ARES(2014)2425342 - 22/07/2014

Organisation and running of a scientific workshop to complete selected invasive alien species (IAS) risk assessments

Contractor: Natural Environment Research Council

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* denotes the author did not attend the workshop or contribute to final decisions with respect to the compliance of the risk assessment to the minimum standards but made substantial contributions in providing information to address gaps on species prior to the workshop

AUTHOR BIOGRAPHIES

Helen Roy, Group Head and Principal Scientist, leads zoological research within the UK Biological Records Centre (part of the NERC Centre for Ecology & Hydrology), which is the UK focus for terrestrial and freshwater species recording. The BRC database contains over 15 million records of more than 12000 species. Helen's work focuses on the use of large-scale and long-term datasets on the distribution and abundance of species to understand and predict the effects of environmental change on biodiversity. The current focus of her research is predicting the biological impact of invasive alien species (IAS). Helen has worked on IAS for 10 years and as a community ecologist for 20 years. She is responsible for maintenance and further development of the Delivering Alien Invasive Species Inventories for Europe (DAISIE) web database, and the GB-Non-Native Species Information Portal (GB-NNSIP). The GB-NNSIP provides information to underpin IAS strategy in GB and also includes an effective system for early warning for the funding body (Defra). In addition Helen developed the GB biodiversity indicator for IAS. Recently she led a consensus workshop, on behalf of Defra, to derive a list of IAS predicted to arrive, establish and threaten biodiversity within GB. Helen led the task "Establishment of an EU information system on alien and invasive alien species" as part of the EU IAS strategy consultation. She is the chair of the newly formed COST Action ALIEN Challenge (TD1209) which has been implemented to link and analyse information on IAS across Europe. Helen also has extensive expertise in citizen science and recently led a major review which was published both as an extensive report and a guide to citizen science. Helen has recently been awarded the Zoological Society of London prestigious Silver Medal in recognition of her contribution to understanding and appreciation of zoology, recognising her leading role in science communication. Both the GB-NNSIP (and associated research on IAS within GB) and the COST Action highlight the expertise of Helen in leading large, multidisciplinary research teams to deliver high quality research. Helen was the project leader for the recently completed "Invasive alien species – framework for the identification of invasive alien species of EU concern" (ENV.B.2/ETU/2013/0026). She co-led the workshop described through this report.

Riccardo Scalera, IUCN/SSC Invasive Species Specialist Group (ISSG), is a naturalist with over 16 years of professional experience in the field of conservation biology, wildlife management and vertebrate ecology, and a proficient expertise on European environmental policy and legislation, particularly in the field of nature protection and biodiversity (e.g. Habitats and Birds directives), sustainable exploitation of natural resources (e.g. in relation to the CITES and related Wildlife Trade regulations, etc.) and some relevant financial programmes (LIFE, Horizon 2020). Riccardo has worked for several public institutions and private companies - at both the international level (i.e. including the European Commission, the EEA, the REA, the JRC, the Council of Europe, IUCN International, WWF-European Policy Programme) and the national level (the Ministry of the

Environment in both Italy and Denmark, the Italian Ministry of Agriculture, the University of Rome) – across a number of biodiversity and nature conservation issues. Moreover he has been working as journalist, and has published several articles in both popular magazines and scientific journals. In relation to the IAS issue, he has been actively contributing to the development of key EU policy documents such as the EC report "Assessment to support continued development of the EU Strategy to combat invasive alien species", the EEA technical reports on early warning and information system for IAS (no. 5/2010), on SEBI 2010 (no.15/2012) and on the impact of IAS (no. 16/2012) plus other EEA unpublished documents like the review of SEBI indicator 10 and the analysis of EU funding for management and research of IAS in Europe. Moreover, he fed and validated the information in the database for DAISIE (Delivering Alien Invasive Species In Europe), as well as the new EASIN database managed by the JRC. Finally, Riccardo has contributed to draft documents for both the Berne Convention (e.g. a black list of alien species in trade in Europe, and guidelines on IAS and zoos and aquaria) and the Convention of Bonn (a review on the impact of IAS on CMS species, with recommendations for a greater involvement of the convention in the fight against biological invasions) which led to the adoption of specific recommendations. Furthermore, since 2009 he is programme officer of the IUCN/SSC Invasive Species Specialist Group and co-editor of Aliens: the Invasive Species Bulletin. Riccardo is leading communications across all working groups within the newly developed COST Action Alien Challenge (TD1209). Riccardo led Task 5 for the recently completed "Invasive alien species – framework for the identification of invasive alien species of EU concern" (ENV.B.2/ETU/2013/0026). He co-led the workshop described through this report.

Olaf Booy is Technical Coordinator for the Non-native Species Secretariat in Great Britain. He has worked on a wide range of invasive alien species for over 10 years, including practical management, research and policy delivery. He helped to develop GB's invasive alien risk analysis mechanism, which he now manages, working closely with species experts, risk analysts and stakeholders to provide robust evidence to support decision makers. Olaf provided expertise on risk assessments and specifically the GB NNRA on day 1 of the workshop (Niall Moore provided the same on day 2). He also provided additional information for many species.

Etienne Branquart is the head of the invasive species unit at the "Service Public de Wallonie". He coordinates preventive and control actions against invasive species for the Walloon Government. Etienne formerly worked for the Belgian Biodiversity Platform for which he established the Belgian Forum on Invasive Species and developed the Belgian list and information system on invasive species (incl. ISEIA quick screening protocol). This list system inspired the development of different tools by policy makers, including a national code of conduct on invasive ornamental plants and new regulatory tools. Etienne has also been the scientific supervisor of the Belgian Alien Alert project that produced the Harmonia+ horizon scanning tool and has been actively involved with different scientists in the development of detailed risk assessment reports for more than 20 non-native species in Belgium. He is involved as a national expert within the EPPO panel on invasive plants and the EC project "IAS - Framework for the identification of IAS of EU concern". During the workshop, Etienne provided expertise on the risk assessments of invasive aquatic plants.

Belinda Gallardo is a postdoctoral researcher currently based at Pyrenean Institute of Ecology (IPE-CSIC) in Spain. She is specialized in the use of ecological modelling to predict the spread, distribution and impact of invasive species. She is particularly interested in the interplay between climate change, ecosystem services and invasive species. During the workshop she provided advice on climate change to underpin collation of information in relation to the minimum standard "Includes possible effects of climate change in the foreseeable future".

Piero Genovesi is the chair of IUCN SSC Invasive Species Specialist Group Masters and a senior scientist with ISPRA. He was a co-author in 2004 of the European Strategy on Invasive Alien Species of the Bern Convention and served on the SSC task force that produced the IUCN Guidelines on Reintroductions and other Conservation Translocations, adopted by IUCN in 2012. Since 2009 Piero has been the Chair of the IUCN SSC Invasive Species Specialist Group, and since 2013 a member of the Steering Committee of IUCN SSC. Piero collaborates with major international institutions, such as the Convention on Biological Diversity, the European Union, the Bern Convention, the European Environment Agency, and the Convention on Migratory Species. He has published several papers on the patterns of invasions and the responses to this threat, including articles and commentaries for illustrious journals such as Science, Nature, PNAS, PLoS, Frontiers in Ecology and the Environments, Conservation Biology, Trends in Ecology and Evolution and Global Change Biology. During the workshop Piero contributed general expertise on invasion biology and more specifically on impacts on threatened species and protected habitats to support the collation of information in relation to the minimum standard "Includes status (threatened or protected) of species or habitat under threat". Piero also provided expertise on the risk assessments of vertebrates.

Melanie Josefsson is within the Policy Development Department of the Swedish Environment Protection Agency. She has extensive expertise on IAS and contributes as an international expert to many panels and committees including the CBD and Noabanis. Melanie provided general expertise on risk assessments throughout the workshop but specifically contributed to the risk assessments for vertebrates and aquatic species.

Marianne Kettunen is a principal policy analyst at the Institute for European Environmental Policy (IEEP) London / Brussels. She is an expert on EU and global biodiversity policy with specific focus on the integration of information on ecosystem services and related socio-economic benefits into policies and decision-making. She has also worked extensively on IAS, including authoring several EU-level policy assessments since 2007 and leading the study developing the aggregated 12 billion EUR cost estimate for IAS impacts in the EU. Marianne was instrumental to the delivery of "Invasive alien species – framework for the identification of invasive alien species of EU concern" (ENV.B.2/ETU/2013/0026). During the workshop she provided advice on ecosystem services to underpin collation of information in relation to the minimum standard "Can broadly assess environmental impact with respect to ecosystem services".

Merike Linnamägi is a senior officer in the Nature Conservation Department of Estonian Ministry of Environment. She is the leading specialist in Estonian alien species administration and was involved in the preparation of the new EU invasive alien species regulation. Merike is member of European and Mediterranean Plant Protection Organization (EPPO) Panel on Invasive Alien Plants and member of the Steering Committee of the European Network on Invasive Alien Species (NOBANIS). During the workshop Merike provided expertise on risk assessments generally and specifically aquatic animals.

Frances Lucy is a researcher and lecturer at the Institute of Technology, Sligo. She is Director of CERIS, the Centre for Environmental Research Innovation and Sustainability at IT Sligo. Her main research interests are aquatic invasive species, fisheries science and human waterborne pathogens. She is involved in a range of international invasive species forums in both Europe and North America. Frances is Editor-in-Chief of the journals, Aquatic Invasions and BioInvasions Records. Frances is a member of the core committee for COST Action ALIEN Challenge TD1209, in which she leads the short term scientific missions. During the workshop Frances provided expertise on aquatic species.

Angeliki- Kelly Martinou is an ecologist who has recently joined the Joint Services Health Unit in Cyprus where her work focuses on the impact and management of insect vectors of human pathogens. Previously, she worked as a postdoctoral researcher and consultant in the UK, Greece and Cyprus on research projects regarding invasive pests and invasive biocontrol agents. She has developed a strong interest in addressing the ecosystem services approach in IAS research. Through the COST Action ALIEN CHallenge TD1209 she developed an invasive alien species database for Cyprus (CYIAS) under the guidance of Argyro Zenetos (HCMR). During the workshop she provided expertise on plants.

Niall Moore is the head of the Non-native Species Secretariat in Great Britain and Chief Non-native Species Officer for England. He has been working on alien species in both a research capacity and in policy delivery for over two decades, including establishing the risk analysis mechanism for GB which has overseen the completion of nearly 100 risk assessments, many of which were considered by the workshop. Niall provided expertise on risk assessments and specifically the GB NNRA on day 1 of the workshop (Olaf Booy provided the same on day 2).

Jan Pergl focuses on the research of population biology of invasive plants, with interest in modelling techniques, application of GIS and analysis of large datasets. He is currently project coordinator of research project "Naturalization of garden plants as a result of interplay of species traits, propagule pressure and residence time" and participates in the COST Action ALIEN Challenge in which he leads a working group. Currently he is employed at Department of Invasion Ecology at the Institute of Botany. He participated in several EU projects (ALARM, PRATIQUE, DAISIE and GIANT ALIEN) and closely cooperates with the Ministry of the Environment of the Czech Republic in the field of biological invasions. During the workshop Jan contributed knowledge on risk assessments for plants.

Wolfgang Rabitsch is senior expert on nature conservation, biogeography, non-indigenous species and the impact of climate change on biodiversity at the Department of Biodiversity & Nature Conservation at the Environment Agency Austria in Vienna. He contributed to several global and European projects and initiatives (DAISIE, NOBANIS, EASIN, SEBI2010, Habitat Directive, GBO4) for the European Commission, the European Environment Agency and national authorities. He co-developed a risk assessment and early warning tool for invasive alien species in Germany and Austria (GABLIS). Recently, he co-authored the new “Austrian Biodiversity Strategy 2020+”. During the workshop Wolfgang contributed knowledge on risk assessments for insects and vertebrates.

Wojciech Solarz is a principal scientist at the Institute of Nature Conservation, Polish Academy of Sciences. His main research themes include theoretical aspects of biological invasions and practical solutions to mitigate their impacts. He is the vice-chair of the Bern Convention Expert Group on Invasive Alien Species, member of the State Council for Nature Conservation and manager of the Alien Species in Poland portal. During the workshop Wojciech contributed knowledge on risk assessments for vertebrates.

Teodora Trichkova is a researcher at the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences. Her main areas of research are: biology and ecology of freshwater fish, aquatic invasive alien species, invasive alien species risk assessment and management. She is a chair of the East and South European Network for Invasive Alien Species (ESENIAS) and focal point for the Lower Danube River in the Danube Region Invasive Alien Species Network (DIAS).

