action at EU level.

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[18] To avoid possible overlaps between the veterinary legislation and the future framework on IS, it is necessary to coordinate the development of the CAPH and the EU Strategy on IS. Therefore, expertise on IS would be needed to implement measures within the CAPH to tackle those IS considered as high risk after a careful risk assessment and following the international framework on animal health (i.e. OIE/SPS rules).

[19] Part of the conference resolution: "to complement existing European activities to close gaps in pathways, habitats and taxonomic groups in order to build a cooperative legal framework and to address IS at the appropriate level".

[20] Final Publication of the Conference, see http://www.fundacion-biodiversidad.info/eei/pdf/PUBLICACION%20FINAL/Version%20Ingles/Versioningles.pdf

(7) A consistent and coherent policy on IS in the EU will bring additional benefits to the fight against IS. As described under section 1.2, at the moment there exists a patchwork of Community instruments which can partially address the IS issue. In many cases import of proven IS continues (e.g. *Hydrocotyle ranunculoides* (floating pennywort), a water ornamental plant, is covering water bodies and thus destroying water ecosystems and causing problems for the shipping industry). Important pathways, e.g. ships' ballast water, are not controlled and are allowing invasion of further species.

(8) Certain categories of IS are not covered at all under the current legislative framework, nor can this be done easily simply by modifying the existing legislation. For organisms outside the specified categories (mammals, certain birds (subject to legislation in force to control avian diseases) aquaculture species, vectors of diseases affecting wild animals, some plants, some insects, etc.) there are no Community-backed controls on import and export and no restrictions on intra-Community trade and movement.

(9) The environmental impact of invasive species tends to be much greater in EU Overseas Countries and Territories (OCTs) and Outermost Regions (OR) than in continental Europe. Island biodiversity is exceptionally vulnerable to invasion because of the long evolutionary isolation of island ecosystems. IS in OCTs and ORs thus have a disproportionately high impact on wider European biodiversity. Socio-economic consequences are also greater in remote territories where livelihoods, culture and economic opportunities often depend on biodiversity and ecosystem services. Climate change, in association with other environmental pressures, is predicted to aggravate the situation by disrupting ecosystem function and altering species' distribution.

3. OBJECTIVES

The Communication "Towards an EU Strategy on IS" is the first stage of a two-step process to develop an EU Strategy on IS. The overall objectives of the policy proposal are:

- to substantially reduce the impact of invasive species on EU biodiversity,
- to contribute towards the target of halting the loss of biodiversity by 2010 and beyond and in particular to tackle the adverse effects of IS in relation to native European biodiversity,
- to minimise the economic impact felt by different sectors as a result of IS and thus to contribute to the Lisbon Strategy,
- to tackle the negative economic and social effects and costs that IS may engender for Europeans and in particular their wellbeing and health.

It has been demonstrated above that there are certain gaps in the existing EU legislation, and consequently not all IS-related issues can be tackled efficiently by the current legal frameworks in place. The development of new legislation takes time and considering the results of scientific research that has demonstrated an exponentially increasing threat by IS, the first step focuses on options and measures that could be implemented immediately while carrying out the work needed for the second step, i.e. developing the EU Strategy on IS. The purpose of the Communication "Towards an EU Strategy on invasive species" and the present accompanying impact assessment is to describe the IS problem and the associated costs and to

set out the types of response that could be envisaged as part of an EU strategy. To the extent possible the costs as well as the benefits of the potential responses are described mainly in qualitative terms.

4. POLICY OPTIONS

With a view to taking action to counteract the negative impact of IS on the economy, society and the European environment and biodiversity, the following options have been identified:

> Option A: **Business as usual**: continuation with the ongoing implementation of existing instruments.
>
> Option B: **Maximise use of existing approaches**: best use of existing legislation, development and implementation of voluntary codes of conduct, development of an early warning and information system, maintenance of the European inventory of IS, increasing awareness, exchange of best practice, implementation of eradication and control measures at national level.
>
> Option B+: **Amend existing legislation:** (e.g. phytosanitary and wildlife trade legislation) to widen the scope to formally take IS issues into account.
>
> Option C: **Comprehensive, dedicated EU legal instrument:** this option includes the rapid introduction of new legislation, entailing a comprehensive approach towards tackling IS, coupled with maximal use of the basic tools described in option B.

The options A, B and C outlined below are cumulative options of increasing intensity and effectiveness, while options B+ and C are mutually exclusive. Increased intensity requires increased resources, and therefore depends on the willingness to invest. The measures identified in option B are not stand-alone measures. They should be seen as **cumulative measures** which are part of the approach seeking to tackle IS problems in an integrated manner and maximise the use of existing instruments and legislation. **It is feasible and desirable to implement certain of these measures immediately**, while developing further the comprehensive EU Strategy on IS. The suggested measures include actions for the prevention of intentional and unintentional introduction, early warning and information, eradication, containment and control of established IS species. Horizontal measures including financing mechanisms, research, functioning surveillance, risk assessment and monitoring systems and raising awareness of the public, authorities and concerned industry sectors are also addressed. These measures would become an integral part of the future comprehensive EU Strategy on IS.

4.1. Option A: "Business as Usual"

Under this option the existing legal frameworks that tackle in a very fragmented and non-comprehensive way the issues of IS identified in the problem definition would continue to be implemented.

For organisms harmful to plants or plant products and for animal and fish diseases European states have a comprehensive framework of laws and procedures that are harmonised with international phytosanitary, zoosanitary and trade rules. Coverage is mainly focused on agricultural pests and diseases affecting crops, livestock and farmed fish. The framework

provides for biosecurity controls in the form of certification, quarantine procedures and post-entry surveillance as necessary, as well as measures to control spread. The effectiveness of these instruments is facilitated through clearly identifiable host and pest targets as well as the direct economic benefits of regulation. Because these contaminant pests have an economic impact, strict regulations on imports are in place. For example, the Plant Health Directive (2000/29/EC) provides lists of pest species that must be banned from being introduced into particular Member States. Existing legislation in the field of plant health is mainly based on the European and Mediterranean Plant Protection Organization (EPPO) recommendations. EPPO maintains lists of invasive alien species that are recommended for regulation to its 50 member countries. There are currently five invasive alien plants that are recommended for regulation.

Regarding Biological Control Agents, European countries differ in their national regulations and capacity for assessing the environmental risks of these agents. EPPO has compiled a list of widely used Biological Agents which are considered to be environmentally safe. This list is currently being updated. Identification of target species facilitates the control and eradication of pests, pathogens and parasites of economic significance.

Council Regulation 708/2007 establishes a framework governing aquaculture practices in relation to alien species to assess and minimise the possible impact of these and any associated non-target species on aquatic habitats. It establishes a framework to asses and minimise possible impacts on species, habitats and ecosystem functions which may be expected to arise from the introduction or translocation of aquatic organisms and non-target species in aquaculture and from the spreading of these into the wild. Species that may threaten wild fauna and flora are marginally covered by the Wildlife Trade Regulation (Council Regulation 338/97), where four invasive animal species[21] are currently listed and cannot be imported into EU territory. However, the spread of these species within the EU's territory is not currently regulated.

With regard to controls on the introduction of alien organisms to the natural environment, the Habitats and Birds Directives contain restrictions on deliberate introductions of alien species into the wild. In relation to control and eradication of IS, the Habitats, Birds, and Water Framework Directives may impose some obligations through requirements to maintain the ecological status of certain sites.

Species of birds that are not native to the European territory of the Member States are not protected by the Birds Directive unless specifically mentioned in the Directive's Annexes[22]. The Canada goose (*Branta canadensis*) and Wild turkey (*Meleagris gallopavo*) have been introduced into Europe and are listed as huntable species under the Birds Directive. However, Canada Geese also naturally occur as migrants in very small numbers and the Wild Turkey does not show invasive patterns. There would not appear to be similar listings of non-native species in the species annexes of the Habitats Directive. However, there is at present a reference to an invasive species, Azolla, as a typical species associated with the natural habitats type (Code 3150) "Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation".

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[21] Species listed are the red-eared slider (Trachemys scripta elegans); the American bullfrog (Rana catesbeiana); the painted turtle (Chrysemys picta); and the American ruddy duck (Oxyura jamaicensis).

[22] A listing of non-native bird species is available on the web site of the Commission at http://ec.europa.eu/environment/nature/conservation/wildbirds/eu_species/introd_species_en.htm

However, as demonstrated above this option does not provide for a comprehensive way to deal with all aspects of IS (see also in 2.3 the identified reasons for taking action at EU level). In the wake of the expected dramatic increase of IS it can be expected that the costs in relation to damage caused by IS will increase accordingly under this scenario.

Although this option implies some measures to prevent the introduction of certain IS, it will not be sufficient to counteract the increasing threat. With regard to early warning and rapid eradication, the BAU option is not functional. Sporadic eradication measures in some countries cannot solve the problem. The situation is the same in relation to control and long-term containment.

4.2. Option B: "Maximise the use of existing approaches"

This option involves making the best use of existing EU legislation, combined with voluntary codes of conduct, the establishment of an early warning and information system, maintenance of the European Invasive Species inventory, awareness-raising activities, exchange of best practice, and eradication and control measures at national level.

The measures under this option should be implemented immediately while developing the EU Strategy on IS, which will be subject to follow-up of the present Communication.

In the following section the measures are grouped according to the "three-stage hierarchical approach"[23]: 1) prevention, 2) early detection and eradication, 3) control and long-term containment. This approach addresses new introductions (via prevention) as well as established species (via steps 2 and 3).

4.2.1. Prevention

Prevention is seen as the most cost-efficient way to tackle the risks posed by IS. This involves giving priority to measures taken to prevent such species being introduced into EU territory in the first place or spreading to new areas within EU territory. To identify relevant species for attention, to channel resources effectively and to assess and mitigate their risks, risk analysis procedures are necessary to justify which species should be prohibited or controlled. The existing system for Pest Risk Analysis used for assessing and mitigating plant pest risks can be used as an example. Work is in hand within the EU to develop more generic assessment tools.

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[23] The three-stage hierarchical approach entails:
1) Prevention – Prevention is generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment of IS. Priority should be given to preventing the introduction of IS into the EU and spread between MS.
2) Early detection and rapid eradication – If an IS has been introduced, early detection and rapid eradication is the most cost-effective way of preventing its establishment and wider spread.
3) Long-term control and containment – If eradication is not feasible, IS population should be controlled in order to prevent further spread. Control measures should be implemented.

Best use of existing legislation

As identified in the problem definition several Community legislative instruments in place provide a basis for addressing aspects of IS prevention. However, gaps remain in particular with regard to the regulation of trade in order to avoid new introductions of IS. There are obstacles to the use of the Wildlife Trade Regulation as well as the veterinary and phytosanitary legislation. Neither of them is optimal to fully tackle the IS issues. Nevertheless, the most efficient interim approach may be to identify those IS with the worst impact and seek to have them covered by the instrument that can best accommodate them. This may mean that some highly invasive species in trade known as worst invaders could be listed as "ecological threat species" under the Wildlife Trade Regulation while invasive animal and plant species that can be considered as pests of plants could be covered by the phytosanitary legislation.

Voluntary codes of conduct

Voluntary codes of conduct or good practices agreed and implemented by concerned industries including horticulture and the pet and ornamental fish trade can be a very efficient tool to prevent the introduction of IS. Cooperation with concerned industries is essential. A Code of conduct on horticulture and invasive alien plants[24] is currently being developed under the Bern Convention on the Conservation of European Wildlife and Natural Habitats and EPPO. A few Member States are developing species- or sector-specific codes of conduct, e.g. the German and Austrian botanic gardens have recently drawn up a voluntary code of conduct for the cultivation and trade of IS[25].

4.2.2. Early warning and information

Currently, early detection occurs on an ad hoc basis in most MS and the possibility of a more systematic approach should be considered. Early warning and prevention of the harmful impact of invasive alien species on ecosystems is a fundamental requirement of the European Biodiversity Strategy and the EU Action Plan to 2010 and Beyond (European Commission, 2006) yet, in the absence of reliable regional analyses, the European states have been unable to tackle this issue strategically (Miller *et al.* 2006; Hulme *et al.* 2007).

Early detection and eradication imply an early warning and information system based on an up-to-date inventory of all alien species known to inhabit Europe. *DAISIE, a pan-European inventory of alien species*[26], a three-year (February 2005-March 2008) research project supported by the Sixth RTD Framework Programme with €2.4 million in funding, has delivered a pan-European inventory of invasive alien species mobilising existing expertise for species records. This inventory also includes and describes alien species that have a high likelihood of introduction or spontaneous spread from neighbouring countries, identifies priority species and provides a platform for European reporting on biodiversity indicators, and highlights areas where Europe will need to direct resources to manage biological invasions.

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[24] Available at http://www.cbd.int/doc/?mtg=sbstta-13 (go to “others”)

[25] Kiehn M, Lauerer M, Lobin W & Schepker H (2008): Grundsätze im Umgang mit invasiven und potenziell invasiven Pflanzenarten in Botanischen Gärten. Unpubl. Report, 3 pp.

[26] See http://www.europe-aliens.org/index.jsp

It is hoped that the DAISIE database will encourage the exchange of data among different geographical regions and thereby serve as a node in the Global Information System for Invasive Species. Documenting current invasions, predicting new invasion sites, and preventing invasions are vital to the protection of biological diversity in Europe. Prediction of, and rapid response to, invasive species requires ready access to invasive species knowledge bases in many countries. It follows that internet-accessible knowledge bases are a valuable tool which can provide crucial information for the early detection, eradication, and containment of invasive species—which is most feasible for species that have just arrived. With direct access to national knowledge bases throughout Europe, managers and policy-makers addressing the invasive species challenge should easily obtain data on which species are invasive or potentially invasive in particular habitats, and use this information in their planning efforts. Agencies responsible for pest control can quickly determine if a species of interest has been invasive elsewhere in Europe. Importers of new alien species (e.g. nurseries, botanical gardens, pet trade) can access data to make responsible business choices. Land managers can learn about control methods that have been useful in other areas, reducing the need to commit resources for experimentation and increasing the speed at which control efforts can begin. The information available in the database also presents an outstanding resource to synthesise current knowledge and trends in relation to biological invasions in Europe. The data will help identify the scale and spatial pattern of invasive species in Europe, shedding light on the environmental, social, economic and other factors involved in invasions, and can be used as a framework for considering indicators for early warning purposes.

The future of the inventory may increasingly see a move away from a single database to the integration of national databases across the same infrastructure. In addition to regular scientific update, it is also important that the inventory be institutionally recognised as the basis of a possible future Early Warning and Information System for IS. It is suggested to have it permanently hosted by the EEA, which would be provided with the appropriate resources to keep it up and running. A feasibility study for an IS early warning and information system is currently commissioned by the EEA. The amount necessary to keep the inventory up to date as the basis for an Early Warning and Information System has been estimated at about €500 000 annually, while the amount invested for its initial development was €2.4 million. Meanwhile *Aquatic Invasions (AI),* an electronic open-access journal focusing on biological invasions in European inland and coastal waters and potential donor areas of aquatic invasive species for Europe[27], is also serving several online databases on invasive species, including the DAISIE information system described above, through publication of national checklists of aquatic alien species, which represent a core component of this project database (Gollasch and Nehring 2006, Alexandrov et al. 2007, Galil 2007, Kerckhof et al. 2007, Minchin 2007). The timely publication of verified checklists and new IS findings may help to keep the DAISIE information system up to date. Figure 6 (in Annex) demonstrates the role of AI in a European Early Warning System. *Aquatic Invasions* facilitates the flow of essential information needed for the decision-making processes. Work is underway to develop an online risk assessment toolkit with early warning functions, which may serve as an interactive transmitter of primary information on IS from data providers upwards to the level of decision-making. *Aquatic Invasions* will play an important role as an essential component of this new electronic information framework for invasive alien species (Panov et al.2008). The online journal BIORISK[28] could fulfil the same function for terrestrial IS.

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27 See http://www.aquaticinvasions.ru/

28 See http://www.pensoft.net/Brochure-BIORISK.pdf

The North European and Baltic Network on Invasive Alien Species (NOBANIS)[29] has developed a network of common databases on alien and invasive species of the region. The geographic scope of NOBANIS has recently increased and now also covers Central Europe. The common portal facilitates access to IS-related data, information and knowledge in the region and its website hosts detailed fact sheets of the worst invasive species. Information is kept up to date via a network of national contact points. NOBANIS is thus a vital complementary IS information hub to DAISIE.

