TECHNICAL SUPPORT TO EU STRATEGY ON INVASIVE ALIEN SPECIES (IAS)

Assessment of the impacts of IAS in Europe and the EU

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Marianne Kettunen (IEEP)
Piero Genovesi (ISPRA)
Stephan Gollasch (Go-Consult)
Shyama Pagad (ISSG)
Uwe Starfinger (Institut für Ökologie, Technical University of Berlin, Germany)
Patrick ten Brink (IEEP)
Clare Shine (IEEP)

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EXECUTIVE SUMMARY

Invasive alien species (IAS) are non-native species whose introduction and/or spread outside their natural past or present ranges pose a risk to biodiversity. IAS have been recognised as the second most important threat to biodiversity at the global level (after direct habitat loss or destruction) and they represent a serious impediment to conservation and sustainable use of global, regional and local biodiversity. IAS have also significant adverse impacts on the services provided by ecosystems (i.e. so called ecosystem services).

Ecosystem services play a fundamental role in supporting economic development and human well-being. The disruption of these services as a result of biological invasions is known to have adverse socio-economic and cultural impacts. For example, a number of human health problems, e.g. allergies and skin damage, are caused by IAS. IAS can also reduce yields from agriculture, forestry and fisheries or obstruct transportation by blocking waterways. IAS are also known to decrease water availability and intake and cause land degradation. Certain invasions of alien species have also led to declines in recreational or cultural heritage values associated with different landscapes and water bodies.

The economic costs and benefits associated with species introductions and biological invasions have attracted increasing attention during the past decade. It is of course acknowledged that non-native species can offer higher economic returns in some sectors, for example through plantations of fast-growing non-native conifers, satisfying demand for exotic products, pets and garden plants. However, a growing body of evidence suggests that IAS can have, and indeed have had, significant negative economic impacts that can also be measured in monetary terms.

This report presents the outcomes of a five-month study designed to provide a more complete picture of the different environmental, social and economic costs and benefits of IAS in Europe. It aims to provide a quantified review and estimates of overall impacts (e.g. known and estimated costs) of IAS.

The study concludes that a range of IAS taxa is causing impacts, including ecological, social and economic impacts, in Europe. These impacts are known to have significant ecological impacts and affect a wide rage of ecosystem services that underpin human wellbeing, including provisioning of food and fibre (agriculture, forestry and fisheries / aquaculture), regulating the spread of human diseases and aesthetic, recreational and tourism benefits.

According to existing data the total costs of IAS in Europe are estimated to be at least 12.5 billion EUR per year (according to documented costs) and propably over 20 billion EUR (based on some extrapolation of costs) per year. These costs result mainly from costs of damage due to IAS and costs of IAS control measures. Most of the information on monetary impacts of IAS comes from terrestrial plants and vertebrates and the majority of these documented costs have taken place in the EU.

Based on the information on IAS impacts on ecosystem services and what is known about their monetary costs it is clear that several important European economic sectors are affected by IAS. The most affected sectors include agriculture, fisheries and aquaculture, forestry and health sectors. According to the available information the total documented costs to these sectors amount to almost 6 billion EUR per year[1].

The report also concludes that available data on IAS monetary costs remain rather scarce and unevenly distributed between different geographic areas and IAS taxa. Thus, the figures presented in the report are significant underestimates of the real situation. The analysis of IAS impacts on ecosystem services indicate that in reality a far greater number of IAS cause socio-economic effects than are documented in monetary terms.

As for the future, it can be reliably assumed that introductions of new IAS to the EU and Europe will continue and the spread of already established IAS is likely to increase. Furthermore, the effects of climate change are also predicted to aggravate the situation as they may further enable the establishment of some newcomers. As a consequence the risks posed by the invasion of non-native species, including both ecological risks and risks to different economic sectors, are only likely to increase. For example, the impacts of IAS in European forests and to the forestry sector have not been as severe as in the North America, however given the rate of introduction and changing climatic conditions it might be only a matter of time before Europe faces negative impacts of similar magnitude. Furthermore, if not careful some EU policies, such as the current policies on energy and climate change, may encourage further IAS introductions in Europe.

The report provides clear evidence that IAS have had significant negative environmental, social and economic impacts in Europe. It also shows that there is an economic case for improving the control of IAS invasions to and within the European territory, including the EU, in future.

[1] Note: in several cases the existing data was not specific enough to allow to link costs to a specific sector.

ACRONYMS

ALARM	Assessing Large-scale Risks for biodiversity
COM	Commission Communication
DAISIE	Delivering Alien Invasive Species Inventories for Europe
DIPNET	Disease Interactions and Pathogen Exchange between Farmed and Wild Aquatic Animal Populations
EC	European Community
ERNAIS	European Network on Aquatic Invasive Species
GIDS	Global Invasive Species Database
IAS	Invasive alien species
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
IMPASSE	Environmental Impacts of Alien Species in Aquaculture
IOC	Intergovernmental Oceanographic Commission
NEMO	Baltic Marine Biologists Working Group on Non-indigenous Estuarine and Marine Organisms
NEOBIOTA	European Group on Biological Invasions
NOBANIS	North European and Baltic Network for Invasive Species
SEBI 2010	Streamlining European 2010 Biodiversity Indicators project
WGBOSV	ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors
WGITMO	ICES Working Group on Introductions and Transfers of Marine Organisms
UK	United Kingdom
US	United States

1 INTRODUCTION

1.1 What are invasive alien species?

Invasive alien species (IAS) are non-native species whose introduction and/or spread outside their natural past or present ranges poses a threat to biodiversity (see definitions, Box 1). IAS occur in all major taxonomic groups, including animals, plants, fungi and micro-organisms and an estimated 480,000 IAS have been introduced around the world (Pimentel *et al* 2001). IAS affect the terrestrial, freshwater and marine environment: a quick review of existing IAS databases reveals that alien species have invaded virtually every ecosystem type on the planet[2].

It is of course to be noted that many non-native species introduced outside their natural territories do not cause problems in their new locations (e.g. Williamson 1997). On the contrary, many introduced species underpin national production systems (agriculture, fisheries, aquaculture, forestry) and have very considerable benefits for local and national economies (e.g. van der Weijden et al. 2007). Others are highly appreciated sources of wellbeing for society (e.g. ornamental plants, pets and recreational fishing stock). However, many of those introduced species that do become established and proliferate are now known to be highly destructive to the environment as well as to more visible economic and human interests.

In addition to direct habitat loss and distructions, IAS have been recognised as one of the most important threat to biodiversity at the global level (e.g. Millenium Ecosystem Assessment 2005). They represent a serious impediment to conservation and sustainable use of global, regional and local biodiversity and have significant adverse impacts on the goods and services provided by ecosystems. Environmental degradation caused by pollution, habitat loss and human-induced disturbance already creates favourable conditions for IAS to establish and spread. The effects of climate change are predicted to aggravate the situation. There is already evidence that changes in climatic conditions can alter species' distributions and may make it easier for alien species to become established outside their natural distribution (e.g. Franke & Gutow 2004, Hiscock *et al* 2004, ICES WGITMO 2008).

Increasing travel, trade, and tourism associated with globalisation and expansion of the human population have facilitated the intentional and unintentional movement of species beyond their natural biogeographical barriers. This is particularly true in Europe and the EU where citizens today are more mobile than ever before. Ever-increasing trade between Europe and the rest of the world guarantees a steady supply of the world's biological resources into and out of Europe. The enlargement of the European Community provides expanded opportunities for the free movement of people and goods within Europe, which makes it easier to translocate organisms to new areas, intentionally or by accident. Depending on the recipient ecosystem and other factors, some of these organisms may establish and proliferate.

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[2] E.g. the Global Invasive Species Database (GISD) http://www.issg.org/database/welcome/ and the DAISIE database http://www.europe-aliens.org/

Box 1. Definitions of terms

The definitions used in this report correspond to those used in the CBD Guiding Principles (CBD Decision VI/23) and the European Strategy on IAS, with an exception in relation to the term 'introduction' – see discussion below and in Section 6.3). These definitions are identical to the ones used in the earlier study for the European Commission by Miller *et al* (2006).

'*Invasive alien species*' means an alien species whose introduction and/or spread threaten biological diversity.

'*Alien species*' refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. NB: some international/regional/national instruments (e.g. Conventions) use the terms 'exotic species', 'non-indigenous species' or 'non-native species' when referring to 'alien species'. In this report the term 'alien species' has been used throughout the text, but where applicable the references used in the original texts have been maintained.

'*Introduction*' refers to the movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present). This movement can be either within a country or between countries or areas beyond national jurisdiction. NB: in this report, movements between countries are referred to as 'exports' or 'imports'. Introduction is used to mean introduction into the wild.

'*Intentional introduction*' refers to the deliberate movement and/or release by humans of an alien species outside its natural range.

'*Unintentional introduction*' refers to all other introductions which are not intentional.

'*Establishment*' refers to the process whereby an alien species in a new habitat successfully produces viable offspring with a likelihood of continued survival.

See http://www.biodiv.org/decisions/default.aspx?dec=VI/23

1.2 What do we know about the impacts of IAS?

The known impacts of invasive alien species are wide ranging. IAS have been identified as a major cause of extinction of native species throughout the globe (e.g. McNeely *et al* 2001). In Europe, for example, the grey squirrel (*Sciurus carolinensis* Gmelin, 1788), American mink (*Mustela vison* Schreber, 1777) and crayfish (*Pacifastacus leniusculus* (Dana, 1852)) are known to out-compete and displace native species. In addition to threatening native species, a wide range of IAS are known to have significant impacts on the structure and functioning of the European ecosystems, such as Canadian waterweed (*Elodea canadensis* Michx), nutria (*Myocastor coypus* (Molina, 1782)), water hyacinth (*Eichhornia crassipes* (Mart.)) and comb jellyfish (*Mnemiopsis leidyi* A. Agassiz, 1865) (e.g. Shiganova 1997, Bilio & Nierman 2004, Hulme 2007, Panzacchi *et al* 2007). Box 2 below summarises the main ecological effects of IAS. (DAISIE 2008)

Given their proven ability to severely disrupt natural ecosystems IAS are increasingly seen as a threat to ecosystem services, i.e. the different resources and processes provided or maintained by natural ecosystems that benefit humankind (e.g. Millenium Ecosystem Assessment 2005). These range from provision of food and water, regulation of local and regional climate to maintaining nutrient cycles and crop pollinators and creating possibilities for tourism and recreation.

Ecosystem services play a fundamental role in supporting economic development and human well-being. The disruption of these services as a result of biological invasions is known to have adverse socio-economic and cultural impacts. For example, a number of human health problems, e.g. allergies and skin damage, are caused by IAS (e.g. plant species such as giant hogweed (*Heracleum mantegazzianum* Sommier & Levier), common ragweed (*Ambrosia artemisiifolia* L.) and silver wattle (*Acacia dealbata* Link). IAS can reduce yields from agriculture, forestry and fisheries or obstruct transportation by blocking waterways or clog industrial water intakes of, for example, power plants. IAS are also known to decrease water availability and cause land degradation. Certain invasions of alien species, such as Azolla water fern (*Azolla filiculoides* Lam.) and Eastern white pine (*Pinus strobes* L.), have led to declines in recreational or cultural heritage values associated with different landscapes and water bodies (e.g. DAISIE 2008, see Chapter 4 for more details).

In general, the impacts of IAS on ecosystems and their species, including humans, vary significantly depending upon the invading species, the extent of the invasion, and the type and vulnerability of the ecosystem concerned. Some impacts, such as the impacts of epidemic diseases, are of global importance whereas others occur on a more limited geographic scale. Whether the extent of such impacts is regional, sub-regional, transboundary or local, the damage caused is often of fundamental importance to the areas and ecosystems in question. For example, localised biological invasions can cause local extinctions or affect the flow of ecosystem services to several beneficiaries whilst the invasion of highly water-intense plants can change ecosystems' water balance and negatively affect their capacity to supply water for human use (e.g. Pieterse et al. 2003, Bright 1998, Daily 1997, Williamson 1997). Even where a species has invaded only a restricted area, it may have a high probability of expanding its range and causing further damage in the future. In contrast, other species may already be globally widespread and causing cumulative but less visible damage (IUCN 2005)

The economic costs and benefits associated with species introductions and biological invasions have attracted increasing attention during the past decade. It is of course acknowledged that non-native species can offer higher economic returns in some sectors, for example through plantations of fast-growing non-native conifers. They can also satisfy demand for exotic products (e.g. fur trade), fulfil domestic needs and preferences (e.g. pets and many garden plants) and be used as biocontrol agents as part of pest management programmes for agriculture and other sectors (Hulme 2007, van der Wijden 2007). However, a growing body of evidence suggests that IAS can have, and indeed have had, significant negative economic impacts that can also be measured in monetary terms.

The best-known study on IAS impacts is the assessment of known environmental and economic costs of IAS in the United States (US), United Kingdom (UK), Australia, South Africa, India and Brazil carried out in 2001 and updated in 2005 (Pimentel et al. 2001, Pimentel et al. 2005). This study estimated that invasions of non-native species in the six countries concerned cause over US$ 314 billion in damage per year. This sum translates into US$ 240 annual cost per capita in these six countries. Assuming similar costs worldwide, Pimentel estimated that damage from invasive species would be more than US$ 1.4 trillion per year, representing nearly 5 per cent of the world GDP.

In Europe, no equivalent study has been carried out. However a recent European Commission-supported study known as DAISIE (Delivering Alien Invasive Species Inventories for Europe) estimated that more than 1,300 alien species invading Europe have adverse economic impacts (Vila & Basnou 2008). DAISIE also made a pioneering attempt to collect information on IAS impacts, including monetary costs, for the whole of Europe and this information has been used as the basis for the preparation of this report for the Commission.

Existing information on IAS is still very far from complete. To begin with, of the estimated 5-30 million species on earth, only about 1.5 million species have been identified and described (CBD 2007, Pimentel *et al* 2001) and far fewer have been the focus of evaluation studies. Furthermore, majority of the existing studies on IAS have been carried out outside Europe. Similarly, a recent review of the impact of invasive alien insects worldwide found that only 3 out of the 50 species studied had been considered for Europe (DAISIE 2008).

The threat posed by IAS to conservation and sustainable use of biodiversity, including their negative effects on human well-being, has been formally recognised both at international and European (e.g. EU) levels. However, a recent assessment (Miller *et al* 2006) shows that existing measures within the EU, both at Community and Member States level, are inadequate to address the risks posed by IAS. Improving measures to control negative IAS impacts has therefore been prioritised in current EU biodiversity policy. The 2006 EU Biodiversity Action Plan sets out a number of specific targets in relation to IAS (COM/2006/216), including the development of a Community strategy for invasive alien species.

Expanding information on IAS impacts in Europe and the EU, including their monetary costs, is critical to raise awareness of the scale of the problem in our region. A monetary cost estimate may also show that the costs of refunding the rate of newly introduced species by, for example, implementing species vector management tools are well spent. Improved data and understanding of the issue is needed to support the development and strengthening of the EU policy and legislative framework for IAS.

Box 2. The main negative ecological effects of IAS (with examples)

- **Competition with other organisms**: plants like Japanese knotweed (*Fallopia japonica* (Houtt.) Dcne.*)* or Giant hogweed (*Hercleum mantegazzianum*) compete with native plans causing changes to habitat structure
- **Predation** on native organisms: Predation by American mink (*Mustela vision*) has caused significant population declines of ground nesting birds and small mammals
- **Hybridisation** with a related species or varieties, such as the North American grass *Spartina alterniflora* Loisel. *a* which hybridized with the European *Spartina maritima* (M.A. Curtis) Fern. and produced the very invasive hybrid *Spartina anglica* C.E. Hubbard, which has radically changed coastal mudflat habitats in e.g. Great Britain, Denmark and Germany
- **Toxicity**: toxic algae blooms are caused by alien phytoplankton such as *Chattonella verruculosa* (Hara & Chihara)
- **Providing a reservoir / vector for parasites and pathogens**: rainbow trout is a host for the salmon parasite *Gyrodactylus salaris*
- **Disrupting pollination** : *Impatiens glandulifera* Royle 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* L., alter nutrient availability via nitrogen-fixing
- **Altering the local food web**: when appearing in large densities Asian date mussel (*Musculista senhousia (*Benson, 1842*)*) can shift the community from suspension-feeding to primarily deposit-feeding
- **Altering the composition and functioning habitats and ecosystems**: Water hyacinth (*Eichhornia crassipes*) changes water flow by overgrowing and blocking water bodies.
- Finally, resulting for the effects above, **causing extinction** of native species: crayfish plague (*Aphanomyces astaci* Schikora) is known to threaten local populations of native crayfish with extinction.

Source: Adapted from Braat L. & P. ten Brink *et al* (2008).

2 OBJECTIVES & SCOPE

It has been widely acknowledged that alien species are causing important ecological and socio-economic impacts worldwide. However, as indicated in the introduction, comprehensive studies on the overall impacts of IAS at the regional and national levels are still lacking in Europe and the EU.

This report presents the outcomes of a five-month study designed to provide a more complete picture of the different environmental, social and economic costs and benefits of IAS in Europe. This is a picture which has so far been lacking. To meet this objective, an aggregated assessment of the impacts of IAS at European level was carried out. Based on the assessment, a quantified review and estimates of overall impacts (e.g. known and estimated costs) of IAS were developed (see Chapter 3 for detailed approach and methodology).

The study analysed available information from the whole of Europe, including both EU and non-EU countries and also provides an overview of known IAS impacts in EU outermost regions and overseas countries and territories (i.e. the EU overseas entities). The information gathered covers terrestrial, marine and inland water ecosystems, including species from all known main IAS groups, including mammals, plants, reptiles and amphibians, fishes, arthropods, molluscs and livestock and human diseases. It does not cover the impacts of genetically modified organisms (GMOs) as these fall outside the scope of the study and are already subject to specific Community legislation. The study also seeks to provide information on the impact of IAS on different socio-economic sectors.

It is to be noted that this study does not aim to calculate the net benefits or costs of IAS in / for Europe. Obviously there are wide range of benefits from non-native species that are important and that can usefully be maximised to our advantage (e.g. benefits provided by non-native crops and pets). At the same time, and usually independently of the benefits, it is possible to minimise the negative impacts and risks of IAS. This study aims to consolidate information that can be used to better understand these impacts and risks, including to take action to minimise them.

Given the scattered nature and lack of available information, it is not (yet) possible to produce exhaustive estimates of IAS impacts in Europe and the EU. However, the assessment and estimates presented in this report serve as one of the first, albeit very general, indication of the extent and significance of overall IAS impacts at the European level. It is hoped that the information gathered by the study will prove to be useful in making the case for strengthening the framework for IAS prevention and control across the EU and in the rest of Europe.

The assessment of IAS impacts presented in this report forms a part of a broader project for the European Commission to support the development of the EU Strategy on IAS. It is expected that this strategy will be published by the end of 2009 or early 2010. The overarching objective of the project is to provide the Commission with relevant information, including recommendations, on possible policy options for controlling IAS and their impacts in the EU.

The work carried out in the context of the project, including this current report on IAS impacts, builds upon the earlier assessment for the Commission on ‘Scope options for EU action on invasive alien species’ (Miller *et al* 2006). This assessment provided information on gaps and inconsistencies in the existing EU policy and legislative framework for IAS and constitutes the main baseline for the Commission’s project.

Information generated from several other current EU and European initiatives on IAS also forms an important baseline for this project. These include the SEBI 2010 project on streamlining European 2010 biodiversity indicators; research projects DIPNET, DAISIE (see Chapter 3 below), ALARM and IMPASSE[3] carried out in the context of

[3] Disease Interactions and Pathogen Exchange between Farmed and Wild Aquatic Animal Populations (DIPNET); Delivering Alien Invasive Species Inventories for Europe (DAISIE); Assessing Large-scale Risks for biodiversity (ALARM); and Environmental Impacts of Alien Species in Aquaculture (IMPASSE)

the 6th EU Framework Programme for Research and Technological Development; the North European and Baltic Network for Invasive Species (NOBANIS); the European Group on Biological Invasions (NEOBIOTA); the Baltic Marine Biologists Working Group on Non-indigenous Estuarine and Marine Organisms (NEMO), the European Network on Aquatic Invasive Species (ERNAIS); and the relevant International Council for the Exploration of the Sea (ICES) Working Groups.