Johan van Valkenburg is currently a Senior Scientist at the National Plant Protection Organisation of the Netherlands (NVWA), leading research projects relating to invasive non-native plants. This work ranges from pathway analysis of seed contaminants in bird feed and soil borne contaminants in bonsai, to building an information system on potential invasive plant species for the Netherlands and neighbouring countries (http://www.q-bank.eu/Plants/) and creating field guides in order to identify them. During the workshop he was in close collaboration with Etienne Branquart responsible for the analysis of the risk assessment of aquatic plants and providing missing information.

Argyro Zenetos is currently a research Director at the Institute of Biological Resources and Inland Waters HCMR, with a 30 year experience in the systematics and biodiversity of benthic macrofauna. Environmental impact studies and development of indicators related to pollution/disturbance from industrial effluent, (tannery, red mud, coarse metalliferous waste), oil spills, and trawling are included among her research activity. She is the co-ordinator of the Hellenic network on Aquatic Invasive Species (ELNAIS) http://elnais.hcmr.gr. As a member of the SEBI2010 expert group on “trends in invasive alien species -see http://biodiversity-chm.eea.eu.int/information/indicator/F1090245995, *she is* responsible for marine alien species and has developed a Pan-European database which is updated to June 2014 under EEA contracts. Member of the EASIN Editorial Board and Consultant to UNEP MAP RAC/SPA for the development of MAMIAS (a Mediterranean Alien Species database). Argyro is a national expert in ESENIAS and COST Action ALIEN Challenge TD1209.

ACKNOWLEDGEMENTS

The project team is grateful to the European Commission for funding this study. Particular thanks to Myriam Dumortier, Valentina Bastino and Spyridon Flevaris for their invaluable support and guidance throughout. Thanks also to all the additional experts who contributed information so willingly and enthusiastically. Particular thanks to Sarah Brunel, for providing advice at an early stage of the work. We would like to thank Prof. Dr. F. Guler Ekmekci, Prof. Leopold Füreder and Dr. Lucian Parvulescu for contributions of information on aquatic organisms. Thanks also to Sandro Bertolino, Stelios Katsanevakis, Adriano Martinoli, Maria Vittoria Mazzamuto, John Gurnell, Peter Lurz and Lucas Wauters for drafting new risk assessment protocols for consideration against the minimum standards.

Helen Roy and Riccardo Scalera would like to gratefully acknowledge the inspiring contributions made by all the workshop participants – without the expertise they so generously provided this report would not have been possible.

Contents

EXECUTIVE SUMMARY

The introduction and spread of invasive alien species (IAS) constitutes one of the most important drivers of global change in biodiversity and ecosystem services. Robust risk assessment methods are required for IAS to provide the foundation upon which to prioritise appropriate action.

In a previous study (Roy, Schonrogge et al. 2014) minimum standards were developed to provide an assessment framework for risk assessments and ultimately for underpinning the development of a proposed list of "IAS of EU concern", in accordance to the provisions of the Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. In practice, of the protocols assessed in detail, only four (GB NNRA, EPPO DSS, Harmonia^{+} and ENSARS) were sufficiently compliant with the minimum standards to be considered and of these only the GB NNRA and EPPO DSS have published IAS risk assessments. As a result, using the information from such "substantially compliant" protocols, a draft list of approximately 50 species was compiled. It is important to note that this list of species is based on availability of robust risk assessments already completed through methods which are almost compliant with the minimum standards, and it does not constitute the list of "IAS of EU concern".

In view of the application of the forthcoming EU Regulation on IAS (and building-on ENV.B.2/ETU/2013/0026) the Commission hosted a 2-day scientific workshop to examine the selected risk assessments and pool the existing knowledge existing in the EU to complete the missing information, on the basis of robust scientific evidence, in order to make them fully compliant with the minimum standards, wherever possible.

The workshop was led by Helen Roy (CEH) and Riccardo Scalera (ISSG). An additional 16 experts from fifteen member states were selected based on their expertise in invasion biology and represented a breadth of expertise from a variety of perspectives including taxonomic (all taxa), environmental (freshwater, marine and terrestrial), impacts (environmental, socio-economic and health) and disciplines (ecologists, conservation practitioners, scientists, policy-makers, risk assessors). In view of the gaps across risk assessments for ecosystem services and climate change two experts were invited to guide the development of approaches for these specific themes.

In total the risk assessments for 56 species were considered. The GB NNRA and EPPO DSS have published IAS risk assessments which, when considering species that score medium to high impact, together cover 51 species (noting that *Fallopia japonica* and *F. sachalinensis* are separate species). Two further risk assessments were suggested for consideration by the GB Non-Native Species Secretariat which follow the GB NNRA protocol: coati (*Nasua nasua*) and skunk (*Mephitis mephitis*), although scored as low impact. Finally an additional three species have been considered through new European–wide risk assessments, with the reported outcome of high impact, for this project which again follow the GB NNRA protocol: Pallas squirrel (*Callosciurus erythraeus*), grey squirrel (*Sciurus carolinensis*) and coypu (*Myocastor coypus*).

The main gaps across all risk assessments were in relation to climate change and ecosystem services but additional information was also required on benefits as mentioned with minimum standard "Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)" and in some cases information to support the minimum standard "Includes status (threatened or protected) of species or habitat under threat" was missing.

It was agreed that systematic consideration of a list of questions in relation to the minimum standards on ecosystem services and climate change would be useful guidance for experts. An outline of the approaches agreed through the workshop for the minimum standards "Includes possible effects of climate change in the foreseeable future" and "Can broadly assess environmental impact with respect to ecosystem services" were developed as guidance for documenting information in relation to climate change and ecosystem services.

Each species was considered separately with the experts providing an overview of the information available for addressing the identified gaps. After all species had been considered the workshop participants (excluding the EC, Helen Roy and Riccardo Scalera) adopted a consensus approach to confirm whether or not the risk assessment was compliant with the minimum standards and whether the overall score of the risk assessment remained applicable. No changes were made to the scores but any recommendations were noted. There were very few recommendations for change. The outcome for each risk assessment was agreed and summarised as "compliant" or "not compliant" with the minimum standards.

Of the risk assessments for the 56 species considered through this project, 53 were agreed to be fully compliant with the minimum standards. However, Pacific oyster, *Crassostrea gigas*, although compliant with the minimum standards should be excluded as it is not within the scope of the regulation (see art 2.e) because it is listed in annex IV of Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture. Four of the risk assessments were not considered to be compliant because of major information gaps: *Elodea canadensis* (Canadian pondweed), *Heracleum mantegazzianum* (giant hogweed), *M. mephitis* (skunk), *N. nasua* (coati).

SUMMARY OF DELIVERABLES

Deliverable 1: Description of gaps per risk assessment protocol

Refer to: Table 2.1

Deliverable 2: Approximately 50 (or more) updated risk assessments, including all necessary references, clearly indicating which risk assessments comply or do not comply with the minimum standards. The risk assessments will be provided with clear evidence of the modifications made through this process. Additionally the way in which the gaps have been addressed will be documented in a format that will be useful to guide future risk assessments.

Refer to: Overview of information compiled against the minimum standards for each risk assessment considered through the workshop

Deliverable 3: A report on the workshop that will guarantee full transparency of the process.

See: Workshop report.

Deliverable 4: For the risk assessments still not meeting the minimum standards: a detailed description of the missing information.

Refer to: 4. Concluding remarks

ACRONYMS

IAS – Invasive Alien Species

CBD – Convention on Biological Diversity

CEH – Centre for Ecology & Hydrology

CICES – Common International Classification of Ecosystem Services

COST – European Cooperation in Science and Technology

EAA – Environment Agency Austria

EASIN – European Alien Species Information Network

EPPO – European and Mediterranean Plant Protection Organisation

EPPO DSS – EPPO Decision Support Scheme

EC – European Commission

EU – European Union

GB NNRA – Great Britain Non-Native Risk Assessment

GISD – Global Invasive Species Database

IEEP – Institute for European Environmental Policy

IPCC – Intergovernmental Panel on Climate Change

IPPC – International Plant protection Convention

ISEIA – Invasive Species Environmental Impact Assessment Protocol

ISSG – IUCN Species Survival Commission Invasive Species Specialist Group

IUCN – International Union for Conservation of Nature

MAES – Mapping and Assessment of Ecosystems and their Services

MEA – Millennium Ecosystem Assessment

MS – Member State

MSFD – Marine Strategy Framework Directive

NAAEC – North American Agreement on Environmental Cooperation

NAFTA – North American Free Trade Agreement

NIS – non-indigenous species

NNSS – GB non-native species secretariat

OIE – World Organisation for Animal Health

PRA – Pest Risk Analysis

PRATIQUE – Pest Risk Analysis TechnIQUES

RA – Risk assessment

SAC - Special areas of Conservation

SPS – Sanitary and Phytosanitary Measures

TEEB – The Economics of Ecosystems and Biodiversity

WFD – Water Framework Directive

WoRMS – World Register of Marine Species

WRA – Weed Risk Assessment

WTO – World Trade Organisation

GLOSSARY

Alien species (= non-native species) are species introduced (i.e. by human action) outside their natural past or present distribution; including any part, gametes, seeds, eggs or propagules of such species that might survive and subsequently reproduce as defined by the Convention on Biological Diversity (CBD). Lower taxonomic ranks such as subspecies, varieties, races or provenances can also be non-native.

Biodiversity is biological diversity at all scales: the variety of ecosystems in a landscape; the number and relative abundance of species in an ecosystem; and genetic diversity within and between populations as defined by the Convention on Biological Diversity (CBD).

Ecosystem services are the benefits people obtain from ecosystem processes and functions as defined by the Convention on Biological Diversity (CBD).

Climate change refers to change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC).

Invasive alien species (IAS) are species that are initially transported through human action outside of their natural range across ecological barriers, and that then survive, reproduce and spread, and that have negative impacts on the ecology of their new location and / or serious economic and social consequences as defined by the Convention on Biological Diversity (CBD).

Minimum standards are common criteria which provide a framework to ensure that risk assessment protocols are effective and of sufficient scope and robustness to ensure compliance with the rules of the WTO.

Risk assessment of IAS is the technical and objective process of evaluating biological or other scientific and economic evidence to identify potentially invasive species and determine the level of invasion risk associated with a species or pathway and specifically whether an alien species will become invasive (Genovesi *et al.*, 2010).

1. Introduction

The introduction and spread of invasive alien species (IAS) today constitutes one of the most important drivers of global change in biodiversity and ecosystem services (Sala *et al.*, 2000). For this reason, the prevention and management of IAS has been established as one of six key objectives in the European Biodiversity Strategy to 2020 (European Commission, 2011). Robust risk assessment methods are required for IAS to provide the foundation upon which to base measures that may affect imports into the EU and future agreements with trade partners without infringing the rules and disciplines of the World Trade Organisation (WTO) (Roy *et al.*, 2014b, Shine *et al.*, 2010).

In 2014, the Centre for Ecology & Hydrology (CEH) together with a broad consortium of experts completed a study (Roy *et al.*, 2014b) commissioned by the European Commission (ENV.B.2/ETU/2013/0026) to support the development of a framework for the identification of invasive alien species (IAS) of EU concern, in view of the Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (enforced from 1st January 2015). The study included a critical review of the existing risk assessment methods and a list of minimum standards (see section below “Minimum Standards”) that a risk assessment method should meet in order to be considered sufficiently robust. Such minimum standards were agreed by a consensus of experts invited to a dedicated workshop in Brussels and included key elements found within the above mentioned IAS regulation (still under the form of a draft pending approval at that stage). A key result of the study was that none of the existing risk assessment methods screened fully complied with the agreed minimum standards.

In practice, of the protocols assessed in detail, only four (GB NNRA, EPPO DSS, Harmonia^{+} and ENSARS) were sufficiently compliant with the minimum standards to be considered for developing the proposed list of “IAS of EU concern”. Of these only the GB NNRA and EPPO DSS have published IAS risk assessments. As a result, using the information from such “substantially compliant” protocols, a draft list of approximately 50 species was compiled. It is important to note that this list of species is based on availability of robust risk assessments already completed through methods which are almost compliant with the minimum standards (Roy *et al.*, 2014b); it does <u>not</u> constitute the list of “IAS of EU concern”.

In view of the application of the forthcoming rules on IAS (and building-on ENV.B.2/ETU/2013/0026) the Commission hosted a 2-day scientific workshop to examine the selected risk assessments and pool the existing knowledge existing in the EU to complete the missing information, on the basis of robust scientific evidence, in order to make them fully compliant with the minimum standards, wherever possible. This approach also matches the priorities for further follow-up suggested in the conclusion of ENV.B.2/ETU/2013/0026 (Roy *et al.*, 2014b). Here we report on the outcomes of the workshop.