A system for early warning and eradication should also contain methods and expertise for risk assessment of invasive species so as to rapidly evaluate risks and identify what measures are necessary to manage the risks, tools for sharing information with partners within the system, monitoring schemes to identify new invasive species and alien species already present in the area that have begun to exhibit invasive characteristics, and response plans to enable and ensure a rapid response and eradication where necessary.

Criteria-based risk assessment of IS is one of the key principles in implementing the precautionary approach in IS management (Genovesi & Shine 2003). Hence, several national risk assessment methodologies and blacklists of IS have been recently developed in Europe: e.g. Switzerland[30], Belgium[31], UK[32] and Germany and Austria[33]. These methodologies and the experience gained in their national implementation deliver important information for developing a European risk assessment system.

Early warning and information systems already exist in the Plant Health framework. EUROPHYT allows the notification of interceptions of pests between countries. EPPO publishes a monthly Reporting Service on invasive alien species freely available at http://www.eppo.org/PUBLICATIONS/reporting/reporting_service.htm.

4.2.3. Eradication and control measures

Detected IS should be eradicated within a limited period of time before the population is established, i.e. as soon as possible. Early action has been proven to be much more economically and environmentally effective. Rapid intervention should be preferred to a long approval process for plans, so that eradication remains feasible. Ensuring public understanding is crucial to avoiding public protests reflecting, for instance, concerns of animal right groups. At the moment eradication programmes for invasive alien species that threaten the ecological status of Natura 2000 sites can be supported under LIFE+. Currently there are a number of projects that include actions for eradicating IS, for example €1 827 130 will be provided to Spain and the UK for eradication of the ruddy duck *Oxyura jamaicensis*,

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29 participating countries in NOBANIS: Austria, Belgium, Denmark, Estonia, Finland, Faroe Islands, Germany, Greenland, Iceland, Ireland, Latvia, Lithuania, The Netherlands, Norway, Poland, European part of Russia, Slowakia, Sweden. http://www.nobanis.org/default.asp

30 Weber, E., Köhler, B., Gelpke, G., Perrenoud, A. & Gigon, A. (2005): Schlüssel zur Einteilung von Neophyten in der Schweiz in die Schwarze Liste oder die Watch-Liste. Bot. Helv. 115: 169-194.

31 Branquart, E. (2007): Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium, Version 2.5. http://www.IS.biodiversity.be

32 Copp, G.H., Garthwaite, R. & Gozlan, R.E. (2005): Risk identification and asseement of non-native freshwater fishes: concepts and perspectives for the UK. CEFAS, science series technical report 129, 32 pp.

33 Essl F, Klingenstein F, Nehring S, Otto C, Rabitsch W & Stöhr O (2008): Schwarze Listen invasiver Arten – ein wichtiges Instrument für den Naturschutz! Natur und Landschaft, in press.

through a programme running from 2005 to 2010. The Council of Europe has recommended that its countries eradicate specific invasive alien plants. EPPO has long experience of providing recommendations for eradication and containment of species (e.g. about to be published, recommendation on *Ambrosia artemisiifolia*, *Heracleum mantegazzianum, Sicyos angulatus*, etc.). Public-private partnerships will be encouraged, which ought to be mutual beneficial and prevent or at least lower ecological, economic and social damage.

4.3. Suboption B+: Adapting existing legislation

This option involves amending existing legislation to widen the scope to formally take IS issues into account. This includes adjustment of existing legislation on plant/animal health to cover a broader range of potentially invasive organisms and expansion of the list of "ecological threat" species for which import and internal movement are prohibited under the Wildlife Trade Regulation to prevent trade in a larger number of IS. Additional resources would need to be dedicated to IS in the assessment process and in the border control activities performed by Member States. Member States should receive clarification on the scope of national IS measures consistent with the EC Treaty.

With regard to preventing the introduction of certain IS, this option would strengthen option B, as the legal framework would prohibit intentional introduction. However, it is unlikely to be sufficient to counteract the increasing threat, as none of the current legislation is really tailored to dealing with IS. With regard to early warning this option could be a major breakthrough, but eradication measures remain subject to the goodwill of the countries concerned; this option will bring some improvement, but it will not solve the problem. The situation is the same in relation to control and long-term containment.

Option B+ and option C are mutually exclusive.

4.4. Option C: Comprehensive, dedicated EU legal instrument

Building on the measures outlined under option 2 an EU Strategy on IS could be developed to combat the threat posed by biological invasions, through coordinated action taking into account international policy instruments, guiding principles and procedures addressing invasive species strategies relevant to Europe. The EU Strategy on IS shall be subject to follow-up to the Communication addressed in this impact assessment. Therefore the following outline only gives a brief overview on the vision, objectives and underlying principles of a future comprehensive EU strategy on IS.

Box 3: EU Strategy on IS

Vision: Europe where biodiversity, native species, incl. the genetic variations, and ecosystem services are not declining or being lost due to IS.

Global objective: To substantially reduce the impact of invasive species on EU biodiversity, to contribute to halting biodiversity loss by 2010 and beyond, to minimise economic and social costs caused by IS and thus contribute to the Lisbon Strategy.

Specific objectives:

(1) Measures to address intentional and unintentional introduction are in place.

(2) Measures to address "escapees" and established IS species are in place (eradication, containment, control).

(3) A well-functioning early warning and information system is in place supported by functioning surveillance and monitoring systems.

(4) Financing mechanisms to eradicate/control IS are in place.

(5) MS implement national strategies and cooperate at EU level.

(6) The public understands and accepts necessary measures and contributes to the objective.

Source: IS discussion paper

In discussions with representatives of the Member States and other stakeholders, some general principles for the development of a strategy have been identified as building blocks. These are:

– Precautionary principle

– Subsidiarity principle

– Cooperation

– Solidarity principle

– Public involvement

In addition, the strategy should incorporate the relevant existing international principles and strategies like the CBD Guiding Principles as well as the European Strategy on IAS (adopted by the Bern Convention under the Council of Europe). The strategy should make use of the best examples from various other institutions and initiatives and EU Member States' national IS strategies where available.

4.5. Horizontal issues

The following horizontal issues are relevant for all options.

Communication, education and public awareness

It is essential to have an informed and engaged public in order to address the IS issue successfully. Administrative / legal instruments alone cannot cover all aspects of IS. The aim of communication, education and awareness-raising activities should be to build a sense of responsibility amongst European citizens with regard to import, export and unintentional introduction of potential IS to and from third countries and their movement in the intra-Community trade zone, and also in relation to detection/reporting, eradication and/or control

programmes where public support can be crucial to achieving a successful outcome. A better informed public would probably bring fewer invasive species into their gardens and ponds.

An important segment of these activities would be directed towards policy makers as well as to sectors engaged in activities that lead to unintentional introduction. These include the retail sector where emphasis should be put on preventing potential escapes of species. Voluntary instruments could be used to involve retailers.

The other major objective of public awareness would be to foster acceptance by the public of the need for measures to address IS. The public is more sensitive to eradication of some species, especially mammals and birds e.g. grey squirrels, and consequently more communication would be needed here.

Communication and awareness-raising activities should address all relevant levels: EU, national, regional and local.

Exchange best practice and support action at Member State level

Coordination should be improved and strong partnerships built. Action to address the IS issue should be strengthened at Member State level. There is a strong need for development and implementation of national strategies on IS, as is already being done in a number of Member States. Due to the different economic sectors and groups that are affected by the very nature of IS, Member States should be encouraged to include all involved sectors and to develop wide consultation processes. It is important to link national and regional strategies. There is a need to provide and disseminate to the Member States relevant information available. Existing web-based instruments could be used for this purpose, like the EC CHM[34] hosted in the EEA.

Knowledge base

Serious challenges posed by massive human-mediated introductions of invasive species have resulted in the strengthening of international cooperation in research, information exchange and management of aquatic invasions within the framework of different international group activities related to aquatic invasions in Europe and adjacent areas.

However, further development and expansion of research to include terrestrial organisms should be supported in a streamlined way that builds on existing European frameworks. It would be important to analyse research gaps and needs and to ensure that there is a good balance between research on assessing the risks and extent or severity of the problem, e.g. prediction of invasion for new species, and research into developing cost-effective control and management methods, e.g. bio-control. Research into better prediction of invasions should address: increasing knowledge about vectors, the inherent factors that may prevent IS and those that facilitate them. There is also still a lot to learn about the magnitude and pathways of invasive species, how they impact on ecosystems, and how climate change will affect biological invasions. The integrated approach initiated in the ALARM project should be pursued further.

[34] EC Clearing House Mechanism, http://biodiversity-chm.eea.europa.eu/

Monitoring and reporting, and the development of appropriate indicators, should also be supported in order to obtain feedback on policy effectiveness. Duplication with other existing monitoring and reporting requirements should be avoided so as not to squander resources, and synergies should therefore be explored with similar work taking place in the field of nature and biodiversity, but also in the various sectors identified (i.e. agriculture, forestry, fisheries). The results of research and monitoring should feed into information systems and should also support the exchange of information on good and bad practices.

Financing

Adequate financing for dealing with IS should be ensured and sought. Over the last 15 years the EC has helped to finance almost 300 projects addressing invasive alien species, for a total budget exceeding €132 million. This was shown in an analysis of the LIFE Programme and the Framework Programmes for Research and Technological Development (RTD), being the two major EU funding sources for management actions and research on IS (Scalera R. 2008).

Currently it is mainly the LIFE+ programme that supports action on IS through specific projects. However, outside this specific nature conservation project-oriented regime and project-based financing, other sources are needed to support a number of further actions and to develop more flexible mechanisms, particularly given the far-reaching impact generated by IS across all sectors and the critical importance of rapid response to maximise chances of eradication.

If new measures are required from Member States, the issue of financing will be important. The option of dedicated EU funding for IS, similar to the solidarity fund under plant protection policy, will be examined in greater detail during the follow-up to this Communication. An assessment of the exact financial needs of the Member States with regard to the financing of appropriate measures to prevent, eradicate and control IS in their territory will be carried out. Possibilities of using other EU funding mechanisms could be sought post-2013. Apart from the analysis of the financial needs, a scoping analysis is planned with a view to identifying how the various EU Funds can contribute financially to awareness/communication, control and eradication activities. In addition, opportunities should be explored for involving the private sector through the use of insurance and other economic and financial instruments. Guaranteeing sufficient resources and establishing financial self-sufficiency is important for long-term control and containment measures. Efforts to maximise the available resources and their sustainability can be sought by promoting full participation of local communities and key stakeholders in project development, management and implementation to ensure a long-term local commitment.

5. COMPARING THE OPTIONS

The dramatic increase in IS linked to extended trade activities and human mobility leads to environmental and economic damage and will get even worse in the future. Option 1 would be likely to lead to hasty and costly "end of pipe" reactions in the future, which may well go beyond the costs generated by options 2 and 3. Table 4 below compares the options:

Table 4: Comparison of the four options examined

	A) Business as Usual	B) Maximising existing approaches	B+ Amending existing legislation	C) Comprehensive EU Strategy
Level of intensity with regard to resources needed	No additional resources are to be used.	The suggested measures require an additional (medium) input in the form of more resources, for e.g. proper maintenance of the IS inventory, which is the basis for an early warning and information system that would need about €500 000 annually.	The suggested measures require a medium to high input to amend the existing relevant legislation.	The development and implementation of an EU Strategy on IS needs commitment of significant resources. The analysis of necessary resources is subject to the second step.
Likely economic effects-impact	Expected increase of IS will lead to further increases in economic losses (estimated current costs in Europe: 12.7 billion/year- note that this amount is likely to be an underestimate, as it is based on available information on documented costs, which does not cover all IS impacts), while the same will happen outside the EU.	Expected increase of IS will lead to further increases in economic losses, while the same will be experienced outside the EU. Some marginal decrease in the impact may occur due to increased awareness of IS and action at local and national level. However, this decrease is likely to be counterbalanced by the overall increase in IS.	As option B, with a slight decrease of IS introduction and consequent decrease of economic effects-impact once the relevant legislation will have been amended and implemented. However, the effectiveness will be hampered, because patchiness and legal uncertainties will remain.	Implementation of an EU Strategy on IS will help to slow down the rate of increase of the problem in particular by decreasing the occurrence of new introductions, thus significantly reducing economic losses.

	A) Business as Usual	B) Maximising existing approaches	B+ Amending existing legislation	C) Comprehensive EU Strategy
Likely environmental effects-impact	The expected increase of IS will lead to further pressure on biodiversity and hamper the efforts to halt biodiversity loss. It will lower the resilience of ecosystems and their capacity to adapt to climate change, the same will happen outside the EU.	The increased awareness and application of voluntary codes of conducts and the implementation of national IS strategies where available, may lead to local success, however in absence of a co-ordinated approach the gaps in tackling the issue of IS will remain.	As option B, with a slight decrease of IS introduction and consequent decrease of environmental effects-impact once the relevant legislation will have been amended and implemented. However, the effectiveness will be hampered, because patchiness and legal uncertainties will remain.	The implementation of an EU Strategy on IS will help to alleviate the problem in particular by decreasing the threat of new introductions. Co-ordinated eradication and control measures will stabilise and eventually improve the situation and contribute to halting biodiversity loss.
Likely social effect - impact	The expected increase of IS will have increased negative health implications, which will in turn heighten public awareness, increasing public pressure for action, the same as is happening already in places outside the EU e.g. New Zealand, Australia, USA…	The expected increase of IS will lead to aggravation of negative health effects, which will in turn heighten public awareness, increasing public pressure for action, and the same is expected to happen outside the EU. Communication actions will encourage responsible behaviour by the public and the sectors involved in trading IS (pet trade, horticulture, energy ...)	As option B, with a slight decrease of IS introduction and consequent decrease of social effects-impact once the relevant legislation will have been amended and implemented. However, the effectiveness will be hampered, because patchiness and legal uncertainties will remain.	The implementation of an EU Strategy on IS will significantly alleviate the problem and increase awareness of the public and the sectors concerned, and stimulate more responsible behaviour.
Uncertainty to reach the policy objectives	It is certain that with the BAU option only, the EU will fail to successfully deal with the threat and subsequent impact of IS.	The suggested measures are elements towards dealing with IS in a more comprehensive and strategic manner. However, as stand-alone measures they are deemed insufficient to reach the European policy objectives set.	The amending of existing legislation will bring some improvement, but it does not provide for comprehensive and strategic instruments necessary to cope successfully with IS.	The implementation of an EU Strategy on IS would be more likely to reach the European policy objectives set.

	A) Business as Usual	B) Maximising existing approaches	B+ Amending existing legislation	C) Comprehensive EU Strategy
Development of impact over time	The currently existing problems will continue to increase and accelerate and will most likely be aggravated by the impact of climate change.	The already existing problems will continue to increase, maybe at a slightly lower level, and will most likely be aggravated by the impact of climate change.	As option B	The implementation of an EU Strategy on IS will help to stabilise and eventually improve the situation.
Affected groups	All groups of society and certain economic sectors (e.g. agriculture, forestry, fishery, tourism, health, energy)	All groups of society and certain economic sectors (e.g. agriculture, forestry, fishery, tourism, health, energy)	All groups of society, in particular sectors involved in trade with IS including pet trade, horticulture, energy, etc.	All groups of society, in particular sectors involved in trade with IS including pet trade, horticulture, energy, etc.
Obstacles to compliance	n/a	Institutional inertia due to the overloaded agendas and insufficient commitment of resources prevent the maximisation and prioritisation of existing resources including the establishment of an Early Warning and Information System including the maintenance of the IS inventory	Amending existing legislation is a tedious undertaking, where effort and benefit have to be properly balanced. The willingness and preparedness of the parties involved are limited, as the measure is largely perceived as an additional burden beyond their remit.	Insufficient commitment and deployment of resources prevent the development and implementation of a comprehensive EU Strategy on IS.

The following table outlines a range of generic IS policy options and measures, their scope of application, and some of the costs they may entail. These measures will be further analysed in the second phase of this work, with a view to identifying those measures that will be part of the EU Strategy on IS.