The Commission's work is also supported by a number of stakeholder consultations that will be conducted during the course of the project.

3 CONTENT & METHODOLOGY

This report consists of the following sections:

1. Review of known impacts of IAS on biodiversity, including impacts of IAS that can threaten native species with extinction (Section 4.1 & Annex IV)
2. Review of the known impacts of IAS on ecosystem services (Section 4.2 & Annex IV)
3. Review of the known social impacts of IAS, including impacts on human health (Section 4.3)
4. Review of the known economic impacts of IAS (Section 4.5 & Annexes II and III)
5. Review of known impacts of IAS in the EU overseas entities (Chapter 5)
6. Conclusions and recommendations (Chapter 6)

The work carried out in the context of this study is based on an extensive literature review on known impacts of IAS in Europe. In addition, information has also been collected from the existing international and regional IAS databases, including the Global Invasive Species (GISD)[4], North European and Baltic Network on Invasive Alien Species database (NOBANIS)[5] and DAISIE database.

To avoid duplication of previous efforts this study has aimed to maximise the use of existing information and previous analyses. In particular, this study builds upon the work carried out in the context of the EU funded DAISIE project. DAISIE identified the hundred worst invasive species in Europe[6], mainly based on current knowledge about the ecological effects of IAS within the European territory. Detailed datasheets were developed to provide state-of-the-art information on these hundred listed species, including their environmental, social and economic impacts. In addition, the DAISIE project specifically collected information on the environmental and economic

[4] GISD: http://www.issg.org/database/species/search.asp?st=100ss

[5] NOBANIS: http://www.nobanis.org/

[6] DAISIE list of the hundred worst invasive species in Europe: http://www.europe-aliens.org/index.jsp

risks posed by IAS in Europe (Vila & Basnou 2008). This represents the first systematic attempt to synthesise exiting information on the economic costs of IAS in Europe.

The DAISIE 100 list and the information on environmental and economic risks of IAS have been used as a starting point for the assessment of impacts presented in this report. The DAISIE data have been complemented by a review of any additional existing literature on IAS impacts in Europe. Based on this information a list of species with demonstrated ecological/environmental, social and/or economic impacts within the European territory has been developed. For each listed species existing evidence on their specific impacts has then systematically collected and analysed. In general, the main aim of the approach has been to provide both qualitative and quantitative (e.g. monetary) assessments of the known impacts of IAS in Europe.

It should be noted that **species identified and analysed in the context of this study do not form an exhaustive inventory of all European IAS with impacts on biodiversity and human wellbeing**. For example, the existing information forming the basis for this analysis tends to be biased towards the most notorious invaders. However, the IAS considered in this report can be regarded to provide a representative overview of the current situation in Europe.

Finally, as the approach adopted in this study is somewhat different and complementary to the research carried out by DAISIE (e.g. DAISIE review on the environmental and economic risks posed by IAS, Vila & Basnou 2008) it is recommended that the results from both studies should be considered in parallel in order to obtain the most comprehensive picture of the impacts of IAS in Europe.

Details of the approach and methodology used to analyse the different impacts of IAS are presented below.

Ecological impacts: Exiting information on the ecological impacts of IAS in Europe has been analysed according to the type and cause of impact. Three different types of ecological impacts have been identified including 1) impacts on a single component of the ecosystem, i.e. usually native species; 2) impacts on ecosystem functioning; and 3) impacts that threatens native species with extinction (e.g. local, regional or global extinction). Naturally, these identified impacts are often interlinked, for example the treath of extinction is a “subset” of the other two impacts. However, it has been considered that for the purpose of this work it would be useful to make a distinction between these main three observed outcomes caused by IAS.

Additionally, the underlying causes of the above listed IAS impacts have been investigated. These causes refer to the ecological processes through which IAS can alter ecosystems and their functioning. In this context, altogether five ecological processes have been considered including 1) predation; 2) herbivory[7] and competition; 3) habitat change; 4) crossbreeding with native species, i.e. hybridisation; 5) impacts on native species’ health. Finally, an additional analysis

[7] IAS can cause negative impacts on native species and ecosystems by changing the intensity and patterns of herbivory / grazing within the ecosystems. This can lead to the reduction of target species, e.g. native grasses and other plants.

based on the IUCN Red List has been carried out to examine the relationship between IAS and risk of species extinction in Europe in more detail.

Impacts on ecosystem services: The effects of IAS on ecosystem services, i.e. different goods and services provided by ecosystem that benefit human wellbeing, have been examined to obtain an overview of the social and economic impacts of IAS in Europe. Potentially affected ecosystem services were identified according to the classification developed by the Millennium Ecosystem Assessment (MA) in 2005 (i.e. provisioning, regulating, cultural and supporting services). Both negative and positive impacts of IAS on ecosystem services were considered. The information on ecosystem service impacts was also used as a basis for obtaining an overview of the social impact of IAS in Europe.

Economic impacts: The methodology used to develop aggregated costs estimates is based on similar previous assessments, e.g. the 2001 Pimentel study and the recent work by van der Weijden *et al* (2007) on costs of IAS in the Netherland. In this study, two broad estimates have been developed: one building on the actual costs data from the studies (real or estimated costs), without any further estimation, and another where some extrapolation has been carried out on the basis of information on the area affected by IAS. In the latter case, information on the area affected by an IAS and its known range in Europe have been used to transfer values from a identified study area to full IAS European range. The extrapolated estimate is more representative of the full potential costs in Europe, but is still a partial estimate that underestimates the total impact (for discussion see Chapter 4.4).

As noted earlier, the 125 species are considered to provide a representative overview of the ecological and ecosystem service related impacts of IAS in Europe. The aim of this analysis of IAS economic impacts, however, has been to develop as complete and up-to-date estimates as possible on the known costs of IAS. Consequently, a number of additional species (9), i.e. species not featuring in the analysis of economic and ecosystem service related impacts of IAS, are included in the economic impact analysis. In addition, a number of available cost estimates for specific species groups have been taken into consideration (14 cases).

While calculating aggregated estimates on the impacts of IAS the following main approaches and methods have been used.

General approach and methods for developing IAS costs estimates

- The approach adopted in this study focuses on analysing species-specific information on IAS. Consequently, the assessment of economic impacts is also based on costs and benefits of IAS at a species level. Information non-attributable to a specific species / species group, e.g. costs of controlling all IAS within certain geographic area, could not be included in the analysis.
- The original data are presented both as annual costs applying to a particular geographic area (e.g. region, country, Europe) and as a one-off cost or NPV (net present value). For the purpose of the analysis all numbers have been converted into annual figures. To deriver an annuity from the latter figures (one-off costs of NPVs) the values have been divided by 14, which is the annuity factor using a 4 per cent real discount and a 20-year timescale;

- The original data are given in different currencies (e.g. EUR, USD,GBP and SEK). All costs have been converted into EUR value by a) either applying the exchange rate of the year costs have occurred or when the year of costs is unknown using b) standard rates of 1 EUR = 0.7 GBP and 1 EUR = 1.25 USD. If the costs have taken place during a certain time period an average exchange rate over this period has been calculated and applied;
- Effects of inflation have been taken into account by assuming a standard 3 % annual inflation rate and presenting the available cost figures in today's terms (see Annex III for more detiled information). If no information on the time period over which the cost occurred was available the year of publication has been used as the reference point. This will most likely lead to a slight underestimate of costs.

Extrapolation of costs for the whole IAS European range

- Where possible, information on the area coverage (km^2) of IAS impact (i.e. country or region) and the total known range of the IAS in question (retrieved from the DAISIE database) has been used to extrapolate cost information to broader European level. The potential costs of a species in Europe have been calculated as: cost data (EUR / year) / area of impact (km^2) x known IAS range in Europe (km^2). This therefore assumes that the average area costs in one area is reflective of costs in other areas of Europe and that a benefits / costs transfer technique can be applied.
- In the majority of cases the area of IAS impact (km^2) has been roughly estimated as equal to the land (terrestrial species) or water (marine and inland water species) cover of the country / region (see Annex II for more details).
- For species with multiple cost data from different geographic locations an average cost / area (EUR / km^2) has been calculated as follows: (($area_1$ cost / $area_1$ of impact) + ($area_2$ cost / $area_2$ of impact) + ($area_3$ cost / $area_3$ of impact) + etc.) / total number of cases. In cases where several cost items have been available for the same area, these cost items have been summed up to form an $area_x$ cost estimate (i.e. when several costs items have been available for a species within one Member State). The average costs / area has then been used as a basis for estimating the potential costs for the species' full range in Europe.

Annex III provides more detailed information on the original references and calculations used when analysing the monetary costs of IAS in Europe. Annex IV gives a detailed list of references used in gathering information on the ecological and ecosystem service related impacts of IAS.

4 REVIEW OF THE KNOWN IMPACTS OF IAS IN EUROPE

A total of 125 IAS with existing evidence of significant environmental, social and economic impacts in Europe were selected for analysis in this study (Annex I)[8]. These species cover all major biomes ranging from marine ecosystems (e.g. marine coastal regions) to terrestrial areas and inland waters. Furthermore, they represent a range of taxonomic groups including plants, invertebrates, vertebrates and fungi.

As noted above, the aim of this study has not been to provide an exhaustive inventory of IAS impacts in Europe but the existing data and the resulting overview is mainly based on the impacts of the most notorious invaders. Naturally, this is only a subset of the total number of non-native species and IAS within the European territory. It has been estimated, that there are altogether 11,495 non-native species in Europe (DAISIE project, D. Roy, pers. com.).

In general, available information indicates that terrestrial ecosystems have suffered most from IAS impacts (71 IAS species with demonstrated terrestrial impacts) (Table 1). There is less evidence of the impacts of IAS in marine and freshwater areas, although it is well-known that these ecosystems have also been significantly affected by biological invasions (21 and 24 species with demonstrated impacts on marine and freshwater ecosystems respectively). Impacts on terrestrial regions are divided more or less equally between different taxa whereas in marine and fresh water ecosystems most identified impacts seem to have been caused by invertebrates.

With regard to the geographic scale, in the majority of cases the available information on IAS impacts is rather general and only available at the European level. Thus, it is often difficult to identify the specific locations of impacts within Europe. However, the data compiled for this study suggest that existing evidence on IAS impacts in Europe comes mainly from within the EU (the EU-15 in particular). This also reflects the fact that the number of studies on IAS is generally higher in the EU-15 countries than other parts of Europe. For 65 species identified in this study the information comes exclusively from the EU area whereas evidence from non-EU countries could only be found for 24 species. Nonetheless, it is clear from existing information that IAS are causing impacts through out the Europe, i.e. in both EU and non-EU countries.

The overview presented above should only be taken as an indication of the real extent of IAS impacts in Europe. It is likely that these results reflect a lack of existing information and research in certain areas and taxa. In particular, it is widely acknowledged that more data on the spread and effects of IAS in the east and southeast Europe is still required. Similarly, some large taxonomic groups, such as plants and invertebrates, may still be underrepresented in comparison to their smaller counterparts (Vila & Basnou 2008).

[8] In addition, information on the costs of additional nine species was included in the economic impact analysis.

Table 1. Invasive alien species with demonstrated impacts (environmental, social and economic) in Europe analysed in this study. These species represent only a subset of the total number of IAS in Europe, however it is considered that they provide a representative sample of the known impacts caused by IAS within Europe and the EU.

Taxa / biome of IAS	Total number of species with documented impacts
Fungus (freshwater / terrestrial)	5 (1 freshwater / 4 terrestrial)
Freshwater invertebrate	10
Freshwater vertebrate	3
Freshwater plant	5
Marine invertebrate	19
Marine vertebrate	3
Marine plant	13
Terrestrial invertebrate	20
Terrestrial vertebrate	21
Terrestrial plant	26
TOTAL	**125**

4.1 Impacts of IAS on biodiversity

Existing studies indicate that species can often be introduced outside their natural boundaries without any noticeable impacts on the recipient ecosystem Williamson 1996, Reise at al 1999). This is the case when non-native speciesbecome established in their new habitats, whilst not spreading nor becoming invasive. However, it is also widely acknowledged that when an introduced species does become invasive and trigger ecological changes, these are usually unfavourable to native species and ecosystems.

The results of this study indicate that the most common negative ecological impact of IAS is damage to different components, e.g species, of the ecosystem (Table 2). In addition, several IAS are known to cause adverse effects on the natural functioning of ecosystems. In both cases, competition with native species and herbivory can be identified as the main underlying causes for the impacts. For example, all non-native marine invertebrates identified by this study are known to cause negative effects on native species due to herbivory or predation. Predation and IAS-induced changes in habitat are also recurring causes for negative ecological impacts.

Hybridisation and negative effects on the health of native species are identified as the most common ecological impacts of IAS and are known to cause significant damage to several species. For example, species such as brook trout (*Salvelinus fontinalis* (Mitchill, 1814)), ruddy duck (*Oxyura jamaicensis* (Gmelin, 1789)) and Japanese deer (*Cervus nippon* Temminck, 1838) can threaten native species with local extinctions due to hybridisation. Similarly, the crayfish plague (*A Aphanomyces astaci*) has caused extinction of several local populations of native crayfish throughout Europe (See also Section 4.1.1 below).

Finally, it is to be noted that in a majority of cases the full range and true nature of IAS impacts on the ecosystems they invade are still unknown. Therefore, the results presented in Table 2 should be interpreted with caution (i.e. the real number of species for different impacts is likely to be higher).

Table 2. Overview of the documented negative ecological impacts of IAS in Europe according to impact type and cause. Total number of IAS analysed in this study is given in the first column in brackets.

IAS taxa / biome	**Impact on single component of ecosystem (i.e. other species)**				
	Predation*	Competition / herbivory	Impact on habitat	Hybridisation	Health risk to native species
Fungus (freshwater / terrestrial) (5)	n/a	No info	1	No info	5
Freshwater invertebrate (10)	5	4	4	2	4
Freshwater vertebrate (3)	3	3	2	1	2
Freshwater plant (5)	n/a	4	4	No info	No info
Marine invertebrate (19)	18	18	12	No info	1
Marine vertebrate (3)	1	1	No info	No info	No info
Marine plant (13)	n/a	10	7	No info	3
Terrestrial invertebrate (20)	1	8	4	1	3
Terrestrial vertebrate (21)	11	11	7	3	8
Terrestrial plant (26)	n/a	22	9	1	1
Total	**39**	**81**	**50**	**8**	**27**
	Impact on ecosystem functionality				
	Predation*	Competition / herbivory	Impact on habitat	Hybridisation	Health risk to native species
Fungus (freshwater / terrestrial) (5)	n/a	No info	1	No info	No info
Freshwater invertebrate (10)	4	4	7	No info	4
Freshwater vertebrate (3)	2	3	2	No info	2
Freshwater plant (5)	n/a	1	5	No info	No info
Marine invertebrate (19)	17	11	11	1 (1)**	No info
Marine vertebrate (3)	No info	No info	No info	No info	(2)**
Marine plant (13)	n/a	3	7	No info	No info
Terrestrial invertebrate (20)	2	4	4	No info	No info
Terrestrial vertebrate (21)	5	3	6	No info	No info
Terrestrial plant (26)	n/a	3	9	No info	No info
Total	**30**	**32**	**52**	**1**	**6**
	Threatens native species with extinction				
	Predation	Competition / herbivory	Impact on habitat	Hybridisation	Health risk to native species
Fungus (freshwater / terrestrial)	No info	No info	No info	No info	1

(5)					
Freshwater invertebrate (10)	1	2	2	No info	3
Freshwater vertebrate (3)	No info	No info	No info	1	No info
Freshwater plant (5)	No info	1	No info	No info	No info
Marine invertebrate (19)	3	3	2	No info	1
Marine vertebrate (3)	No info	No info	No info	No info	No info
Marine plant (13)	No info	6	2	No info	No info
Terrestrial invertebrate (20)	1	1	No info	No info	No info
Terrestrial vertebrate (21)	4	6	No info	2	1
Terrestrial plant (26)	No info	2	1	No info	No info
Total	**9**	**21**	**7**	**3**	**6**

* Plants are not considered to predate

** Number in brackets is a species with possible impact, not included in total calculations

4.1.1 IAS threatening native species with extinction

The analysis conducted in this study indicates that the negative effects of competition and herbivory are the most common ways that IAS threaten native species with extinction or local population declines. In addition, there are a number of examples where other causes, such as predation, hybridisation and impacts on species health, have resulted in detrimental impacts on the survival of native species (for some examples see Box 3 and Section 4.1. above).

Box 3. Examples of species threatened by global or regional extinction due to IAS in Europe

Noble crayfish (*Astacus astacus* (Linnaeus, 1758)) whose range extends from France to the Balkan peninsula, to parts of Scandinavia in the north, and western parts of the Russian Federation, is listed as 'Vulnerable (VU)' in the IUCN Red List of Threatened Species (http://www.iucnredlist.org/).

A. astacus restricted to freshwater habitats, is commonly found in streams, rivers and lakes. Decline in populations have been reported largely due to its susceptibility to crayfish plague *(Aphanomyces astaci*) which is carried and transmitted by the introduced North American signal crayfish (*Pacifastacus leniusculus*) intentionally introduced to Europe for aquaculture purposes.

The **Iberian frog** (*Rana iberica* Boulenger, 1879) is listed as 'Near Threatened (NT)' in the IUCN Red List of Threatened Species. *R. iberica* which is endemic to Portugal and north western and central Spain is an aquatic species found in shady habitats; breeding and larval development take place in shallow stagnant water bodies.

Major threats to this species include degradation and loss of habitats; predation by introduced non-native salmonids, like brook trout (*Salvelinus fontinalis*) and the introduced mustelid, American mink (*Mustela vison*).

In Spain *R. iberica* is protected by national legislation and listed in the national Red Data Book as vulnerable. This species is listed on Appendix II of the Berne Convention and on Annex IV of the EU Natural Habitats Directive.

Other examples of European species threatened with extinction include the **whiteheaded duck** (*Oxyura leucocephala* (Scopoli, 1769)) through hybridisation with Ruddy duck (*O. jamaicensis)* and the endemic **European mink** (*Mustela lutreola* (Linnaeus, 1761)) threatened by American mink (*M. vison*).

Sket 1996, Sket, B. 1996. Astacus astacus. In: IUCN 2007. 2007 IUCN Red List of Threatened Species, Tejedo et al. 2004, Tejedo, M., Bosch, J., Martínez-Solano, I., Salvador, A., García-París, M. & Gil, E.R. 2004. Rana iberica. In: IUCN 2007.

At the international level, the International Union for Conservation of Nature (IUCN)

The IUCN Red List of Threatened Species is recognised as the authoritative inventory of globally threatened species[9]. The Red List, which covers a wide range of taxonomic groups including plants, vertebrates, invertebrates and fungi, provides information on taxa that have been globally assessed using the IUCN's Red List Criteria and Categories[10].

According to the Red List threat processes vary within and between taxonomic groups and have been found to be dynamic, changing over time. The 2004 Global Species Assessment (Baillie *et al.* 2004) explains that habitat destruction, degradation and fragmentation are overall the greatest threat for assessed terrestrial species. Birds, mammals and amphibians are vulnerable to specific threat types, 33 per cent of threatened mammals are impacted by over-exploitation, 29 per cent of threatened amphibians by pollution, including climate change, and 17 per cent by disease (mainly by the chytrid fungus *Batrachochytrium dendrobatidis* gen. et sp. Nov.). IAS have been identified as a major threat affecting 30 per cent of threatened birds, 11 per cent of threatened amphibians and 8 per cent of threatened mammals (Baillie *et al.* 2004). Additionally, IAS are the biggest threat to freshwater species after habitat loss and pollution.