The minimum standards

Minimum standards were developed through the EC-funded project Invasive alien species – framework for the identification of invasive alien species of EU concern (ENV.B.2/ETU/2013/0026) (Roy *et al.*, 2014b). The fourteen derived minimum standards represent the critical components of a risk assessment that are necessary to achieve overarching, robust and rigorous assessment of the risk of an IAS:

1. *Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)*

The description of the species should provide sufficient information to ensure the risk assessment can be understood without reference to additional documentation. This is seen as essential for decision-makers to rapidly extrapolate the relevant information for their needs.

Taxonomic status should be clearly explained. It should be clear as to whether the risk assessment refers to a distinct species or a species complex. The highest taxonomic resolution possible should be used, with mention of the taxonomic authority. Most relevant synonyms should be included in the description.

Invasion history should provide information on countries and regions invaded, including in the assessment areas and beyond, with dates of first observations, successes and failures of previous introductions, etc.

The species' distribution range (native and introduced) provides useful context for understanding the actual and potential range of the IAS.

The geographic scope of the risk assessment (the 'risk assessment area') should be clearly defined. Risk assessments that are conducted at a national-level may be applicable to other countries within the same biogeographic region but may be less relevant for countries in other biogeographic regions or even irrelevant for the complete EU-region.

Socio-economic benefits, if appropriate, should be described to ensure an objectivity and recognition of the services that may be provided by the species. Additionally this component is mentioned within the Regulation. However, it should be noted that the experts participating in the workshop were concerned that it is not intuitive to include consideration of benefits in a risk assessment, which is normally concerned with adverse consequences only, with beneficial aspects taken into consideration by stake-holders or decision makers in the broader process of assessing impacts of IAS and related decisions. It was agreed that socio-economic benefits would not constitute a stand-alone minimum standard but inclusion of a qualitative description of socio-economic benefits as a component of the general description was seen as appropriate.

2. *Includes the likelihood of entry, establishment, spread and magnitude of impact*

Entry, establishment, spread and impact are critical components of a risk assessment. Entry and establishment are usually expressed as “likelihood”, spread as “likelihood”, “rate” or “rapidity” and impact as “magnitude”.

3. *Includes description of the actual and potential distribution, spread and magnitude of impact*

Description of actual and potential distribution coupled with spread and magnitude of impact informs the classification of an alien as invasive or not.

4. *Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional*

Pathway information is essential for informing invasion management strategies. All pathways of entry should be considered for a given species, and pathway categories should be clearly defined and sufficiently comprehensive.

5. *Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes*

Environmental impact should consider negative effects on biodiversity (species decline/extinction or diversity decline) and effects on the structure and processes of natural or semi-natural ecosystems (Blackburn *et al.*, 2014).

6. *Can broadly assess environmental impact with respect to ecosystem services*

The assessment of impacts on ecosystem services should systematically cover all key ecosystem services, ranging from provisioning services to regulating and even supporting services such as outlined in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005).

7. *Broadly assesses adverse socio-economic impact*

The assessment of adverse socio-economic impacts of IAS should qualitatively but systematically cover a range of possible socio-economic consequences, ranging from impacts on economic sectors and human health to impacts on broader wellbeing. As per the general nature of risk assessments, the assessment should focus on the negative/adverse impacts to inform decision makers of the potential risks, whereas possible socio-economic benefits of IAS would be considered in the decision-making stage.

8. *Includes status (threatened or protected) of species or habitat under threat*

Threatened species and habitats are those that are critically endangered, endangered or vulnerable according to the relevant Red Lists. Any impact on a threatened or vulnerable species or habitat may be more critical, or perceived as being more critical, than on common species and habitats because threatened or vulnerable species and habitats may be less resilient to biological invasions. However, when severely threatened by the invasive species, a common species or habitat may also become threatened.

9. *Includes possible effects of climate change in the foreseeable future*

Alien species are likely to be in the process of establishing or expanding when they are first assessed, and so it is essential to consider both the current situation but also predictable changes in the foreseeable future. Alien species may profit from climate change and the risk assessment should take possible effects into account.

10. Can be completed even when there is a lack of data or associated information

The best available evidence should be used throughout the risk assessment process. It is acknowledged that there may be a paucity of information on some species, but it is essential that risk analysis can still proceed if a precautionary approach is to be adopted. Therefore, it is essential that a range of sources, including expert opinion, are included and documented (see minimum standard "Documents information sources").

11. Documents information sources

The information sources should be well documented and supported with references to the scientific literature (peer-reviewed publications). If this is lacking, it may also include other sources (so called "grey literature" and expert opinion or judgment). Technical information such as data from surveys and interceptions may be relevant.

12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary

Many risk assessments are divided into related component sections such as entry, establishment, spread and impact alongside an overall summary. Both the individual questions and the system summarizing risks should be consistent and unambiguous. The summary information could be as a nominal scale (for example low, medium, high risk) or numerical scale (1 = low risk to 5 = high risk). It is important that summaries are provided for each component of the risk assessment so that decision-makers can rapidly refer to the most pertinent aspects for their needs.

13. Includes uncertainty

For many biological invasions there may be a lack of information and a high degree of uncertainty surrounding the risk assessment, simply because the species may represent a new incursion. Alternatively, there may be information available but the assessor may still have a level of uncertainty with respect to the interpretation of the information into a response to a risk assessment question. Therefore, it is essential that the answers provided within risk assessments are accompanied by an assessment of the uncertainty (for example degree of certainty or level of confidence) from the assessor (Baker *et al.*, 2008).

14. Includes quality assurance

It is essential that the risk assessment is robust and rigorous reflecting the current state of knowledge. As such, it is important that the quality of the risk assessment is assured. There are many possible approaches to quality assurance from peer-review after the risk assessment has been conducted through to the involvement of a panel of experts invited to undertake the assessment in a collaborative manner.

2. The workshop

Selection of experts

The project was led by Helen Roy (CEH) and Riccardo Scalera (ISSG). An additional 16 experts from fifteen member states were selected based on their expertise in invasion biology (see "Author Biographies"). The 18 experts (including Helen Roy and Riccardo Scalera) represented a breadth of expertise from a variety of perspectives including taxonomic (all taxa), environmental (freshwater, marine and terrestrial), impacts (environmental, socio-economic and health) and disciplines (ecologists, conservation practitioners, scientists, policy-makers, risk assessors). In view of the gaps across risk assessments for ecosystem services and climate change two experts were invited to guide the development of approaches for these specific themes: Belinda Gallardo and Marianne Kettunen were chosen for climate change and ecosystem services respectively. Myriam Dumortier (EC Policy Officer) and Spyridon Flevaris (EC Policy Officer) provided guidance throughout and approved the selection of experts and overall workshop programme.

Selection of species

The list of minimum standards developed through the study ENV.B.2/ETU/2013/0026 (Roy *et al.*, 2014b) to support the development of a framework for the identification of IAS of EU concern concluded that none of the existing risk assessment methods screened fully complied with the agreed minimum standards. However, of the protocols assessed in detail four (GB NNRA, EPPO DSS, Harmonia^{+} and ENSARS) were sufficiently compliant with the minimum standards to be considered for developing the proposed list of "IAS of EU concern". However, of these only the GB NNRA and EPPO DSS have published IAS risk assessments which, when considering species that score medium to high impact, together cover 51 species (Annex 1). Two further risk assessments were suggested for consideration by the GB Non-Native Species Secretariat which follow the GB NNRA protocol: coati (*Nasua nasua*) and skunk (*Mephitis mephitis*), although scored as low impact within the GB NNRA protocol (with medium uncertainty). Finally an additional three species have been considered through new European–wide risk assessments, with the reported outcome of high impact, for this project which again follow the GB NNRA protocol: Pallas squirrel (*Callosciurus erythraeus*), grey squirrel (*Sciurus carolinensis*) and coypu (*Myocastor coypus*) (risk assessments for these three additional species are in Annex 2). Therefore, in total 56 risk assessments were available for completion of information gaps against the minimum standards during the workshop.

Pre-workshop activities

There were four key aims to achieve in advance of the workshop:

1. Review and consolidation of the gaps across the risk assessed species
2. Distribution of risk assessment protocols to relevant experts participating in the workshop with instructions for providing information to complete, where possible, the agreed gaps
3. Development of recommended approaches for consideration of effects of climate change and impacts on ecosystem services
4. Consideration of European-wide relevance of risk assessments

Review and consolidation of the gaps across the risk assessed species

The main gaps across all risk assessments were in relation to climate change and ecosystem services but additional information was also required on benefits as mentioned with minimum standard “Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)” and in some cases information to support the minimum standard “Includes status (threatened or protected) of species or habitat under threat“was missing (Table 2.1). The table was reviewed by Sarah Brunel (EPPO), Niall Moore (NNSS representing GBNNRA) and Olaf Booy (NNSS representing GBNNRA).

In total 51 species were considered to have almost compliant risk assessments (Roy *et al.*, 2014b) and, as mentioned above (Species selection) additional risk assessments following the GBNNRA protocol were also provided for coati (*N. nasua*), skunk (*M. mephitis*), grey squirrel (*S. carolinensis*), Pallas squirrel (*C. erythraeus*) and coypu (*M. coypus*).

Table 2.1 Species (scientific and common names) with associated risk assessment protocol(s) (EPPO (= EPPO DSS), GB (=GB NNRA) or new risk assessments) considered during the workshop. All the species were scored as medium or high impact through the relevant risk assessment other than coati (*Nasua nasua*) and skunk (*Mephitis mephitis*) which were scored as low impact by the GB NNRA protocol but considered relevant for reconsideration in the European-wide context. The information gaps derived in relation to the fourteen minimum standards (Roy *et al.*, 2014b) are also documented*. The expert(s) representing the specific risk assessment at the workshop are provided.

*The information gaps, corresponding to the minimum standards described above, addressed by the experts and discussed during the workshop are indicated in the table below as follows (numbers refer to specific minimum standards): (1) socio-economic benefits and / or distribution of the species (as required in the Description), (6) environmental impact with respect to ecosystem services, (8) includes status of species or habitat under threat, (9) includes possible effects of climate change.

Scientific name	**Common name**	**Broad group**	**Protocol**	**Information gaps**	**Expert**
Ambrosia artemisiifolia	Common ragweed	Plant	EPPO GB	1, 6, 8, 9	Kelly Martinou Jan Pergl
Azolla filiculoides	Water fern	Plant	GB	1, 6, 8, 9	Johan van Valkenburg Etienne Branquart
Baccharis halimifolia	Eastern Baccharis	Plant	EPPO		Kelly Martinou Jan Pergl
Branta canadensis	Canada goose	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Melanie Josefsson
Callosciurus erythraeus	Pallas's squirrel	Vertebrate	NEW		Piero Genovesi
Cabomba caroliniana	Fanwort	Plant	EPPO	1, 8	Johan van Valkenburg Etienne Branquart
Caprella mutica	Japanese Skeleton Shrimp	Invertebrate	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Cervus nippon	Sika deer	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Wolfgang Rabitsch Melanie Josefsson

Scientific name	**Common name**	**Broad group**	**Protocol**	**Information gaps**	**Expert**
Corvus splendens	Indian house crow	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Wolfgang Rabitsch
Crassostrea gigas	Pacific Oyster	Invertebrate	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Crassula helmsii	Australian swamp stonecrop	Plant	EPPO GB	6, 8, 9	Johan van Valkenburg Etienne Branquart
Crepidula fornicata	Slipper Limpet	Invertebrate	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Didemnum vexillum	Carpet Sea-squirt	Invertebrate	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Eichhornia crassipes	Water hyacinth	Plant	EPPO	6, 8, 9	Johan van Valkenburg Etienne Branquart
Elodea canadensis	Canadian water/pondweed	Plant	GB	1, 6, 8, 9	Johan van Valkenburg Etienne Branquart
Eriocheir sinensis	Chinese mittencrab	Invertebrate	GB	1, 6, 8, 9	Melanie Josefsson Frances Lucy
Fallopia japonica	Japanese knotweed	Plant	GB	1, 6, 8, 9	Kelly Martinou Jan Pergl
Fallopia sachalinensis	Giant knotweed	Plant	GB	1, 6, 8, 9	Kelly Martinou Jan Pergl
Heracleum mantegazzianum	Giant hogweed	Plant	EPPO	1	Kelly Martinou Jan Pergl
Heracleum persicum	Persian hogweed	Plant	EPPO	1	Kelly Martinou Jan Pergl
Heracleum sosnowskyi	Sosnowski's hogweed	Plant	EPPO	1	Kelly Martinou Jan Pergl
Hydrocotyle ranunculoides	Floating pennywort	Plant	EPPO GB	1, 6, 8, 9	Johan van Valkenburg Etienne Branquart