Table 5: Generic IS policy measures and actions, scope and indicative types of costs

Type of measures / actions	Scope of application	Possible types of costs associated with the measures /actions	Possible actors
Prevention			
Pre-import controls (process and product standards that exporters must meet in order to gain access to markets).	Country of export.	Offshore inspection and quarantine (personnel, equipment, procedures such as fumigation, certification). Pathway controls e.g. offshore ballast water exchange pre-entry.	Border controls, Custom services
Specific controls to mitigate IS threats to the natural environment should be coordinated with import regulations and procedures to ensure plant, animal and food health	Borders	Customs services; maintenance of entry points; border inspections; quarantine procedures and equipment (X-rays, laboratories, sniffer dogs, fumigation); post-entry quarantine where necessary. Import risk analysis procedures. Listing of species/commodities that are authorised /restricted. Training and capacity-building	Border controls, Custom services
Controls on intentional introductions.	Point of import or in-country.	Risk assessment procedures. Listing of authorised/restricted species. Permit/licensing systems. Measures to minimise escape risk (e.g. from contained facilities). Follow-up monitoring and reporting. Compliance (including voluntary).	Competent Authorities Research Institutions Border controls, Custom services
Pathway management measures (commodities, transportation, sectoral activities etc.).	Variable.	Pathway/vector risk assessment to assess means of entry/dispersal of IAS that could affect biodiversity. Technical measures to address identified risks. Follow-up monitoring. Deterrents/incentives to support best practices	Competent Authorities Research Institutions Border controls, Custom services, Civil Society

Type of measures / actions	Scope of application	Possible types of costs associated with the measures /actions	Possible actors
Regulatory/voluntary controls on in-country movement, trade, other uses (aim is prevention of spread: measures support long-term containment)	Countrywide or targeted at specific areas (non-invaded areas; vulnerable ecosystems like wetlands; protected areas; islands etc.)	Permit/licensing systems e.g. for retail and other containment facilities. Legal prohibitions (e.g. on release). Monitoring and reporting. Compliance and enforcement. Physical barriers and deterrents for IAS exclusion (from crops, protected areas, gardens, lakes) or containment (in already invaded areas). Modification to physical infrastructure e.g. alteration to dams.	Competent Authorities Research Institutions Retailers Construction sector
Targeted communication campaigns and conflict reduction measures	Countrywide or issue-specific	Information materials, media campaigns, participatory consultations for controversial species/issues.	Civil Society Government
Early detection and rapid response			
Monitoring and early warning systems.	Around major entry points/disturbed areas where easier for IAS to establish/protected areas/ vulnerable ecosystems.	Monitoring protocols. Personnel and equipment. Coordination of volunteer contributors. Well-structured reporting systems.	Government Research Institutions Civil Society
Information exchange	European, national, transboundary, regional, global.	Operational coordination. Data protocols. Electronic infrastructure.	Government Research Institutions Civil Society Industry (e.g. pets, ornamental)
Rapid response procedures.	Where needed (aquatic as well as terrestrial ecosystems).	Authority under relevant legislation (private as well as public property). Capacity (trained teams). Contingency planning and equipment. Funding for rapid response.	Government Research Institutions Civil Society Industry (e.g. pets, ornamental)

Type of measures / actions	Scope of application	Possible types of costs associated with the measures /actions	Possible actors
Long-term control and containment			
General measures for eradication, control or containment.	National.	New/revised legislation as necessary Strategic planning. Management plans based on ecosystem approach or for individual IAS. Research, supported by risk and environmental impact assessment for control techniques. Public consultation procedures. Transboundary consultation where necessary; Personnel, equipment, training. By-laws (local regulations). Monitoring of results. Compliance (including voluntary).	Government Research Institutions Civil Society Industry (e.g. pets, ornamental)
Mechanical (plants)	Where needed.	e.g. thinning/removal of trees and shrubs; grazing and mowing regimes; mechanical removal of algae.	idem
Mechanical (animals)	Where needed.	e.g. shooting, trapping, snares; drainage of ponds; cleaning of catchment installations and clogged gear; de-fouling of fishing gear and boats.	idem
Chemical	Where needed.	Herbicides and pesticides (constraints include resistance of target species, Ban on use of certain chemicals, lack of target specificity, contamination). Poison (e.g. bait): risk assessment to avoid impact on non-target species. Contraceptive techniques.	idem
Biological control	Where needed.	Research to ensure introduced agent is host-specific. Appropriate legislation. Notification/consultation directed to other potentially affected countries. Monitoring.	idem
Restoration	Where needed.	Replanting, structural repair, ongoing maintenance. Incentive measures.	idem

Type of measures / actions	Scope of application	Possible types of costs associated with the measures /actions	Possible actors
Legal and institutional framework			
Strengthened IAS policies and legal framework.	European, National, local.	Review of existing measures. Development of coordinated national strategy/action plan. Development or amendment of legislation and regulations. Development of voluntary protocols, incentives, financing and cost-recovery mechanisms.	Government Civil Society Industry (e.g. pets, ornamental)
Creation of/mandate for a high-level mechanism to coordinate IAS policy and planning, including in the natural environment.	European, National.	Operating costs of national coordination mechanism and/or technical advisory committees.	Government
European IAS database (stand-alone or integrated into other biodiversity information mechanisms)	European and National (scope to pool resources with neighbouring countries).	Researcher time and equipment to establish baseline information. Technical infrastructure (links to national and international clearing-house mechanisms). Maintenance and regular updating of database and broad links. Public access.	Government Research Institutions Civil Society
Training and capacity-building.	National, local.	Awareness-building at governmental and technical level. Taxonomy cost of diagnosis. All areas of operation, as needed.	Government Research Institutions Universities, Secondary schools Civil Society

6. CONCLUSIONS

Scientific research and experience with projects targeting the control or eradication of IS have demonstrated the magnitude of the IS problems for various economic sectors and made it clear that the problem will exponentially increase unless appropriate action is taken urgently. A coordinated approach at EU level is indispensable, as the impacts are transboundary. Therefore the development of an EU Strategy on tackling IS is the most appropriate way to address the problem and meet the policy objectives set.

It has been demonstrated that developing this strategy will take some time, to allow actions and the legislative framework to be studied in detail and appropriately prepared. Subsequently, the measures outlined under option B need to be taken up as soon as possible and with immediate effect. These include the establishment of an EU Early Warning and Information System and the maintenance of the European inventory of alien species that has

been delivered by the DAISIE project. These two distinct actions, together with improved communication, raising awareness of the public and the economic sectors affected, education and establishment of voluntary codes of conduct will make for greater EU efficiency in dealing with IS problems.

The collected literature and reports on costs indicate that the eradication, control or long-term containment measures that need to be implemented when and where prevention efforts fail or are not implemented in the first place could be extremely costly. There are also many documented examples of the serious technical constraints involved in finding successful control techniques for individual IS, thus further research and experimentation is needed on these aspects.

The internationally-accepted position implies that prevention is better than cure when it comes to IS and should be prioritised in policy development (see the CBD Guiding Principles). Prevention is likely to be the most cost-effective option, given the sheer scale of negative economic, social and environmental effects of IS. Therefore investment in robust and coordinated prevention and early warning and information systems to minimise any negative impact on biodiversity can deliver positive results for multiple sectors and interests, including:

- more effective conservation of threatened species and their habitats;
- more systematic management of IS threats to vulnerable ecosystems such as wetlands;
- reinforced protection of biodiversity hotspots, including Natura 2000 sites and islands in EU overseas entities;
- maintenance or restoration of ecosystem function and services;
- maintenance or recovery of yields and quality of biological production systems (agriculture, fisheries, forestry);
- avoidance of trade-related problems (e.g. loss of markets due to infested goods);
- reduced constraints on water supply, transportation, energy production, flood and fire risk management;
- preservation or restoration of landscape, recreational and tourism amenity;
- reduced health expenditure for allergy management and disease control.

It is recognised that individual options have associated costs and economic implications for different categories of stakeholders. The aim should be to select and combine those policy options and within these the measures that efficiently minimise IS risk, keep the costs of supply for a service/activity low, minimise the cost of compliance and administration and ensure fairness between different categories of stakeholders. A common and cooperative approach to the problem of invasive species is essential if we are to find cost-efficient and effective ways to prevent the introduction of invasive species and establish eradication or control programmes.

7. MONITORING AND EVALUATION

The core indicator of progress towards meeting the objectives would be the existence of a functioning pan-European Early Warning and Information System (EWIS) on Invasive Species based on a regularly updated inventory by 2009. EWIS would involve cooperation of researchers, civil society, concerned industry sectors, government institutions and the EEA.

The EU Strategy on IS is one of the actions identified in the EU Biodiversity Action Plan (BAP). Reporting on progress made with regard to tackling the threat of IS is an integral part of the BAP reporting.

"Trends in invasive species" is one of the European Headline Indicators for Biodiversity[35] to assess progress towards the 2010 target of Halting Biodiversity Loss. The key policy questions concern control of the main pathways for invasive species establishing in Europe and management actions for invasive species prioritising the species that create the largest negative impact on biodiversity and are directly relevant for the monitoring and evaluation of the measures dealt with in this impact assessment report.

[35] For more information see SEBI (Streamlining European Biodiversity Indicators) 2010 http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995

LIST OF ANNEXES, SUPPORT DOCUMENTS AND REFERENCES

Annexes

Annex A: Figures and tables

Annex B: Description of relevant EU research projects

Annex C: Examples of costs and benefits of IS policy measures

Support documents and key references

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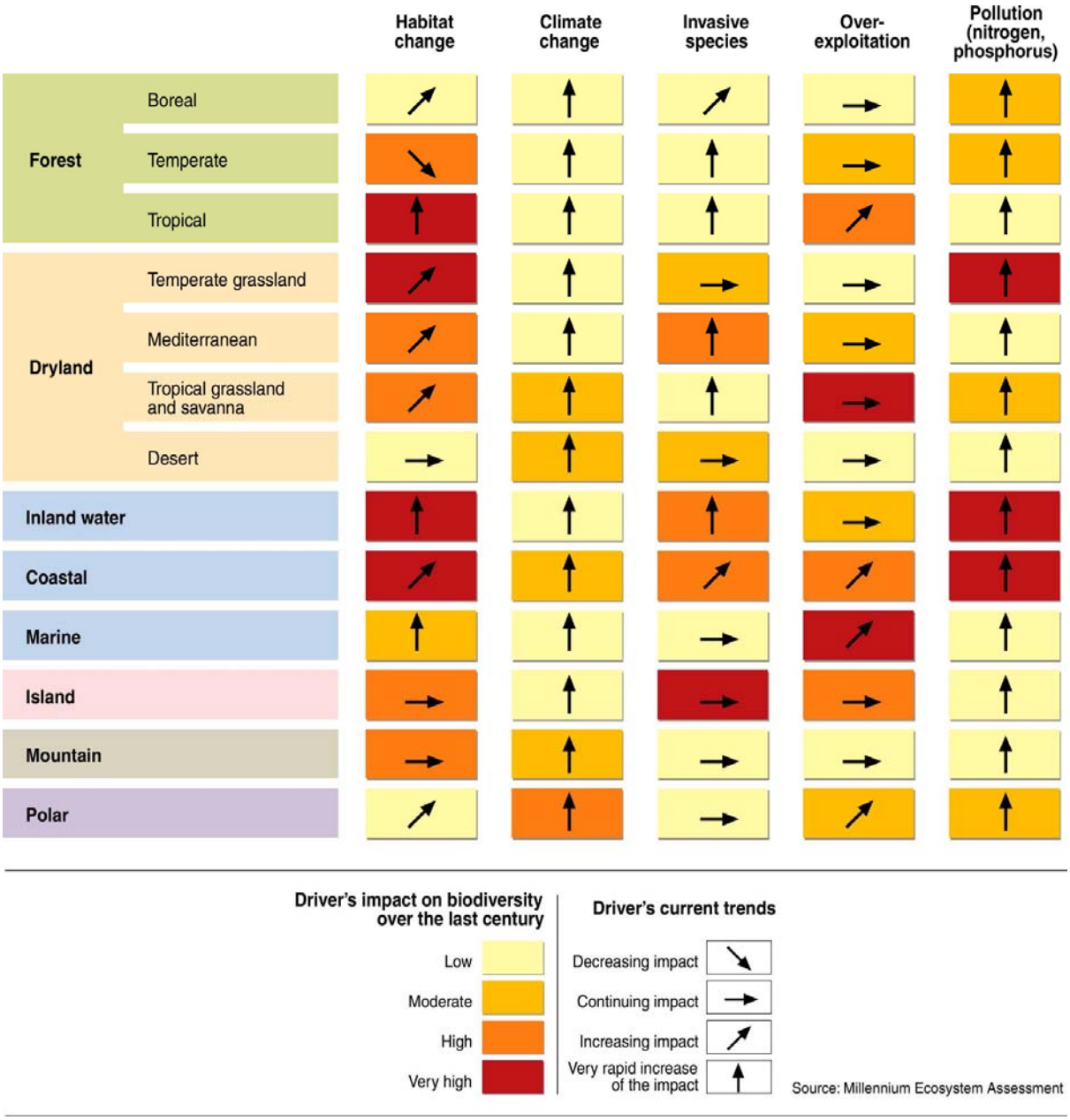
ANNEX A - Figures and Tables

Figure 1 demonstrates the main direct drivers on biodiversity

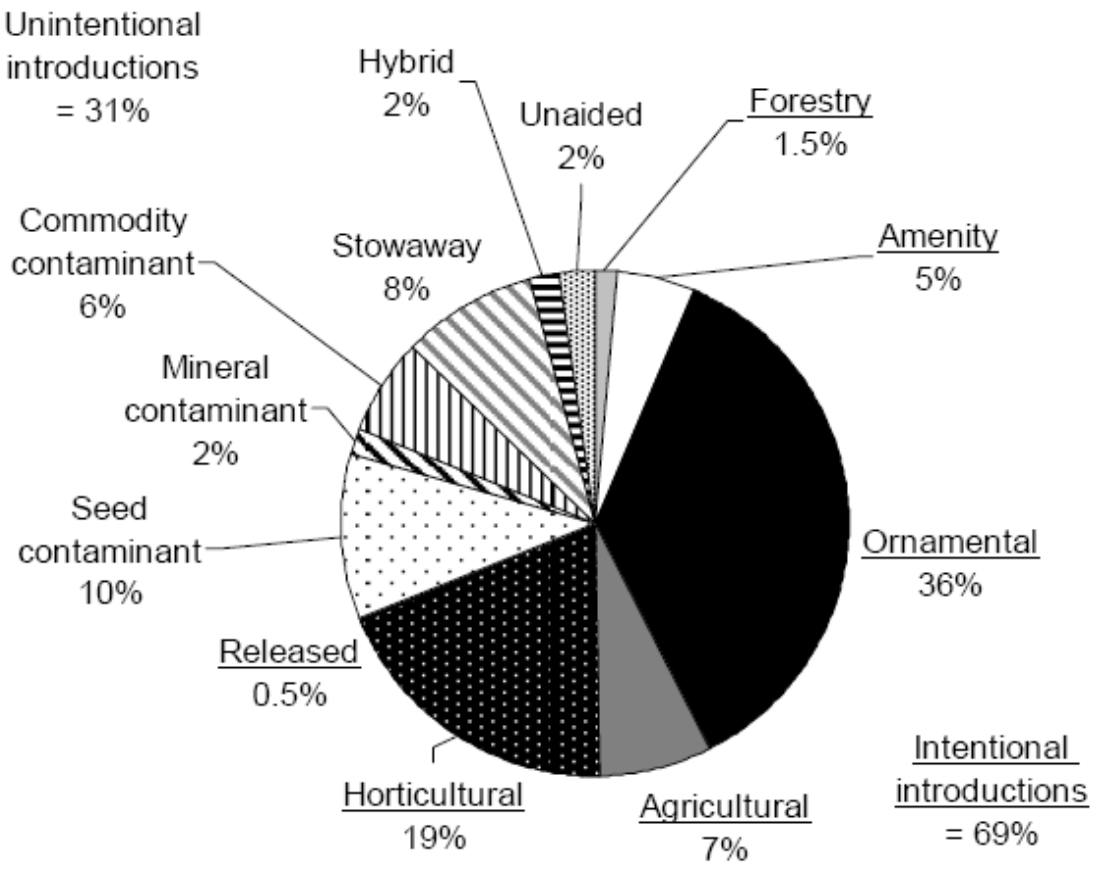
Main Direct Drivers

The cell color indicates the impact to date of each driver on biodiversity in each biome over the past 50–100 years. The arrows indicate the trend in the impact of the driver on biodiversity. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively increasing trends in impact. This Figure is based on expert opinion consistent with and based on the analysis of drivers of change in various chapters of the assessment report of the Condition and Trends Working Group. This Figure presents global impacts and trends that may be different from those in specific regions.