Threat assessments take into account past, present and future threats over time frame of three generations or 10 years, whichever is the longer but not exceeding 100 years into the future. Major threat categories include: habitat loss/degradation (human induced), invasive alien species (directly affecting the species), harvesting (hunting/gathering), accidental mortality, persecution, pollution (affecting habitat and/or species), natural disasters, changes in native species dynamics, intrinsic factors and human disturbance. Threat types listed under 'invasive alien species (directly affecting the species)'[11] include competitors, predators, hybridisers, pathogens/ parasites, and other and unknown. Taxa that have been assessed as having a higher risk of extinction are listed as either 'critically endangered', 'endangered' or 'vulnerable'. Taxa that are close to qualifying for the above three categories are listed as "near threatened"; taxa that have been assessed as being widespread and abundant are listed as "least concern"; and taxa that lack in distribution or abundance data and therefore cannot be assessed are listed as 'data deficient'. Two other categories assigned are 'extinct' and 'extinct in the wild'.

As regards the threatened species in European countries, an analysis of the IUCN Red List of Threatened Species (version 2006) of all assessed taxa indicates that 1911

[9] http://www.iucnredlist.org/

[10] http://www.iucnredlist.org/static/programme

[11] www.iucnredlist.org/info/major_threats

species out of ~ 16000 are under threat from or have been impacted by at least one invasive species related threat type (Table 3). Between 11 – 12 per cent (222) of these species occur in the European region (Table 4). A brief analysis of these 222 assessed threatened species in the European region indicates that an almost equal proportion of threatened species occur in terrestrial and freshwater ecosystems. The main invasive species related threat type impacting threatened amphibians, birds and reptiles is predators. Degradation/loss of habitat and competition are the major threat types impacting threatened plants. Threatened fish are directly impacted through predation, hybridisation and competition. The major threat types impacting threatened mammals are competition, hybridisation and the impact of pathogens and parasites.

In general, this European level assessment of the Red List supports and complements the findings of the analysis of ecological impacts presented above.

Table 3. The status of all globalle threatened species that are impacted by at least one invasive species related threat type (excluding marine species)

Taxa	Critically endangered (CR)	Endangered (EN)	Vulnerable (VU)	Near Threatened (NT)	Data Deficient (DD)	Total
Amphibians	62	91	68	55	57	333
Arthropods	6	9	10	nil	3	28
Birds	77	105	166	77	1	426
Fish	57	40	60	10	16	183
Fungi	1	nil	nil	nil	nil	1
Mammals	13	33	34	7	8	95
Misc	2	nil	1	nil	nil	3
Molluscs	30	10	9	1	9	59
Plantae	219	82	101	4	1	407
Reptiles	15	8	5	2	nil	30
Totals	482	378	454	156	95	1565

Table 4. The status of globally threatened species categories that occur in Europe and are impacted by at least one invasive species related threat type (excluding marine species)

Taxonomic category	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Near Threatened (NT)	Extinct (E)
Amphibians	nil	5	2	10	nil
Birds	1	5	2	2	1
Fish	19	22	29	4	2
Mammals	1	3	3	1	nil
Molluscs	nil	nil	1	nil	nil
Plants	24	4	3	nil	nil
Reptiles	5	3	nil	2	1
Totals	50	42	40	19	4

4.2 Impacts on ecosystem services

An overview of the known IAS impacts on ecosystem services, according to our study, is presented in Table 6 (at the end of this section) and a summary of the main IAS taxa responsible for impacts on different services is given in Table 5 (below). In general, the results indicate that the majority of known impacts of IAS on ecosystem services in Europe are negative. However, there are also a number of IAS that can have positive, or both positive and negative, effects on ecosystems' capacity to support human wellbeing.

Table 5. The main taxa groups causing IAS impacts on ecosystem services in Europe

Type of ecosystem service affected by IAS	Main taxa causing IAS impact
Provisioning Services	
Food and fibre	Invertebrates (terrestrial & marine); plants (terrestrial); vertebrates (terrestrial); fungi
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. IAS is 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 foodwed	Invertebrates (marine & freshwater)

4.2.1 Provisioning services

The analysis revealed a total of 57 IAS 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 (impacts of 54 species) are caused by IAS having adverse effects on **provisioning of food**. For example, IAS cause declines in fish catches, and aquaculture, crop, wood and livestock production (e.g. livestock health). In addition, in some cases (3 species) a decline in **provisioning of water** due to the blockage of water ways has been recorded (i.e. some aquatic exotic plants, such as water hyacinth (*Eichhornia crassipes*) and New Zealand pigmyweed (*Crassula helmsii* A. Berger).

With regard to positive impacts of IAS on provisioning services, seven IAS were identified. These include species that can increase the provisioning of game (e.g. muntjac deer, *Muntiacus reevesi* (Ogilby, 1839)), wood (*Eucalyptus sp.*), fish / aquaculture (e.g. Kuruma prawn, *Marsupenaeus japonicus* (Bate, 1888)) and fur (racoon dog, *Nyctereutes procyonoides* (Gray, 1834)). Similarly, the zebra mussel (*Dreisena polymorpha*) is known for its high water filtering capacity, thus it can play an important role in purifying and improving water quality in aquatic systems. However, it should be emphasised that that despite their positive impacts on provisioning, most of these species also have serious negative effects on other ecosystem services, such as fire regulation (*Eucalyptus* sp) and human health (racoon dog) (see Section 4.2.2 below).

In a number of cases (16 species) IAS have been found to have both negative and positive impacts on provisioning services. In these occasions IAS cause declines in stocks or yields of native species while simultaneously provding a source of food and fibre themselves.

4.2.2 Regulating services

Regulating services can be defined as ecosystem processes that directly or indirectly benefit human wellbeing. These processes include, for example, an ecosystem's ability to retain, regulate and purify water and help to maintain climatic conditions at local and regional levels. Ecosystems can also function as natural buffers to natural hazards and provide resistance to outbreaks of various diseases.

According to the analysis, 60 IAS are known to have negative effects on regulating services in Europe. Regulation of water and prevention of disease outbreaks are the two categories of regulating services most often affected negatively by IAS (for both categories, 13 species with negative impacts on the provisioning of service were identified). In the context of **water regulation**, IAS are known to block or alter natural and artificial water ways (e.g. due to burrowing) which has knock-on impacts on water flow. These impacts are known to cause, for example, local flooding (e.g. Japanese knotweed, *Fallopia japonica*). IAS can also change an ecosystem's water balance and water retention capacity by increasing evapotranspiration (e.g. black cherry, *Prunus serotina* Lindley).

As regards ecosystem services related to **human, animal or plant health**, several cases were identified where IAS have been documented to cause health risks because they function as disease vectors. Examples include racoon dog (*Nyctereutes procyonoide),* racoon (*Procyon lotor* (Linnaeus, 1758), muskrat (*Ondatra zibethicus* (Linnaeus, 1766)), brown rat (*Rattus norvegicus* (Berkenhout, 1769)) and even the common cat (*Felis catus* Linnaeus, 1758).

In addition, several (16) species have been identified as negatively affecting human health by causing allergies and injuries (e.g. common ragweed, *Ambrosia artemisiifolia*; silver wattle, *Acacia dealbata;* giant hogweed, *Heracleum mantegazzianum;* oak processionary moth, *Thaumetopoea processionea* Linnaeus; prickly-pear cacti, *Opuntia maxima*; rabbitfish, , *Siganus rivulatus* Forsskål, 1775; and bay barnacle, *Balanus improvisus* Darwin, 1854. All of these species are also recognised as causes for decreased recreation and tourism values (see Section 4.2.3 below).

IAS are also known to have negative impacts on **erosion control, water quality and resistance of ecosystems to wild fires**. For example, invasive mammals can cause erosion by burrowing whilst invasive plants may outcompete native plants that play an important role in binding soil with their roots (borrowing: e.g. Louisiana crayfish (*Procambarus clarkii* (Girard, 1852)) and European rabbit (*Oryctolagus cuniculus* (Linnaeus, 1758)); competition: Himalayan balsam (*Impatiens glandulifera*)). Similarly, *Eucalyptus* sp. and pampas grass (*Cortaderia selloana* (J.A. & J.H. Schultes) Aschers. & Graebn.) are known to increase the intensity of fires in areas dominated by these species. Finally, IAS can also **damage infrastructure** due to burrowing (invertebrates and vertebrates) or via their root systems (plants).

No documented European examples of negative impacts of IAS on the maintenance of air quality and climate regulation were identified in this study. However, existing evidence on significant adverse effects of IAS on the growth and structure of woodlands and forests, for example due to non-native diseases and pests (e.g. Dutch elm disease, *Ophiostoma novo-ulmi* Brasier, 1991 and Oak processionary moth, *Thaumetopoea processionea*), indicates that IAS also indirectly reduce an ecosystem's capacity to maintain natural climate conditions and air quality at a local level.

Similarly, a number of examples outside Europe indicate that IAS could negatively affect pollination services (i.e. pollination of crops by native insects) and ecosystems natural capacity to control outbreaks of pests (e.g. Bjerknes *et al* 2007, Munoz *et al* 2008). Thus, even though such examples were not identified in this study it is likely that such impacts take place in Europe.

With regard to positive impacts on regulating services, there are a number of IAS (7) that can improve an ecosystem's capacity to control erosion or purify water. For example, *Azolla* sp. can be used to treat sewage water and increase removal of nutrients from the water column. Some IAS are regularly used to control erosion, e.g. stabilise mudflats and coastlines (e.g. common cord grass, *Spartina anglica*). Finally, some IAS plants, namely Chinese sumac (*Ailanthus altissima* (P. Mill)) and black locust (*Robina pseudoacaria*), can help to improve local air quality as they invade industrial areas where native vegetation is scarce.

4.2.3 Cultural services

Most of the identified negative impacts of IAS on cultural services, i.e. different cultural, social, recreational and educational values of ecosystems, are caused by the **reduction of recreational use and/or tourism** due to invasion of non-native species (40 species). This decrease can take place due to a number of reasons, including decreased aesthetic value caused by IAS invasion, nuisance to humans and/or recreational activities, and impacts of IAS 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 IAS can also hinder fishing and angling activities as well clogging of fishing nets, cages and other equipment (plankton-algae, *Coscinodiscus wailesii*). Shell debri washed ashore may also cut bathers feet (Zebra mussel, *Dreissena polymorpha* and American jacknife clam, *Ensis americanus*).

In a number of cases (9 species) IAS are also reported to **negatively affect broader cultural values** in the areas they have invaded. For example, landscapes with high cultural significance, such as oak and cypress forests in the Mediterranean, are known to suffer from invasions of non-native pests, such as the ink disease (*Phytophthora cinnamomi* Ronds (1922*)*) and cypress cancer (*Seiridium cardinale* (Wagener) Sutton & Gibson)). Similarly, IAS have also been responsible of reducing the populations of several charismatic and/or locally important species. For further discussion of cultural impacts of IAS, see Section 4.3 below.

On the positive side, 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 (*Felis cattus*), rhododendron (*Rododentron ponticum L.*), Japanese deer (*Cervus nippon*) and ornamental fish used in private and public aquaria.

In general, the assessment of IAS impacts on cultural services, such as the aesthetic value of landscape, is highly subjective. This means that views about the impact of non-native species on these services can often be either positive or negative, depending on the perspective of the person or organisation concerned. However, some clear cases of negative examples exist, for example when an area suffering from IAS invasion is specifically designated to protected unique landscape value and character. For example, the extensive invasion of *R. ponticum* in the Snowdonia National Park in Wales is considered to be a serious problem as the plant is altering the landscape character of the area (H. Thomas, pers. com.).

4.2.4 Supporting services

Supporting services consist of ecosystem processes that are essential for the maintenance of all the other services discussed above. These processes include, for example, primary production, soil and sediment formation and nutrient cycling.

This report found that IAS have the potential to modify all identified supporting processes via, for example, changing their physical environment (e.g. by dominating the habitat) and modifying ecosystem food webs and species dynamics.

Negative impacts on supporting services have been documented for a total of 22 IAS species. In a few cases, these effects are identified as positive to the overall functioning of the ecosystem. However, in several other cases, the nature of these impacts is still unclear.

Table 6. Overview of the documented impacts of IAS on ecosystem services in Europe. The figures are based on the analysis of 125 IAS included in this study.

Type of ecosystem service affected by IAS	**Number of IAS per impact type**			**Description of main impacts**
	Negative	**Positive**	**Both positive & negative**	
Provisioning Services				
Food and fibre	54	6	16	**Negative:** IAS cause decline in fish catch / aquaculture, crop & wood production and have negative effects on livestock **Positive**: IAS used to increase provisioning of game, wood, fish / aquaculture & fur **Negative / positive:** IAS cause decline in native stocks but are / can themselves be used as food and fibre
Fuel	-	(1)	-	**Positive:** Common cord grass (*S. anglica*) can be possibly used as a source for biomass fuel
Biochemicals, natural medicines, and pharmaceuticals	-	-	-	
Ornamental resources	-	-	-	
Fresh water	3	1	-	**Negative:** IAS reduce water supply by blocking water ways **Positive:** Zebra mussel (*D. polymorpha*) filters water and plays an important role in purifying and improving water quality in aquatic systems.
Total	**57**	**7**	**16**	

TYPE OF ECOSYSTEM SERVICE AFFECTED BY IAS	Number of IAS per impact type			Description of main impacts
	Negative	Positive	Both positive & negative	
Regulating services				
Air quality maintenance	-	2	-	**Positive:** Chinese sumac (*A. altissima*) and black laurel (*R. pseudoacaria*) can help to improve local air quality as they invade industrial areas where native vegetation is scarce
Climate regulation (e.g. temperature and precipitation, carbon storage)	-	-	-	
Water regulation (e.g. flood prevention, timing and magnitude of runoff, aquifer recharge)	13	-	-	**Negative:** IAS block or alter natural & artificial water ways with impacts on water flow characteristics (e.g. flooding); IAS change ecosystems water balance / retention by increasing evapotranspiration
Erosion control	8	3	2	**Negative:** IAS cause erosion by outcompeting native plants that help to bind soil (plants) or burrowing (invertebrates & vertebrates) **Positive:** IAS are used to stabilise mudflats and coastlines **Negative / positive:** IAS can both cause & control erosion, depending on the circumstances / environment
Water purification / quality maintenance and waste management	4	2 (1)	-	**Negative:** Water quality decline due to euthropication and/or increase in organic substance in water column due to mass prolification of IAS in water ecosystems **Positive:** Some aquatic IAS (plants & invertebrates) can improve water purification, *Azolla* sp. can be used to treat sewage and remove nutrients
Regulation of human / animal / plant diseases (i.e. IAS is a vector for disease)	13	-	-	**Negative:** IAS function as a potential disease vector
Biological control (e.g. loss of natural predator of pests)	-	-	-	
Pollination	-	-	-	

TYPE OF ECOSYSTEM SERVICE AFFECTED BY IAS	Number of IAS per impact type			Description of main impacts
	Negative	Positive	Both positive & negative	
Storm protection (damage by hurricanes or large waves)	-	-	-	
Fire resistance (change of vegetation cover leading to increased fire susceptibility)	2	-	-	**Negative:** *Eucalyptus* sp. and pampas grass (*C. selloana*) increase intensity of fires
Avalanche protection	-	-	-	
Other: human health other than diseases (e.g. allergies and injuries)	16	-	-	**Negative:** IAS cause allergies (plants & pollen) or injuries (cuts, burns, rashes etc.). All of these IAS are also reported to reduce cultural services due to negative impacts on recreation / tourism
Other: destruction of infrastructure	4	-	-	**Negative:** IAS roots or burrowing activities damage infrastructure
Total	**60**	**7**	**2**	
Cultural services				
Cultural / natural heritage values	9	-	-	**Negative:** IAS are reported to negatively effect landscapes with high cultural value or charismatic species
Aesthetic / cultural value, recreation and ecotourism	40	9	14	**Negative:** Changes caused by IAS within ecosystem negatively affect area's recreational and/or tourism value **Positive:** Some IAS are highly appreciated as pets, ornamentals or game species. **Negative / positive:** Cultural / aesthetic value of some IAS is highly subjective (e.g. value of landscape invaded by IAS plants)
Total	**49**	**9**	**14**	

TYPE OF ECOSYSTEM SERVICE AFFECTED BY IAS	Number of IAS per impact type			Description of main impacts
	Negative	Positive	Both positive & negative	
Supporting services				
Primary production	5	-	1	IAS can alter primary production by changing the composition / abundance of photosynthesising species
Nutrient cycling	12	1	3	IAS can alter the nutrient cycling by changing ecosystem N fixing capacity (plants) or by causing changes in nutrient usage / foodwebs
Soil / sediment formation	-	-	5	IAS can alter the formation (rate and composition) of soil / sediment
Other: changes in species dynamics and/or ecosystem's foodweb	5	1	2	IAS can cause non-specified changes in supporting services due to changes in predator - prey dynamics and/or foodweb structures
Total	**22**	**2**	**11**	

4.3 Social impacts

The analysis found no specific studies on the social effects of IAS in Europe. The existing literature on IAS impacts is often more focused on assessing the ecological or economic impacts of IAS and social dimensions of IAS invasions tend to receive less attention.

However, the analysis of the impacts of IAS on ecosystem services clearly indicates that non-native species can significantly affect the aspects of social wellbeing. Firstly, there are a number of IAS with demonstrated negative effects on cultural services, including cultural and natural heritage values. In addition, the economic impacts of IAS on local livelihoods, e.g. due to collapses of fish stocks, are likely to have caused broader socio-economic impacts in affected communities.

Secondly, a significant amount of evidence exists on the negative effects of IAS on human health. The analysis of IAS impacts on ecosystem services shows that almost 30 of the total of 125 studied species can negatively affect human health either by functioning as disease vectors or causing allergies. Furthermore, the existing data on the costs of human epidemic diseases clearly also reflects the importance of these alien pathogens to broader wellbeing (see Table 10 below).

On the positive side, it is known that several IAS species have high social value, for example a range of non-native pets and ornamental form an integral part of our culture and every day lives. These species can also play an important role in individual's wellbeing, including maintaining mental health.

Finally, as mentioned above, the assessment of social impacts of IAS can be highly subjective depending on the perspective of the person or organisation concerned. Thus, obtaining overall quantitative estimates on social impacts of IAS is rather difficult.

4.4 Economic impacts

This study has carried out an assessment of the known costs of IAS in Europe based on the available information on the monetary costs of IAS (available for altogether 61 individual species and 14 specific IAS species groups, see Table 8 and the the discussion below). This review of current information on the economic impacts of IAS in Europe reveals that a wide range of IAS taxa have been responsible for monetary costs in Europe (Table 7 and Annex II). It also gives an indication of the ecosystems in which most documented monetary impacts of exotic species invasions have occurred. Most of the information on monetary impacts of IAS comes from terrestrial ecosystems, i.e. terrestrial plants and vertebrates, and the majority of these documented costs have taken place in the EU.

In general, the existing evidence of IAS economic impacts 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 negative impacts on 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 IAS on human health, e.g. treatment costs of asthma. Information on the monetary resources needed to control IAS is available across different IAS taxa and invaded ecosystems.

Based on the information on documented costs (i.e. real & estimated costs without any extrapolation or benefits transfer) the total **documented monetary impacts** of IAS in Europe amount to a total of **12.5 billion EUR / year** (Tables 7 & 8). Majority of these costs, i.e. 9.6 billion EUR, result from the damage caused by IAS whereas the rest, i.e. 2.8 billion EUR, are related to the control of IAS. Costs related to terrestrial IAS (e.g. vertebrates, plants and invertebrates) form a major part of this estimate. They include, for example, damage caused by pests to agriculture and forestry.

Given the limited availability of documented costs, and clear underestimation that these numbers represents, a partial and conservative **extrapolation of costs** has been carried out to provide a more comprehensive picture of the real magnitude of potential economic impacts of IAS in Europe[12]. The extrapolation has been carried out on the basis of information on the area affected by IAS and the known range of IAS in Europe. Given these information requirements the extrapolation of costs was possible for 25 IAS considered in this study. As a result, the cost estimates from identified study areas have been transferred to cover the full current range of IAS in Europe for those IAS for which information on wider range is available. As a result the total costs of IAS can be estimated as **20 billion EUR / year** (Table 8). This should still be seen as an underestimate for it only covers a limited number of IAS. Also, the extrapolation is only based on a subset of real IAS costs, i.e. it does not cover the loss of biodiversity related existence, bequest and option values due to IAS invasion.