Scientific name	Common name	Broad group	Protocol	Information gaps	Expert
Lagarosiphon major	Curly waterweed	Plant	GB	1, 6, 8, 9	Johan van Valkenburg Etienne Branquart
Lithobates (Rana) catesbeianus	North American bullfrog	Vertebrate	GB	1, 6, 8, 9	Merike Linnamagi Wolfgang Rabitsch
Ludwigia grandiflora	Water-primrose	Plant	EPPO GB	1	Johan van Valkenburg Etienne Branquart
Ludwigia peploides	Floating water-primrose	Plant	EPPO		Johan van Valkenburg Etienne Branquart
Lysichiton americanus	American skunk cabbage	Plant	EPPO GB	1	Johan van Valkenburg Etienne Branquart
Mephitis mephitis	Skunk	Vertebrate	GB	1, 6, 8, 9	Piero Genovesi Melanie Josefsson
Muntiacus reevesii	Muntjac deer	Vertebrate	GB	1, 6, 8, 9	Piero Genovesi Melanie Josefsson
Myocastor coypus	Coypu	Vertebrate	NEW		Piero Genovesi
Myiopsitta monachus	Monk parakeet	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Wolfgang Rabitsch
Myriophyllum aquaticum	Parrot's feather	Plant	GB	1, 6, 8, 9	Johan van Valkenburg Etienne Branquart
Nasua nasua	Coati	Vertebrate	GB	1, 6, 8, 9	Piero Genovesi Melanie Josefsson
Orconectes limosus	Spiny-cheek Crayfish	Invertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Orconectes virilis	Virile Crayfish	Invertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Oxyura jamaicensis	Ruddy duck	Vertebrate	GB		Wojciech Solarz Wolfgang Rabitsch

Scientific name	Common name	Broad group	Protocol	Information gaps	Expert
Pacifastacus leniusculus	Signal Crayfish	Invertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Parthenium hysterophorus	Whitetop Weed	Plant	EPPO		Kelly Martinou Jan Pergl
Persicaria perfoliata (Polygonum perfoliatum)	Asiatic tearthumb	Plant	EPPO	1	Kelly Martinou Jan Pergl
Potamopyrgus antipodarum	New Zealand Mudsnail		GB	1	Argyro Zenetos Frances Lucy
Procambarus clarkii	Red Swamp Crayfish	Invertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Procambarus spp.	Marbled Crayfish	Invertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Procyon lotor	Raccoon	Vertebrate	GB	1, 6, 8, 9	Wolfgang Rabitsch Melanie Josefsson
Pseudorasbora parva	Stone moroko	Vertebrate	GB	1, 6, 8, 9	Merike Linnamagi Teodora Trichkova
Psittacula krameri	Rose-ringed parakeet	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Teodora Trichkova
Pueraria lobata	Kudzu Vine	Plant	EPPO	1	Kelly Martinou Jan Pergl
Rapana venosa	Rapa Whelk	Invertebrate	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Sargassum muticum	Japweed, wireweed	Plant	GB	1, 6, 8, 9	Argyro Zenetos Frances Lucy
Sciurus carolinensis	American Grey Squirrel	Vertebrate	NEW		Piero Genovesi Melanie Josefsson
Senecio inaequidens	Narrow-leaved ragwort	Plant	EPPO	1	Kelly Martinou Jan Pergl

Scientific name	Common name	Broad group	Protocol	Information gaps	Expert
Sicyos angulatus	Star-cucumber	Plant	EPPO	1	Kelly Martinou Jan Pergl
Solanum elaeagnifolium	Silver-leaved Nightshade	Plant	EPPO		Kelly Martinou Jan Pergl
Solidago nemoralis		Plant	EPPO	6, 8, 9	Kelly Martinou Jan Pergl
Tamias sibiricus	Siberian chipmunk	Vertebrate	GB	1, 6, 8, 9	Piero Genovesi Melanie Josefsson
Threskiornis aethiopicus	Sacred ibis	Vertebrate	GB	1, 6, 8, 9	Wojciech Solarz Wolfgang Rabitsch
Vespa velutina	Asian hornet	Invertebrate	GB	1, 6, 8, 9	Wolfgang Rabitsch Piero Genovesi

Distribution of risk assessment protocols to relevant experts participating in the workshop with instructions for providing information to complete, where possible, the agreed gaps

The EPPO and GBNNRA risk assessment protocols completed for the species outlined in Table 2.1 were distributed to the experts to complete the information gaps that had been determined, as far as possible, in advance of the workshop. Additionally, the experts were provided with the new risk assessments completed immediately before the workshop for the five additional species: coati (*N. nasua*), skunk (*M. mephitis*), grey squirrel (*S. carolinensis*), Pallas squirrel (*Callosciurus erythraeus*) and coypu (*M. coypus*).

The experts were invited to discuss the information gaps with others (Table 2.2) with relevant expertise beyond the invited participants. An excel spreadsheet was circulated to the experts for compilation of information against the determined gaps. Additionally experts were requested to maintain a list of information sources used throughout the process. All information provided was compiled and circulated to workshop participants three days in advance of the workshop. Further information was added through the workshop following the formal discussions.

Table 2.2 Experts, their relevant affiliation and the contribution made by them to addressing the knowledge gaps to meet the aims of the workshop

Expert	Affiliation	Contribution
Sarah Brunel	International Plant Protection Convention, Italy	Overview of knowledge gaps in relation to the EPPO DSS
Guler Ekmekci	Faculty of Science, Hacettepe University, Ankara, Turkey	Information on *Pseudorasbora parva*
Leopold Füreder	Institute of Ecology, University of Innsbruck, Austria	Information on crayfish
Lucian Parvulescu	Department of Biology and Chemistry, West University of Timisoara, Romania	Information on *Orconectes limosus*
Sandro Bertolino	University of Turin DISAFA Entomology & Zoology Grugliasco (TO), Italy	Information on *Sciurus carolinensis, Myocastor coypus* and *Callosciurus erythraeus*
Stelios Katsanevakis	University of the Aegean, Department of Marine Sciences, Lesvos Island, Greece	Information on marine species, particularly on *Siganus luridus*
Adriano Martinoli	Università degli Studi dell'Insubria Department of Theoretical and Applied Sciences Lombardia, Italy	Information on *Sciurus carolinensis* and *Callosciurus erythraeus*
Maria Vittoria Mazzamuto	Università degli Studi dell'Insubria, Department of Theoretical and Applied Sciences, Lombardia, Italy	Information on *Callosciurus erythraeus*
John Gurnell	Queen Mary University of London, London, UK	Information on *Sciurus carolinensis*

Peter Lurz	The University of Edinburgh Royal (Dick) School of Veterinary Studies Scotland, United Kingdom	Information on *Sciurus carolinensis*
Lucas Wauters	Università degli Studi dell'Insubria, Department of Theoretical and Applied Sciences, Lombardia, Italy	Information on *Sciurus carolinensis* and *Callosciurus erythraeus*

Development of recommended approaches for consideration of effects of climate change and impacts on ecosystem service

Marianne Kettunen (IEEP) and Belinda Gallardo (IPE-CSIC) were invited to consider approaches for incorporating consideration of ecosystem services and climate change into risk assessments respectively. Both experts were invited to give overview presentations at the workshop.

Consideration of European-wide relevance of risk assessments

The relevance of the risk assessments to the EU needs to be considered. The EPPO DSS extends beyond Europe and the GBNNRA is restricted to the context of Britain. One possibility would be to add a proforma to all risk assessments that outlines the EU context for each species such as an “EU IAS Risk Assessment Chapeau” (Roy *et al.*, 2014b) (see Box 1.1). For some species such a chapeau would provide a straightforward solution to extending the applicability of a regional risk assessment to Europe. However, for some other species this addition will not be sufficient to fully incorporate all risks and it would be important to note that the risk assessment could not be considered as a European-wide risk assessment in these cases. It should be noted that the information provided in relation to occurrence is the best available amongst the pool of experts involved in this study but is not comprehensive. Given the dynamic nature of biological invasions, thorough consideration of the up-to-date species range would require a more in depth study, contacting all local experts for the taxa in all countries, and this was not within the scope of the study. Furthermore, according to the provision of the EU regulation (art.4,3b) (b) it is sufficient that the impact of species is shown in just one country, provided that for such species: "they are found, based on available scientific evidence, to be capable of establishing a viable population and spreading in the environment under current conditions and in foreseeable climate change conditions in one biogeographical region shared by more than two Member States or one marine subregion excluding their outermost regions".

Box 1.1: Proposed EU IAS Risk Assessment Chapeau - supporting information to increase the relevance of regional or member state risk assessments

RUDDY DUCK

In how many EU member states has this species been recorded? List them.

17: AT, BE, CZ, DK, DE, ES, FI, FR, IE, HU, IT, LU, NL, PL, PT, SI, UK.

In how many EU member states has this species currently established populations? List them.

4: UK, France, Netherlands, Belgium.

In how many EU member states has this species shown signs of adverse impacts? List them.

1: Spain as it is the only member state with a remaining white-headed duck population.

In which EU Biogeographic areas could this species establish?

Atlantic, Mediterranean, Continental, Pannonian, Boreal and possibly Alpine.

In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.

27 MS. All the remaining member states apart from Luxembourg which may not have sufficient suitable wetlands.

In how many EU member states could this species have adverse impacts in the future [given current climate] (where it is not already established)? List them.

If this species became established in Spain it would be highly invasive there. If the white-headed duck were to be restored to its former EU range, ruddy duck would also be invasive in other member states: Italy, Portugal, France, Hungary, Greece, Romania, Bulgaria, Slovenia, Croatia and Cyprus.

Are there any benefits or uses associated with this species?

Apart from keeping in wildfowl collections there are no significant benefits provided by this species in the EU.

The Workshop - Agenda

The agenda for the workshop was refined during the workshop and was ultimately structured as below (all presentations are provided as Supplementary Information 1).

Workshop on risk assessment of IAS

9-10 December 2014

Overarching aim:

Examine the selected risk assessments and pool the existing knowledge within the EU to complete the missing information, on the basis of robust scientific evidence, in order to make them compliant with the minimum standards, wherever possible.

9 December 2014

1100 Arrival and coffee

1115 Welcome and aims of the workshop (Helen Roy)

1120 GBNNRA (Olaf Booy)

1135 Harmonia^{+} (Etienne Branquart)

1155 EPPO (Johan van Valkenburg)

1210 Approaches to assess ecosystem services within risk assessments (Marianne Kettunen)

1235 Approaches to assess climate change within risk assessments (Belinda Gallardo)

1300 Lunch

1340 Discussion and consensus on approach (led by Helen Roy)

1400 Discussions and consolidation of work completed so far and summary of gaps (Riccardo Scalera)

1600 Coffee

1630 Discussions and consolidation of work completed so far and summary of gaps (led by Helen Roy and Riccardo Scalera)

1800 Review of progress (led by Helen Roy)

1900 Close

10 December 2014

0900 Aims of day 2 (Helen Roy)

0905 Review species for which gaps still existed following discussion through day 1 (led by Riccardo Scalera)

1000 Assessment of consensus across the group of experts on overall risk assessment score and additional information (led by Helen Roy)

1030 Coffee

1100 Preparation of feedback on each species (all)

1230 Lunch
1300 Reflections on European-wide relevance of the risk assessment protocols (led by Etienne Branquart and Niall Moore)
1320 Overview of ecosystem service approach refined through workshop (Marianne Kettunen)
1330 Overview of climate change approach refined through workshop (Belinda Galllardo)
1340 Preparation of feedback on each species (all)
1500 Final discussions and description of reporting plans (led by Helen Roy)
1600 Close

Notes on approaches adopted through the workshop

The agenda was agreed and adopted during the workshop.

The EC highlighted the importance of the workshop while acknowledging that this was an opportunity to review the information gaps within existing risk assessments against the derived minimum standards (Roy *et al.*, 2014b) to ensure compliance where possible. The project leaders (Helen Roy and Riccardo Scalera) highlighted that the aim of the workshop was not to comprehensively review the entire risk assessments, which had already been agreed as almost compliant against the majority of the minimum standards (Roy *et al.*, 2014b), but to complete information gaps and provide recommendations with respect to whether or not the additional information would be likely to alter the overall score. Therefore, when participants agreed through consensus that the overall outcome of the assessment was "compliant" with the minimum standards, after consideration of the available additional information, this decision was not based on a re-assessment of the full risk assessment. This project report should not stand in isolation but be considered as additional information alongside the full risk assessments and ENV.B.2/ETU/2013/0026 (Roy *et al.*, 2014b).