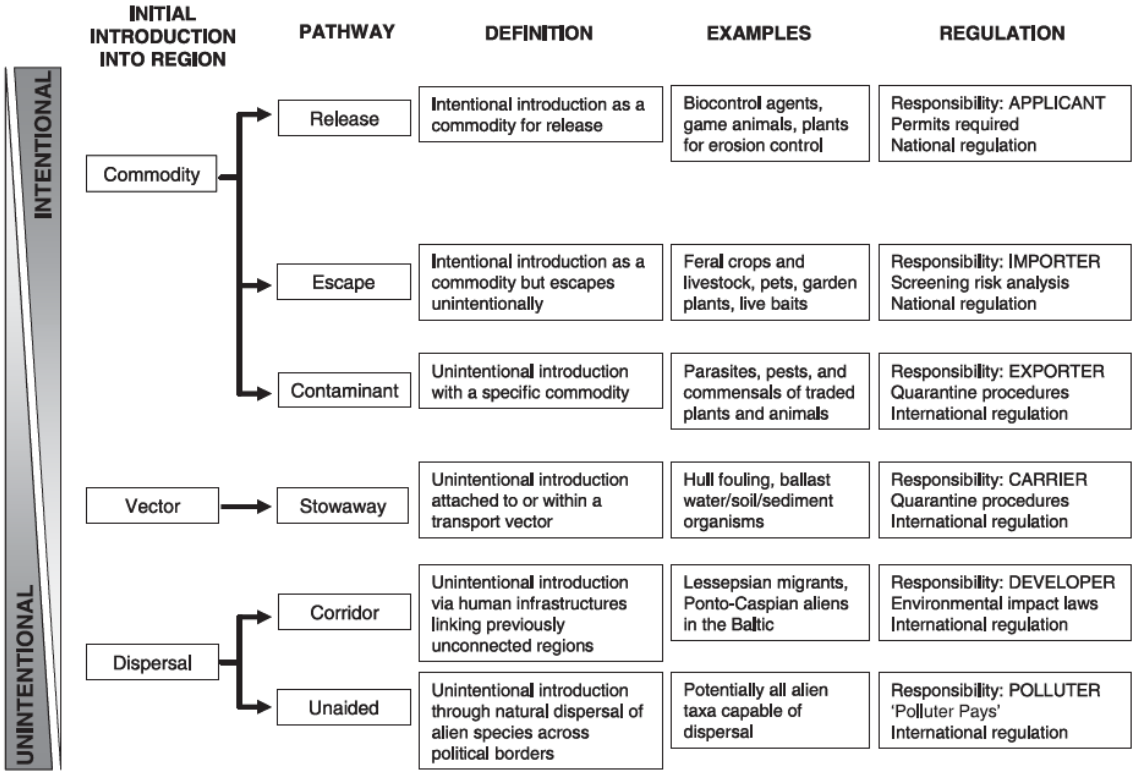
Source: Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC.

Figure 2 demonstrates the relative contribution of pathways of introduction shown for naturalised aliens to Europe, i.e. species with the area of origin outside Europe. Pathways of intentional introductions are underlined, unintentional not. Based on 2024 naturalised aliens, data from Lambdon et al. (2008)



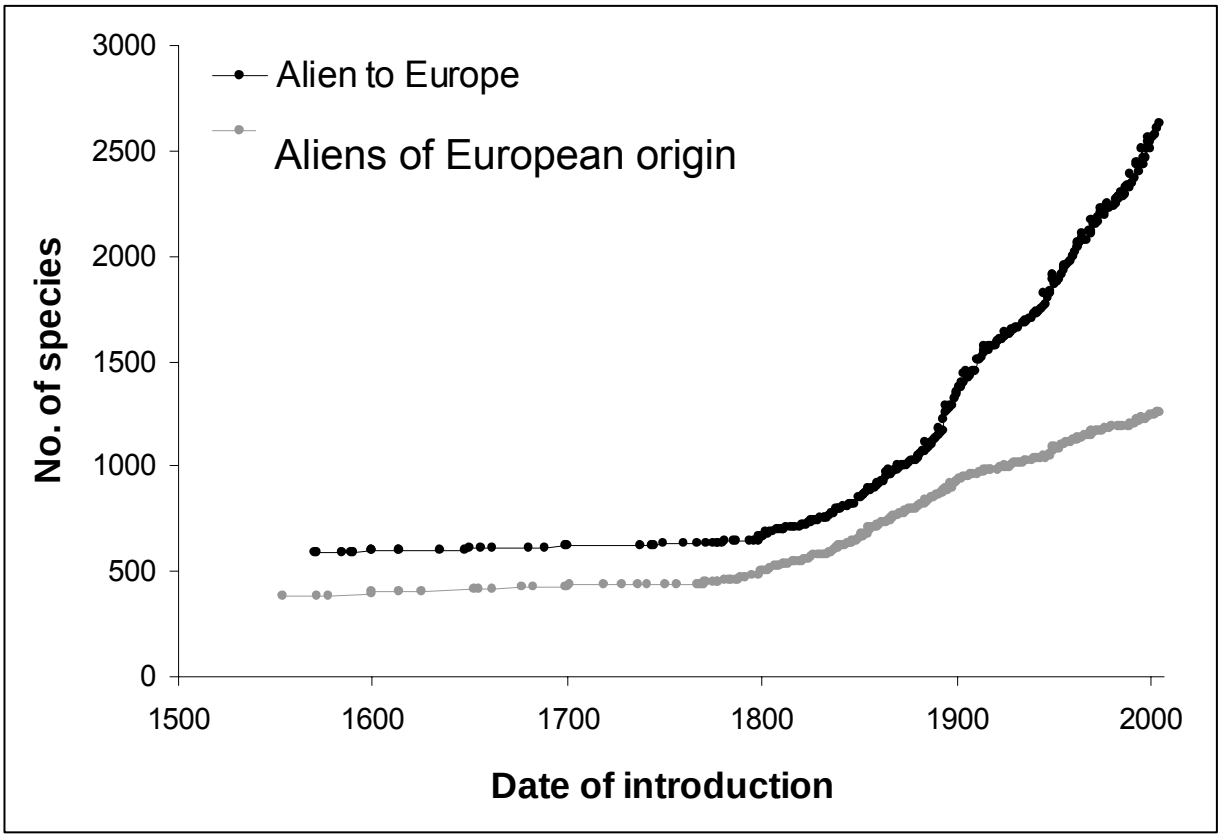
*Source: Hulme P. et al 2008, "**A pan European inventory of alien species: rationale, implementation and implications or managing biological invasions**"; chapter in DAISIE (eds) The Handbook of Alien Species in Europe, (in press) Springer, Berlin*

Figure 3 represents a simplified framework to categorise pathways of initial introduction of alien species into a new region. Alien species may, as a direct or indirect result of human activity, arrive and enter into a new region through three broad mechanisms: the importation of a commodity, the arrival of a transport vector and/or natural spread from a neighbouring region where the species is itself alien. Five pathways are associated with human activity either as commodities (release and escape), contaminants of commodities, stowaways on modes of transport and opportunists exploiting corridors resulting from transport infrastructures. The sixth category highlights alien species that may arrive unaided in a region as a result of natural spread (rather than human transport) following a primary human-mediated introduction in a neighbouring region. For each pathway a brief description is presented with examples. The different regulatory approaches for each pathway are also illustrated. While a case is often made regarding differences between intentional vs. unintentional introductions, the scheme highlights a gradient of human intention that reflects the difficulty in distinguishing between ignorant and premeditated action.



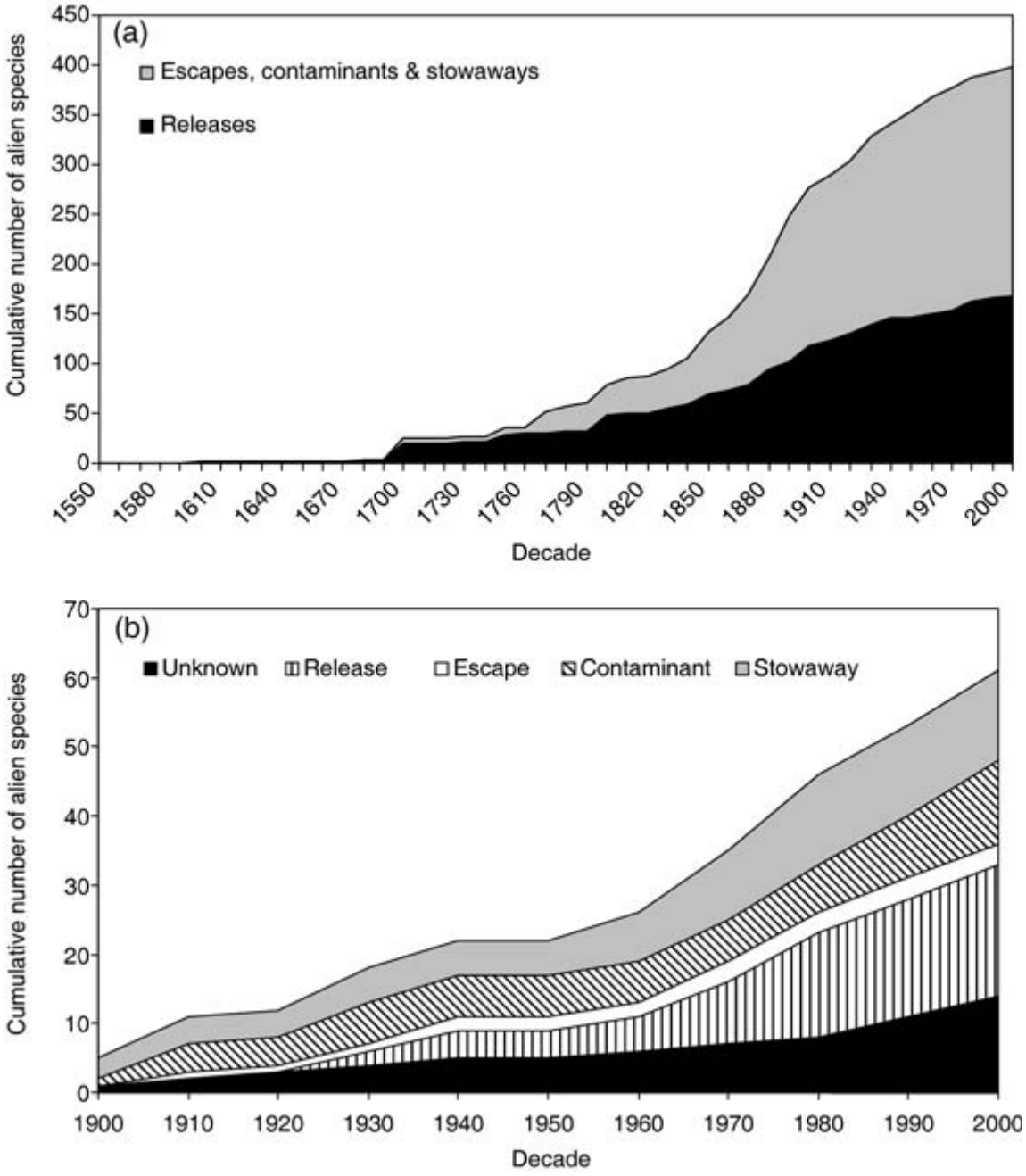
Source: Hulme P., Bacher S., Kenis M., Klotz S., Kühn I., Minchin D., Nentwig W., Olenin S., Panov V., Pergl J., Pysek P., Roques A., Sol D., Solarz W., Vilà M., ***Grasping the routes of biological invasions: a framework for integrating pathways into policy****, Journal of Applied Ecology,*

Figure 4 shows the increasing invasion trends



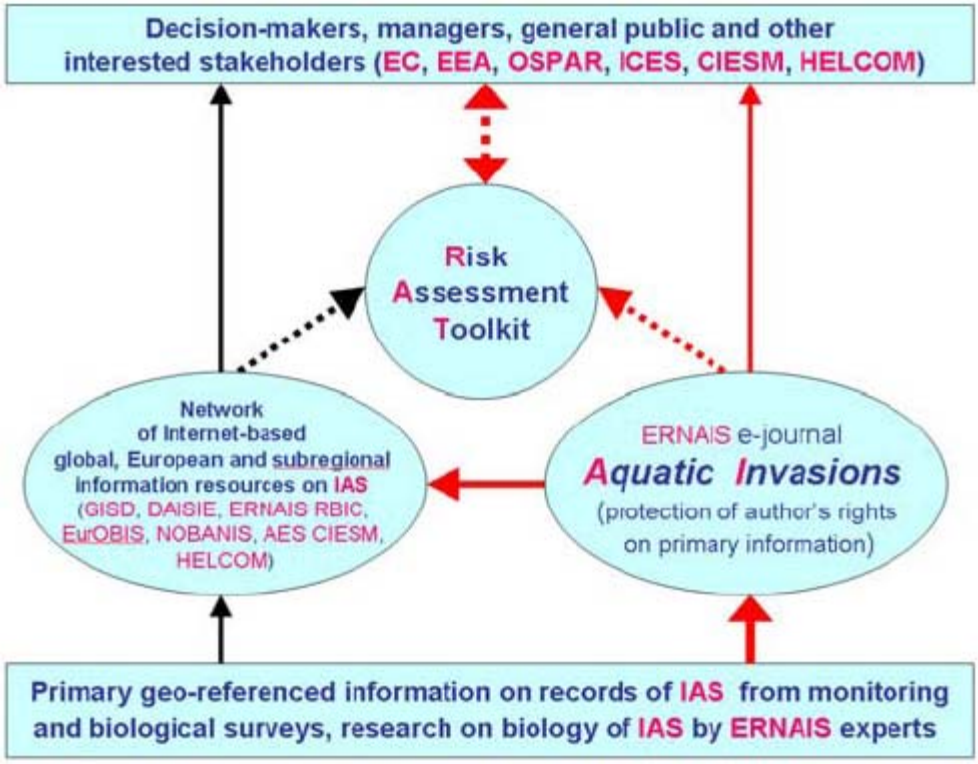
Source: DAISIE project

Figure 5 shows the temporal trends in the mode of introduction of (a) terrestrial plants and (b) marine species in Nordic countries



Sources: Data from the North European and Baltic Network on Invasive Alien Species http://www.nobanis.org/, accessed on 10/01/2007).

Figure 6 demonstrates the role of e-journal *Aquatic Invasions* in the developing European early warning system on invasive alien species (IAS).