It should be noted that the data on IAS impacts often originate from rather local sources for which the exact area of impact is unknown. To err on the conservative side, to arrive at a value of cost of IAS per unit of affected area in the study country that can be applied to other affected countries/regions in Europe, the country's whole area is used as a proxy for the area of impact. This gives a national estimate which can be used to derive an estimate for the whole European range of the IAS. Clearly, where this approach is used to extrapolate smaller-scale case specific cost estimates then the real impact of IAS are underestimated. Thus, it is important to note that the total extrapolated estimate of all IAS impacts is also bound to be underestimated. Nevertheless, this approach was considered to be a useful addition to calculations based on the local documented costs.

Unfortunatelly, the data do not allow a further destinction to be made, for example, between one-off and reoccurring costs of control. In addition, it is not possible to

[12] I.e. where information is available on the costs of an IAS for a given area (the study area) and where the full European range of this given IAS is known (from DAISIE database) costs numbers can be created for the full range. This takes place by applying the costs from known case study areas (i.e. costs per unit area of the study area) to the wider area impacts by the IAS These extrapolated costs estimates assume that the level of impact / costs are similar through out the known European range of each IAS. See Chapter 3 for further methodological details.

investigate the overall relationship between costs of damage and costs of control in a long run. A more detailed and estensive dataset would be required to look into these aspects in the future.

As regards the available information (non-extrapolated) on the **documented costs of IAS on different economic sectors** (i.e. a specific "subset" of the above **12.5** billion EUR), the results indicate that agricultural sector has been suffering most from the impacts of IAS (**5.5** billion EUR / year) (Table 9). Fisheries and forestry related impacts from IAS only figure marginally in the available data. When these and health sector impacts are added to the agricultural losses, the total documented costs for agricultural, fisheries, forestry and health sectors amount to about **6 billion EUR / year** (excluding costs of epidemic animal and human diseases). Again, this figure is based on the documented data, with no attempt at extrapolation or gap filling. Like the other aggregate costs estimates above, this figure is likely to be an underestimate of the real situation as the forestry costs clearly seem to be underrepresented and no monetary values exists for costs of IAS on the tourism sector.

When considering the **costs of the most severe epidemic human disease**s, i.e. AIDS and influenza, the estimated costs due to loss of productivity and treatment are presented in Table 10. These estimates indicate that the costs of these epidemic diseases arise to **17 and 24 billion EUR in the EU and Europe respectively**.

A very limited amount of information was found on the monetary benefits of IAS considered in this study. It was found that the Chinese mitten crab (*Eriocheir sinensis*) has been estimated to result in 3 – 4.5 million EUR annual benefits in Europe during the ten year period 1994-2004 (e.g. Gollash et Rosenthal 2006). Similarly, fishing of introduced king crab (*Paralithodes camtschaticus*) in Norwegian water has been estimated to amount to around 53.4 million NOR (6.8 million EUR) revenues to fishermen in 2007 whereas the export values of the crab are likely to reach 90 – 100 million NOK per year (11.5 – 12.8 million EUR) (S. Gollash, pers. com). In some locations in Norway the landing values of king crab are close to the values of the cod fishery. It is also known that the introduced Manila clam (*Tapes philippinarum*) can have a high economic value. In 2002 the total production in the world was 2.36 million tonnes, and in Italy alone (second world produced after China) was over 41000 tonnes. The production is increasing very rapidly, and in 2005 the overall economic income of the *Tapes philippinarum* in Northern Italy raised to 178 million EUR, making this the cultivated marine species with the highest economic importance in the country (Veneto Agricoltura 2007).

In addition to the example above, the analysis of IAS impacts on ecosystem services indicates that actual number of IAS with potential positive socio-economic impacts can be much higher. It is to be noted, however, that in the majority of the cases these positive effects are also accompanied by negative impacts on native species and/or ecosystems.

The analysis clearly shows that the available data on IAS monetary costs (and benefits) remains scarce and unevenly distributed between different geographic areas and IAS taxa (Table 7 and Annex 2). Information on economic impacts was found for only 52 of the 125 IAS species considered for their ecological and ecosystem service related impacts in this study. In addition, information on the costs of additional nine species was included in the economic impact analysis and some costs items for groups of IAS (a total of 14 cases) could be located to complement the species specific data (see Table 8). Given this limited data availability, the overview of costs presented in this chapter can be only taken as indicative of the actual economic impacts of IAS in Europe. In reality, the figures presented in Tables 7, 8 and 9 are likely to be significant underestimates of the real situation. For example, marine and freshwater invertebrate IAS are often reported to cause negative effects on fisheries and aquaculture (e.g. see Chapter 4.2 above), however evidence of their monetary impacts is very limited. Additionally, costs of recent outbreaks of animal diseases, such as BSE, which have taken place in a number of EU countries have not been included in these annual calculations due to their exceptional and one-off nature. It is also still uncertain whether BSE should be considered as IAS.

Table 7. Overview of the documented economic costs (real costs & estimates) due to different IAS taxa in Europe. See Annexes II & III for original data and references.

Taxa / biome of IAS	SUM of known costs in EU (million EUR / year)	No of cases / species	SUM of known costs in non-EU (million EUR / year)	No of cases / species	SUM of known costs in Europe (million EUR / year)	No of cases	TOTAL (million / EUR)
Fungus & bacteria (freshwater / terrestrial)	1909.0	4 / 2	0.2	1 / 1	no info		1909.2
Freshwater invertebrate	147.7	7 / 6	47.4	2 / 1	no info		195.1
Freshwater vertebrate	0.1	3 / 3	no info		no info		0.1
Freshwater plant	25.7	13 / 9	no info		no info		25.7
Marine invertebrate	33.3	2 / 2	no info		41.2	3 / 2	74.4
Marine vertebrate	no info	no info	no info		no info		0.0
Marine plant	19.0	2 / 2	no info		no info		19.0
Terrestrial invertebrate	1473.6	14 / 10	no info		no info		1473.6
Terrestrial vertebrate	4822.0	42 / 18	no info		no info		4822.0
Terrestrial plant	3740.8	34 / 10	no info		no info		3740.8
Various taxa / species	198.1	2	no info		no info		198.1
TOTAL	**12369.3**	**124 / 62**	**47.6**	**3 / 2**	**41.2**	**3 / 2**	**12458.0**

Table 8. Overview of the recorded economic costs (real costs & estimates) due to different IAS taxa in Europe. Extrapolated costs for whole current European range have been calculated for and used in the case of 25 species See Annexes II & III for original data, references and information on the calculations.

Ref. number (for Annex III)	*Name of species*	Common name	Biome / taxa	Total cost / species in Europe (million EUR / year)	Extrapolated costs (real & estimated) / species in Europe (million EUR / year)	Documented + Extrapolated
1	*Aphanomyces astaci*	Crayfish plague	Freshwater fungus	0.21	70.02	70.02
2	*Anguillicola crassus*	Eel swim-bladder nematode	Freshwater invertebrate	32.58		32.58
3	*Dreissena polymorpha*	Zebra mussle	Freshwater invertebrate	0.002		0.00
4	*Eriocheir sinensis*	Chinese mitten crab	Freshwater invertebrate	0.86		0.86
5-7	*Gyrodactylus salaris*	Salmon fluke	Freshwater invertebrate	106.16	12237.62	6118.81
8-10	*Pacifastacus leniusculus*	Crayfish	Freshwater invertebrate	53.28		53.28
11	*Procambarus clarkii*	Red swamp or Louisiana crayfish/crawfish	Freshwater invertebrate	2.21	400.86	400.86
12	*Artemisia vulgaris*	Mugworth	Freshwater plant	7.40		7.40
13	*Cabomba caroliniana*	Green Cabomba	Freshwater plant	0.35		0.35
14-15	*Hydrocotyle ranunculoides*	Floating pennywort	Freshwater plant	3.02		3.02
16	*Crassula halmsii*	New Zealand Pigmyweed	Freshwater plant	1.13		1.13
17-20	*Eichhornia crassipes*	Water hyacinth	Freshwater plant	7.93		7.93
21	*Lagarosiphon major*	Curly water thyme	Freshwater plant	0.26		0.26
22	*Ludwigia grandiflora*	Water primrose	Freshwater plant	0.01		0.01
23	*Nymphoides peltata*	Yellow floating hear	Freshwater plant	5.56		5.56
24	*Percottus gleni*	Amur / chinese sleeper	Freshwater vertebrate	0.004		0.00
25	*Cercopagis pengoi*	Fish-hook waterflea	Freshwater vertebrate	0.03	0.07	0.07
26	*Pseudorasbora parva*	Topmouth hudgeon	Freshwater vertebrate	0.08		0.08
27	**Unspecified plant pathogens**		Fungus & other	1785.00		1785.00
28	*Crassostrea gigas*	Pacific / Japanese oyster	Marine invertebrate	1.00		1.00
29	*Mnemiopsis leidyi*	Sea walnut, comb jelly	Marine invertebrate	26.73	102.31	102.31
30-31	*Teredo navalis*	Common shipworm	Marine invertebrate	14.42		14.42

32	*Balanus improvisus*	Bay barnacle	Maritine invertebrate	32.29		32.29
33	*Chrysochromulina polylepis*	unspecified (micro algae)	Marine plant	17.23		17.23
34	*Chattonella verruculosa*	unspecified (micro algae)	Marine plants	1.73		1.73
35	*Aeromonas salmonicida*	Furunculosis	Maritime bacteria	0.24		0.24
36-37	*Ophiostoma novo-ulmi*	Dutch elm disease	Terrestrial fungi	123.79		123.79
38-39	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	1.34	15.49	15.49
40	*Anoplophora chinensis*	Citrus longhorned beetle	Terrestrial invertebrate	0.32	0.64	0.64
41	*Arion lusitanicus*	Iberian slug	Terrestrial invertebrate	29.85		29.85
42	*Bursaphelenchus xylophilus*	Pinewood nematode	Terrestrial invertebrate	0.12		0.12
43	*Cameraria ohridella*	Horse chestnut leaf-miner	Terrestrial invertebrate	24.76	225.24	225.24
44	*Diabrotica virgifera*	Western corn rootworm	Terrestrial invertebrate	515.00		515.00
45-47	*Ephestia kuehniella*	Mill or Flour Moth	Terrestrial invertebrate	5.98		5.98
48	***Oryzaephilus surinamensis, Rhyzopertha dominica***	Sawtoothed Grain Beetle & Lesser grain borer	Terrestrial invertebrate	16.61		16.61
49	*Thaumetopoea processionea*	Oak processionary moth	Terrestrial invertebrate	0.36		0.36
50	**Unspecified alien cockroaches**		Terrestrial invertebrate	22.50		22.50
51	**Unspecified arthropods**		Terrestrial invertebrate	856.80		856.80
52-55	*Ambrosia artemisifolia*	Common ragweed	Terrestrial plant	38.70	225.39	225.39
56	*Carpobrotus edulis*	Hottentot fig, freeway iceplant, cape fig	Terrestrial plant	0.29	66.12	66.12
57	*Eucalyptus spp*	Eucalyptus	Terrestrial plant	1.58		1.58
58-65	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	2298.27	1727.61	1727.61
66-73	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	22.81	30.74	30.74
74	***Heracleum sosnowskyi and H. mantegazzianum***	Hogwees sp.	Terrestrial plant	0.17		0.17
75	*Heracleum sosnowskyi*	Hogweed	Terrestrial plant	0.13		0.13
76	*Lupinus polyphyllus*	Large-leaved Lupine	Terrestrial plant	0.34		0.34
77	*Pennisetum setaceum*	African fountain grass	Terrestrial plant	0.62		0.62
78-81	*Prunus serotina*	Black cherry, wild black	Terrestrial plant	30.82	32.09	32.09

		cherry				
82-83	*Rhododendron ponticum*	Rhododendron	Terrestrial plant	96.67	223.51	223.51
84	*Rosa rugosa*	Japanese rose	Terrestrial plant	0.87	2.72	2.72
85	**Unspecified weed species**		Terrestrial plant	1249.50		1249.50
86	*Branta canadensis*	Canada goose	Terrestrial vertebrate	1.41	22.69	22.69
87	*Cervus nippon*	Sika deer, Japanese deer	Terrestrial vertebrate	0.95	2.73	2.73
88	*Columbia livia*	common pigeon	Terrestrial vertebrate	240.98		240.98
98-90	*Felis catus*	common cat	Terrestrial vertebrate	5.38		5.38
91	***Felis catus, Rattus sp***	Common cat, rat sp.	Terrestrial vertebrate	0.25		0.25
92	*Hystrix hodgsoni*	Chinese Porcupine	Terrestrial vertebrate	0.05		0.05
93-94	*Lithobates catesbeianus*	American bullfrog	Terrestrial vertebrate	0.45	0.14	0.14
95	*Muntiacus reevesi*	Muntjac deer	Terrestrial vertebrate	0.02		0.02
96-100	*Mustela vison*	American mink	Terrestrial vertebrate	10.95	105.29	105.29
101-105	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	6.80	65.69	65.69
106-107	*Nyctereutes procyonoides*	Raccoon dog	Terrestrial vertebrate	0.43	0.92	0.92
108-114	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	50.03	599.17	599.17
115-117	*Oryctolagus cuniculus*	European Rabbit	Terrestrial vertebrate	1098.82		1098.82
118	*Oxyura jamaicensis*	Ruddy duck	Terrestrial vertebrate	0.82	1.00	0.82
119	*Phasianus colchicus*	Common pheasant	Terrestrial vertebrate	1.76		1.76
120-121	*Rattus norvegicus*	Norway rat, brown rat	Terrestrial vertebrate	0.32	311.20	311.20
122	***Rattus rattus & Mus musculus***	European rat & house mouse	Terrestrial vertebrate	49.12		49.12
123-124	***Rattus sp.***	Rat sp.	Terrestrial vertebrate	3351.76		3351.76
125-126	*Sciurus carolinensis*	Grey squirrel	Terrestrial vertebrate	1.66	1.02	1.02
127	***Mustela vision & Nyctereutes procyonoides***	American mink and racoon dog	Terrestrial vertebrate	0.03		0.03
128	***Oxyura jamaicensis, Threskiornis aethiopicus, Branta canadensis***	Ruddy Duck, sacred ibis, Canada goose	Terrestrial vertebrate	0.001		0.001

129	***Mustela vison, Nyctereutes procyonoides, Percottus glenii, Orconectes limosus, Heracleum sosnovskyi , Acer negundo L., Lupinus polyphyllus Lindl***	Various	Various	0.07		0.07
130	***Lagarosiphon major, Hydrocotyle ranunculoides and Dreissena polymorpha***	Curly Waterweed, floating pennywort, zebra mussels	Various	0.01		0.01
131	**Unspecified alien horticulture & agriculture pests**		Various	198.00		198.00
	Total			**12458.02**		**20085.27**

* See Annex III, reference 4 for more detailed information on calculating this figure.

Table 9. Overview of the documented economic costs (real costs & estimates) of different IAS taxa on different economic sectors in Europe. See Annexes II & III for original data and references.

Economic sector & pest taxa	**Costs of damage (million EUR / year)**	**Costs of control (million EUR / year)**
Agriculture*		
Terrestrial plants (weeds)	1249.5	no info
Terrestrial invertebrates (pests)	1389.3	29.9
Terrestrial vertebrates	1054.2	no info
Freshwater invertebrates	2.2	no info
Fungi / bacteria	1785.0	no info
Pests non-specified for taxa	no info	no info
Total	**5510.1**	
Fisheries / aquaculture		
Freshwater invertebrates	192.6	no info
Freshwater vertebrate	0.032	no info
Marine invertebrates	27.7	no info
Marine plants	19.0	no info
Terrestrial vertebrate	2.1	no info
Fungi / bacteria	0.2	no info
Total	**241.6**	
Forestry		
Terrestrial plants (weeds)	no info	25.4
Terrestrial invertebrate	no info	0.4
Terrestrial vertebrate	1.1	no info
Fungi / bacteria	123.8	no info
	150.7	
Health*		
Terrestrial invertebrates	22.5	1.7

Terrestrial plants	39.6	11.4
Freshwater plant	7.4	no info
Total	**82.5**	
TOTAL (million EUR / year)	**5985.0**	

* Costs of epidemic animal and human diseases excluded, see table 10 below

Table 10. Estimation of the costs of HIV / AIDS and influenza in EU and Europe. Estimates based on extrapolating existing data from the Netherlands and the UK to the EU and European level.

Human disease	**Costs EU** (million EUR / year)	**Costs Europe** (million EUR / year)
HIV + influenza (costs due to loss of productivity)[1]	10,499.36	15,035.33
AIDS & influenza (treatment costs)[2]	6,154.74	8,813.73
Total	**16,654.10**	**23,849.05**

[1] Extrapolation to EU and European level based on information on 53 - 160 million EUR / year costs for HIV and 391 - 782 million EUR / year costs for influenza in the Netherlands (van der Weijden *et al* 2007). The extrapolated estimate = (costs in the NL / total population in the NL) x total population in EU / Europe

[2] Extrapolation to EU and European level based on information on 1 billion $US / year costs in the UK (Pimentel *et al* 2001, exchange rate 1 EUR = 0.75 UDS used). The extrapolated estimate = (costs in the UK / total population in the UK) x total population in EU / Europe.

5 ISSUES RELATED TO IMPACTS OF IAS IN THE EU OVERSEAS ENTITIES

The 28 overseas entities of the European Union, linked to 6 Member States (France, Spain, Portugal, the Netherlands, UK and Denmark) are predominantly island ecosystems (situated in the Caribbean, Oceania, Atlantic and the western Indian Ocean). Many have high levels of endemism and are concentrated in biodiversity 'hotspots'.

Habitats and species in these areas are vulnerable to a range of threats, including habitat degradation and loss, climate change effects (e.g. sea level rise and extreme weather events) as well as IAS impacts on native biodiversity. The conservation of these areas is of key importance in the global context. Introduction of IAS is considered to be a major factor leading to the loss of island biodiversity (see Box 4 for example). A very high proportion of post 1600 extinctions have been of island species (Groombridge 1992).

An analysis of the IUCN Red List of Threatened Species (version 2006)[13] of all taxa indicates that 1565 species out of approximately 16000 listed species are under threat from at least one invasive species (Table 10). As many as 123 of these threatened species occur on some overseas entity of the European Union (Table 11). Furthermore, a breakdown of the Red List category and taxa indicates that at least 21 species have gone extinct as a result of the impacts of IAS among other threats.

Globally 67 per cent of threatened birds on islands are under threat by IAS, with the predominant threat type being predator impacts. Table 12 indicates that as many as 77 bird species that occur within EU overseas entities are threatened. Plant species are the next major taxonomic group impacted by at least one invasive species related threat type.

With regards to the socio-economic impacts of IAS in the EU overseas entities, the livelihood and economies of many of these territories are highly reliant on their biodiversity. This due to the fact that several overseas entities are relative isolated, thus signicantly dependent on their own natural resources. In addition, tourism plays an important role in several of these areas. Any loss of biodiversity would therefore impact on social and cultural values as well as on their economies. Detrimental socio-economic impacts, negative impacts on human health and subsequent impacts on ecosystem services by invasive alien species have been reported in several European overseas entities.

For example the negative impacts of the introduced mammal predator, the black rat (*Rattus rattus* (Linnaeus, 1758)) range from devastating ecological impacts on populations of seabirds, negative impacts on provisioning of food, to negative impacts on human health. In Martinique and Guadeloupe rodents are vectors and hosts of leptospirosis whose prevalence in humans and animals is 40 times higher in Martinique and Guadeloupe than in metropolitan France (in Lorvelec *et al* 2004). Similarly, in Tristan da Cunha black rats pose an as yet un-quantified risk to human health on the island. People on Tristan are in general concerned about the potential for rats to spread disease on the island.

Rats are also well known as pests of crops, particularly sugar cane. The Plant Protection Department of Guadeloupe estimates 5 per cent annual production losses in banana plantations and food crops (in Pascal *et al* 2004a). A study in Martinique has estimated the loss attributable to rodents to be 40 per cent of turnover per hectare (in Pascal *et al* 2004).

Similarly, the growing of potatoes, which are a staple food crop in Tristan da Cunha, is affected by rats. Rats often damage seed potato stores and the seed potatoes required for each year's crop have to be held in rodent-proof wire cages. Similarly, potatoes for consumption are usually stored in sheds within the settlement, and are prone to rat feeding damage and to contamination through soiling from rat urine and faeces. Rats also feed on other island crops (e.g. pumpkins). The school and supermarket have had ongoing problems with rodent infestation, requiring closures for poisoning.