The presentations provided an overview of the main risk assessment protocols (EPPO, GBNNRA and Harmonia^{+}) alongside perspectives on ecosystem services and climate change approaches to review existing information and guide the completion of gaps in relation to these themes. It was agreed that systematic consideration of a list of questions in relation to the minimum standards on ecosystem services and climate change would be useful guidance for experts. An outline of the approaches agreed through the workshop for the minimum standards “Includes possible effects of climate change in the foreseeable future“ and “Can broadly assess environmental impact with respect to ecosystem services” are provided in the section “Workshop outputs”. The two tables (Table 3.1 and 3.2) which underpin the approach were provided to all experts during the workshop as guidance for documenting information in relation to climate change and ecosystem services.

Each species was considered separately with the relevant experts (Table 2.1) providing an overview of the information available for addressing the identified gaps. A brief opportunity was provided for discussion and all information was documented. After all species had been considered the workshop participants (excluding the EC, Helen Roy and Riccardo Scalera) adopted a consensus approach (Roy *et al.*, 2014a) to confirm whether or not the risk assessment was compliant with the minimum standards and whether the overall score of the risk assessment remained applicable. However, no changes were made to the scores but any recommendations were noted and included within the tables outlining the additional information for each species. There were very few recommendations for change. The outcome for each risk assessment was agreed and summarised as "compliant" or "not compliant" with the minimum standards. Detailed notes on the information relevant to complete the gaps associated with the minimum standards are documented within the section "Overview of information compiled against the minimum standards for each risk assessment considered through the workshop".

3. Workshop outputs

Approach to inclusion of the minimum standard "Includes possible effects of climate change in the foreseeable future" within risk assessment protocols

Climate change has been identified as a major gap in current risk assessment protocols. There is increasing evidence that climate changes have enabled IAS to expand into regions where previously they were not able to survive and reproduce (Walther *et al.*, 2009). In addition, IAS are likely to be in the process of establishing or expanding when they are first assessed, and so it is essential to consider not only the current situation but also predictable changes in the foreseeable future. Climate change is especially relevant when assessing species not yet present in the assessed area, and whose climatic suitability might increase in the future.

Overview of inclusion of climate change considerations within specific risk assessments

EPPO DSS

Currently the EPPO DSS, like most risk assessment protocols, does not include specific questions about climate change. However, comments on the likely influence of climate change on the spread and establishment of the IAS under investigation are often included within other answers. This raises concern over the potential for double counting because climate change may have already been considered within questions about current climatic suitability or potential for spread.

GBNNRA

The original version of GBNNRA did not specifically addres climate change. However, this protocol is continuously reviewed and updated, and in its latest version includes three questions about climate change. Questions relate to: the aspects of climate change most likely to affect the risk posed by the species; the timescale over which these changes are likely to occur; and the change in risk posed by the species as a result of climate change (requiring the assessor to indicate what aspects of the risk assessment (i.e entry, establishment, spread, impact and overall risk) are likely to change). No further specific questions about the potential impact of climate change on the species patterns of introduction, establishment and spread are currently included.

Harmonia$^+$

Harmonia$^+$ purposely did not consider climate change in their original version, since it was considered that climate change would only increase the uncertainty associated with the risk assessment. The latest version has nevertheless included a new climate change dedicated section. In this section, the assessor is asked to revise all of the risk assessment modules in light of the future climate predictions. The protocol thus includes eight questions on the likely changes in the introduction, establishment, spread and impacts of IAS due to climate change. However, the protocol emphasizes changes in temperature and does not mention other expected changes, such as precipitation, baseflow conditions, nitrogen deposition, CO_2 concentration etc. Despite this shortfall, Harmonia$^+$ seems to address climate change more comprehensively than either the EPPO DSS or GBNNRA. Additional questions could still be formulated within Harmonia$^+$ to identify the specific aspects of climate change (apart from temperature) most likely to influence a species.

Addressing climate change within risk assessment protocols

One approach to investigate the potential consequences of climate change for IAS is to follow the four major stages of invasion: introduction, establishment, spread and impact. Climate change can alter patterns of human transport, changing the propagule pressure of species with the potential to become invasive (Hellmann *et al.*, 2008). Propagule pressure can increase because of new or increased transport between source and target regions or because of enhanced survival of propagules during transport. Climate change may also prolong the optimal climatic conditions for successful colonization or provide conditions that are closer to the climatic optimum of IAS, overall for warm-climate species (Walther *et al.*, 2009). This will increase their growth, reproductive success and fitness, providing them with a competitive advantage over native species. Climate change may also increase the rate of spread and extend suitable areas for invasive species, which might offer new opportunities for introductions. In contrast, cold-climate species may see their potential area of distribution reduced by climate change. IAS can benefit from extreme climatic events such as floods and strong winds that may allow them to spread further. Extreme events can open new areas for colonisation preferably by IAS as opposed to other species. An increase in the species coverage, abundance and per-capita effect is very likely to increase its impacts.

Approaches

Expert opinion

Climate change related questions are often answered based on the assessor's expert opinion about the current distribution and environmental limits of the species. Such expert information has the advantage of being simple, intuitive, time and cost-effective. On the other hand, this information is highly subjective and does not allow for comparison across species.

Experiments

Laboratory tolerance experiments are an important source of objective information on the species response to climatic and associated changes, such as CO_2 or increased nutrients. This information is rigorously obtained, can be compared across taxa, and is subject to very little uncertainty. However, laboratory experiments are an oversimplification of real conditions and do not take into account the complex inter-specific relationships established in natural ecosystems that strongly determine the outcomes of invasion.

Climate matching

Climate matching is one of the most important sources of climate-change related information. However, climate matching models are only available for a limited number of species, and even then, predictions are subject to a high degree of uncertainty. Climate matching models are again an oversimplification, which do not take into account community level interactions or the capacity of the species to adapt to future changes. The major advantage of climate matching models is that they provide coarse spatially explicit information on the likely distribution of species in the future.

Recommendations

Together, expert opinion, tolerance experiments and climate matching provide complementary information on the probable consequences of climate change on IAS and should therefore be used in parallel whenever possible. However, it is important to note that the overarching consideration is whether or not the risk posed by the species is likely to be significantly affected by future climate change. Therefore, a measured approach to the assimilation of information on climate change is required.

The following recommendations to address climate change within risk assessment protocols can be made:

- Define the future scenario to be considered by establishing the timeframe (e.g. 2030, 2050 or 2080) and likely environmental changes in terms not only of temperature, but also of precipitation, nitrogen deposition, CO_2, seal level, salinity and acidification.
- Revisit the four stages of the invasion process: introduction, establishment, spread and impact. Construct specific questions for each of them (as in Table 3.1)

Table 3.1 Recommended minimum climate change related aspects that should be reviewed within risk assessment protocols. Information might be lacking for many of these aspects, but the assessor should at least reflect systematically on each aspect.

QUESTION	ASPECTS TO CONSIDER	EXAMPLES
What **ASPECTS of climate change**, if any, are most likely to affect the risk assessment for this species?	CLIMATE WATER CHEMISTRY BASEFLOW CONDITIONS AIR COMPOSITION	Temperature Precipitation N-deposition CO_2 Sea-level Salinity Acidification
Are the **INTRODUCTION** pathways and propagule pressure for the species likely to change due to climate change?	HUMAN PATHWAYS ENV. PATHWAYS	Trading routes Propagule pressure Frequency Extreme weather events
Is the risk of **ESTABLISHMENT** of the species likely to change due to climate change?	PHYSIOLOGICAL CONSTRAINTS FITNESS	Climate limited species Increased growth/ reproduction Inter-specific competition
Are the risk and patterns of **SPREAD** of the species likely to change due to climate change?	RANGE SHIFT REPRODUCTION DISPERSAL PATTERNS	Density-dependent dispersal Extreme weather events
How are the species' **IMPACTS** likely to change due to climate change and the associated changes in spread and abundance?	ENVIRONMENTAL SOCIO-ECONOMIC ECOS. SERVICES	Increased fitness and per-capita effects

Approach to inclusion of the minimum standard "Can broadly assess environmental impact with respect to ecosystem services" within risk assessment protocols

A number of general aspects related to ecosystem services were discussed in the meeting, with dedicated reflections on how these aspects affect the use of the concept in the context of IAS policy. The key discussion points included:

- Definition and the 'essence' of the ecosystem service concept, including its role as a lynchpin between ecosystem functioning and final socio-economic benefits originating from nature (see Figure 3.1), the need to differentiate between the nature's and human inputs in final benefits such as food, and the importance of considering the trade-offs between different services
- Advantages and disadvantages of different ecosystem service classifications currently being used, including the Common International Classification on Ecosystem Services (CICES)
- Difference between IAS impacts on ecosystem services resulting in socio-economic consequences and socio-economic impacts with no clear link to ecosystem services (e.g. impacts on man-made infrastructure)

- Reflecting the integration of ecosystem services into IAS related decision-making in a broader context, in particular how – building on IAS risk assessments – socio-economic assessment of ecosystem services impacts can further support IAS risk management, for example by demonstrating the cost-effectiveness of early management actions in comparison to the alternative scenarios.
- Consideration of documenting information on the ecosystem services provided by IAS within socio-economic benefits (within the minimum standard "Description")

In general, the group of experts seemed to be of the opinion that a more systematic consideration of IAS impacts on ecosystem services in the context of risk assessments, complementing the consideration of ecological and socio-economic impacts, would be helpful and should therefore be recommended.

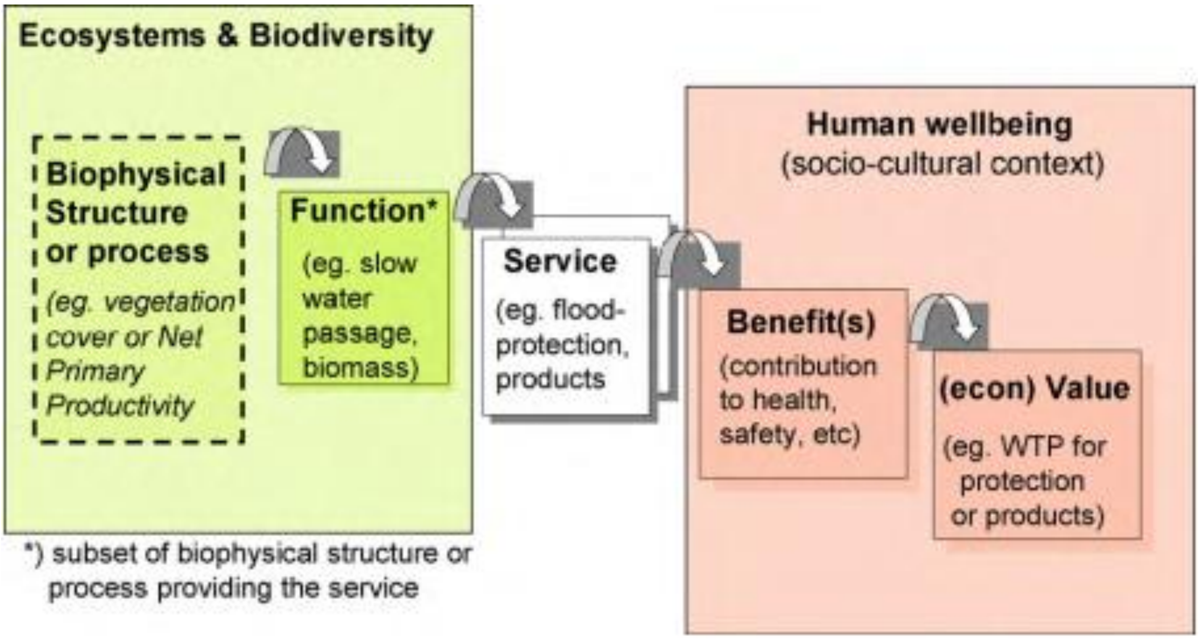

Figure 3.1 Cascade-model to link ecosystem properties to human wellbeing (De Groot *et al.*, 2010)

Addressing the gap regarding ecosystem services in the existing risk assessments

The following approach was adopted to address the gaps regarding ecosystem service related aspects in the existing risk assessments and to ensure their consistency against the minimum standards. The risk assessments were reviewed by dedicated species-specific experts to highlight any information they already contained as regards impacts on ecosystem services. In addition, further information on ecosystem service impacts, where available, was gathered by species-specific experts. This information was then used by the group of experts in the workshop to jointly assess the existing risk assessments for compliance against the minimum standard on ecosystem services. A check list of ecosystem services (see Table 3.2) was used in the validation process, to ensure systematic consideration of the whole range of ecosystem services across all existing RAs.

It is important to note that this check list was considered fit-for-purpose for this expert workshop only. It is not to be considered a commonly agreed generic list of ecosystem services, suggested to be considered in the context of IAS risk assessments.