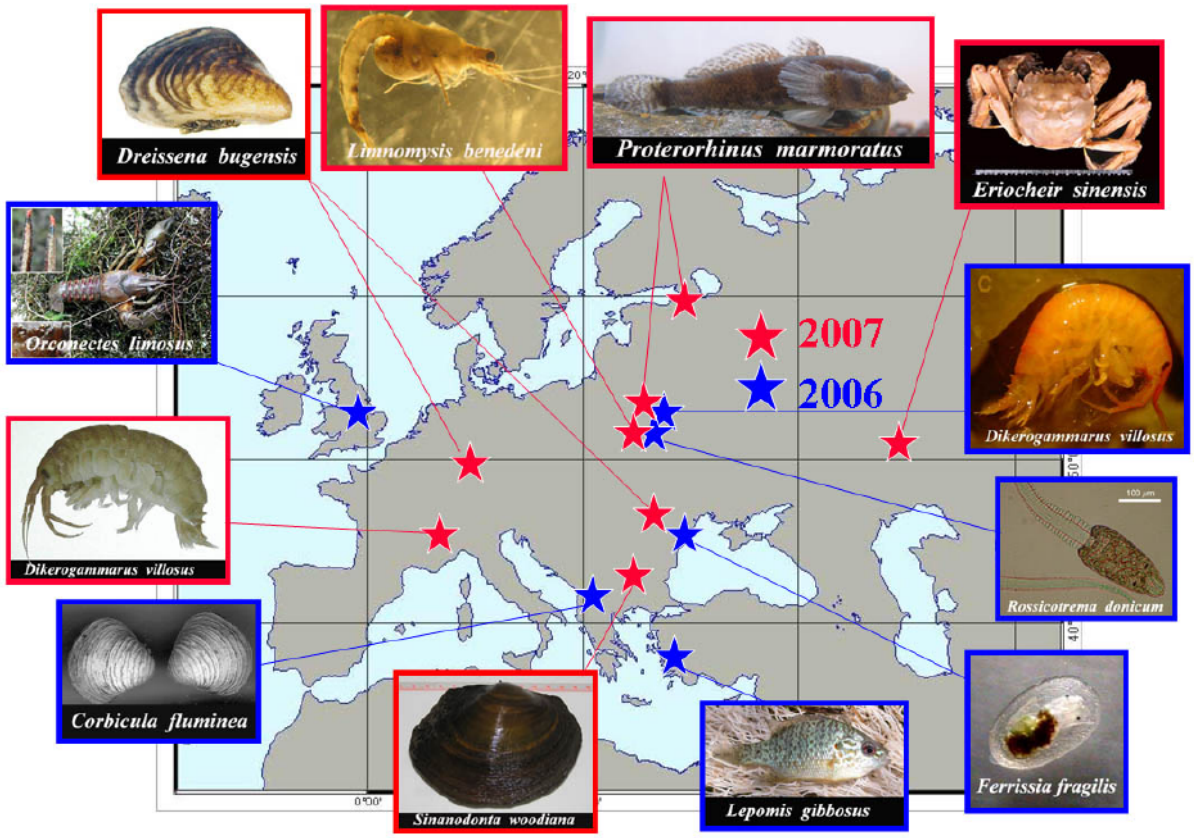


Role of e-journal *Aquatic Invasions* in the developing European early warning system on invasive alien species (IAS), modified from Panov and Gollasch (2006). GISD – Global Invasive Species Database (**http://www.issg.org/database/**), DAISIE - EC FP6 Strategic Targeted Research Project "Delivering Alien Invasive Species Inventories for Europe" information resources (**http://www.europe-aliens.org**), ERNAIS – European Research Network on Aquatic Invasive Species (**http://www.zin.ru/rbic/projects/ernais/**), RBIC – Regional Biological Invasions Centre information system (**http://www.zin.ru/rbic/**), EurOBIS - The European Ocean Biogeographic Information System (**http://www.marbef.org/data/eurobis.php**), ICES – International Council for the Exploration of the Sea (**http://www.ices.dk**), NOBANIS – North European and Baltic Network on Invasive Alien Species (**http://www.nobanis.org/**); AES CIESM – Atlas of Exotic Species of the International Commission for the Scientific Exploration of the Mediterranean Sea (**http://www.ciesm.org/online/atlas/**), EC – European Commission (**http://ec.europa.eu/**), EEA – European Environment Agency (**http://www.eea.europa.eu/**), OSPAR - OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic (**http://www.ospar.org/**), HELCOM – Baltic Marine Environment Protection Commission **(http://www.helcom.fi/**), Risk Assessment Toolkit – online risk assessment instrument with early warning functions currently under development in frameworks of EC FP6 Integrated Project ALARM (Panov et al. 2008)

*Source: Panov V. et al, "**New electronic journal "Aquatic Invasions": an important part of the developing European early warning system on aquatic invasive species**", ALARM deliverable D 5.1.7 Feb 2008*

Figure 7 and Figure 8 show selected new geo-referenced records of invasive alien species in European inland waters in 2006-2007, published in the second volume of *Aquatic Invasions*

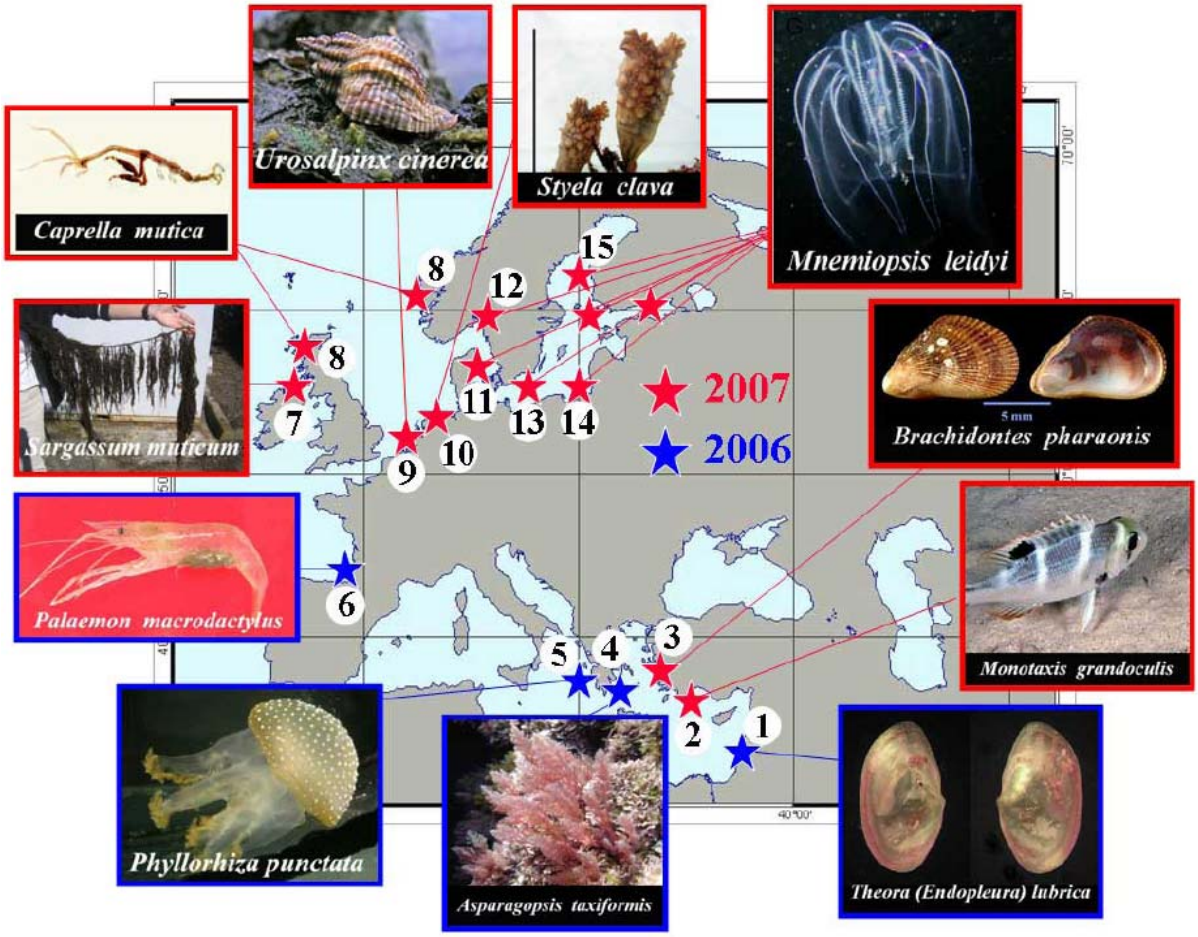
Figure 7



Selected new geo-referenced records of invasive alien species in European inland waters in 2006-2007, published in the second volume of *Aquatic Invasions:* 1 – the spiny-cheek crayfish, *Orconectes limosus* in UK (Holdich and Black 2007), 2 – the Ponto-Caspian amphipod *Dikerogammarus villosus* ("killer shrimp") in Lac du Bourget, France (Grabowski et al. 2007), 3 – the Quagga mussels *Dreissena bugensis* in the Main River, Germany (van der Velde and Platvoet 2007), 4 – the Quagga mussels *Dreissena bugensis* in Ukraine (Son 2007), 5 – the tubenose goby *Proterorhinus marmoratus* from the River Pripyat, Belarus (Rizevsky et al. 2007), 6 – the tubenose goby *Proterorhinus marmoratus* from the Neva River estuary, Russia (Antsulevich 2007), 7 - the Ponto-Caspian amphipod *Dikerogammarus villosus* in the Dnieper River, Belarus (Mastitsky and Makarevich 2007), 8 – the North American freshwater limpet *Ferrissia fragilis* in Ukraine (Son 2007), 9 – the parasite trematode *Rossicotrema donicum* from Lake Lukomskoe, Belarus (Mastitsky 2007), 10 – the Ponto-Caspian mysid *Limnomysis benedeni* from the River Pripyat, Belarus (Semenchenko et al. 2007), 11 – the Chinese mitten crab, *Eriocheir sinensis* from the Volga River, Russia (Shakirova et al. 2007), 12 – the Asian clams *Corbicula fluminea* and *C. fluminalis* in Serbia (Paunović et al. 2007), 13 – the Asian clam *Sinanodonta woodiana* from Eastern Romania (Popa et al. 2007), 14 – the North American sunfish *Lepomis gibbosus* in Turkey (Özcan 2007)

*Source: Panov V. et al, "**New electronic journal "Aquatic Invasions": an important part of the developing European early warning system on aquatic invasive species**", ALARM deliverable D 5.1.7 Feb 2008*

Figure 8



Selected new geo-referenced records of invasive alien species in European coastal waters in 2006-2007, published in the second volume of *Aquatic Invasions:* 1 – the Asian bivalve *Theora (Endopleura) lubrica* from Mediterranean coast of Israel (Bogi and Galil 2007), 2 – the Indo-Pacific humpnose big-eye bream, *Monotaxis grandoculis* in the Mediterranean Sea (Bilecenoglu 2007), 3 - the Red Sea mussel *Brachidontes pharaonis* from the Turkish coasts (Doğan et al. 2007), 4 - the red alga *Asparagopsis taxiformis* in Greece (Tsiamis and Panayotidis 2007), 5 - the tropical scyphomedusa *Phyllorhiza punctata* in the Central Mediterranean Sea (Abed-Navandi and Kikinger 2007), 6 - the oriental shrimp *Palaemon macrodactylus* in Gironde Estuary, France (Beguer et al. 2007), 7 – the Pacific alga *Sargassum muticum* on the west coast of Scotland (Harries et al. 2007), 8 – the Asian amphipod *Caprella mutica* in coastal waters of UK and Norway (Cook et al. 2007), 9 - the American oyster drill, *Urosalpinx cinerea* in The Netherlands (Faasse and Ligthart 2007), 10 – the Asian tunicate *Styela clava* from the central German Bight (Krone et al. 2007), 11 – the North-American ctenophore *Mnemiopsis leidyi* in Danish waters (Tendal et al. 2007), 12 – *Mnemiopsis leidyi* in the Oslofjorden, Norway (Oliveira 2007), 13 - *Mnemiopsis leidyi in south-western Baltic Sea (*Kube et al. 2007), 14 - *Mnemiopsis leidyi* in the Gulf of Gdańsk, southern Baltic Sea (Janas and Zgrundo 2007), 15 - *Mnemiopsis leidyi* in the north-eastern Baltic Sea (Lehtiniemi et al. 2007)

*Source: Panov V. et al, "**New electronic journal "Aquatic Invasions": an important part of the developing European early warning system on aquatic invasive species**", ALARM deliverable D 5.1.7 Feb 2008*

Figures 9-12 proportion of different taxonomic groups listed according to 4 different introduction categories *(see also table 5)*

Figure 9: Proportion of different taxonomic groups listed as category A (species introduced intentionally as the commodity itself for being released into the environment, n = 77 species)

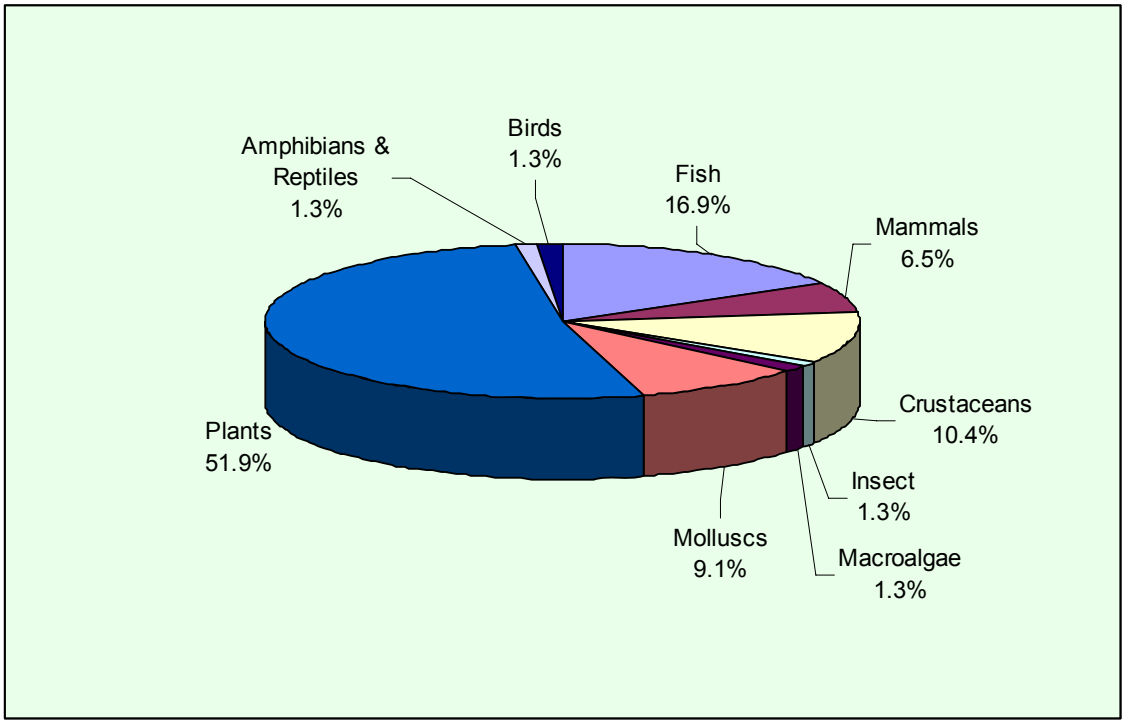


Figure 10: Proportion of different taxonomic groups listed as category B (species introduced intentionally as the commodity itself for being kept in a controlled environment, n = 45 species)

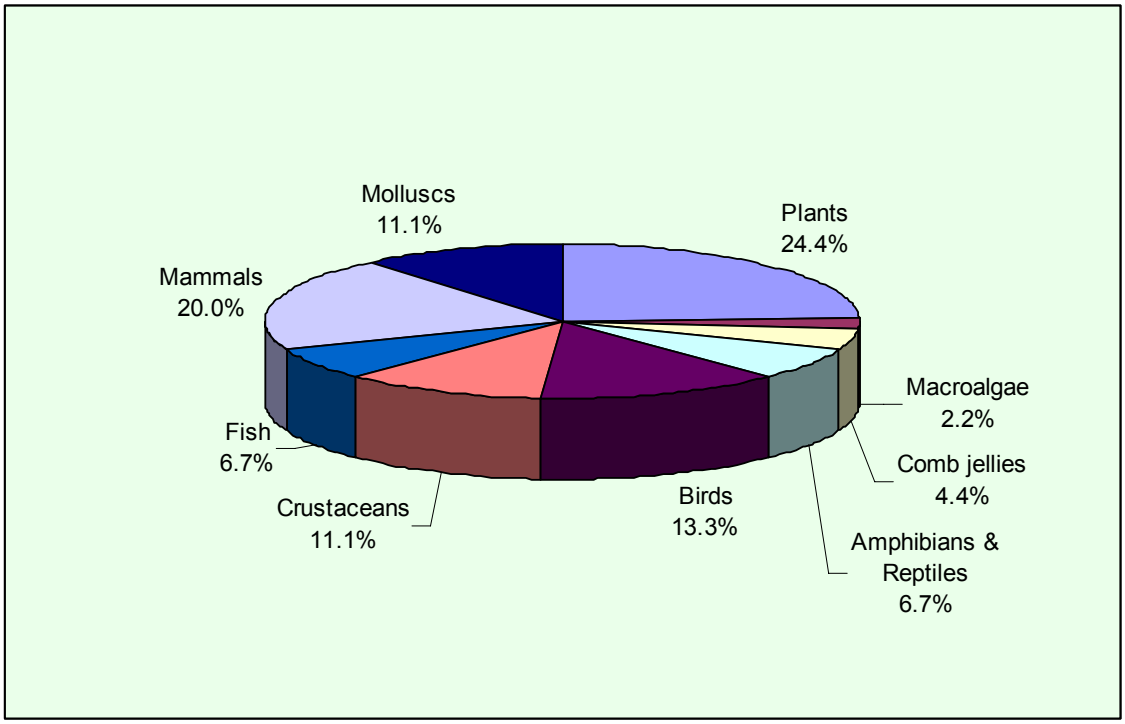


Figure 11: Proportion of different taxonomic groups listed as category C (sp. Unintentionally introduced as a contaminant of a specific commodity: n = 205 species)