[13] http://www.iucnredlist.org/

Table 11. The number of globally threatened species that occur in the EU overseas entities and are threatened by IAS

Red List Category	Taxa
Critically Endangered (CR)	29
Endangered (EN)	31
Vulnerable (VU)	47
Near Threatened (NT)	16
Data Deficient (DD)	-
Total	123

Table 12. The number of globally threatened species in the EU overseas entities that are threatened by IAS, according to taxa group

Taxonomic category	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Near Threatened (NT)
Amphibians	1	3	1	1
Birds	10	20	35	12
Fish	nil	nil	nil	nil
Mammals	nil	1	nil	nil
Molluscs	nil	nil	nil	nil
Plants	15	7	10	3
Reptiles	3	nil	1	nil
Totals	29	31	47	16

Box 4. Example of IAS threatening native species with extinction in the EU overseas entities

The Tahiti Monarch *Pomarea nigra* (Sparrman, 1786) is listed as 'Critically Endangered' in the IUCN Red List of Threatened Species[13]. Major threats include habitat alteration due to the spread of invasive alien species like **miconia** (*Miconia calvescens* D.C.) and the **African tulip tree** (*Spathodea companulata* (Pal.)). Predation by introduced mammals particularly the **black rat** (*Rattus rattus* (Linnaeus, 1758)) is another major factor. Studies have also shown that introduced birds like the **red vented bulbul** (*Pycnonotus cafer* (Linnaeus, 1766)) and the **common myna** (*Acridotheres tristis* (Linnaeus, 1766)) are threats. Nest failure and early fledgling death have been reported in areas where these introduced birds are present. *P. nigra* which is endemic to Tahiti in French Polynesia has a recovering population of 45 individuals (2004). Twenty seven individuals were reported during September 1998. Conservation action both ongoing and being considered include control of rats, and removal of introduced birds and restoration of habitat by the removal of introduced plants.

The **black rat** is the main threat to the survival of the endemic and endangered Reunion cuckoo-shrike (*Coracina newtoni* (Pollen, 1866)) listed as 'Endangered' in the IUCN Red List, pairs of which are only found at the Nature Reserve of Roche écrite. Studies are flawed, but it is highly likely that *Rattus rattus* also has an impact on endemic malacofauna and on vegetation. For example, black rats consume the seeds of rare and threatened plant species such as *Gastonia cutispongia* Lam.) and the red latan palm (*Latania lontaroides* (Gaertner) H.E.Moore listed as 'Endangered' in the IUCN Red List .

In Martinique, the impact of the black rat has been identified and quantified on the islets of Saint Anne. It reportedly reduces by 30 per cent to 100 per cent the fledging success of several species of seabirds and also reduces the abundance index of certain terrestrial carcinofauna species such as the zombie crab (*Gecarcinus ruricola* (Linnaeus, 1758)) (Pascal *et al* 2004).

In Guadeloupe, the black rat and Norway rat (*Rattus norvegicus*), are suspected to have participated in the extinction of 3 endemic rodent species of the French Antilles (in Lorvelec et al. 2001).

In Fajou Island (Guadeloupe), the sharp decline in the black rat population combined with the eradication of the predatory mongoose, ended the destruction of hawksbill turtle nests (*Eretmochelys imbricata (*Linnaeus, 1766*)*) listed as 'Critically Endangered' in IUCN Red List), and led to a re-colonisation of the dryer parts of the island by the clapper rail (*Rallus longirostris* Boddaert, 1783), which had been strictly confined to the mangroves. The abundance indicies of the clapper rail and the terrestrial crab *Cardisoma guanhumi* Latreille, 1828 increased (Lorvelec *et al* 2004).

On Tristan da Cunha, populations of small seabirds have been dramatically reduced through the impacts of rats over the past 120 years. Firm evidence of rat predation on broad-billed prion (*Pachyptila vittata* (G. Forster, 1777*)*) eggs has been found on the island. It is likely that if rats remain on Tristan, the populations of seabirds will continue to decline. This will be a major biodiversity loss, as Tristan itself is the only known breeding site within the Tristan archipelago for at least four species of seabirds.

The endemic Tristan thrush (*Nesocichla eremita* Gould, 1855) listed as 'Near Threatened' in the IUCN Red List, is almost certainly affected by rat predation. Thrush nests tend to be constructed on or near the ground, making them highly vulnerable to rat predation. The relative scarcity of thrushes on Tristan in comparison to their abundance on the nearby rodent-free islands of Nightingale and Inaccessible is strongly suggestive of the effects of rodent predation.

Rats are probably affecting the breeding success of the Atlantic petrel (*Pterodroma incerta* (Schlegel, 1863)) listed as 'Vulnerabe (VU)' in IUCN Red List. It is likely that the Tristan moorhen (*Gallinula nesiotis* P. L. Sclater, 1861) listed as 'Vulnerabe' in IUCN Red List was extirpated from Tristan as a result of predation by black rat, combined with feral cat predation, habitat loss and hunting by islanders.

6 CONCLUSIONS & RECOMMENDATIONS

According to the analysis carried out in this study, a range of IAS taxa are causing substantial ecological, social and economic impacts, in Europe. These impacts are known to affect a wide rage of ecosystem services that underpin human wellbeing, including provisioning of food and fibre (agriculture, forestry and fisheries / aquaculture), regulating the spread of human diseases, aesthetic, recreational and tourism benefits of ecosystems).

The study indicates that everal important European economic sectors are negatively affected by IAS. The most affected sectors include agriculture, fisheries and aquaculture, forestry and health sectors. In addition, the results of the negative effects of IAS on ecosystem services also indicate that IAS have possible negative impacts on the tourism sector, however monetary evidence of these costs is still lacking. On the otherhand, very limited information was found on the monetary benefits of IAS species considered in this study. Furthermore, in the majority of cases where some positive socio-economic effects were identified (e.g. on some ecosystem services, see Table 6) they were accompanied by significant negative ecological impacts, i.e. impacts on native species and/or ecosystems.

Given the range of sectors affected by IAS it is clear that the action to prevent and control IAS should be collaborative efforts amongst different players and stakeholders at local to national and EU levels. For example, trade in agriculture and forestry products are known to be one of the IAS gateways to Europe and these sectors are also among the most frequently affected by IAS invasions. Thus, there are clear responsibilities and incentives for these sectors to take action to minimise risks posed by IAS. Marine and freshwater transport is known to function as important vector for non-native species invasions. The study clearly indicates that there are significant ecological and socio-economic impacts of aquatic invasions to fisheries and aquaculture sectors. In general, the existing evidence of possible economic costs should create a clear case for action for by the following sectors: agriculture, horticulture, forestry, hunting, pet trade, aquaculture, angling, tourism, maritime trade.

As regards the EU overseas entities, these geographically remote areas represent the main hotspots for biodiversity conservation in the Union. There is clear evidence that IAS threaten the unique biodiversity in these areas. In addition, non-native species can have significant negative effects on local communities (e.g. local economies) in these areas. Thus, there is a clear case for the EU to increase its support for IAS measures in these remote but biodiversity-rich regions that fall under its responsibility.

6.1 Discussing the gaps of knowledge

The growing body of evidence on impacts of IAS on native species and ecosystems provides a rather reliable basis for assessing the general ecological impacts of IAS in Europe. However, gaps in ecological information still exist. Furthermore, the social and economic effects of IAS are far infrequently documented, thus the current picture of IAS impacts on human wellbeing and economy in Europe remains rather incomplete.

The analysis clearly shows that the available data on IAS monetary costs remains rather scarce and unevenly distributed between different geographic areas and IAS taxa. In reality, the cost estimates presented in the report are propably significant underestimates of the real situation. The analysis of IAS impacts on ecosystem services indicate that a far greater number of IAS cause socio-economic effects than are documented in monetary terms. For example, marine and freshwater invertebrates are often reported to have negative effects on fisheries and aquaculture; however, evidence on their monetary impacts is very limited. Similarly, there is a clear lack of information on the costs of IAS to certain economic sectors (e.g. tourism, health and forestry). Finally, hardly any data could be found on the costs of IAS outside the EU.

When considering the results of this study in the light of other existing estimates of IAS monetary impacts it should also be noted that the calculations presented in this report are mainly based on the known and documented impacts of IAS with only limited extrapolations of costs. In addition, single IAS events, such as disease outbreaks, were excluded in order to come up with a general (and rather conservative) estimate for IAS annual costs. Thus, the results presented in this study are not directly comparable with studies such as those by Pimentel *et al* (2001; 2005). Nevertheless, they strongly support the economic case for improving the control and management of IAS in Europe.

There are a number of reasons for the apparent lack of available evidence on monetary costs (and benefits) of IAS. This is partly because, apart from epidemic diseases and some regional IAS infestations (such as the invasions of *Eriocheir sinensis* in Europe and *Mnemiopsis leidyi* in the Black Sea), the impacts of IAS can remain very local and getting a full handle on these impacts is relatively difficult. This local nature of impacts also makes it difficult to create wider and more generic regional estimates of IAS effects, costs in particular, as extrapolating existing case specific evidence often dilutes the impact. In general, a far more comprehensive body of evidence on monetary costs and benefits is needed to improve the understanding of economic impacts of IAS in Europe.

6.2 Future outlook

As for the future outlook, it can be reliably assumed that introductions of new IAS to the EU and Europe will continue. In addition, the spread of already established IAS is likely to increase. Furthermore, the effects of climate change are predicted to aggravate the situation and there is already evidence that changes in climatic conditions can alter species' distributions and may make it easier for some alien species to become established in Europe. As a consequence the risks posed by the invasion of non-native species, including both ecological risks and risks to different economic sectors, are only likely to increase.

For example, the impacts of IAS in European forests and to the forestry sector have not been as severe as in the North America where negative impacts caused by non-native pests, e.g. the emerald ash borer (*Agrilus planipennis*), gypsy moth (*Lymantria dispar*) and hemlock woolly adelgic (*Adelges tsugae*), are well documented (EAB 2008, USDA Forest Service 2003). However, given the rate of introduction and changing climatic conditions it might be only a matter of time before Europe faces negative impacts of similar magnitude (e.g. see EPPO 2008).

Furthermore, if not careful, the current EU policies on energy and climate change may encourage further IAS introductions in Europe. This might be the case, for example, if non-native species will be used as cultivation of biofuels to meet the new EU targets for renewable energy consumption. Consequently, the impacts of IAS in European continent are likely to increase in the future creating a stronger case for further immediate actions to address the risks of IAS.

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Annex I. List of 125 invasive alien species with existing evidence on impacts (environmental, social and/or economic) in Europe considered in the context of this study

Name of species	Common name	Biome / taxa	Native range	DAISIE 100 species list (D) / non-DAISIE 100 species list (ND)
Freshwater fungus				
Aphanomyces astaci	Crayfish plague	Freshwater fungus	N America	D
Freshwater invertebrate[14]				
Anguillicola crassus	Eel swim-bladder nematode	Freshwater invertebrate	E Asia	D
Cercopagis pengoi	Fish-hook waterflea	Freshwater invertebrate	Caspian	D
Corbicula fluminea	Asian clam	Freshwater invertebrate	SE Asia, Australia, Africa	D
Cordylophora caspia	Freshwater hydroid	Freshwater invertebrate	Ponto - Caspian	D
Dikerogammarus villosus	"Killer" shrimp	Freshwater invertebrate	Ponto - Caspian	D
Dreissna polymorpha	Zebra mussel	Freshwater invertebrate	Black, Caspin and Aral Seas	D
Eriocheir sinensis	Chinese mitten crab	Freshwater invertebrate	S China, Japan, Taiwan	D
Gyrodactylus salaris	Salmon fluke	Freshwater invertebrate	N Europe	D
Pacifastacus leniusculus	Signal crayfish	Freshwater invertebrate	NW America	ND
Procambarus clarkii	Red swamp or Louisiana crayfish/crawfish	Freshwater invertebrate	Mexico, S -central USA	D
Neogobius melanostomus	Round goby	Freshwater vertebrate	Caspian, Black and Azov Seas	D
Freshwater vertebrate				
Pseudorasbora parva	Stone moroko, toupmouth gudgeon	Freshwater vertebrate	E Asia	D

[14] Some species also occur in brackish waters

Salvelins fontinalis	Brook trout	Freshwater vertebrate	N America	D
Freshwater plant				
Azolla filiculoides	Azola water Fern	Freswater plant	Temperate & tropical regions of the Americas	ND
Crassula helmsii	New Zealand Pigmyweed	Freswater plant	Australasia	D
Eichhornia crassipes	Water hyacinth	Freswater plant	S America	ND
Elodea canadensis	Canadian waterweed	Freswater plant	N America	D
Hydrocotyle ranunculoides	Floating pennywort	Freswater plant	North America	ND
Marine invertebrate[15]				
Balanus improvisus	Bay barnacle, acorn barnacle	Marine invertebrate	Atlantic	D
Brachidontes pharaonis	(Red Sea mussel)	Marine invertebrate	Indian Ocean, Red Sea	D
Crassostrea gigas	Pacific oyster	Marine invertebrate	NW Pacific	D
Crepidula fornicata	Slipper limpet	Marine invertebrate	N America	D
Ensis americanus	American jack knife clam	Marine invertebrate	Atlantic coast of N America	D
Ficopomatus enigmaticus	Tube worm	Marine invertebrate	unknown	D
Marenzelleria neglecta	Red-gilled mud worm	Marine invertebrate	Atlantic coast of N America	D
Marsupenaeus japonicus	Kuruma prawn	Marine invertebrate	Indo-Pacific	D
Mnemiopsis leidyi	Sea walnut, comb jelly	Marine invertebrate	American Atlantic coast	D
Musculista senhousia	Asian date mussel	Marine invertebrate	W Pacific	D
Paralithodes camtschaticus	Red king crab, Alaska crab	Marine invertebrate	Okhotsk, Japan & Bering Sea, N Pacific	D
Percnon gibbesi	Sally lightfoot crab	Marine invertebrate	W and E coast of America, E Atlantic	D
Pinctada radiata	Gulf pearl oyster	Marine invertebrate	Indo-Pacific	D
Portunus pelagicus	Blue swimming crab	Marine invertebrate	Indo-Pacific Ocean, Red Sea	D
Rapana venosa	Veined rapa whelk	Marine invertebrate	Sea of Japan, ellow, Bohai and E China Seas	D

[15] Some species also occur in brackish waters

Rhopilema nomadica	Nomad jellyfish	Marine invertebrate	E Africa, Red Sea	D
Styela clava	Asian sea-squirt	Marine invertebrate	Sea of Othotsk, Korea and Siberia	D
Teredo navalis	Common shipworm	Marine invertebrate	unknown	D
Tricellaria inopinata	unspecified	Marine invertebrate	N America, Japan to Taiwan, Australia	D
Marine plant				
Chrysochromulina polylepis	unspecified (micro algae)	Marine plant	unknown (cryptogenic), could be native	ND
Alexandrium catenella	unspecified (micro algae)	Marine plants	NW Pasific Ocean	D
Bonnemaisonia hamifera	unspecified (macro algae)	Marine plants	NW Pasific (Japan)	D
Caulerpa racemosa	Grape algae	Marine plants	W Australia	D
Caulerpa taxifolia	Caulerpa alga	Marine plants	Caribbean, Indian Ocean, Pacific, Red Sea	D
Chattonella verruculosa	unspecified (micro algae)	Marine plants	Japan	D
Codium fragile tomentosoides	Green sea fingers	Marine plants	Japan	D
Coscinodiscus wailesii	unspecified (micro algae)	Marine plants	N Pacific	D
Halophila stipulacea	Halophila seagrass	Marine plants	W Indian Ocean	D
Odontella sinensis	Chinese diatom	Marine plants	Hong Kong HArbour	D
Siganus rivulatus	Wireweed	Marine plants	NW Pasific	ND
Spartina anglica	Common cord grass	Marine plants	Britain	D
Undaria pinnatifida	Wakame, Japanese kelp	Marine plants	NW Pasific	D
Marine vertebrate				
Fistularia commersoni	Blue-spotted cornetfish, smooth flutemouth	Marine vertebrate	Indo-Pacific, E Central Pacific	D
Saurida undosquamis	Brushtooth lizardfish	Marine vertebrate	Indo-W Pacific	D
Siganus rivulatus	Marbled spinefoot, rabbitfish	Marine vertebrate	W Indian Ocean	D
Terrestrial fungus				
Ceratocystis ulmi	unspecified	Terrestrial fungus	unknown	ND
Ophiostoma novo-ulmi	Dutch elm disease	Terrestrial fungus	Asia	D
Phytophthora cinnamomi	Phytophthora root rot, ink disease	Terrestrial fungus	SE Asia-Oceania	D
Seiridium cardinale	Cypress canker	Terrestrial fungus	unknown	D
Terrestrial invertebrate				
Aedes albopictus	Asian tiger mosquito	Terrestrial invertebrate	SE Asia	D
Anoplophora chinensis	Citrus longhorned	Terrestrial invertebrate	E Asia	D

	beetle			
Anoplophora glabripennis	Asian longhorned beetle	Terrestrial invertebrate	E Asia	D
Aphis gossypi	Cotton aphid	Terrestrial invertebrate	unknown	D
Arion vulgaris	Lusitanian slug, Spanish slug	Terrestrial invertebrate	SW Europe	D
Bemisia tabaci	Cotton whitefly	Terrestrial invertebrate	India	D
Bursaphelenchus xylophilus	Pine wood nematode	Terrestrial invertebrate	N America	D
Cameraria ohridella	Horse chestnut leaf-miner	Terrestrial invertebrate	Balkanic	D
Ceratitis capitata	Mediterranean fruit fly, medfly	Terrestrial invertebrate	Tropical E America	D
Diabrotica virgifera	Western corn rootworm	Terrestrial invertebrate	Mesoamerica	D
Ephestia kuehniella	Mill or Flour Moth	Terrestrial invertebrate	India (?)	ND
Frankliniella occidentalis	Western flower thrips, alfalfa thrips	Terrestrial invertebrate	N America	D
Harmonia axyridis	Harlequin ladybird	Terrestrial invertebrate	C and E Asia	D
Leptinotarsa decemlineata	Colorado beetle	Terrestrial invertebrate	Mexico	D
Linepithema humile	Argentine ant	Terrestrial invertebrate	S America	D
Liriomyza huidobrensis	Serpentine leaf miner	Terrestrial invertebrate	S America	D
Oryzaephilus surinamensis	Sawtoothed Grain Beetle.	Terrestrial invertebrate	Tropical areas	ND
Rhyzopertha dominica	lesser grain borer	Terrestrial invertebrate	Tropical areas	ND
Spodoptera littoralis	African cotton leaf worm	Terrestrial invertebrate	Tropical & subtropical Africa	D
Thaumetopoea processionea	Oak processionary moth	Terrestrial invertebrate	C & S Europe	ND
Terrestrial plant				
Acacia dealbata	Silver wattle, blue wattle	Terrestrial plant	Australia	D
Ailanthus altisssima	Tree of heaven, Chinese sumac	Terrestrial plant	e Asia	D
Ambrosia artemisifolia	Common ragweed	Terrestrial plant	N America	D
Campylopus introflexus	Heath star moss	Terrestrial plant	S America, Pasific Islands	D
Carpobrotus edulis	Hottentot fig, freeway iceplant, cape fig	Terrestrial plant	S Africa	D
Cortaderia selloana	Pampas grass	Terrestrial plant	S America	D
Echinocystis lobata	Wild cucumber, wild balsam apple	Terrestrial plant	N America	D
Eucalyptus spp	Eucalyptus	Terrestrial plant	Australia	ND
Fallopia bohemica	Bohemian knotweed	Terrestrial plant	None (Hybrid origin)	ND
Fallopia japonica	Japanese knotweed	Terrestrial plant	e Asia	D
Fallopia sachalinensis	Giant knotweed	Terrestrial plant	E-Asia	ND
Hedychium gardnerianum	Kahili ginger, wild ginger	Terrestrial plant	Indian Subcontinent	D
Heracleum mantegazzianum	Giant hogweed	Terrestrial plant	Caucasus	D