In general, the review process revealed that the GBNNRA and EPPO DSS often implicitly consider impacts of IAS on ecosystem services, either when assessing the possible impacts of IAS on ecosystem structure and function or when considering possible socio-economic implications of invasion. However, no systematic approach (e.g. ecosystem service check list) has so far been used to integrate the ecosystem service component into the assessments.

Recommendations

The workshop participants (guided by Marianne Kettunen) recommend that a more systematic and comprehensive approach to consider possible IAS impacts on ecosystem services in the context of risk assessments, ideally consistent across all existing IAS risk assessment protocols, would be developed. This common approach should be user-friendly and fit-for-purpose, so that rather than an academic exercise it should be developed with a dedicated purpose of improving the EU and national response to IAS. In principle, it could take a form of a dedicated stand-alone module, supported by appropriate guidance, which could be integrated into existing risk assessments by the countries and/or relevant parties applying them. Such a module would include a) check list of ecosystem services to be considered (broadly based on the CICES classification now promoted to be used in other EU policy arenas) and b) a check list of a full range of possible socio-economic impacts, duly reflecting the knowledge on ecosystem service impacts (e.g. impacts on broader wellbeing and sustainable development). These checklists should be accompanied by brief guidance explaining the concept of ecosystem services and the use of the concept in the context of IAS risk assessments, including the interlinkages between ecological impacts, ecosystem services and socio-economic implications.

Finally, it was also considered that providing guidance and capacity building on the broad use and usefulness of ecosystem services concept in the context of IAS policy, risk assessments and IAS risk management would be useful. This would include, for example, dedicated guidance to stakeholders on how to assess the socio-economic value of IAS impacts on ecosystem services.

Table 3.2 Checklist of ecosystem services, classification as used in Roy et al. (2014) and based on classification used in the context of The Economics of Ecosystems and Biodiversity (TEEB) initiative (www.teeb.org)

Provisioning services
Provisioning of food
Raw materials (fibres, wood,
biofuels, ornamental resources).
Biochemical, natural medicines, etc.
Fresh water
Regulating services
Air quality regulation
Climate regulation
Water regulation and cycling
Soil formation
Erosion regulation
Nutrient cycling
Photosynthesis and primary
Production
Pest and disease regulation
Pollination
Habitat or supporting services
Habitats for species
Maintenance of genetic diversity
Cultural services
Recreation and mental and physical health
Tourism
Aesthetic appreciation and
inspiration for culture, art and design
Spiritual experience and sense of place

Overview of information compiled against the minimum standards for each risk assessment considered through the workshop

Notes in relation to the documented information for the minimum standards

Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) (1) – in most cases the information gap was in relation to socio-economic benefits. It should be noted that the information included was not limited to European specific examples.

For some species information on the distribution range was also required. It should be noted that the information provided in relation to occurrence is the best available amongst the pool of experts involved in this study but is not comprehensive. However, in part the relevance of this information within risk assessments is to provide context for the provision within the EU regulation (art.4,3b) (b) "they are found, based on available scientific evidence, to be capable of establishing a viable population and spreading in the environment under current conditions and in foreseeable climate change conditions in one biogeographical region shared by more than two Member States or one marine subregion excluding their outermost regions". Therefore, it is sufficient that the impact of species is shown in just one country.

Includes status of species or habitat under threat (8) – various information sources were used but the threat to Red List species as documented in the Global Invasive Species Database (GISD) was considered an extremely valuable source. Although the species listed in the GISD extend beyond those native to Europe it provides an indication on the extent of threat to similar species or functional groups for example, sea birds.

Scientific name	*Ambrosia artemisiifolia*
Common name	Common ragweed
Broad group	Plant
Number of and countries wherein the species is currently established	19: AT, BE, CZ, DE, DK, ES, FI, FR, HR, HU, IT, LV, NL, PL, RO, SK, SL, SE, UK
Risk Assessment Method	EPPO, GB NNRA
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14124%20PRA-Ambrosia.doc https://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/99-7775%20repPRA%20Ambrosia%20spp.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=865
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Ambrosia artemisiifolia* may be used for phytoremediation of soils contaminated with heavy metals (Bassett & Crompton, 1975, Kang *et al.*, 1998), as an anti-inflammatory agent (Stubbendieck *et al.*, 1994) and as an antibacterial agent (Kim *et al.*, 1993). *Ambrosia artemisiifolia* is able to successfully remove soil Pb and Cd during repeated croppings; tissue Pb was correlated with exchangeable soil Pb at r2=0.68 in *A. artemisiifolia* (Pichtel *et al.*, 2000).
6. Can broadly assess environmental impact with respect to ecosystem services	*Ambrosia artemisiifolia* may also serve as an alternative host for crop diseases (several species) for example in the CABI compendium: *Meloidogyne arenaria* race 2 (Tedford & Fortnum, 1988), *M. incognita* race 3 (Tedford & Fortnum, 1988), *Erysiphe cichoracearum* (Bassett & Crompton, 1975), *Albugo tragopogonis* (Bassett & Crompton, 1975), *Plasmopara halstedii* (Bassett & Crompton, 1975), *Entyloma compositarum* (Bassett & Crompton, 1975), *Entyloma polysporum* (Bassett & Crompton, 1975), *Puccinia xanthii* (Bassett & Crompton, 1975), Aster yellow virus (Bassett & Crompton, 1975), Cucumber mosaic virus (Kazinczp *et al.*, 2001), *Cuscuta gronovii* (Bassett & Crompton, 1975), *Protomyces gravidus* (Cartwright & Templeton, 1988), *Septoria* sp. (Bohár & Schwarczinger, 1999), *Phoma* sp. (Briere *et al.*, 1995) and *Sclerotinia sclerotiorum* of sunflower (Bohár & Kiss, 1999).

	In summary the main impacts are on food crops. Some impacts on cultural services (recreation and tourism) are possible. All other impacts are indirect and were assessed to be minor. For example, impacts on fuel and fodder crops are expected to be minor because they are usually produced in continuous cover regimes and so do not provide the necessary habitat disturbance required by *A. artemisiifolia*. Further information from GISD (http://www.issg.org/database/welcome/) indicates that *A. artemisiifolia* fruits are a food source for the bobwhite quail but can cause illness in livestock when ingested (USGS-NPWRC, 2006).
8. Includes status (threatened or protected) of species or habitat under threat	There are no reports of significant evidence of adverse effects from *A. artemisiifolia* on biodiversity in Europe (as it occurs in crops, along roads or in disturbed areas) (Bullock *et al.*, 2010). Its occurrence along roads is a result of unintentional spread by human activities of feeding wild animals.
9. Includes possible effects of climate change in the foreseeable future	Future global change may increase the spread and consequently the extent of this species in Europe (Cunze *et al.*, 2013, Dullinger *et al.*, 2009, Essl *et al.*, 2009). Climatic conditions, especially cooler and damp autumn conditions, are considered to be the main reason for *A. artemisiifolia* not establishing in the North of Europe, however in the predicted warmer future climate, establishment seems likely (Rich, 1994). According to climate models, a North-east shift and doubling of the suitable surface area (from 3.47 to 7.10*106km) is predicted (Cunze *et al.*, 2013). Increasing CO_2 concentrations are also likely to influence the negative health impacts of *A. artemisiifolia* (Ziska & Caulfield, 2000). Pollen production in a projected 21st century concentration of CO_2 (600 µmol mol–1) increased by 320% compared to pre-industrial levels of CO_2 (280 µmol mol–1). A 61% increase in pollen production is predicted under a CO_2 rich environment (Wayne *et al.*, 2002). It is anticipated that climate change may exacerbate ragweed allergies by increasing pollen production and extending the pollen season (Bullock *et al.*, 2010). Inclusion of predicted climate change within models slightly increases the economic impacts of ragweed. When management is included in the

	models, the future impacts are reduced. Economic impacts of ragweed in 20 years time with climate change rise slightly (by around 3%) compared to a scenario without climate change. When controls are introduced, there is a significant decrease (over 25%) in the impacts following climate change, as controls limit ragweed, shifting its range to follow its 'climate space' across the study area. Nevertheless, the distribution of is predicted to shift northwards with climate change, with substantial cost increases in some areas (e.g. Germany, France, Poland). Climate and land use change are predicted to have a large impact on the distribution of ragweed in Europe. Models suggest that climate change will permit ragweed to spread into cropland and urban habitats in Northwest Europe, potentially reaching as far north as the southern Baltic coastline by 2050. Depending on the climate and land use change scenario considered, models predict heavy invasion and increased impacts to crops and public health in Germany, Netherlands, Belgium, northeast France, southern UK, Czech Republic, Poland and western Ukraine. Furthermore models also suggest that the population and impacts of ragweed will decline in the current invasion hotspots, because of a combination of excessively high temperatures and potential abandonment of cropland in eastern Europe. We consider this prediction to be less certain than the northward range expansion since ragweed's response to high temperatures is less well-resolved than its response to cold and there is great uncertainty in the land use change scenarios for some countries.
11. Documents information sources	**Bassett IJ, Crompton CW. 1975.** The biology of Canadian weeds.: 11. *Ambrosia artemisiifolia* L. and *A. psilostachya* DC. *Canadian Journal of Plant Science* **55:** 463-476. **Bohár G, Kiss L. 1999.** First report of Sclerotinia sclerotiorum on common ragweed (Ambrosia artemisiifolia) in Europe. *Plant Disease* **83:** 302-302. **Bohár G, Schwarczinger I. 1999.** First Report of a Septoria sp. on Common Ragweed (*Ambrosia artemisiifolia*) in Europe. *Plant Disease* **83:** 696-696. **Briere S, Watson A, Paulitz T, Hallett S. 1995.** First report of a *Phoma* sp. on common ragweed in North America. *Plant Disease* **79**. **Bullock J, Chapman D, Schafer S, Roy D, Haynes T, Beal S, Wheeler B, Dickie I, Phang Z, Tinch R. 2010.** Assessing and controlling the spread and the effects of common ragweed in Europe. Final report: ENV: B2/ETU/2010/0037. https://circabc. europa.

	eu/sd/d/d1ad57e8-327c-4fdd-b908-dadd5b859eff/Final_Final_Report. pdf [Accessed: March, 2013]. **Cartwright R, Templeton G. 1988.** Biological limitations of *Protomyces gravidus* as a mycoherbicide for giant ragweed, *Ambrosia trifida*. *Plant Disease* **72:** 580-582. **Cunze S, Leiblein MC, Tackenberg O. 2013.** Range expansion of *Ambrosia artemisiifolia* in Europe is promoted by climate change. *ISRN Ecology* **2013**. **Dullinger S, Kleinbauer I, Peterseil J, Smolik M, Essl F. 2009.** Niche based distribution modelling of an invasive alien plant: effects of population status, propagule pressure and invasion history. *Biological Invasions* **11:** 2401-2414. **Essl F, Dullinger S, Kleinbauer I. 2009.** Changes in the spatio-temporal patterns and habitat preferences of *Ambrosia artemisiifolia* during its invasion of Austria. *Preslia* **81:** 119-133. **Kang B, Shim S, Lee S, Kim K, Chung I. 1998.** Evaluation of *Ambrosia artemisiifolia* var. *elatior*, *Ambrosia trifida*, *Rumex crispus* for phytoremediation of Cu and Cd contaminated soil. *Korean Journal of Weed Science* **18:** 262-267. **Kazinczp G, Horvatff J, Takacs A. 2001.** Role of weeds in the epidemiology of viruses. **Kim C, Kang B, Lee I, Ryoo I, Park D, Lee K, Lee H, Yoo I. 1993.** Screening of biologically active compounds from weeds. *Korean Journal of Weed Science* **14:** 16-22. **Pichtel J, Kuroiwa K, Sawyerr H. 2000.** Distribution of Pb, Cd and Ba in soils and plants of two contaminated sites. *Environmental pollution* **110:** 171-178. **Rich T. 1994.** Ragweeds (*Ambrosia* L.) in Britain. *Grana* **33:** 38-43. **Stubbendieck JL, Friisoe GY, Bolick MR. 1994.** Weeds of Nebraska and the Great Plains. **Tedford E, Fortnum B. 1988.** Weed hosts of *Meloidogyne arenaria* and *M. incognita* common in tobacco fields in South Carolina. *Journal of nematology* **20:** 102. **TEEB. 2010.** *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*. Earthscan: London and Washington. **Vila M, Espinar JL, Hejda M, Hulme PE, Jarosik V, Maron JL, Pergl J, Schaffner U, Sun Y, Pysek P. 2011.** Ecological impacts of invasive alien plants: a meta-analysis of their effects on species,

	communities and ecosystems. *Ecology Letters* **14:** 702-708. **Wayne P, Foster S, Connolly J, Bazzaz F, Epstein P. 2002.** Production of allergenic pollen by ragweed (*Ambrosia artemisiifolia* L.) is increased in CO2-enriched atmospheres. *Annals of Allergy, Asthma & Immunology* **88:** 279-282. **Ziska LH, Caulfield FA. 2000.** Rising CO2 and pollen production of common ragweed (*Ambrosia artemisiifolia* L.), a known allergy-inducing species: implications for public health. *Functional Plant Biology* **27:** 893-898.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Riccardo Scalera Belinda Gallardo
Notes	Main impacts are on food crops. All other impacts are indirect and were assessed to be minor.
Outcome	Compliant