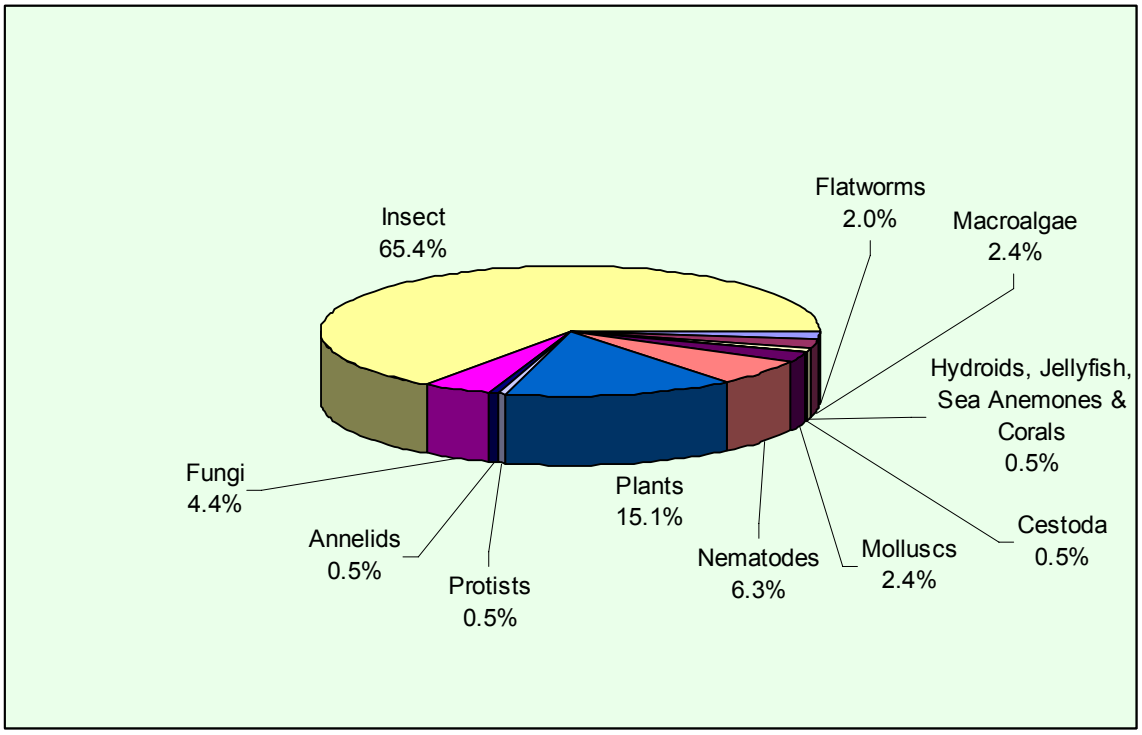
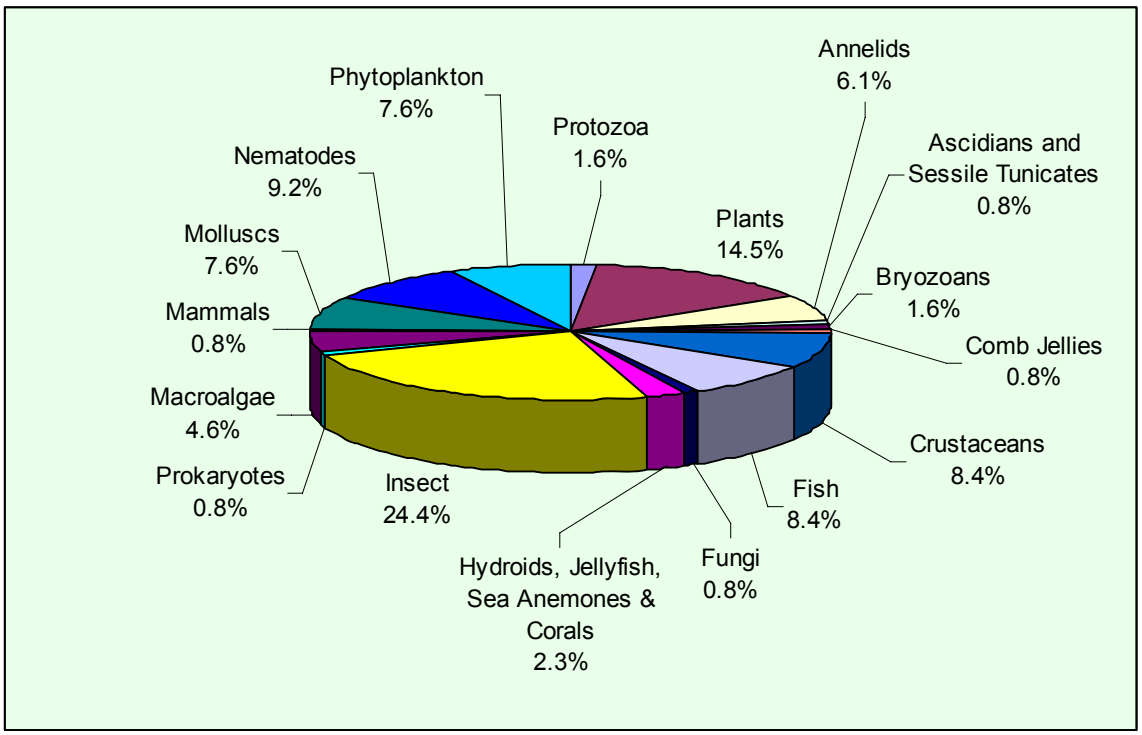


Figure 12: Proportion of different taxonomic groups listed as category D (sp. Unintentionally introduced with movements of people or of machinery; n = 131 species)



Source : Genovesi P, Scalera R, ***Towards a Black List of Invasive Alien Species Entering Europe Through Trade and Proposed Responses****, document prepared the Convention on the Conservation and European Wildlife and Natural Habitats, November 2007*

Table 1: Examples of pathogens and parasites transmitted to native hosts following the introduction of specific alien species into Europe

Taxon	*Alien host*	*Native host*	*Alien parasite/pathogen*
Plants	*Rhododendron ponticum*	*Quercus petraea*	Sudden oak death fungus
Crustacea	*Pacifastacus leniusculus*	*Austropotamobius pallipes*	Crayfish plague fungus
Insects	*Apis cerana*	*Apis mellifera*	Varroa mite
Fish	*Pseudorasbora parva*	*Leucaspius delineatus*	Rosette agent parasite
Fish	*Anguilla japonica*	*Anguilla anguilla*	Swim-bladder nematode
Mammals	*Cervus nippon*	*Cervus elaphus*	Asiatic blood nematode
Mammals	*Mustela vison*	*Mustela lutreola*	Aleutian disease virus
Mammals	*Sciurus carolinensis*	*Sciurus vulgaris*	Parapox virus

Source: Hulme P. ***Biological Invasions in Europe: Drivers, Pressures, States, Impacts and Responses****, The Royal Society of Chemistry, 2007*

Table 2: Monetary costs (million € per year) of alien species invading Europe

Species	Biome/taxa	Region	Cost item	Cost	Reference
Carpobrotus spp.	Terrestrial plant	Spain	Control/eradication	0.29	Andreu & Vilà 2007
Eucalyptus spp.	Terrestrial plant	Spain	Control/eradication	1.58	Andreu & Vilà 2007
Fallopia japonica	Terrestrial plant	UK	Eradication	0.81	Child et al. 2001
F. japonica, F. bohemica, F. sachalinensis	Terrestrial plant	Czech Rep.	Control/containment	0.02	Křivánek 2006
Heracleum mantegazzianum	Terrestrial plant	Czech Rep.	Control/containment	0.01	Křivánek 2006
H. mantegazzianum	Terrestrial plant	Denmark	Control	0.08	Nielsen et al. 2005 REF???
H. mantegazzianum	Terrestrial plant	UK	Control	0.19	Shaw 2003
H. mantegazzianum, F. japonica, F. bohemica, F. sachalinensis, Impatiens glandulifera, Rudbeckia laciniata	Terrestrial plant	Czech Rep.	Control/containment	0.02	Křivánek 2006?
Pennisetum setaceum	Terrestrial plant	Spain	Control/eradication	0.62	Andreu & Vilà 2007
Pinus strobus, Larix decidua	Terrestrial plant	Czech Rep.	Control/containment	0.05	Hentschel & Hentschelová 2003
Rhododendron ponticum	Terrestrial plant	UK	Control	66.26	Gritten 1995
Anoplophora chinensis	Terrestrial invertebrate	Italy	Control	0.30	Tomaino pers. comm.
Branta canadensis	Terrestrial vertebrate	Germany	Eutrophication	1.02	Gebhart 1996
C. nippon	Terrestrial vertebrate	Scotland	Control	0.82	White & Harris 2002
Chrysolophus pictus	Terrestrial vertebrate	Germany	Damages	1.28	Gebhart 1996
Felis catus, Rattus sp.	Terrestrial vertebrate	Italy	Eradication	0.19	Scalera & Zaghi 2004
F. catus, Rattus sp.	Terrestrial vertebrate	France	Eradication	0.21	Scalera & Zaghi 2004
F. catus	Terrestrial vertebrate	UK	Control	3.62	White & Harris 2002
Hystrix hodgsoni	Terrestrial vertebrate	UK	Eradication	0.03	Smallshire & Davey 1989
Muntiacus reevesi	Terrestrial vertebrate	UK	Control	0.02	White & Harris 2002
Mustela vison	Terrestrial vertebrate	UK	Eradication	0.55	Moore et al. 2003
M. vison	Terrestrial vertebrate	Estonia	Eradication	0.12	Scalera & Zaghi 2004
Myocastor coypus	Terrestrial vertebrate	UK	Eradication	0.45	Gosling & Baker 1989
M. coypus	Terrestrial vertebrate	Italy	Riverbank damages	2.14	Panzacchi et al. 2007
M. coypus	Terrestrial vertebrate	Italy	Agricultural damages	0.19	Panzacchi et al. 2007
M. coypus	Terrestrial vertebrate	Italy	Control	0.52	Panzacchi et al. 2007
Oryctolagus cuniculus	Terrestrial vertebrate	Germany	Control	5.11	Gebhart 1996
O. cuniculus	Terrestrial vertebrate	UK	Control	41.18	White & Harris 2002
O. cuniculus, Rattus sp, M. coypus, M. vison	Terrestrial vertebrate	France	Control/eradication	0.29	Scalera & Zaghi 2004
O. cuniculus, Rattus sp.	Terrestrial vertebrate	France	Eradication	0.23	Scalera & Zaghi 2004
Lithobates catesbeianus	Terrestrial vertebrate	UK	Eradication	0.01	Adrados & Briggs 2002
Rattus norvegicus	Terrestrial vertebrate	UK	Eradication	0.28	Scalera & Zaghi 2004
Sciurus carolinensis	Terrestrial vertebrate	UK	Control	0.46	White & Harris 2002
Azolla filiculoides	Freshwater plant	Spain	Control/eradication	1.00	Andreu & Vilà 2007
Crassula helmsii	Freshwater plant	UK	Control	0.88	Shaw 2003
Eichhornia crassipes	Freshwater plant	Spain/Guadina Basin	Control/eradication	3.35	Andreu & Vilà 2007
Dreissena polymorpha	Freshwater invertebrate	Spain	Infrastructure & boat damage	2.00	Alonso 2006
Oxyura jamaicensis	Freshwater vertebrate	Spain	Eradication	0.06	Cevallos pers comm
O. jamaicensis	Freshwater vertebrate	UK	Eradication	0.75	Scalera & Zaghi 2004
Chattonella spp.	Marine algae	Norway	Toxic bloom	7.43	Hopkins 2002
Chrysochromulina polylepis	Marine algae	Norway	Toxic bloom	8.18	Hopkins 2002
Cercopagis pengoi	Marine invertebrate	Gulf of Fidland	Decline fish catches	0.02	Panov et al. 1999
Rhopilema nomadica	Marine invertebrate	Levantine coast	Infrastructure damage	0.04	Galil & Zenetos 2002, Gollash & Rosenthal 2007

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Source: Vilá M. and Basnou C., ***State of the art review of the environmental and economic risks posed by invasive alien species in Europe****, DAISIE deliverable 14, February 2008*

Table 3: Estimated monetary costs (million € per year) of alien species invading Europe

Species	Biome/taxa	Region	Cost item	Min-max cost	Source
Ceratocystis ulmi	Terrestrial fungus	Germany	Restoration	3.5 - 13.42	Reinhardt et al. 2003
Plant pathogens	Terrestrial fungus	UK	Loss crop production	1400	Pimentel et al. 2001
30 naturalized species	Terrestrial plant	UK	Control	151.04	Williamson 2002
126 alien weed species	Terrestrial plant	UK	Control	523.18	Prus 1997
Ambrosia artemisiifolia	Terrestrial plant	Germany	Medical	19.8 - 49.9	Reinhardt et al. 2003
Fallopia japonica, F. sachalinensis	Terrestrial plant	Germany	Bank and dam damage	15.8 -31.7	Reinhardt et al. 2003
Fallopia japonica, F. sachalinensis	Terrestrial plant	Germany	Control	5.9 - 6.6	Reinhardt et al. 2003
Fallopia japonica, F. sachalinensis	Terrestrial plant	Germany	Damage railway infrastructures	2 - 2.7	Reinhardt et al. 2003
Heracleum mantegazzianum	Terrestrial plant	Germany	Medical	0.309 - 1.96	Reinhardt et al. 2003
Heracleum mantegazzianum	Terrestrial plant	Germany	Control	11.26	Reinhardt et al. 2003
Lupinus polyphyllus	Terrestrial plant	Germany	Control	0.3	Reinhardt et al. 2003
Prunus serotina	Terrestrial plant	Germany	Control	15.6 - 39.6	Reinhardt et al. 2003
Cameraria ohridella	Terrestrial invertebrate	Germany	Control	10.02 - 33.8	Reinhardt et al. 2003
Ephestia kuehniella	Terrestrial invertebrate	Germany	Loss stored grain	0.78	Reinhardt et al. 2003
E. kuehniella	Terrestrial invertebrate	Germany	Monitoring	0.02 - 0.2	Reinhardt et al. 2003
E. kuehniella	Terrestrial invertebrate	Germany	Control	3.8 - 5	Reinhardt et al. 2003
Oryzaephilus surinamensis, Rhyzopertha dominica	Terrestrial invertebrate	Germany	Loss stored grain	3.4-13.7	Reinhardt et al. 2003
O. surinamensis, R. dominica	Terrestrial invertebrate	Germany	Control/consulting	7.8 - 21.6	Reinhardt et al. 2003
Arthropods	Terrestrial invertebrate	UK	Loss crop production	2800	Pimentel et al. 2001
Columba libia	Terrestrial vertebrate	UK	Loss stored grain, construction damages vector disease	200	Pimentel et al. 2001
Felis catus	Terrestrial vertebrate	UK	Bird consumption	800	Pimentel et al. 2001
Mustela vison	Terrestrial vertebrate	Germany	Control	3.8 - 4.6	Reinhardt et al. 2003
Ondatra zibethicus	Terrestrial vertebrate	Germany	Loss fish cultivation	1.0 - 2.7	Reinhardt et al. 2003
O. zibethicus	Terrestrial vertebrate	Germany	Bank and dam damage	2 - 2.5	Reinhardt et al. 2003
O. zibethicus	Terrestrial vertebrate	Germany	Control	2.96 - 4.36	Reinhardt et al. 2003
Oryctolagus cuniculus	Terrestrial vertebrate	UK	Loss crop and pasture production	800	Pimentel et al. 2001
Lithobates catesbeianus	Terrestrial vertebrate	Germany	Control	0.26 - 0.52	Reinhardt et al. 2003
Rattus sp.	Terrestrial vertebrate	UK	Damages	2800	Pimentel et al. 2001
Eriocheir sinensis	Freshwater invertebrate	Germany	Control/Eradication	0.03-0.05	Fladung pers. comm.
E. sinensis	Freshwater invertebrate	Germany	Loss in commercial fisheries	2.4-2.8	Fladung pers. comm.
E. sinensis	Freshwater invertebrate	Germany	Bank erosion	0.007-0.02	Fladung pers comm.
Mnemiopsis leidyi	Freshwater invertebrate	Black Sea	Loss commercial fisheries	16.99	Travis 1993
M. leidyi	Freshwater invertebrate	Black Sea	Loss commercial fisheries	12.27	Knowler 2005
Procambarus leniusculus	Freshwater invertebrate	Scotland	Eradication	0.1	Collins 2006
Teredo navalis	Marine invertebrate	Baltic Sea	Infrastructure damage	0.7-1.4	Leppäkoski et al. 2002
T. navalis	Marine invertebrate	North Sea	Infrastructure damage	3.6	Hoppe pers. comm.,