Impatiens glandulifera	Himalayan balsam	Terrestrial plant	Central Asia, Himalayas	D
Larix decidua	European Larch	Terrestrial plant	Europe	ND
Lupinus polyphyllus	Large-leaved Lupine	Terrestrial plant	W N America	ND
Opuntia maxima	Prickly-pear cacti	Terrestrial plant	Tropical America	D
Oxalis pes-caprae	Bermuda buttercup	Terrestrial plant	S Africa	D
Paspalum paspalodes	Knotgrass	Terrestrial plant	Tropical Africa & America	D
Pennisetum setaceum	African fountain grass	Terrestrial plant	N Africa	ND
Pinus strobus	Eastern white pine	Terrestrial plant	N America	ND
Prunus serotina	Black cherry, wild black cherry	Terrestrial plant	E C N America	D
Rhododendron ponticum	Rhododendron	Terrestrial plant	SW and SE Europe	D
Robinia pseudoacacia	Black locust, black laurel	Terrestrial plant	N America	D
Rosa rugosa	Rugosa rose, Japanese rose	Terrestrial plant	E Asia	D
Rudbeckia laciniata	Cutleaf coneflower	Terrestrial plant	N America	ND
Terrestrial vertebrate				
Branta canadensis	Canada goose	Terrestrial vertebrate	Neoartic N America	D
Cervus nippon	Sika deer, Japanese deer	Terrestrial vertebrate	E Asia	D
Chrysolophus pictus	Golden Pheasant	Terrestrial vertebrate	Asia / China	ND
Columbia livia	Rock dove (Feral pigeon)	Terrestrial vertebrate	Europe, N Africa, W. Asia	ND
Felis catus	Domestic cat	Terrestrial vertebrate	Africa (origin for domestication)	ND
Hystrix hodgsoni	Chinese Porcupine	Terrestrial vertebrate	E Asia	ND
Lithobates catesbeianus	American bullfrog	Terrestrial vertebrate	E part of N America	D
Muntiacus reevesi	Muntjac deer	Terrestrial vertebrate	China	ND
Mustela vison	American mink	Terrestrial vertebrate	N America	D
Myocastor coypus	Coypu, nutria	Terrestrial vertebrate	S America	D
Nyctereutes procyonoides	Raccoon dog	Terrestrial vertebrate	NE Asia	D
Ondatra zibethicus	Muskrat.	Terrestrial vertebrate	N America	D
Oryctolagus cuniculus	European Rabbit	Terrestrial vertebrate	Europe	ND
Oxyura jamaicensis	Ruddy duck	Terrestrial vertebrate	N and C America	D
Procyon lotor	Raccoon	Terrestrial vertebrate	S Canada to Panama	D
Psittacula krameri	Rose-ringed parakeet	Terrestrial vertebrate	Central Africa, SW Asia	D
Rattus norvegicus	Norway rat, brown rat	Terrestrial vertebrate	NE Asia	D
Sciurus carolinensis	Grey squirrel	Terrestrial vertebrate	E part of N America	D

Tamias sibiricus	Siberian chipmunk	Terrestrial vertebrate	European Russia, Asia	D
Threskiornis aethiopicus	Sacred ibis	Terrestrial vertebrate	Africa	D
Trachemys scripta	Common slider	Terrestrial vertebrate	E USA	D

Annex II. Representation of the documented (real & estimated) costs of different IAS species in Europe collected and analysed in this study. More detailed information on the original references and the calculations carried out in the context of this study are found in Annex III.

Ref. number *(for Annex III)*	**Name of species**	**Common name**	**Biome / taxa**	**Annual costs** (milloin EUR per year)	**Cost item**	**Real occurred costs (R) or estimates costs (E)**	**Total cost / species in Europe** (million EUR / year)
1	*Aphanomyces astaci*	Crayfish plague	Freshwater fungus	0.21	Damage	R	**0.21**
2	*Anguillicola crassus*	Eel swim-bladder nematode	Freshwater invertebrate	32.58	Damage	n/a	**32.58**
3	*Dreissena polymorpha*	Zebra mussle	Freshwater invertebrate	0.0019	Control	E	**0.0019**
4	*Eriocheir sinensis*	Chinese mitten crab	Freshwater invertebrate	0.86	Damage	E	**0.86**
5	*Gyrodactylus salaris*	Salmon fluke	Freshwater invertebrate	26.79	Damage	R	
6	*Gyrodactylus salaris*	Salmon fluke	Freshwater invertebrate	20.60	Damage	E	**106.16**
7	*Gyrodactylus salaris*	Salmon fluke	Freshwater invertebrate	58.78	Damage	E	
8	*Pacifastacus leniusculus*	Crayfish	Freshwater invertebrate	0.10	Control	E	
9	*Pacifastacus leniusculus*	Crayfish	Freshwater invertebrate	52.99	Damage	E	**53.28**
10	*Pacifastacus leniusculus*	Crayfish	Freshwater invertebrate	0.18	Control	R	

11	*Procambarus clarkii*	Red swamp or Louisiana crayfish/crawfish	Freshwater invertebrate	2.21	Damage	E	**2.21**
12	*Artemisia vulgaris*	Mugworth	Freshwater plant	7.40	Damage	E	**7.40**
13	*Cabomba caroliniana*	Green Cabomba	Freshwater plant	0.35	Control	R	**0.35**
14	*Hydrocotyle ranunculoides*	Floating pennywort	Freshwater plant	3.00	Control	E	**3.02**
15	*Hydrocotyle ranunculoides*	Floating pennywort	Freshwater plant	0.02	Control	R	
16	*Crassula halmsii*	New Zealand Pigmyweed	Freshwater plant	1.13	Control	E	**1.13**
17	*Eichhornia crassipes*	Water hyacinth	Freshwater plant	3.74	Control	R	**7.93**
18	*Eichhornia crassipes*	Water hyacinth	Freshwater plant	0.21	Control	R	
19	*Eichhornia crassipes*	Water hyacinth	Freshwater plant	0.09	Control	R	
20	*Eichhornia crassipes*	Water hyacinth	Freshwater plant	3.89	Control	E	
21	*Lagarosiphon major*	Curly water thyme	Freshwater plant	0.26	Control	R	**0.26**
22	*Ludwigia grandiflora*	Water primrose	Freshwater plant	0.01	Control	E	**0.01**
23	*Nymphoides peltata*	Yellow floating hear	Freshwater plant	5.56	Control	E	**5.56**
24	*Percottus gleni*	Amur / chinese sleeper	Freshwater vertebrate	0.0044	Control	R	**0.0044**
25	*Cercopagis pengoi*	Fish-hook waterflea	Freshwater vertebrate	0.03	Damage	E	**0.03**
26	*Pseudorasbora parva*	Topmouth hudgeon	Freshwater vertebrate	0.08	Control	E	**0.08**
27	**Unspecified plant pathogens**		Fungus & other	1785.00	Damage	E	**1785.00**
28	*Crassostrea gigas*	Pacific / Japanese oyster	Marine invertebrate	1.00	Damage	E	**1.00**
29	*Mnemiopsis leidyi*	Sea walnut, comb jelly	Marine invertebrate	26.73	Damage	E	**26.73**

30	*Teredo navalis*	Common shipworm	Marine invertebrate	5.72	Damage	E	**14.42**
31	*Teredo navalis*	Common shipworm	Marine invertebrate	8.70	Damage	E	
32	*Balanus improvisus*	Bay barnacle	Maritine invertebrate	32.29	Control	R	**32.29**
33	*Chrysochromulina polylepis*	unspecified (micro algae)	Marine plant	17.23	Damage	R	**17.23**
34	*Chattonella verruculosa*	unspecified (micro algae)	Marine plants	1.73	Damage	E	**1.73**
35	*Aeromonas salmonicida*	Furunculosis	Maritime bacteria	0.24	Control	R	**0.24**
36	*Ophiostoma novo-ulmi*	Dutch elm disease	Terrestrial fungi	118.14	Damage	R	**123.79**
37	*Ophiostoma novo-ulmi*	Dutch elm disease	Terrestrial fungus	5.65	Damage	E	
38	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	1.31	Control	R	**1.34**
39	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	0.03	Control	E	
40	*Anoplophora chinensis*	Citrus longhorned beetle	Terrestrial invertebrate	0.32	Control	R	**0.32**
41	*Arion lusitanicus*	Iberian slug	Terrestrial invertebrate	29.85	Control	E	**29.85**
42	*Bursaphelenchus xylophilus*	Pinewood nematode	Terrestrial invertebrate	0.12	Control	R	**0.12**
43	*Cameraria ohridella*	Horse chestnut leaf-miner	Terrestrial invertebrate	24.76	Control	E	**24.76**
44	*Diabrotica virgifera*	Western corn rootworm	Terrestrial invertebrate	515.00	Damage	E	**515.00**
45	*Ephestia kuehniella*	Mill or Flour Moth	Terrestrial invertebrate	0.88	Damage	E	**5.98**

46	*Ephestia kuehniella*	Mill or Flour Moth	Terrestrial invertebrate	0.12	Control	E	
47	*Ephestia kuehniella*	Mill or Flour Moth	Terrestrial invertebrate	4.97	Control	E	
48	**Oryzaephilus surinamensis, Rhyzopertha dominica**	Sawtoothed Grain Beetle & Lesser grain borer	Terrestrial invertebrate	16.61	Damage	E	**16.61**
49	*Thaumetopoea processionea*	Oak processionary moth	Terrestrial invertebrate	0.36	Control	E	**0.36**
50	**Unspecified alien cockroaches**		Terrestrial invertebrate	22.50	Damage	E	**22.50**
51	**Unspecified arthropods**		Terrestrial invertebrate	856.80	Damage	E	**856.80**
52	*Ambrosia artemisifolia*	Common ragweed	Terrestrial plant	36.27	Damage	E	**38.70**
53	*Ambrosia artemisifolia*	Common ragweed	Terrestrial plant	2.12	Damage	E	
54	*Ambrosia artemisifolia*	Common ragweed	Terrestrial plant	0.30	Control	E	
55	*Ambrosia artemisifolia*	Common ragweed	Terrestrial plant	0.01	Control	E	
56	*Carpobrotus edulis*	Hottentot fig, freeway iceplant, cape fig	Terrestrial plant	0.29	Control	R	**0.29**
57	*Eucalyptus spp*	Eucalyptus	Terrestrial plant	1.58	Control	R	**1.58**
58	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	2262.26	Control	E	**2298.27**
59	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	0.06	Control	R	
60	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	0.21	Control	R	
61	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	7.91	Damage	E	

62	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	26.84	Control	E	
63	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	0.03	Control	E	
64	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	0.96	Control	R	
65	*Fallopia japonica*	Japanese knotweed	Terrestrial plant	0.0031	Control	E	
66	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	0.01	Control	R	**22.81**
67	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	1.19	Damage	E	
68	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	2.64	Control	E	
69	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	8.70	Control	E	
70	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	1.36	Control	E	
71	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	8.37	Control	E	
72	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	0.38	Damage	E	
73	*Heracleum mantegazzianum*	Giant hogweed	Terrestrial plant	0.16	Control	E	
74	*Heracleum sosnowskyi and H. mantegazzianum*	Hogwees sp.	Terrestrial plant	0.17	Control	E	**0.17**
75	*Heracleum sosnowskyi*	Hogweed	Terrestrial plant	0.13	Control	R	**0.13**
76	*Lupinus polyphyllus*	Large-leaved Lupine	Terrestrial plant	0.34	Control	E R	**0.34**
77	*Pennisetum setaceum*	African fountain grass	Terrestrial plant	0.62	Control	**?**	**0.62**

78	*Prunus serotina*	Black cherry, wild black cherry	Terrestrial plant	2.00	Control	R	**30.82**
79	*Prunus serotina*	Black cherry, wild black cherry	Terrestrial plant	1.58	Control	E	
80	*Prunus serotina*	Black cherry, wild black cherry	Terrestrial plant	23.39	Control	E	
81	*Prunus serotina*	Black cherry, wild black cherry	Terrestrial plant	3.84	Control	E	
82	*Rhododendron ponticum*	Rhododendron	Terrestrial plant	1.92	Control	E	**96.67**
83	*Rhododendron ponticum*	Rhododendron	Terrestrial plant	94.75	Control	R	
84	*Rosa rugosa*	Japanese rose	Terrestrial plant	0.87	Control	E	**0.87**
85	**Unspecified weed species**		Terrestrial plant	1249.50	Damage	E	**1249.50**
86	*Branta canadensis*	Canada goose	Terrestrial vertebrate	1.41	Damage	E	**1.41**
87	*Cervus nippon*	Sika deer, Japanese deer	Terrestrial vertebrate	0.95	Control	E	**0.95**
88	*Columbia livia*	common pigeon	Terrestrial vertebrate	240.98	Damage	E	**240.98**
89	*Felis catus*	common cat	Terrestrial vertebrate	4.31	Control	E	**5.38**
90	*Felis catus*	common cat	Terrestrial vertebrate	1.07	Damage	E	
91	Felis catus, Rattus sp	Common cat, rat sp.	Terrestrial vertebrate	0.25	Control	R	**0.25**
92	*Hystrix hodgsoni*	Chinese Porcupine	Terrestrial vertebrate	0.05	Control	E	**0.05**
93	*Lithobates catesbeianus*	American bullfrog	Terrestrial vertebrate	0.44	Control	E	**0.45**
94	*Lithobates catesbeianus*	American bullfrog	Terrestrial vertebrate	0.01	Control	R	

95	*Muntiacus reevesi*	Muntjac deer	Terrestrial vertebrate	0.02	Control	E	**0.02**
96	*Mustela vison*	American mink	Terrestrial vertebrate	4.75	Control	E	**10.95**
97	*Mustela vison*	American mink	Terrestrial vertebrate	0.51	Control	R	
98	Mustela vison	American mink	Terrestrial vertebrate	0.13	Control	R	
99	*Mustela vison*	American mink	Terrestrial vertebrate	0.32	Control	R	
100	*Mustella vision*	American mink	Terrestrial vertebrate	5.25	Control	R	
101	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	0.80	Control	E (?)	**6.80**
102	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	0.86	Control	R	
103	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	4.64	Control	R	
104	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	0.19	Control	R	
105	*Myocastor coypus*	Coypu, nutria	Terrestrial vertebrate	0.32	Control	E	
106	*Nyctereutes procyonoides*	Raccoon dog	Terrestrial vertebrate	0.01	Control	R	**0.43**
107	*Nyctereutes procyonoides*	Raccoon dog	Terrestrial vertebrate	0.42	Control	R	
108	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	23.00	Damage	R	**50.03**
109	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	12.77	Damage	R	

110	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	3.09	Control	R	
111	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	2.09	Damage	E	
112	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	2.54	Damage	E	
113	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	4.14	Control	E	
114	*Ondatra zibethicus*	Muskrat.	Terrestrial vertebrate	2.3968	Control	R	
115	*Oryctolagus cuniculus*	European Rabbit	Terrestrial vertebrate	1044.00	Damage	E	
116	*Oryctolagus cuniculus*	European Rabbit	Terrestrial vertebrate	7.06	Damage	R	**1098.82**
117	*Oryctolagus cuniculus*	European Rabbit	Terrestrial vertebrate	47.77	Control	E	
118	*Oxyura jamaicensis*	Ruddy duck	Terrestrial vertebrate	0.82	Control	R	**0.82**
119	*Phasianus colchicus*	Common pheasant	Terrestrial vertebrate	1.76	Damage	E	**1.76**
120	*Rattus norvegicus*	Norway rat, brown rat	Terrestrial vertebrate	0.32	Control	R	**0.32**
121	*Rattus norvegicus*	Norway rat, brown rat	Terrestrial vertebrate	0.00	Control	R	
122	*Rattus rattus & Mus musculus*	European rat & house mouse	Terrestrial vertebrate	49.12	Damage & control	E	**49.12**
123	Rattus sp.	Rat sp.	Terrestrial vertebrate	3351.75	Damage	E	**3351.76**
124	Rattus sp.	Rat sp.	Terrestrial vertebrate	0.01	Control	E	

125	*Sciurus carolinensis*	Grey squirrel	Terrestrial vertebrate	0.53	Control	E	**1.66**
126	*Sciurus carolinensis*	Grey squirrel	Terrestrial vertebrate	1.12	Damage	E	
127	*Mustela vision & Nyctereutes procyonoides*	American mink and racoon dog	Terrestrial vertebrate	0.03	Control	R	**0.03**
128	*Oxyura jamaicensis, Threskiornis aethiopicus, Branta canadensis*	Ruddy Duck, sacred ibis, Canada goose	Terrestrial vertebrate	0.0014	Control	R	**0.001**
129	*Mustela vison, Nyctereutes procyonoides, Percottus glenii, Orconectes limosus, Heracleum sosnovskyi , Acer negundo L., Lupinus polyphyllus Lindl*	Various	Various	0.07	Control	R	**0.07**
130	*Lagarosiphon major, Hydrocotyle ranunculoides and Dreissena polymorpha*	Curly Waterweed, floating pennywort, zebra mussels	Various	0.01	Control	R	**0.01**
131	**Unspecified alien horticulture & agriculture pests**		Various	198.00	Control	R + E	**198.00**
	Total						**12458.02**

Annexes III. Detailed information on the original references and the calculations carried out when assessing the economic impacts of IAS in Europe

Ref. number *(for Annex II)*	Reference	Information used as basis for calculating the annual cost figure					Information used in the context of extrapolations
		Time when costs occurred	**Original cost information**	**Exchange rate used** (reference year)	**Inflation** (with 0.3% annual inflation rate, using 2007 as reference point)	**Other relevant information**	**Area where costs occurred**
1	Barbaresi, S. & Gherardi. F. 2000. The invasion of the alien crayfish *Procambarus clarkii* in Europe, with particular reference to Italy. Biological Invasions 2: 259–264, 2000.	1987-1992	min US$ 150,000 / year	1 USD = 0.84 EUR (1990)	Average inflator = 1.7 (1987-1992)		Range in Norway from DAISIE database
2	Starkie, A., 2003. Management issues relating to the European eel, *Anguilla anguilla*. Fisheries Management and Ecology, 2003, 10, 361–364	1991	Estimated loss of 250 t of eel during 1991 in the western basin	1 USD = 0.81-0.73 EUR (1991)	Avarage inflator 1.5 (1991 -1995)	Price for European eel in 1994/1995 was 119 $ / kg	
3	Hans Erik Svart, Ministry of Environment, Denmark, pers. comm. (as in Shine et al. 2009)	2008 (year of comm.)	DKK 200,000 (one off)	1 EUR = 0.13 DKK	No inflator used		
4	Gollasch, S. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Eriocheir sinensis.* – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org.	1912 - (about) 2005	~ 80 million EUR total costs since its first occurrence in 1912		No inflator used		
5	NOU 1999 in Johnsen., B O.; Jensen A J., 1986. Infestations of Atlantic salmon Salmo salar by *Gyrodactylus salaris* in Norwegian Rivers. Journal of	n/a	total loss of > 500 million US dollars.	1EUR = 1.25 USD		Annual cost calculated total / 14, i.e. based on 4 % discout rate in 20 year timescale	

	Fish Biology. 29(2). 1986. 233-242.						
6	Johnsen B.O. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Gyrodactylus salaris.* – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org,	2006 (year of publication)	20 million Euro / year		Inflator 1.03 (2006)		Water area of Norwey (Wikipedia)
7	Radford, A., Riddington, G., Paffrath, S., Bostock, J. & Shinn, A. 2006. An Economic Evaluation of the Impact of the Salmon Parasite *Gyrodactylus salaris* (Gs) Should it be Introduced into Scotland. Final Report to the Scottish Executive Environment and the Rural Affairs Department Project No. SAQ/001/0	n/a	Total loss of £ 34.5 million of income to households Total loss of 1966 full time equivalent jobs (FTEs) to the Scottish economy Total £ 633 million Net Economic Value lost			Annual cost calculated total / 14, i.e. based on 4 % discout rate in 20 year timescale	Scotland water area (Wikipedia)
8	Collins 2006 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2006	0.1 million EUR / year		Inflator 1.03 (2006)		
9	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	362.6 - 595.7 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
10	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006 (year of publication)	1.63 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)		