Scientific name	*Azolla filiculoides*
Common name	Water fern
Broad group	Plant
Number of and countries wherein the species is currently established	19: BE, CZ, BG, DE, DK, GR, ES, FR, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=235
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic	Socio-economic benefits: *Azolla filiculoides* is traded and imported for ornamental purposes (Brunel, 2009).

benefits)	
6. Can broadly assess environmental impact with respect to ecosystem services	The plant may affect provisioning, regulating and cultural services; it has been documented to interfere with irrigation systems (Hassan & Ricciardi, 2014). Dense mats reduce the quality of drinking water, increase siltation, reduce area available for recreation, clog irrigation pumps and reduce water flow in irrigation canals (Hill & Julien, 2004).
8. Includes status (threatened or protected) of species or habitat under threat	Not documented. Low impact in The Netherlands as it mainly thrives in degraded and eutrophicated habitats outside protected areas (Johan van Valkenburg personal communication).
9. Includes possible effects of climate change in the foreseeable future	Evidence from laboratory experiments indicates that Impact may rise. No change is predicted in Ireland (Kelly *et al.*, 2014). Present distribution may be linked to temperature, particularly the low temperature tolerance of the plant. The distribution extent of *A. filiculoides* could be expected to expand if climate changes were to influence temperatures, potentially making more sites suitable for colonisation. It should be noted that in many areas the populations of the plant fluctuate greatly year-on-year. It is thought that this is a consequence of the *Azolla* weevil *Stenopelmus rufinasus*, which is capable of causing local extinctions. It is difficult to predict how climate change might influence the relationship between the weed and the weevil. *Azolla filiculoides* was shown to be able to survive sub-zero temperatures but died after 18 hours exposure to -4°C (Janes, 1998). The species optimum growth is achieved at 21-24°C (Van der Heide *et al.*, 2006). The range of the weed could be expected to expand if climate change were to influence the temperatures in the north of Europe, potentially making more sites available for colonisation. Biomass and C assimilation is significantly increased at elevated CO_2, T and P concentrations, and that N-fixation was optimum at 21-29°C (Cheng *et al.*, 2010).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Cheng W, Sakai H, Matsushima M, Yagi K, Hasegawa T. 2010.** Response of the floating aquatic fern *Azolla filiculoides* to elevated CO2, temperature, and phosphorus levels. *Hydrobiologia* **656:** 5-14. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become

	pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Hill MP, Julien MH. 2004.** The transfer of appropriate technology; key to the successful biological control of five aquatic weeds in Africa. XI International Symposium on Biological Control of Weeds, 370. **Janes R. 1998.** Growth and survival of *Azolla filiculoides* in Britain I. Vegetative production. *New phytologist* **138:** 367-375. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Van der Heide T, Roijackers RM, Van Nes EH, Peeters ET. 2006.** A simple equation for describing the temperature dependent growth of free-floating macrophytes. *Aquatic Botany* **84:** 171-175.
Main experts	Johan van Valkenburg Etienne Branquart
Other contributing experts	Belinda Gallardo
Notes	GBNNRA concludes high risk but the experts recommend the risk should be downgraded to medium because of fluctuating populations and impact level. It is noted that this species mostly colonizes eutrophicated areas. Furthermore the uncertainty is medium to high due to conflicting scientific information related to impact. Area at risk: Already colonized most of the European countries in the different bioregions (see q-bank and CABI ISC).
Outcome	Compliant

Scientific name	*Baccharis halimifolia*
Common name	Eastern Baccharis
Broad group	Plant
Number of and countries wherein the species is currently	6: BE, ES, FR, IT, NL, UK

established	
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/13-18359_PRA_record_Baccharis_halimifolia.pdf http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/13-18698_PRA_Report_Baccharis_halimifolia.pdf
9. Includes possible effects of climate change in the foreseeable future	Climate matching models exist but only for Australia (Sims-Chilton *et al.*, 2010) using the following optimum temperature: 12-27℃ (5-35℃). These models suggest decreasing suitability for the species under climate change in Australia, but this has not been tested in Europe.
11. Documents information sources	**Sims-Chilton N, Zalucki M, Buckley Y. 2010.** Long term climate effects are confounded with the biological control programme against the invasive weed *Baccharis halimifolia* in Australia. *Biological Invasions* **12:** 3145-3155. **van Valkenburg J, Duistermaat L, Meerman H. 2014.** *Baccharis halimifolia* L. in Nederland: waar blijft struikaster? *Gorteria* **37:** 25-30.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis Belinda Gallardo
Notes	The risk assessments comply with the minimum standards. According to the EPPO report *B. halimifolia* has already established in several EPPO countries (France, Spain, Belgium, UK, Italy) and it is widespread in the Atlantic coast. It was intentionally introduced to act as a windbreak. The management of road sides by mowing or any soil disturbance that creates bare soil favours *B. halimifolia*. It colonizes natural and semi natural habitats such as saltmarshes and coastal dunes but also anthropogenic habitats (van Valkenburg *et al.*, 2014). No additional data were found for this species based on the literature search.
Outcome	Compliant

Scientific name	*Branta canadensis*
Common name	Canada goose

Broad group	Vertebrate
Number of and countries wherein the species is currently established	12: BE, DE, DK, FI, FR, IE, LT, LV, NL, PL, SE, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=236
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Branta canadensis* is hunted widely in North America, and in Sweden and some other parts of Europe, thereby providing some economic and/or social benefits (CABI ISC, 2011, Madsen & Andersson, 1990). This species is also kept in zoos (Meissner & Bzoma, 2009, Topola, 2014), wildfowl collections, and as a pet (Jansson *et al.*, 2008), however, the market for the species appears to be very limited (W. Solarz personal communication). The ISIS database estimates that there are approximately 460 individuals kept in 40 European institutions (ISIS, 2014). In areas where the species is still rare, it is perceived as an attraction both by birdwatchers and the general public (Avifaunistic Commission - the Polish Rarities Committee, 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	Resting and roosting by *B. canadensis* on open water results in the deposition of heavy nutrient and bacterial loads into lakes and small ponds through the deposition of droppings. This may lead to eutrophication of still waters (McLaughlan *et al.*, 2014, Watola *et al.*, 1996), thus affecting provisioning services (fresh water) as well as cultural services (recreation, tourism, aesthetic appreciation). However, most droppings sink to the bottom and have little effect unless major 'wind event' (Unckless & Makarewicz, 2007). Water associated ecosystem services may also be affected by intense herbivory which severely damages natural vegetation along shorelines and in shallow waters (Gebhardt, 1996). Feeding damage on land can create bare spots that may be subject to erosion (French & Parkhurst, 2001). Feeding on agricultural crops negatively effects yields and may incur high costs to famers and landowners (Allan *et al.*, 1995).

	Large amounts of faeces in soil, on a local scale, can alter nutrient cycling (Banks *et al.*, 2008). Cultural services are also affected because of the aggressive behavior of the species and trampling that damages grassy areas (Conover & Chasko, 1985).
8. Includes status (threatened or protected) of species or habitat under threat	Canada goose hybridizes with Lesser white-fronted goose *Anser erythropus* , which is an already threatened species (Ruokonen *et al.*, 2000). The Fennoscandian subpopulation of this species is 30–50 breeding pairs. Canada goose can damage natural habitats of conservation value due to water and ground fouling, trampling and herbivory. Overgrazing of aquatic and terrestrial plants and trampling may damage these areas (French & Parkhurst, 2001, Gebhardt, 1996, McLaughlan *et al.*, 2014, Watola *et al.*, 1996).
9. Includes possible effects of climate change in the foreseeable future	Earlier breeding has been reported and attributed to climate warming: up to 30 days from 1951 to 1986 (MacInnes *et al.*, 1990). Simulations of the species' potential future distribution indicate that it has the potential to shift or expand its breeding range north to the northernmost parts of both Scotland and Fennoscandia, as well as to the Kola Peninsula (Huntley *et al.*, 2007). Constraining the distribution of the *B. canadensis* towards the north is also predicted as the species avoids places where summer temperatures reach values above 25^{o}C (Gallardo, 2014).
11. Documents information sources	**Allan JR, Kirby JS, Feare CJ. 1995.** The biology of Canada geese *Branta canadensis* in relation to the management of feral populations. *Wildlife Biology* **1:** 129-143. **Avifaunistic Commission - the Polish Rarities Committee. 2013.** Rare birds recorded in Poland in 2012. *Ornis Polonica* **54:** 109-150. **Banks A, Wright L, Maclean I, Hann C, Rehfisch M. 2008.** Review of the status of introduced non-native waterbird species in the area of the African-Eurasian Waterbird Agreement: 2007 update. *BTO Research Report* **489**. **CABI ISC. 2011.** *Branta canadensis* Datasheet. Accessed on 8.12.2014 http://www.cabi.org/isc/datasheet/91754. **Conover MR, Chasko GG. 1985.** Nuisance Canada goose problems in the

	eastern United States. *Wildlife Society Bulletin*: 228-233. **French L, Parkhurst JA. 2001.** *Managing wildlife damage: Canada goose (Branta canadensis)*. Virginia Cooperative Extension. **Gallardo B. 2014.** Europe's top 10 invasive species: relative importance of climatic, habitat and socio-economic factors. *Ethology Ecology & Evolution* **26:** 130-151. **Gebhardt H. 1996.** Ecological and economic consequences of introductions of exotic wildlife (birds and mammals) in Germany. *Wildlife Biology* **2:** 205-211. **Huntley B, Green RE, Collingham YC, Willis SG. 2007.** *A climatic atlas of European breeding birds*. Lynx Edicions Barcelona. **ISIS. 2014.** International Species Information System. Accessed 19.12.2014. **Jansson K, Josefsson M, Weidema I. 2008.** NOBANIS – Invasive Alien Species Fact Sheet –Branta canadensis. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access 10/12/2014. **MacInnes C, Dunn E, Rusch D, Cooke F, Cooch F. 1990.** Advancement of goose nesting dates in the Hudson Bay region, 1951-1986. *Canadian field-naturalist. Ottawa ON* **104:** 295-297. **Madsen J, Andersson ÅE. 1990.** *Status and management of Branta canadensis in Europe*. Ministry of the Environment, National Environmental Research Institute. **McLaughlan C, Gallardo B, Aldridge D. 2014.** How complete is our knowledge of the ecosystem services impacts of Europe's top 10 invasive species? *Acta Oecologica* **54:** 119-130. **Meissner W, Bzoma S. 2009.** First broods of the Canada Goose Branta canadensis in Poland and problems involved with the growth of its population in the world. *Notatki Ornitologiczne* **50:** 21-28. **Ruokonen M, Kvist L, Tegelström H, Lumme J. 2000.** Goose hybrids, captive breeding and restocking of the Fennoscandian populations of the Lesser White-fronted goose (*Anser erythropus*). *Conservation Genetics* **1:** 277-283. **Topola R.** (ed). 2014. Polish ZOO and Aquarium Yearbook 2013. Warszawa. **Unckless RL, Makarewicz JC. 2007.** The impact of nutrient loading from Canada Geese (*Branta canadensis*) on water quality, a mesocosm approach. *Hydrobiologia* **586:** 393-401.