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Source: Vilá M. and Basnou C., ***State of the art review of the environmental and economic risks posed by invasive alien species in Europe****, DAISIE deliverable 14, February 2008*

Table 4: Examples of situations where major economic sectors act as sources of alien species in Europe and the problems that alien species (from all sources) causes within these particular sectors

Sectors	*Sector as source of alien taxa*	*Aliens as sector problems*
Agriculture	Feral Crops: *Linum usitatissimum*	Agricultural Weeds: *Oxalis pescaprae*
	Nectar/Pollen Sources: *Impatiens glandulifera*	Contaminated Seed: *Amaranthus retroflexus*
	Alien Pollinators: *Bombus* spp.	Hive Parasites: *Varroa destructor*
	Fur Farms: *Mustela vison*	Vertebrate Pests: *Nyctereutes procyonoides*
Aquaculture	Fish Stocking: *Salvelinus alpinus*	Alien Pathogens: Spring viraemia
Energy	Biomass Crops: *Miscanthus chinensis*	Cooling System Fouling: *Dreissena polymorpha*
Health	Medicinal Herbs: *Tanacetum parthenium*	Allergenic Pollen: *Ambrosia artemisifolia*
		Toxic Sap: *Heracleum mantegazzianum*
		Disease Vectors: *Rattus rattus*
Horticulture	Garden Plants: *Mimulus guttatus*	Garden Weeds: *Aegopodium podagraria*
	Landscaping: *Robinia pseudoacacia*	Urban Weeds: *Ailanthus altissima*
Industry	Imported Raw Materials: *Senecio squalidus*	Development Constraint: *Fallopia japonica*
	Pet Industry: *Trachemys scripta elegans*	
Mariculture	Mariculture escapes: *Crassostrea gigas*	Alien Parasites: *Mytilicola orientalis*
Silviculture	Plantation Exotics: *Pinus contorta*	Forestry Weeds: *Prunus serotina*
	Plantation Pests: *Anoplophora glabripennis*	Forestry Pests: *Sciurus carolinensis*
Tourism	Zoological Gardens: *Muntiacus reevesi*	Hybridisation with Natives: *Oxyura jamaicensis*
	Botanical Gardens: *Hedychium gardnerianum*	Biodiversity Loss: *Rhododendron ponticum*
	Sports Fishing: *Oncorhynchus mykiss*	Fishing Tackle Foulant: *Cercopagis pengoi*
	Game Introductions: *Sylvilagus floridensis*	
Transport	Ballast Water: *Eriocheir sinensis*	Hull fouling: *Caprella mutica*
		Air Strikes: *Branta canadensis*
Water	Freshwater transference: *Dreissena polymorpha*	Alien macrofoulants: *Corbicula fluminea*

Source: Hulme P. ***Biological Invasions in Europe: Drivers, Pressures, States, Impacts and Responses****, The Royal Society of Chemistry, 2007*

Table 5: Number of species classified by the following trade categories: A) the alien species is intentionally introduced, as the commodity itself, for being released into the environment (i.e. game species, freshwater fish, tree species of interest for forestry, biocontrol agents, etc.) B) the alien species is intentionally introduced as the commodity itself (i.e. ornamental plants, agricultural plants, pets, crayfishes, etc.) in a containment facility or in a controlled environment (i.e. botanic gardens, greenhouses, agricultural land, zoos, animal-breeding establishments, fish farms, etc.). C) the alien species is unintentionally introduced as a contaminant of a specific commodity (i.e. Anoplophora chinensis introduced in Italy through import of bonsai; parasites of specific fish species, fruit flies, microcell disease Bonamia ostreae transported with oyster shipments, etc) D) the alien species is unintentionally introduced with movements of people or of machinery (i.e. pests in wood packaging, hull fouling, ballast waters, contaminants in containers, hitchhikers on planes, etc.).

(See also figures 5-8)

Taxa	No. Species	No. Species classified	A	B	C	D
Insect	144	144	1		134	32
Plants	76	75	40	11	31	19
Fungi	66	10			9	1
Viruses	42	0				
Prokaryotes	34	1				1
Fish	23	23	13	3		11
Crustaceans	18	18	8	5		11
Molluscs	17	17	7	5	5	10
Nematodes	17	17			13	12
Mammals	15	15	5	9		1
Macroalgae	13	12	1	1	5	6
Phytoplankton	10	10				10
Annelids	9	9			1	8
Birds	7	7	1	6		
Amphibians and reptiles	4	4	1	3		
Flatworms	4	4			4	
Hydroids, jellyfish, sea anemones and corals	4	4			1	3
Comb jellies	3	3		2		1
Ascidians and sessile tunicates	2	1				1
Bryozoans	2	2				2
Protozoa	2	2				2
Cestoda	1	1			1	
Protists	1	1			1	

Source : Genovesi P, Scalera R, ***Towards a Black List of Invasive Alien Species Entering Europe Through Trade and Proposed Responses****, document prepared the Convention on the Conservation and European Wildlife and Natural Habitats, November 2007*

Table 6: List of pathways of IAS introductions in Europe with descriptors for assessment of pathways (Minchin et al. 2007, modified)

Pathway	**Vector**	Descriptor of operating pathway
1. Ships, moveable structures (barges, dredgers, floating docks, navigation buoys) fishing, leisure vessels, floatplanes and small sports craft (jet skis, canoes, paddle craft)	• Water and sediments carried within ballast tanks • Rock and sedimentary ballast • The hull including projections, intakes and cavities of the hull (sea chests, thruster ports and fans, abstraction piping and small crevices) • Boring organisms of the hull and other submerged structures • Bilges and bilge pumping equipment • Wells, tanks and with other cargo • Anchor, anchor chains, lockers, fenders, portable moorings and recesses in the deck and holds • Trailers for the transportation of craft and all adhering and snagged organisms • Dredged materials, coarse gravel extractions to disposed fine sediments	• Regular passage of ships or port within the assessment unit
2. Canals (including irrigation channels, drainage cuts, and cuts, ponds and marina basins)	• Water flow, tidal exchanges, flooding events, storm surges or varying water levels • Transport of floating timber, pontoons, other equipment • Associated with migrating aquatic species • Leakage of water from aquaducts	• Presence of the canal within assessment unit or within inland waterway/invasion corridor AU belongs to.
3. Wild fisheries	• Stock movements • Population re-establishment • Discharges from processing live, fresh and frozen foods • Live bait releases and discharges of live packaging materials • Movements of retrieved fishing equipment, discarded or lost nets, floats, traps etc. • Discards of target and non-target species (bycatch) • Releases of organisms intended as living fish food supplements	

Pathway	Vector	Descriptor of operating pathway
4. Culture activities	• Intentional releases and movement of stock and associated water	• aquaculture is practiced within the catchment area
	• Unintended or unauthorised releases (including from secure fur-farms)	• Stock enhancement known to take place within assessment unit
	• Movement of equipment (nets, cages, lines, pumping equipment, etc.)	
	• Discarded contaminated containers, live packaging materials and/or associated transport media	
	• Broadcasting feeds (live, fresh, frozen)	
	• Release of genetically modified species	
5. Ornamental and live food trade including garden centres and public aquaria)	• Intentional releases (in particular releases from aquaria and ponds)	• Tropical species known to be in cultivation and released to thermal effluents where 'permanent' populations may form
	• Accidental releases (including from ornamental breeding and of incorrectly identified species)	
	• Movement of organisms associated with stones ('live rocks'), corals, gravels and sediments	
	• Untreated waste discharges	
	• Unauthorised releases of imported living foods	
		• Holding tanks for imported foods adjacent to assessment area
6. Leisure activities	• Live bait movements and discharges of live packaging materials	• marina or marinas within assessment unit or leisure craft visit assessment unit
	• Accidental, intentional transport and release of angling catch	• high human activity with festivals and sporting events (including angling involving live bait releases) with provided access via public parks
	• Water sport equipment (diving , fishing gear)	
	• Live souvenirs, fairground prizes	
7. Research and education (including pilot projects)	• Intentional releases involved in field experiments, including translocations	• releases of experimental organisms are known
	• Accidental release	
	• Waste water and biological waste discharges (including flow-through aquaria systems, discarded demonstration materials)	
	• Living food releases from cultures or movements	
	• Field and experimental gear movement (including diving gear)	
	• Caged organisms used for monitoring water quality	

Pathway	Vector	Descriptor of operating pathway
8. Biological control	• Releases to control invasive or otherwise abundant organisms • Releases to reduce impacts of diseases and parasites	• Biological control activities are known
9. Alteration to natural water flow	• Movements of abstracted water for municipal supply (from watering channels to piped and pumped supplies) • Drainage to different river catchments • Irrigation channels • Development of reservoirs with overspill to different catchments • Removal of natural barriers between catchments	
10. Other pathways	• Habitat management (soil stabilisation/ reclaimation using rock barriers, sediments and plantings; use of filterfeeding invertebrates for managing water quality) • Municipal and other waste treatment discharges • Discharged live packing material used for non-living products • Releases of transported water (drinking water for humans and/ or livestock and associated equipment)	• Sand and gravel extraction known to take place in assessment unit. Organic waste known to be released to assessment unit (from food processing plants)

Source: Panov V.et al, ***Interim protocols for risk assessment of aquatic invasive species introductions via European inland waterways****, ALARM deliverable D. 4.1.3.10, February 2008-06-04*

ANNEX B - Relevant EU research projects

DAISIE, a pan-European inventory of alien species (see http://www.europe-aliens.org/index.jsp) a 3 year (February 2005-March 2008) research project supported under the 6th RTD Framework programme with 2.4 million €, delivered a pan-European inventory of invasive alien species mobilising existing expertise for species records. This inventory also includes and describes alien species that have a high likelihood of introduction or spontaneous spread from neighbouring countries, and identifies priority species.

DAISIE focused on four major areas of information gathering and dissemination:

1) *European Alien Species Expertise Registry*

Current expertise in biological invasions is distributed across research organisations throughout Europe and is funded mainly by national programmes. The European Expertise Registry represents a fundamental step towards linking these organisations and individuals in ways that provide added value at European level and provide the critical mass of expertise in invasive alien species research to meet European-scale requirements. The European Expertise Registry facilitates the clustering and information sharing among different national programmes targeting the same invasive alien species, helps establish teams of experts who can, once a new alien incursion has been reported, assess the situation and prepare an action plant for the invasive alien species at a particular site and enables the current breadth and scope of European knowledge on alien species to be assessed. The registry contains information on the field of expertise (distribution, conservation, ecology, economy, genetics, legislation, management, pathways, physiology, risk assessment, and taxonomy) and on the taxonomic and geographic structure of the expertise.. Within 12 months of its launch, the Registry contained information on 1500 experts from nearly 90 countries for almost 3000 higher taxa (family level or higher) and numbers have steadily increased since.

2) *European Alien Species Database*

An up-to-date inventory of all alien species known to inhabit Europe represented the major activity in DAISIE and involved compiling and peer-reviewing national lists of hundreds of species of fungi, plants, invertebrates, fish, amphibians, reptiles, birds and mammals. Data were collated for all 27 European Union member states, and where these states had significant island regions, data were collated separately for these as well. In addition, data were collated for European states that are not in the European Union such as Andorra, Iceland, Liechtenstein, Moldova, Monaco, Norway, Russia, Switzerland, Ukraine as well as former Yugoslavian states in the Balkans. Finally, marine lists were referenced to the relevant maritime state and thus to have full coverage of the Mediterranean, marine data were included for North African and Near East countries. For each species, an attempt was made to gather information on native range, date of introduction, habitat, known impacts and population status. Considerable effort was required to ensure synonyms were accounted for accurately and all national lists were independently reviewed by experts. Records of over 10,000 alien species are included in the database (February 2008), the majority of records are for vascular plants with invertebrates also a significant component (see Olenin et al. 2008).

3) *European Invasive Alien Species Information System*

The provision of selected species accounts covering high profile alien species not only delivers end users with relevant details for species identification and management but also helps raise public awareness of the issue of invasions. Accounts for representative sample of 100 invasive alien species have been produced and each includes information on biology, ecology, distribution, management information, references, links and images. The aim was to generate brief fact sheets that might appeal to the general reader with links to more detailed information for specialists. The accounts cover 3 fungi, 18 terrestrial plants, 16 terrestrial invertebrates, 15 vertebrates, 16 inland and 32 coastal aquatic species invading natural and semi-natural habitats. Selection was based on ensuring a broad spectrum of life forms and functional types, a range of invaded ecosystems and clear examples of different impacts on European biodiversity, economy and health (see Vilà et al. 2008). A key requirement for the effective management of invasive alien species is the ability to identify, map, and monitor invasions in order to assess their extent and dynamics (Hulme 2003).

4) *Species Distribution Maps and Spatial Analysis*

DAISIE had as an objective to establish a common European standard for the graphical presentation of the invasive alien species data as distribution maps. The Common European Chorological Grid Reference System with the size of the mapping grid *ca* 50 × 50 km, depending on the latitude/longitude was used to produce distribution maps. This scheme employs a reasonably detailed resolution for Europe and is commonly used for species mapping. Data sources included European-wide and national atlases as well as regional checklists. The following data were plotted for each species: (a) known presence of the species; (b) known absence. Where known, additional information on (c) species previously present but eradicated and (d) native distribution, was also considered. Where precise information on distribution was missing but the species was known to occur in a country/region/district, the distribution in these administrative units was recorded and mapped by using hatching. A different format was adopted for mapping invaders in aquatic habitats where linear distributions or maritime areas needed to be recorded. Distribution maps were generated for the 100 species for which accounts were produced and can be found in Vilà et al. (2008).

Each of these 4 activities has been integrated together as a single internet portal for information on European alien species[36]. The inventory, accounts, and distribution maps today provide the first qualified reference system on invasive alien species for the European region. The information presents an outstanding resource to synthesise current knowledge and trends in biological invasions in Europe. The data will help identify the scale and spatial pattern of invasive alien species in Europe, understand the environmental, social, economic and other factors involved in invasions, and can be used as a framework for considering indicators for early warning. In addition, the data will assist Member States develop and manage their National Biodiversity Action Plans as well as enable the European Union to monitor its performance towards the 2010 target.

ALARM, Assessing large scale environmental risks on biodiversity (see http://www.alarmproject.net) is a 5 year (February 2004-March 2009) Integrated Project supported under the 6th RTD Framework programme with 13 million €. ALARM integrated 5

[36] See http://www.europe-aliens.org/index.jsp

modules focussing on risks consequent on climate change, biological invasions, environmental chemicals, rates and extent of pollinator loss and socio-economic aspects in the context of current and future European land use. ALARM also looked at combined risks. One of the major outputs will be a Risk Assessment Toolkit for biodiversity.

ALARM currently support the e-journals *Aquatic Invasion*[37] and *Biorisk*[38].

The journal "Aquatic Invasions" was established in 2006 as an initiative of the European Research Network on Aquatic Invasive Species (ERNAIS), with start-up funding from the EC FP6 Integrated Project ALARM. It provides the opportunity for timely publication of first records of biological invaders for consideration in risk assessments and early warning systems. Also, the journal provides the opportunity to publish technical reports on new technologies in management of invasive species and proceedings of relevant international meetings. In 2007, four issues of the second volume of *Aquatic Invasions* with 62 research articles and short communications were released and freely available at the journal website. These papers included 820 new geo-referenced records of invasive alien species in European inland and coastal waters, with 168 records from field surveys in 2007.