11	Anastacio et al. 2005 in Gherardi, F; L. Aquiloni; R. Berti; A. Paglianti; G. Parisi; and E Tricarico, undated. The impacts of *Procambarus clarkii* in Mediterreanean wetlands and proposals for its mitigation.	2000	Losses upto 6.3%	1 EUR = 1.09 USD (2000)	Inflator 1.23 (2000)	PT rice production in 2000 was 149 000 t (http://www.irri.org/science/cnyinfo/portugal.asp). In 2000 the market price for rice was 210 US$ / t (FAO: http://www.fao.org/docrep/010/ah876e/ah876e05.htm)	Water area of Portugal (Wikipedia)
12	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	18.2 - 115.5 SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
13	T. Rotteveel, pers. com., 2007 via EPPO	2007	0.350 million EUR / year		Inflator 1 (2007)		
14	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	2-4 million EUR / year		No inflator used	For ranges an average has been calculated	
15	Carmen Álvarez, Department of Protection of Species, Balearic Islands Government, Spain, pers.comm. (as in Shine et al. 2009)	2009 (year of comm.)	EUR 251,030 (one off) (within LIFE 2000 NAT/E/73550)		No inflator used		
16	Langdon, S. J., Marrs, R. H., Hosie, C. A., McAllister, H. A., Norris, K. M., Potter, J. A. 2005. *Crassula helmsii* in UK ponds: Effects on plant biodiversity and implications for newt conservation. Floristische Rundbriefe. 30(1). 1996. 24-29. Leach & Dawson (1999) in OEPP/EPPO. 2007.	1999 (year of publication)	1.45 - 3 million EUR during 2-3 years		Inflator 1.27 (1999)	Average annual sum for 2.5 years used	

	Data sheets on quarantine pests *Crassula helmsii*						
17	EPPO pest risk assessment (and the references within) http://www.eppo.org/	2005-2008	14,68 million EUR / 4 years		Average inflator 1.02 (2005-2008)		
18	EPPO pest risk assessment (and the references within) http://www.eppo.org/	2007 - May 2008	0.278 million EUR / 1.5 year				
19	EPPO pest risk assessment (and the references within) http://www.eppo.org/	1999-2004	0.47 million EUR / 6 years		Average inflator 1.18 (1999 - 2004)		
20	Pest Risk Analysis for Water Hyacinth (Eichhornia crassipes) in Spain. EPPO PRA. Available online at : http://eppo.org/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14407%20PRA%20record%20Eichhornia%20crassipes%20EICCR.pdf [Accessed on 09/04/09] and Téllez et al. 2008. The Water Hyacinth, Eichhornia crassipes: an invasive plant in the Guadiana River Basin (Spain). Aquatic Invasions (2008) Volume 3, Issue 1: 42-53.	2005-2008	EUR 14.68 million over four years for 75 km / 200 ha river		Average inflator 1.06 (2005-2008)		
21	National experts, pers. com in 2008	2008	0.26 EUR / year		No inflator used		
22	Niall Moore, GB Non-Native Species Secretariat, pers.comm.	2006-2010	£ 35000 (2006-2010)	1 EUR = 0.7£	No inflator used		
23	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi,	2006	28 - 72.8 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	

	Uppsala, Sweden.						
24	National experts, pers. com in 2008	2008	0.015 Lt / year	1 Lt = 0.29 EUR	No inflator used		
25	Nummi, P. 2000. Alien Species In Finland. Case studies by Arto Kurtto, Jyrki Tomminen, Erkki Leppäkoski and Petri Nummi Ministry of the Environment 2000	1996-1998	Minimum US$ 50,000	1 EUR = 0,83 USD (average 1996-1998)	Average inflator 1.13 (1996-1998)		Are of Golf of Finland from Wikipedia
26	Defra. 2007. Impact Assessment of the Order to ban sale of certain non-native species under the Wildlife & Countryside Act 1981. Available online at: http://www.defra.gov.uk/wildlife-countryside/pdf/wildlife-manage/non-native/impact-assessment-order.pdf	2005-2006	£ 77,700 (one off)	1 EUR = 0.7£	Average inflator 1.06 (2005-2006)		
27	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2001 (year of publication)	2 billion US $ / year	1EUR = 1.25 USD	Inflator 1.19 (2001)		
28	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	1 million EUR / year		Inflator 1 (2007)		

29	Knowler, D. 2004. Reassessing the costs of biological invasion: *Mnemiopsis leidyi* in the Black sea.Ecological Economics. 52/2:187-199. Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2004 (year of publication)	16.7 million $US / year and 60 million EUR / 5 year	1EUR = 1.25 USD	Inflator 1.09 (2004)		Area of Black Sea (Wikipedia)
30	Leppakoski et al. 2000 and Hoppe pers. com. in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2000 (year of publication)	0.7 - 1.4 million EUR / year and 3.6 million EUR / year		Inflator 1.23 (2000)	For ranges an average has been calculated	
31	Gollasch (in print) DAISIE fact sheet; Hoppe, K. 2002. *Teredo navalis* – the cryptogenic shipworm. In Leppäkoski E, Gollasch S, Olenin S (eds) Invasive Aquatic Species of Europe: Distribution, Impacts and Management. KLUWER Academic Publishers, Dordrecht, The Netherlands, pp 116-119	2002 (year of publication)	25-50 Million EUR along German Baltic coast		Inflator 1.16 (2002)	For ranges an average has been calculated	
32	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	166 - 418 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
33	Skoldal HR & Dundas I 1991. The *Chrysochromulina polylepis* bloom in the Skagerrak and the Kattegat in May-June 1988: Environmental conditions, possible causes, and effects. ICES Cooperative Research Report, pp 1-59	1988	Outbreak in 1988 killed fish worth 11 Million US$	Average exchange rate in 1988 was 1 US$ = 1.77 German Marks = ca. 0,90 Euro.	Inflator 1.74 (1988)		

34	Gollasch (in print) DAISIE fact sheet: Hopkins 2002. Introduced marine species in Norway. In: Leppäkoski, E., Gollasch, S. & Olenin, S. (eds.): Invasive Aquatic Species of Europe: Distribution, Impacts and Management. KLUWER Academic Publishers, Dordrecht, The Netherlands. 583 pp.	1998	In spring 1998 the species killed 350 t of farmed Norwegian salmon		Inflator 1.3 (1998)	Salmon price Norway in 1998 ca. 30 NOK per kg = 3,8 Euro (http://www.ssb.no/english/magazine/art-2005-02-25-01-en.html)	
35	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	1.7 - 2.4 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
36	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	83 - 2,053 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
37	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2003 (year of publication)	5 (min 3.5 max 13.4) million EUR / year		Inflator 1.13 (2003)		
38	Nowak D, Pasek J, Sequiera RA, Crane D & Mastro V (2001) Potential effect of the Asian longhorned beetle (Coleoptera: Cerambycidae) on urban trees in the United States. Journal of Economic Entomology 94: 116–122.; APHIS (US Animal and Plant Health Inspection Service) (2003) Asian longhorned beetle. http://www.aphis.usda.gov/lpa/issues/alb/alb.html	2001 (year of publication)	1.1 million EUR / year		Inflator 1.19 (2001)		Range from DAISIE database

39	Hélène Menigaux, Ministère de l'Energie, de l'Ecologie, du Développement Durable et de l'Aménagement du Territoire, pers.comm. (as in Shine et al. 2009)	2008	410,000 EUR (one off)				Not included in the exprapolation calculations as area of impact unclear
40	Raffaele Tomaino personal communication; Maspero, M., Jucker, C., Colombo, M., Herard, F., Lopez, J., Ciampitti, M., Caremi, G. & Cavagna, B. 2005. Current situation of *Anoplophora chinensis* in Italy. http://www.eppo.org/QUARANTINE/anoplophora_chinensis/chinensis_in_it.htm	2005 (year of publication)	0.3 million EUR / year		Inflator 1.06 (2005)		Range from DAISIE database
41	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	90 - 450 SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
42	Naturvårdsverket. 2008. National Strategy and action plan for alien species. Swedish Environmental Protection Agency. Naturvårdsverkets rapport 5910.	2008	1.2 m Kr / year	1 EUR = 10 SEK	No inflator used		
43	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	10.02 - 33.8 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
44	DAISIE profile; http://www.gmo-safety.eu/en/maize/bt-concept/330.docu.html	2006 (year of publication)	500 million EUR / year		Inflator 1.03 (2006)		
45	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien	2003 (year of publication)	0.78 million EUE / year		Inflator 1.13 (2003)		

	species in Europe - DAISIE Deliverable 14 Report. 36 pp.						
46	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	0.02 - 0.2 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	
47	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	3.8 - 5 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	
48	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	7.8 - 21.6 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	
49	Defra (2003) in Parliamentary Office of Science and Technology note (April 2008, Number 303) (http://www.parliament.uk/documents/upload/postpn303.pdf)	2008	£ 20,000 - 30,000 / year (2008)	1 EUR = 0.7 £	No inflator used	For ranges an average has been calculated	
50	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	15-30 EUR / year		Inflator 1 (2007)	For ranges an average has been calculated	
51	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien	2001 (year of publication)	960 million $ US / year	I EUR = 1.25 USD	Inflator 1.19 (2001)		

	plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)						
52	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2006	1.1 - 36.4 SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	Range from DAISIE database
53	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2003 (year of publication)	32.1 (min 19.8 max 49.9) million EUR / year		Inflator 1.13 (2003)		
54	Uwe Starfinger, Julius Kühn Institute - Federal Research Centre for Cultivated Plants, pers.comm	2009	EUR 300,000 / year		No inflator used		Areal cover of Berlin (i.e. area where costs occurred)
55	Hélène Menigaux, Ministère de l'Energie, de l'Ecologie, du Développement Durable et de l'Aménagement du Territoire, pers.comm. (as in Shine et al. 2009)	2008	113,750 EUR (one off)		No inflator used		Not included in the exprapolation calculations as area of impact unclear
56	Andreu J and Vilà M. 2007. Análisis de la gestión de las plantas invasoras en España. Ecosistemas 3: 1-16	2007 (year of publication)	0.29 million EUR / year		Inflator 1 (2007)		Range from DAISIE database (only in Minorca, Spain)
57	Andreu J and Vilà M. 2007. Análisis de la gestión de las plantas invasoras en España. Ecosistemas 3: 1-16	2007 (year of publication)	1.58 million EUR / year		Inflator 1 (2007)		
58	Defra (2003) in Parliamentary Office of Science and Technology note (April 2008, Number 303) (http://www.parliament.uk/documents/upload/postpn303.pdf)	2003 (year of publication)	1.54 billion £ / year	1 EUR = 0.7 £	Inflator 1.13 (2003)		Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)
59	Parliamentary Office of Science and Technology note (April 2008, Number 303)	2008 (year of publication)	£ 0.5 million / six years	1 EUR = 0.7 £	No inflator used		Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)

	(http://www.parliament.uk/documents/upload/postpn303.pdf						
60	Křivánek 2006 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2006 (year of publication)	0.2 million EUR / year		Inflator 1.03 (2006)		Total land cover of the Chezh Republic (i.e. Total area - minus water areas) (Wikipedia)
61	Starfinger, U. & Kowarik, I. (2003): NeoFlora - Die wichtigsten invasiven (Pflanzenarten. http://www.floraweb.de/neoflora/handbuch.html)	2003 (year of publication)	7 million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
62	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2003 (year of publication)	15.8 - 31.7 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
63	http://www.defra.gov.uk/wildlife-countryside/resprog/findings/non-native/ecoscope-sect4.pdf	1992 - 2001 (year of publication)	£ 160,000 since 1992 / £ 8 million total	Avarage exchange rate 1 £ = 1.4 EUR (1992 - 2001)	Average inflator 1.37 (1992-2001)		Total land cover of Swansea (Wikipedia)
64	Child et al. 2001 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2001 (year of publication)	0.81 million EUR / year		Inflator 1.19 (2001)		Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)
65	Trevor Renals, Environment Agency, pers.comm. (as in Shine et al. 2009)	2006	£32,000 (one off costs)	1 EUR = 0.7 £	Inflator 1.03 (2006)		Total area of Wales and England
66	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.; Křivánek M. 2006. Biologické invaze a	2003 (year of publication)	0,01 million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)

	možnosti jejich předpovědi (Predikční modely pro stanovení invazního potenciálu vyšších rostlin). Acta Pruhoniciana vol 84, VÚKOZ Průhonice, 83 pp; Starfinger & Kowarik 2003						
67	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.; Křivánek M. 2006. Biologické invaze a možnosti jejich předpovědi (Predikční modely pro stanovení invazního potenciálu vyšších rostlin). Acta Pruhoniciana vol 84, VÚKOZ Průhonice, 83 pp; Starfinger & Kowarik 2003	2003 (year of publication)	1.05 (0.3 - 1.96) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
68	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.; Křivánek M. 2006. Biologické invaze a možnosti jejich předpovědi (Predikční modely pro stanovení invazního potenciálu vyšších rostlin). Acta Pruhoniciana vol 84, VÚKOZ Průhonice, 83 pp; Starfinger & Kowarik 2003	2003 (year of publication)	2.34 million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
69	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.; Křivánek M. 2006. Biologické invaze a možnosti jejich předpovědi (Predikční modely pro	2003 (year of publication)	7.7 (min) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)

	stanovení invazního potenciálu vyšších rostlin). Acta Pruhoniciana vol 84, VÚKOZ Průhonice, 83 pp; Starfinger & Kowarik 2003						
70	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.; Křivánek M. 2006. Biologické invaze a možnosti jejich předpovědi (Predikční modely pro stanovení invazního potenciálu vyšších rostlin). Acta Pruhoniciana vol 84, VÚKOZ Průhonice, 83 pp; Starfinger & Kowarik 2003	2003 (year of publication)	1.2 (min) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
71	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	16.7 - 134 million SEK / year (municipalities) 0.4 - 0.5 million SEK / year (road and railroad admin)	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	Total land cover of Sweden (i.e. total area minus water from Wikipedia)
72	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	0.033 - 6.77 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	Total land cover of Sweden (i.e. total area minus water from Wikipedia)
73	RPS ECOLOGY. 2007. Audit of responsibilities for non-native species within government departments, non-departmental public bodies, agencies, and local government in England, Scotland and Wales. Available online at: http://www.nonnativespecies.org/documents/JPP1294%20Defra%20Audit%20Final.pdf	2007 (year of publication)	£380,000 (over 3 years)	1 EUR = 0.7 £	No inflator used		Total area of river Tweed catchment

74	Klingenstein, F. (2007): NOBANIS – Invasive Alien Species Fact Sheet – Heracleum mantegazzianum. – From: Online Database of the North European and Baltic Network on Invasive Alien Species - NOBANIS www.nobanis.org, Date of access 12/11/2009.http://www.nobanis.org/files/factsheets/Heracleum_mantegazzianum.pdf	2005-2006	EUR 90,000 (2005) and EUR 240,000 (2006) (one off)		Inflator 1.06 (2005)		
75	Vilnis Bernards, Ministry of Environment, Latvia, pers. comm. (as in Shine et al. 2009)	2008	1,754,748 EUR (one off)		No inflator used		
76	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2003 (year of publication)	0.3 million EUR / year 75 - 1340 € / ha . year		Inflator 1.13 (2003)		
77	Andreu J and Vilà M. 2007. Análisis de la gestión de las plantas invasoras en España. Ecosistemas 3: 1-16	2007 (year of publication)	0.62 million EUR / year		Inflator 1.13 (2003)		
78	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	2 million EUR / year		Inflator 1.13 (2003)		Total land cover of NL (i.e. total area minus water from Wikipedia)
79	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2003 (year of publication)	1.4 (0.8 - 2.5) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
80	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt	2003 (year of publication)	20.7 (13.3 - 33.4) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)

	80/03, 1-299.						
81	Reinhardt, F., M. Herle, F. Bastiansen, and B. Streit. 2003. Economic Impact of the Spread of Alien Species in Germany. Texte Umweltbundes-amt 80/03, 1-299.	2003 (year of publication)	3.4 (1.5 - 3.7) million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
82	Edwards & Taylor 2008 and Jackson 2008 in Parliamentary Office of Science and Technology note (April 2008, Number 303) (http://www.parliament.uk/documents/upload/postpn303.pdf)	2008 (year of publication)	total costs £ 9.6 + 11 million = £ 20.7 million	1 EUR = 0.7 £	No inflator used	Annual cost calculated total / 14, i.e. based on 4 % discout rate in 20 year timescale	
83	Gritten RH. 1995. Rhododendron ponticum and some other invasive plants in the Snowdonia National Park. In: Pyšek P, Prach K, Rejmánek M, Wade M. (Eds). Plant invasions: General aspects and special problems. SPB Academic Publishing, Amsterdam	1995 (year of publication)	66.26 million EUR / year		Inflator 1.43 (1995)		Total land cover of UK (i.e. Total area - minus water areas) (Wikipedia)
84	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	1.2 - 14.5 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	Total land cover of Sweden (i.e. total area minus water from Wikipedia)
85	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2001 (year of publication)	1.4 billion $ US / year	I EUR = 1.25 USD	Inflator 1.19 (2001)		

86	Gebhardt 1996 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	1996 (year of publication)	1-3 million DEM / year	1 EUR = 1.95583 DEM	Inflator 1.38 (1996)	For ranges an average has been calculated	Range from DAISIE database
87	White PCL and Harris S. 2002. Economic and environmental costs of alien vertebrate species in Britain. In: Pimentel D. Biological invasions: economic and environmental costs of alien plant. Animal and microbe species. CRC Press, Boca Raton.	2002 (year of publication)	0.82 million EUR / year		Inflator 1.16 (2002)		Range from DAISIE database
88	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2001 (year of publication)	270 million $ US / year (9 US $ per pigeon)	I EUR = 1.25 USD	Inflator 1.19 (2001)		
89	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2001 (year of publication)	3.62 million EUR / year		Inflator 1.19 (2001)		
90	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C.,	2001 (year of publication)	1.2 million $ US / year	I EUR = 1.25 USD	Inflator 1.19 (2001)		

	Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)						
91	Scalere & Zaghi 2004 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2001 (year of publication)	0.21 million EUR / year		Inflator 1.19 (2001)		
92	Smallshire & Davey 1989 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	1989 (year of publication)	0.03 million EUR / year		Inflator 1.7 (1989)		
93	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	0.26 - 0.52 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
94	Adrados & Briggs 2002 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2002 (year of publication)	0.01 million EUR / year		Inflator 1.16 (2002)		Total land cover of Great Britain (i.e. Total area - minus water areas) (Wikipedia)
95	White & Harris 2002 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2002 (year of publication)	0.02 million EUR / year		Inflator 1.16 (2002)		

96	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	3.8 - 4.6 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
97	Moore et al.2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2001 - 2013	0.55 million EUR / year		Average inflator 0.92 (2001-2013)		Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)
98	Scalera & Zaghi 2004 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2004 (year of publication)	0.12 million EUR / year		Inflator 1.09 (2004)		Range from DAISIE database
99	Scalera & Zaghi 2004 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2004 (year of publication)	0.29 million EUR / year		Inflator 1.09 (2004)		Total land cover of France (i.e. Total area - minus water areas) (Wikipedia)
100	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	18 - 77 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	Total land cover of Sweden (i.e. Total area - minus water areas) (Wikipedia)
101	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	0.8 million EUR / year		No inflator used		Total land cover of the Netherlands (i.e. Total area - minus water areas) (Wikipedia)
102	Panzacchi et al 2007 in Vila, M. & Basnou, C. 2008. State of the art review of the	1981-1988	0.45 million EUR / year		Average inflator 1.9 (1981-1988)		Range from DAISIE database

	environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.						
103	Panzacchi et al 2007 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2000	3.77 million EUR / year		Inflator 1.23 (2000)		Range from DAISIE database
104	NOBANIS. 2006.	2006	EUR 2,614,408 (one off)		Inflator 1.03 (2006)		Range from DAISIE database
105	RPS ECOLOGY. 2007. Audit of responsibilities for non-native species within government departments, non-departmental public bodies, agencies, and local government in England, Scotland and Wales. Available online at: http://www.nonnativespecies.org/documents/JPP1294%20Defra%20Audit%20Final.pdf	2007 (year of publication)	£3.4 m (one off)	1 EUR = 0.7 £	No inflator used		Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)
106	National experts, pers. com in 2008	2008	0.04 Lt / year	1 EUR = 10 SEK	No inflator used		Total land cover of Lithuania (i.e. Total area - minus water areas) (Wikipedia)
107	Naturvårdsverket. 2008. National Strategy and action plan for alien species. Swedish Environmental Protection Agency. Naturvårdsverkets rapport 5910.	2008	4.2 million Kr / year		No inflator used		Total land cover of Sweden (i.e. Total area - minus water areas) (Wikipedia)
108	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	23 million EUR / year		Infator 1 (2007)		Total land cover of the Netherlands (i.e. Total area - minus water areas) (Wikipedia)

109	DAISIE profile; http://www.europe-aliens.org/speciesFactsheet.do?speciesId=649#	2006 (year of publication)	12.4 million EUR / year	-	Inflator 1.03 (2006)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
110	DAISIE profile; http://www.europe-aliens.org/speciesFactsheet.do?speciesId=649#	2006 (year of publication)	3 million EUR / year		Inflator 1.03 (2006)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
111	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	1.0 - 2.7 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
112	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	2 - 2.5 million EUR / year		Inflator 1.13 (2003)	For ranges an average has been calculated	Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
113	Reinhardt et al. 2003 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2003 (year of publication)	2.96 - 4. 36 million EUR / year		Inflator 1.13 (2003)		Total land cover of Germany (i.e. Total area - minus water areas) (Wikipedia)
114	Huw Thomas (DEFRA) pers. com.	during the 1930s	£ 2 million total costs	1 EUR = 0.7 £	Average inflator 8.56 (1930 - 1939)	Costs assumed to take place during 5 year period	Total land cover of the UK (i.e. Total area - minus water areas) (Wikipedia)
115	White & Harris 2002 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp;	2002 (year of publication)	1.2 billion $US / year	I EUR = 1.25 USD	Inflator 1.16 (2002)		
116	Gebhardt 1996 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe	1996 (year of publication)	10 million DEM / year	1 EUR = 1.95583 DEM	Inflator 1.38 (1996)		

	- DAISIE Deliverable 14 Report. 36 pp.						
117	White & Harris 2002 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp., Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2002 (year of publication)	41.18 million EUR / year		Inflator 1.16 (2002)		
118	http://www.defra.gov.uk/wildlife-countryside/non-native/pdf/ruddy-duck-qa.pdf	2005-2010	5 yrs eradication program for £ 3.337 million		Average inflator 0.94 (2005 - 2010)		Range from DAISIE database
119	Gebhardt 1996 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	1996 (year of publication)	2.5 million DEM / annually	1 EUR = 1.95583 DEM	Inflator 1.38 (1996)		
120	Scalera & Zaghi 2004 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2008 (date of communication)	0.00499 EUR / two years		No inflator used		Local costs, smallest possible range from DAISIE database = 2500 km2
121	National experts, pers. com in 2008	2003 (year of publication)	0.28 million EUR / year		Inflator 1.13 (2003)		Total are of Malta (from Wikipedia)

122	Gren, I-M., Isacs, L. & Carlson, M. 2007. Calculation of costs of alien invasive species in Sweden – technical report. SLU, Institutionen för ekonomi, Uppsala, Sweden.	2006	335 - 553 million SEK / year	1 EUR = 9.31 SEK	Inflator 1.03 (2006)	For ranges an average has been calculated	
123	Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84: 1–20 (e.g. references within)	2004 (year of publication)	4.1 billion $ US / year	I EUR = 1.25 USD	Inflator 1.09 (2004)		
124	Pier Luigi Fiorentino Alessandro La Posta (CGBN delegate) Ministry for the Environment, Land and Sea Directorate for the Protection of Nature - Division II "Protection of flora and fauna", pers. comm. (as in Shine et al. 2009)	2008 (year of publication)	EUR 200,000 (one off)		No inflator used		
125	White & Harris 2002 in Vila, M. & Basnou, C. 2008. State of the art review of the environmental and economic risks posed by invasive alien species in Europe - DAISIE Deliverable 14 Report. 36 pp.	2002 (year of publication)	0.46 million EUR / year		Inflator 1.16 (2002)		Range from DAISIE database
126	Forestry Commission. 2007. Towards a Forestry Commission England Grey Squirrel Policy. (http://www.forestry.gov.uk/pdf/greysquirrel-annex.pdf/$FILE/greysquirrel-annex.pdf)	2000	£10 million (one off)	1 EUR = 0.7 £	Inflator 1.21(2000)		Total area of Brittain
127	Johanna Niemivuo-Lahti (Senior Adviser, Natural Resources Unit, Ministry of	2009 (year of comm.)	EUR 47,100 (one off)		No inflator used		

	Agriculture and Forestry), pers. comm. (as in Shine et al. 2009)						
128	Pers.comm, Michel Perret, French Ministry of Ecology, Energy, Sustainable Development and Land Planning,	2008	EUR 20,000 per year		No inflator used		
129	National experts, pers. com in 2008	2008 - 2009	0.5 Lt / two years	1 Lt = 0.29 EUR	No inflator used		
130	Shine, C., Kettunen, M., Genovesi, P., Gollasch, S., Pagad, S. & Starfinger, U. 2008. Technical support to EU strategy on invasive species (IAS) - Policy options to minimise the negative impacts of IAS on biodiversity in Europe and the EU. Annex 3: updated information on member state instruments and activities relevant to IAS. (Final module report for the European Commission). Institute for European Environmental Policy (IEEP), Brussels, Belgium. xx pp. + Annexes).	2008	EUR 200,000 (one off)		No inflator used		
131	Wijden van der, W., Leewis, R. & Bol, P. 2007. Biological globalisation – Bio-invasions and their impacts on nature, the economy and public health. KNNV Publishing, Uthrecth, the Netherlands. 223 pp.	2007 (year of publication)	156 - 240 million EUR / year		Inflator 1 (2007)	For ranges an average has been calculated	

Annex IV. Full species specific reference list used in the context of this study to gather information on ecological and ecosystem service related impacts of IAS. More specific references for the economic data can be found in Annex III.

Species name	Reference	WebPage
Anguillicola crassus	Aguilar, A., M.F. A´ lvarez, J.M. Leiro, M.L. Sanmartı´n, 2005. Parasite populations of the European eel *(Anguilla anguilla* L.) in the Rivers Ulla and Tea (Galicia, northwest Spain). Aquaculture 249 (2005) 85– 94	
Anguillicola crassus	Didžiulis, V., 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Anguillicola crassus*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org.	http://www.nobanis.org/files/factsheets/Anguilicola_crassus.pdf
Anguillicola crassus	Joint Nature Conservation Committee (JNCC), 2007. *Anguillicola crassus*. Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage. United Kingdom. (2007).	http://www.jncc.gov.uk/page-1684
Anguillicola crassus	Audenaert, V., T. Huyse, G. Goemans, C. Belpaire, F. A. M. Volckaert., 2003. Spatio-temporal dynamics of the parasitic nematode *Anguillicola crassus* in Flanders, Belgium. Diseases of Aquatic Organisms Vol. 56: 223–233, 2003	
Anguillicola crassus	Cakic, P., Stojanovski, S., Kulisic, Z., Hristovski, N and Lenhardt Mirjana., 2002. Occurrence of *Anguillicola crassus* (Nematoda: Dracunculoidea) in eels of Lake Ohrid, Macedonis. Acta Veterinaria (Beograd), Vol. 52. No 2-3, 163-168, 2002.	
Anguillicola crassus	Koops, H., F. Hartmann, 1989. *Anguillicola*-infestations in Germany and in German eel imports. Journal of Applied Ichthyology 5 (1) , 41–45	
Anguillicola crassus	Gulf States Marine Fisheries Commission (GSMFC), 2003. *Anguillicola crassus* (Kuwahara, Niimi and Hagaki, 1974)	
Anguillicola crassus	Kennedy, C.R. 2007. The pathogenic helminth parasites of eels. Review Journal of Fish Diseases 2007, 30, 319–334	
Anguillicola crassus	Kirk, R. S., J.W. Lewis and C. R. Kennedy., 2000. Survival and transmission of *Anguillicola crassus* Kuwahara, Niimi & Itagaki, 1974 (Nematoda) in seawater eels. Parasitology (2000), 120, 289±295.	

Anguillicola crassus	Kirk, R.S., 2003. The impact of *Anguillicola crassus* on European eels. Fisheries Management and Ecology, 2003, 10, 385–394	
Anguillicola crassus	Palstra, A.P., D.F.M. Heppener, V.J.T. van Ginneken, C. Székely, G.E.E.J.M. van den Thillart., 2007. Swimming performance of silver eels is severely impaired by the swim-bladder parasite *Anguillicola crassus*. Journal of Experimental Marine Biology and Ecology 352 (2007) 244–256	
Anguillicola crassus	Starkie, A., 2003. Management issues relating to the European eel, *Anguilla anguilla*. Fisheries Management and Ecology, 2003, 10, 361–364	
Aphanomyces astaci	Taugbøl, T. and Johnsen, S. I. (2006): NOBANIS – Invasive Alien Species Fact Sheet – *Aphanomyces astaci*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access x/x/200x.	http://www.nobanis.org/files/factsheets/Aphanomyces_astaci.pdf
Aphanomyces astaci	Matthews, Milton and Julian D. Reynolds., 1992. Ecological impact of crayfish plague in Ireland. Hydrobiologia Volume 234, Number 1 / May, 1992	
Aphanomyces astaci	Matthews, M. & J. D. Reynolds., 1990. Laboratory investigations of the pathogenicity of Aphanomyces astaci for Irish freshwater crayfish. Hydrobiologia 203: 121-126, 1990.	
Aphanomyces astaci	Kettunen, M. & ten Brink, P. 2006. Value of biodiversity- Documenting EU examples where biodiversity loss has led to the loss of ecosystem services. Final report for the European Commission. Institute for European Environmental Policy (IEEP), Brussels, Belgium. 131 pp.	
Aphanomyces astaci	Lozán, José Luis., 2000. On the threat to the European crayfish: A contribution with the study of the activity behaviour of four crayfish species (Decapoda: Astacidae). Limnologica - Ecology and Management of Inland Waters. Volume 30, Issue 2, May 2000, Pages 156-161	
Aphanomyces astaci	Nylund, V., and K. Westman. 2000. The prevalence of crayfish plague (Aphanomyces astaci) in two signal crayfish (Pacifastacus leniusculus) populations in Finland. Journal of Crustacean Biology 20(4):777-785.	
Aphanomyces astaci	Rahe, R., and E. Soylu. 1989. Identification of the pathogenic fungus causing destruction to Turkish crayfish stocks Astacus leptodactylus. Journal of Invertebrate Pathology 54(1):10-15.	
Aphanomyces astaci	Taugbol, T., J. Skurdal, and T. Hastein. 1992. Crayfish plague and management strategies in Norway. Biological Conservation 63(1):75-82.	
Azolla filiculoides	Costa, M.L.; Santos, M.C.; and Carrapico, F., 1999. Biomass characterization of *Azolla filiculoides* grown in natural ecosystems and wastewater. Hydrobiologia 1999, vol. 415 (349 p.) (23 ref.), pp. 323-327	

Azolla filiculoides	Hussner, A. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Azolla filiculoides.* – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access x/x/200x.	http://www.nobanis.org/files/factsheets/Azolla_filiculoides.pdf
Azolla filiculoides	Janes, R., 1998a: Growth and survival of *Azolla filiculoides* in Britain. 1. Vegetative reproduction. New Phytologist 138: 367-376	
Azolla filiculoides	Mostert, K. 1998. Dragonflies (Odonata) in the agricultural landscape of South Holland. Levende Natuur. 99(4). July, 1998. 142-149.	
Azolla filiculoides	Janes, Rachel. 1998b. Growth and survival of *Azolla filiculoides* in Britain: II. Sexual reproduction [Article] New Phytologist. 138(2). Feb., 1998. 377-384.	
Azolla filiculoides	Janes, Rachel A.; Eaton, John W.; Hardwick, Keith. 1996. The effects of floating mats of *Azolla filiculoides* Lam. and *Lemna minuta* Kunth on the growth of submerged macrophytes [Article] Hydrobiologia. 340(1-3). 1996. 23-26.	
Azolla filiculoides	Dana, Elías D. and S. Viva ., 2006. *Stenopelmus rufinasus* Gyllenhal 1836 (Coleoptera: Erirhinidae) Naturalized in Spain. The Coleopterists Bulletin Volume 60, Issue 1 (March 2006) pp. 41–42	
Azolla filiculoides	Craigavon Borough Council., 2008. Local Biodiversity Action Plan: Reedbeds	http://www.craigavon.gov.uk/environment/bio/Reedbeds%20plan.doc
Azolla filiculoides	Surrey Biodiversity Plan., 2007. Surrey's Habitat Action Plan (HAP) for standing open water and large reedbeds.	http://www.surreybiodiversitypartnership.org/xwiki/bin/view/Reedbed/ActionPl an
Azolla filiculoides	Smith, Helen., undated. *Dolomedes plantarius* populations in the UK	http://www.wavcott.org.uk/dolomedes/cons.html#PL
Azolla filiculoides	World Conservation Monitoring Centre (WCMC) 1996. *Dolomedes plantarius*. In: IUCN 2007. 2007 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 31 March 2008.	http://www.iucnredlist.org/search/details.php/6790/all
Cercopagis pengoi	Birnbaum, C. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Cercopagis pengoi*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access x/x/200x.	http://www.nobanis.org/files/factsheets/cercopagis_pengoi.pdf
Cercopagis pengoi	Telesh, V. Irena and Henn Ojaveer., The predatory water flea Cercopagis pengoi in the Baltic Sea: invasion history, distribution and implications to ecosystem dynamics in Invasive Aquatic Species of Europe: Distribution, Impacts and Management Erriki Leppakoski and Stephan Gollasch.	

Cercopagis pengoi	Krylov, P.I. ., D.E. Bychenkov, V.E. Panov, N.V. Rodionova and I.V. Telesh., 1999. Distribution and seasonal dynamics of the Ponto-Caspian invader Cercopagis pengoi (Crustacea, Cladocera) in the Neva Estuary (Gulf of Finland). Hydrobiologia. Volume 393, Number 0 / February, 1999	
Cercopagis pengoi	Reise, Karsten ., Sergej Olenin and David W. Thieltges., 2006. Are aliens threatening European aquatic coastal ecosystems? Helgoland Marine Research Volume 60, Number 2 / May, 2006	
Cercopagis pengoi	Gorokhova, Elena; Nikolai Aladin & Henri J. Dumont., 2000. Further expansion of the genus Cercopagis (Crustacea, Branchiopoda, Onychopoda) in the Baltic Sea, with notes on the taxa present and their ecology. Hydrobiologia 429: 207–218, 2000.	
Cercopagis pengoi	Litvinchuk, Larissa F.& Irena V. Telesh., 2006. Distribution, population structure and ecosystem effects of the invader Cercopagis pengoi (Polyphemoidea, Cladocera) in the Gulf of Finland and the open Baltic Sea. OCEANOLOGIA, 48 (S), 2006. pp. 243–257.	
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Cercopagis pengoi	Orlova, Marina I., Irena V. Telesh, Nadezhda A. Berezina, Alexander E. Antsulevich, Alexey A. Maximov, Larissa F. Litvinchuk., 2006. Effects of nonindigenous species on diversity and community functioning in the eastern Gulf of Finland (Baltic Sea). Helgol Mar Res (2006) 60: 98–105	
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Cercopagis pengoi	Grigorovich, Igor A., Thomas W. Therriault & Hugh J. MacIsaac, 2003. History of aquatic invertebrate invasions in the Caspian Sea. Biological Invasions 5: 103–115, 2003.	
Cercopagis pengoi	Ojaveer, Henn., Jonne Kotta, Helen Orav-Kotta, Mart Simm, Ilmar Kotta, Ain Lankov, Arno Põllumäe and Andres Jaanus., 2003. Alien Invasive Species in the North-East Baltic Sea: Monitoring and Assessment of Environmental Impacts. Financed by the US State Department (grant award number SEN100-02-GR069) Estonian Marine Institute, University of Tartu Tallinn 2003	
Cercopagis pengoi	Telesh, I. V., P. V. Bolshagin, and V. E. Panov., 2001. Quantitative Estimation of the Impact of the Alien Species Cercopagis pengoi (Crustacea: Onychopoda) on the Structure and Functioning of Plankton Community in the Gulf of Finland, Baltic Sea. Doklady Biological Sciences, Vol. 377, 2001, pp. 157–159. Translated from Doklady Akademii Nauk, Vol. 377, No. 3, 2001, pp. 427–429.	
Cercopagis pengoi	Nummi, Petri ., 2000. Alien Species In Finland. Case studies by Arto Kurtto, Jyrki Tomminen, Erkki Leppäkoski and Petri Nummi Ministry of the Environment 2000	

Cercopagis pengoi	Zolubas, T.; J. Maksimov and Š. Toliušis., 2004 .Impacts of Cercopagis pengoion Lithuanian Coastal Fishery. Gdynia 25-27.08.2004	
Corbicula fluminea	Rajagopal S.; Van der Velde, G.; De Vaate, A. Bij., 2000. Reproductive biology of the Asiatic clams Corbicula fluminalis and Corbicula fluminea in the river Rhine. Archiv für Hydrobiologie 2000, vol. 149, no3, pp. 403-420 (2 p.1/4)	
Corbicula fluminea	Hartog, Den C; F. W. B. Van Den Brink and G. Van Der Velde., 1992. Why was the invasion of the river Rhine by Corophium curvispinum and Corbicula species so successful?. Journal Of Natural History, 1992, 26, 1121-1129	
Corbicula fluminea	Darrigran, Gustavo., 2002. Potential impact of filter-feeding invaders on temperate inland freshwater environments. Biological Invasions 4: 145–156, 2002.	
Corbicula fluminea	Renard, E. ., V. Bachmann, M. L. Cariou, J. C. Moreteau 2000. Morphological and molecular differentiation of invasive freshwater species of the genus Corbicula (Bivalvia, Corbiculidea) suggest the presence of three taxa in French rivers. Molecular Ecology 9 (12) , 2009–2016	
Corbicula fluminea	Araujo, R.; Moreno, D.; Ramos, M.A. 1993. The Asiatic clam Corbicula fluminea (Müller, 1774) (Bivalvia: Corbiculidae) in Europe. Am. Malacol. Bull. 10(1): 39-49 [Other original].	
Corbicula fluminea	Pfenninger, M., F. Reinhardt, B. Streit 2002. Evidence for cryptic hybridization between different evolutionary lineages of the invasive clam genus Corbicula (Veneroida, Bivalvia) Journal of Evolutionary Biology 15 (5) , 818–829	
Corbicula fluminea	Ortmann, Christian and Manfred K. Grieshaber, 2003. Energy metabolism and valve closure behaviour in the Asian clam Corbicula fluminea. The Journal of Experimental Biology 206, 4167-4178 (2003)	
Corbicula fluminea	Kinzelbach, R., 1995. Neozoans in European waters - Exemplifying the worldwide process of invasion and species mixing. Experientia 51 (1995), Birkh/iuser Verlag, CH-4010 Basel/Switzerland	
Corbicula fluminea	Khalanski, M., Bergot, F., Vigneux, E., 1997. Industrial and ecological consequences of the introduction of new species in continental aquatic ecosystems: the zebra mussel and other invasive species. Bulletin francais de la peche et de la pisciculture. 1997.	
Corbicula fluminea	Karatayev, Alexander Y., Lyubov E. Burlakova, and Dianna K. Padilla., 2005. Contrasting distribution and impacts of two freshwater exotic suspension feeders, Dreissena polymorpha and Corbicula fluminea., in R.F. Dame and S. Olenin (eds.), The Comparative Roles of Suspension-Feeders in Ecosystems, 239–262. ©2005 Springer. Printed in the Netherlands.	
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Corbicula fluminea	Nguyen, Lien T.H. and Niels De Pauw., 2002. The invasive Corbicula species (Bivalvia, Corbiculidae) and the sediment quality in Flanders, Belgium. Belg. J. Zool., 132 (1): 41-48	
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