One of the key benefits of these e-journals is the timely and readily available publication of essential primary scientific information[39] also needed for decision making. The provision of a freely accessible, early warning system for potentially invasive alien species is an essential tool for decision-making to prioritise early eradication efforts, and also for relevant decision support systems. In addition online journals can provide a publication platform for other important information on the management of invasive species including publication of technical reports on new technologies in management of invasive species and proceedings of relevant international meetings. Finally, the fast but comprehensive reviewing process of submitted manuscripts is serving as an effective quality insurance mechanism for IAS information that is freely available to interested stakeholders.

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37 See http://www.aquaticinvasions.ru/

38 See http://www.pensoft.net/Brochure-BIORISK.pdf

39 A manuscript publication, including a comprehensive review process, takes on average less than one month, thereby reducing the publication time lag typical of many regular international journals. In this way *Aquatic Invasions* can facilitate the regional and Pan-European early warning systems on alien species, previously lacking.

ANNEX C - Examples of costs and benefits of IAS policy measures

Taking a policy measure for IAS entails costs, possibly very substantial, which need to be offset against the costs of inaction or delayed intervention to control IAS. There is a growing body of evidence that the benefits of preventive action on IAS often outweigh the costs of inaction (even when these are only partially assessed e.g. the stated economic impact does not reflect all or any damage to ecological, recreational and cultural values).

In the following examples of costs and benefits associated with the IAS policy options are listed. Because monetary cost information is lacking for Europe in many cases, some points of reference are provided from other jurisdictions where appropriate.

The selected examples are loosely grouped for ease of reference but this should not be taken as a formal classification as many of the IAS mentioned could fall into more than one group.

IAS threatening native species and communities

***Lithobates catesbeianus* (American Bullfrog)**. UK early eradication efforts cost 32,000 €. Complete removal of all individuals (including tadpoles) may involve drainage of the water body where they are present which is extremely costly. Current control costs known in EU Member States are 0.4 million €/year (Germany, 0.39; UK eradication 0.01).

***Oxyura jamaicensis* (Ruddy duck).** The UK eradication programme (established 1992 to reduce the population to less than 175 birds, or 5 % of 1999 population) cost an estimated 4.4 million € over a 4-6 year period. It combines a general authorisation for landowners to shoot specimens at any time of the year, subject to a reporting requirement to the relevant ministry, and subjects purchase and sale of specimens to a permit requirement (no permits issued for several years). By 2004, at least 15 countries in the Western Palearctic were implementing control measures and about 5,500 birds have been culled (UK 5,100; France, 246 since 1998; Spain, 217 since 1993). Control cost figures not available for these countries.

Impatiens glandiflora (Himalayan balsam) is invasive in almost all temperate European countries and may outcompete native plants for pollinators (bees), thereby reducing native plant seed production. Eradication is costly and time consuming because of the high ability of the species to regenerate and spread, including through river corridors. The UK Environment Agency estimates eradication costs for England and Wales at 210-240 million €.

IAS policies may support higher investment in control where eradication is technically feasible and high biodiversity values require protection (e.g. native birds on isolated islands at risk from introduced rats and other vertebrates). Over the last 15 years, rat eradications have been successfully completed on increasingly larger offshore islands, i.e. Langara Island (British Colombia, Canada, 3100 ha), Raoul Island (2938 ha) and Little Barrier Island (3083 ha) (New Zealand).

IAS affecting multiple sectors due to impacts on ecosystem function and services

***Myocastor coypus* (coypu)**. In Italy (1995-2000), removal of over 220 thousand coypus cost 2.614 million € whilst riverbank damage exceeded 10 million € and agricultural damage was almost 1 million €. Current control costs available for EU Member States total 5.02 million €/year (Netherlands: prevention/control 0.8 million; East Anglia (UK): eradication 0.45 million; Italy: combined damage/control costs, 3.77 million).

***Ondatra zibethicus* (muskrat)**. In Germany, eradication costs are estimated at 3 million €/year whilst the estimated cost of damage to inland water systems is 12.4 million €/year (4.6 million for sanitary aspects; 2.3 million for waterway maintenance, 1.9 million in losses to hatcheries and fishfarms through damaged ponds and dams).

***Mustela vison* (American mink)**. Damage costs in Germany estimated at 4.2 million €/year to agriculture (free-range poultry), hunting (reared game birds), fisheries (salmon farming) and eco-tourism (predation on ground nesting birds). Current control costs available for EU Member States are as follows: UK, eradication 0.55 million €/year[40]; Estonia control/eradication, 0.12 million €/year; France: control/eradication 0.29 million €/year). In Sweden, an intensive mink hunting programme under the National Action Plan for conservation of the Caspian tern *Hydropogne caspia* (2007-2011) will cost the Swedish Environmental Protection Agency 500,000 SEK (2007 prices) over that period for five areas totalling approximately 200 km^2.

***Fallopia japonica* (Japanese knotweed)**. Extremely high damage and control costs due to breadth of impacts, including damage to masonry, pavements, walls, drainage works and native riparian communities, increased flood risk and increased cost of land clearance for development (where the plant occurs on a development site it can cost tens of thousands of pounds to adequately control). In Germany, estimated costs are 5.9-6.6 million €/year (plant control), 12.3-21.2 million €/year (stabilisation of river banks), 2-7.7 million €/year (clearance of railways) and 3.5-10.5 million €/year (repair of foundations). The Czech Republic spends 0.2 million €/year on control/containment. In the UK, a 2003 estimate put cost of removal from Britain at £1.56 billion. Specific control costs cover attempted eradication (over 1078 million €/year) and research on biocontrol (0.11 million €/year). In Wales (UK), the estimated annual control costs for one county council in 1994 was £300,000.

Invasive aquatic plants affecting inland water systems

Several ornamental aquatic plants that have proliferated in inland water systems can block waterways by forming dense vegetation mats on the surface, thus reducing oxygen and light penetration into the water column and negatively affecting fish life, plants and invertebrates. Depending on the species and recipient ecosystem, socio-economic impacts include reduced opportunities for angling, interference with navigation, increased flood risk and clogged intakes of irrigation, hydropower and water supply systems. Control in aquatic ecosystems presents technical difficulties e.g. physical removal results in many small viable fragments being left in the water, which may spread the plant downstream or elsewhere within lakes and reservoirs.

Examples of known control costs:

***Nymphoides peltata* (Yellow floating heart)**. Total potential costs of controlling the yellow floating heart in Swedish lakes assessed at 28-72.8 million SEK/year, assuming 800-1,300 hectares treated at 35,000-56,000 SEK per hectare;

***Hydrocotyle ranunculoides* (Floating pennywort)**: Netherlands, 3 million €/year;

[40] In 1965-1970, an unsuccessful eradication (trapping) campaign by the Agriculture Ministry of Agriculture cost £105,000: the cost at 1990 prices, excluding associated research costs, was estimated at £552,000 (see annexed Table).

***Crassula halmsii* (New Zealand Pigmyweed)**: UK estimated costs 0.895 million €/year.

Little monetary cost information is available for Europe on ***Azolla filiculoides* (Red water fern)**, a native of South America. However, the plant is well-documented in South Africa where associated damages (coverage of dams, resulting damage to water pumps; deaths of livestock; substantial clearing costs) are estimated at 580 million Rand. One study on the economic benefits of developing biological control showed that bringing *Azolla filiculoides* under control yielded a return on investment of 25:1. Cost of damage was compared to cost of research (510 000 Rand) that led to the release of the biocontrol agent which brought the problem completely under control within 2 years of release.[41]

Invasive terrestrial plants that reduce available water resources

Some invasive alien plants consume a higher proportion of available water resources than native plants in the same ecosystem. Reduced runoff from watersheds with dense stands of invasive trees can affect biological production sectors, human wellbeing and native biodiversity. In such cases, costs of policy intervention can be assessed at least partly by reference to financial benefits that would result from improved water yield.

***Eucalyptus spp* (Eucalyptus)** replaces natural vegetation and use excessive water in Spain, which currently spends 1.58 million €/year on control/eradication. Figures from South Africa assessed the costs of initial clearing of 2,264 ha at 5.02 million Rand for one year (2002-2003) with herbicides costing 992 Rand per hectare.

IAS affecting forest productivity and biodiversity

***Sciurus carolinensis* (Grey squirrel)**. UK estimated costs of control and eradication are 0.46 million €/year (mechanical and chemical measures, research into immunocontraceptive agents). Ongoing control costs are not available for Italy where a proposed rapid eradication programme was blocked by a legal challenge from animal rights movements. Damage costs are available for the UK. In 1999, lost timber revenue at the end of a rotation in state-owned forests in England and Wales was estimated at £2 million (Forestry Commission). In 2000, a Great Britain-wide study assessed total cost to the British timber industry of damage to beech, sycamore and oak as £10 million at the end of the current rotation.

***Prunus serotina* (Black cherry)**. In the Netherlands, control costs are 2 million €/year. In Germany, total damages and costs amount to 27.50 million €/year (increased labour costs for forest management e.g. thinning, 1.4; direct control of pest in forests 20.7; control measures in nature conservation areas, 3.4).

***Rhododendron ponticum* (Rhododendron)**. Current UK expenditures total 68.37 million €/year (technical difficulties both with mechanical and chemical control, no biocontrol agent identified for Europe). Estimated costs of rhododendron removal from woodland in mainland Argyll and Bute £9.6 million; control costs to date in Snowdonia National Park £45 million.

[41] National Biodiversity Strategy and Action Plan (NBSAP). 2004. Towards a National Strategy for Dealing with Invasive Alien Species in South Africa: Stocktaking Report. [Accessed 23 April 2008] Available online at: http://www.environment.gov.za/ProjProg/ProjProg/2004Jun10/stocktaking/IAS_DRAFT_report_2004.doc#_Toc93118802

Pests affecting forests include the fungus *Ophiostoma novo-ulmi* (Dutch elm disease): control costs in Germany for removing dead trees, replanting and loss of wood assessed at an average of 5 million €/year.

Figures from the United States give an indication of the potential magnitude of forest pests: for *Sirex noctilio* (woodwasp) and the associated pathogenic fungus, *Amylostereum areolatum*, the USDA Forest Service estimates that if no action is taken to contain the woodwasp, it could spread across the entire southern pine region in under 55 years and generate damage of US$ 2-11 billion in impacts to softwood production.

IAS affecting aquatic infrastructure and fisheries

Several highly invasive aquatic organisms have reached Europe and/or spread within Europe through common pathways (e.g. shipping and aquaculture) and associated vectors (ballast water, fouling, imports of diseases and pathogens). Economic impacts may relate directly to fisheries and aquaculture production and equipment and/or have indirect impacts on water-related infrastructure e.g. on hydropower generation and pipe systems.

***Dreissena polymorpha* (zebra mussel).** Control techniques focus on ballast water management and measures for prevention of spread. Costs for control and damage are not available specifically for Europe. However, US figures assessed cumulative costs to US and European industrial plants (1989-2000) at US $750 million to US$ 1 billion (National Aquatic Nuisances Clearinghouse, 2000). In the Great Lakes region (US/Canada), damage for the period 2000-2010 has been assessed at US$ 3.1 billion (intake pipes, water filtration equipment, power plants), US $100 million/year (lost power generation based on a one to two day downtime and a 1% reduction in plant heat rate) and $5 billion (potential economic impact).

***Mnemiopsis leidyi* (Sea walnut, comb jelly)**. Control costs not known but estimated impacts on Black Sea fishing nations of 24.53 million €/year, mainly generated by loss of the commercial anchovy catch. Biofouling of fishing equipment by ***Cercopagis pengoi* (Fish-hook waterflea)** in the Primorsk (Koivisto) area led to economic losses at one fish farm of 0.03 million €/year in 1996-1998.

Some cost/benefit figures for IAS control in fisheries are available for the Great Lakes region (US/Canada). Benefits of controlling ***Petromyzon marinus (Sea Lamprey)***, which preys on commercially important fish, are assessed in the range of $2-4 billion/year. If ongoing control was terminated, lost fishing opportunities and indirect are estimated at $500 million/year. Cost of sterile male release in Lake Huron is US$ 300,000 and cost of one lampricide treatment in St Mary's River is $4.2 million. For ***Gymnocephalus cernuus* (Ruffe)**, estimated total cost of control programme over 11 years is US$12 million. Estimated losses for the native fishery were estimated at US$ 0.5 million/year in 2001 and for sport fisheries in Lake Erie, at US$ 60 million/year between 1985-1995.

***Balanus improvisus* (Bay barnacle, Acorn barnacle)**. In Sweden, estimated maintenance costs to defoul pleasure boats estimated to 123-334 million SEK/year. One shipping company, the Broström Group, estimates the cost for anti-fouling treatment per tanker ship of 11,000 GRT (Gross Register Tonnage) to be around 400,000-500,000 SEK every 30 months (i.e. 160,000-200,000 SEK/year. The Swedish Shipowners Association estimates the costs for very large vessels (>40,000) to be around 250,000-500,000 SEK/year.

Where one pathway provides opportunities for multiple species introductions, prevention may involve construction of specific infrastructure to reduce known risk of unwanted introductions (e.g. a salinity barrier in the Suez Canal to prevent Lessepsian migration of non-native aquatic species via the Suez Canal to the Mediterranean). In the US, the cost of constructing an enhanced barrier (electrical fish barrier) to keep the invasive Asian carp out of the Great Lakes is US$9.1 million. In 2002, the U.S. Army Corps of Engineers constructed a temporary electronic dispersal barrier on the Chicago Sanitary and Ship Canal at a cost of approximately $2.2 million.

IAS that threaten animal and human health

Growing risks are associated with IAS as vectors of disease that affect wild and/or farmed animals and in some cases, humans. IAS may also directly impact on human health where the organism or a part thereof is toxic or provokes allergic reactions.

***Cervus nippon* (Sika deer)**: invasive in at least 9 European countries and a documented vector of diseases affecting both wild and farmed animals. UK estimated control costs 0.82 million €/year.

***Aedes albopictus* (Asian tiger mosquito)**. In Italy (Emilia Romagna), costs related to health risk prevention, eradication and communication total 1.10 million €/year.

***Thaumetopoea processionea* (Oak processionary moth)**. In the UK, measures to prevent human health impacts estimated 0.36 million €/year. The Royal Botanic Gardens Kew estimates it will spend £20,000-30,000 in 2008 to control the pest. The future financial implications could be extremely high due to both health costs and oak damage.

Invasive plants affecting human health include **common ragweed (*Ambrosia artemisifolia*)** (health costs in Germany estimated 32.10 million €/year; associated hay fever costs also known to be high in seriously infested regions like the Rhone valley (France), Hungary, Croatia and northern Italy). For ***Heracleum mantegazzianum* (Giant hogweed)**, control costs are available for at least four EU Member States:

Czech Republic, control/containment costs 0.01 million €/year;

Germany, total estimated control costs 12.30 million €/year (medical 1.05, roadside clearance measures 2.34, human health 7.70, nature conservation 1.20);

Estonia, 5-year strategy for nationwide control of alien Heracleum species launched in 2005. Estimated control costs (2005) for 235 hectares are 1.4 million Estonian krooni/year (~90.000 €) and in 2006, 3.36 million Estonian krooni (~240.000 €) for 300 hectares;

in Sweden, the Swedish Road Administration controls giant hogweed along roads in three regions. Cost to the Mälardalen roads authority of weed control at five sites is 28,000 SEK/year at an average cost of 100 SEK/m^2. Costs to the Stockholm road authority range between 100,000-200,000 SEK/year (180,000 SEK in 2006, approximately 130,000 SEK in 2007).

Institutional and operational costs of IAS prevention and control

Operational costs of policies to support IAS prevention and control include improved governance and coordination, strengthened capacities for border control, risk analysis, early

warning and rapid response, and improved information systems, research and training (see section 3 above).

Some Member States are investing in development of national IAS strategies, improved baseline information and targeted management and research. Work is ongoing under the Technical Support contract to identify indicative costs for these operations as they relate to the natural environment, including by reference to non-EU jurisdictions. Figures so far identified for EU Member States are as follows:

in Denmark, the 2008 state budget has earmarked a specific sum for IAS (2 million Danish kroner) for the first time;

in the UK, the Environment Agency spends £1.5 million per annum on staff and project costs for controlling invasive non-native species[42];

in Germany, the Federal State of Schleswig Holstein put a ca. 3 million Euro tender out to co-fund a programme to develop an efficient ballast water treatment system.

[42] Defra (2003) in Parliamentary Office of Science and Technology note (April 2008, Number 303) (http://www.parliament.uk/documents/upload)