	Watola G, Allan J, Feare C. 1996. Problems and management of naturalised introduced Canada Geese Branta canadensis in Britain. *The introduction and naturisation of birds. London, HMSO*.
Main experts	Wojciech Solarz Melanie Josefsson
Other contributing experts	Wolfgang Rabitsch Belinda Gallardo Olaf Booy
Notes	No additional comments.
Outcome	Compliant

Scientific name	*Callosciurus erythraeus*
Common name	Pallas's squirrel
Broad group	Vertebrate
Risk Assessment Method	New following GB NNRA protocol
Additional information sources	**Schockert V. 2012.** Risk analysis of the Pallas's squirrel, *Callosciurus erythraeus*, Risk analysis report of non-native organisms in Belgium. Cellule interdépartementale surles Espèces invasives (CiEi), DGO3, SPW / Editions, 39 pages.
Main experts	Piero Genovesi
Notes	No additional comments.
Outcome	Compliant

Scientific name	*Cabomba caroliniana*
Common name	Fanwort
Broad group	Plant
Number of and countries wherein the species is currently established	6: AT, FR, HU, NL, SE, UK
Risk Assessment	EPPO

Method	
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13385rev%20EPPO%20PRA%20CABCA%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13375rev%20EPPO%20PRA%20report%20CABCA%20rev.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Cabomba caroliniana* is traded and imported for ornamental purposes (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	The plant may affect provisioning, regulating and cultural services through impacts on water body.
8. Includes status (threatened or protected) of species or habitat under threat	Impact on threatened species and habitats are evident for example in the Netherlands found in Natura 2000 habitats (Beringen *et al.*, 2013a, Beringen *et al.*, 2013b).
9. Includes possible effects of climate change in the foreseeable future	Low risk predicted for Ireland (Kelly *et al.*, 2014) but risk may increase in other countries with climate change.
11. Documents information sources	**Beringen MJR, Lamers LPM, Odé B, Pot R, van de Velde G, van Valkenburg JLCH, Verbrugge LNH, Leuven RSEW. 2013a.** Knowledge document for risk analysis of non-native Fanwort (Cabomba caroliniana) in the Netherlands. Reports Environmental Science nr. 420. http://www.q-bank.eu/Plants/Controlsheets/Cabomba_State-of-the-Art.pdf. **Beringen MJR, Lamers LPM, Odé B, Pot R, van de Velde G, van Valkenburg JLCH, Verbrugge LNH, Leuven RSEW. 2013b.** Risk analysis of the non-native Fanwort (*Cabomba carolinianana*) in the Netherlands. Reports Environmental Science nr. 442.

	Brunel S. 2009. Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*.
Main experts	Johan van Valkenburg Etienne Branquart
Notes	EPPO DSS suggests high risk in the Atlantic and Mediterranean region and already established in 6 European countries. Other countries in similar bioregions may be invaded in the future. PRA in NL: http://www.q-bank.eu/Plants/Controlsheets/RAreport_Cabomba_20130830DEFPrintVersion.pdf
Outcome	Compliant

Scientific name	*Caprella mutica*
Common name	Japanese Skeleton Shrimp
Broad group	Invertebrate
Number of and countries wherein the species is currently established	7: BE, UK, NL, IR, DE, DK, SE
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=383
1. Description (Taxonomy, invasion history, distribution range (native and	Socio-economic benefits: *Caprella mutica* could be prey for native fish. *Caprella mutica* has been shown to be the dominant prey item on artificial reef structures, in temperate waters beyond Europe with numbers of *Caprella mutica* positively correlated to fish condition factor (Page *et al.*,

introduced), geographic scope, socio-economic benefits)	2007).
6. Can broadly assess environmental impact with respect to ecosystem services	*Caprella mutica* can reach large densities on anthropomorphic structures, especially in enriched environments, such as fin fish aquaculture, with densities of up to 319 000 individuals m^2 recorded (Ashton *et al.*, 2010).
8. Includes status (threatened or protected) of species or habitat under threat	Likely to be low to non-existent as *C. mutica* invasions in Euurope are so far associated with "areas of human activity, including ports, aquaculture facilities and an oilrig; the species has not yet been found in natural habitats" (Ashton *et al.*, 2007b).
9. Includes possible effects of climate change in the foreseeable future	A global increase in temperature of 2°C (UNFCCC, 2011) is unlikely to impact survival in Europe as temperatures of 25°C (Shevchenko *et al.*, 2004) are found within the native range. *Caprella mutica* can tolerate a wide range of temperatures and salinities and so it is likely to cope with climate change (Ashton *et al.*, 2007a). A global predicted sea level rive of 2.7m, based on capping of temperatures at a 2°C rise (Schaeffer *et al.*, 2012) will lead to the gradual increase in new habitats suitable for colonisation, many of which will be submerged anthropomorphic structures, of which *C. mutica* favours in colonisation. *Caprella mutica* is tolerant of a broad range of temperature and salinity conditions, with 100% mortality at 30 °C (48 h LT50, 28.3 ± 0.4 °C), and salinities lower than 16 (48 h LC50, 18.7 ± 0.2). Although lethargic at low temperatures (2 °C), no mortality was observed, and the species is known to survive at temperatures as low as −1.8 °C. The upper LC50 was greater than the highest salinity tested (40), thus it is unlikely that salinity will limit the distribution of *C. mutica* in open coastal waters (Ashton *et al.*, 2007a). These findings suggest that this species would be able to expand its range southwards along French and Iberian coastlines (Cook *et al.*, 2007).
11. Documents information sources	**Ashton GV, Burrows MT, Willis KJ, Cook EJ. 2010.** Seasonal population dynamics of the non-native *Caprella mutica* (Crustacea,

	Amphipoda) on the west coast of Scotland. *Marine and Freshwater Research* **61:** 549-559. **Ashton GV, Willis KJ, Burrows MT, Cook EJ. 2007a.** Environmental tolerance of *Caprella mutica*: Implications for its distribution as a marine non-native species. *Marine environmental research* **64:** 305-312. **Ashton GV, Willis KJ, Cook EJ, Burrows M. 2007b.** Distribution of the introduced amphipod, *Caprella mutica* Schurin, 1935 (Amphipoda: Caprellida: Caprellidae) on the west coast of Scotland and a review of its global distribution. *Hydrobiologia* **590:** 31-41. **Cook EJ, Willis KJ, Lozano-Fernandez M. 2007.** Survivorship, growth and reproduction of the non-native *Caprella mutica* Schurin, 1935 (Crustacea: Amphipoda). *Hydrobiologia* **590:** 55-64. **Guerra-García J, Ros M, Dugo-Cota A, Burgos V, Flores-León A, Baeza-Rojano E, Cabezas M, Núñez J. 2011.** Geographical expansion of the invader *Caprella scaura* (Crustacea: Amphipoda: Caprellidae) to the East Atlantic coast. *Marine biology* **158:** 2617-2622. **Page HM, Dugan JE, Schroeder DM, Nishimoto MM, Love MS, Hoesterey JC. 2007.** Trophic links and condition of a temperate reef fish: comparisons among offshore oil platform and natural reef habitats. *Marine Ecology Progress Series* **344:** 245-256. **Ros M, Guerra-García J, Navarro-Barranco C, Cabezas M, Vázquez-Luis M. 2014.** The spreading of the non-native caprellid (Crustacea: Amphipoda) *Caprella scaura* Templeton, 1836 into southern Europe and northern Africa: a complicated taxonomic history. *Mediterr Mar Sci* **15:** 145-155. **Schaeffer M, Hare W, Rahmstorf S, Vermeer M. 2012.** Long-term sea-level rise implied by 1.5 ^{o}C and 2 ^{o}C warming levels. *Nature Climate Change* **2:** 867-870. **Shevchenko O, Orlova TY, Maslennikov S. 2004.** Seasonal dynamics of the diatoms of the genus *Chaetoceros* Ehrenberg in Amursky Bay (Sea of Japan). *Russian Journal of Marine Biology* **30:** 11-19. **UNFCCC. 2011.** Report of the Conference of the Parties on its Sixteenth Session, held in Cancún from 29 November to 10 December 2010 http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf.
Main experts	Argyro Zenetos

	Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan
Notes	Additional information on distribution The species could establish in the following biogeographic areas: Celtic Sea, North Sea, Iberian, Bay of Biscay In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? Sweden, Germany, Ireland, United Kingdom, Netherlands, Belgium, Denmark, France, Spain, Portugal and as a Near-neighbour Norway and the Norwegian shelf, can also be added to these distribution lists. Congener: *Caprella scaura* In the Mediterranean and Iberian a con generic species, also dispersed by ships, is established: *Caprella scaura* (Guerra-García *et al.*, 2011, Ros *et al.*, 2014). To explore the current distribution of *C. scaura* in the Iberian Peninsula and adjacent areas, marine fouling communities from 88 marinas along the whole Iberian Peninsula and North Africa, 3 from Italy, 1 from France, 1 from Malta and 1 from Greece were surveyed between June 2011 and June 2012 (Ros *et al.*, 2014). The results of this survey report the first confirmed record of *C. scaura* in Corsica (France), Crete (Greece) and Morocco, and confirm an extensive distribution of *C. scaura* along the Spanish Mediterranean coast and the Strait of Gibraltar. The species was absent along the north Atlantic coast of Spain and the upper distribution limit for the eastern Atlantic coast is the locality of Cascais, on the south coast of Portugal. All populations studied belong to the same morphological form, which match the “varieties” *C. scaura* typica from Brazil and *C. scaura scaura* from Mauritius, suggesting that (1) these two forms correspond to the same “variety”; (2) this “variety” is the only one that is expanding its distribution range and (3) the remaining “varieties” of *C. scaura* complex could represent distinct species with a restricted distribution. It is established in the Iberian Sea: Atlantic Spain (2008); Portugal (2011), Canary isl (2010); Med Spain (2011); Greece (2002); Italy (1994); Med

	France (2012); Malta (2012)
Outcome	Compliant

Scientific name	*Cervus nippon*
Common name	Sika deer
Broad group	Vertebrate
Number of and countries wherein the species is currently established	11: AT, CZ, DE, DK, EE, FR, IE, LT, PL, SK, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=384
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Cervus nippon* is a game species. The International Sika Deer Society (in Germany) forced policy to step back from eradication attempts in NRW (http://sikawild.org/ausrottung). The number of shot animals per year is low in most European countries (a few hundred individuals) with associated costs of from several hundred to more than 2000 € per individual (e.g. http://www.globus-jagdreisen.de/de/jagdlaender/europa/schottland/jagd-auf-sikahirsche/, http://www.premium-jagdreisen.de/product_info.php?products_id=29 (Solarz & Okarma, 2014). Sika deer is farmed for meat, although in significantly lower numbers than other cervids. In Poland the commercial value of farmed sika deer was roughly estimated at 215 000 – 251 000 € (Solarz & Okarma, 2014). The species is kept in zoological gardens and for ornamental purposes by private owners. The ISIS database roughly estimates that there are approximately 885 individuals kept in 48 European institutions (ISIS, 2014). It is also perceived as a local attraction for nature lovers and the general public (Solarz & Okarma, 2014).
6. Can broadly assess environmental impact with respect to	Provisioning services: Damage to forestry in dense populations possible due to browsing and bole scoring (gauging of tree trunks with antlers). In addition to weakening trees and thus decreasing biodiversity value of the

ecosystem services	ecosystems, this also incurs economic losses by lowering timber production and increasing expenditures for prevention measures (Carter, 1984). Regulating services: Repeated browsing of saplings by sika can retard or prevent tree growth, this affecting carbon sequestration (Gill, 1992). Sika also severely damage reed beds in southwest England (Diaz *et al.*, 2005), which has the potential to affect water quality by impeding its purification. Habitat services: Sika deer is a carrier of an alien bloodsucking nematode *Ashworthius sidemi*. It can be transmitted both to wild and domestic ruminants, which potentially poses a threat to biological diversity and may incur economic losses (Demiaszkiewicz, 2014, Demiaszkiewicz *et al.*, 2013, Kowal *et al.*, 2012). Sika hybridises with native red deer (*Cervus elaphus*) thus affecting maintenance of genetic diversity (Biedrzycka *et al.*, 2012, Goodman *et al.*, 1999). Cultural services: As the parasite carrier, sika may not only directly affect habitat services, but also have impact on cultural services through putting at risk species that are valued by hunters, nature lovers, and the general public. Cultural services are also affected because of hybridisation. In parts of Scotland, hybridisation between sika and native red deer means there are no pure-bred individuals of red deer (Goodman *et al.*, 1999). Impacts to the natural heritage (commonly taken as semi-natural woodland and heather moorland) can be unacceptably high when sika reach high densities (Gill *et al.*, 2000).
8. Includes status (threatened or protected) of species or habitat under threat	*Asworthius sidemi*, an alien blood-sucking nematode carried by sika deer, was transmitted to the European bison *Bison bonasus*, vulnerable according to IUCN Red List (Olech, 2008). Infestation includes the largest global population in the Białowieża Forest and may lead to the death of young bisons. Sika impact woodland habitats and reedbeds by browsing on plants and trampling ground flora (Diaz *et al.*, 2005). They can act as ecosystem engineers, altering woodland bird and butterfly communities through vegetation diversity and structural change (Baiwy *et al.*, 2013, Gill, 1992).

9. Includes possible effects of climate change in the foreseeable future	Sika have expanded their range in the UK at an annual rate of 5.3% in recent years and are predicted to be capable of spreading throughout the majority of Great Britain (Acevedo *et al.*, 2010). Each of the few significant population declines throughout the 100-year history of the species presence in Poland was contributed by severe winter conditions, particularly by the deep snow cover (Solarz & Okarma, 2014). The species favours warm climates, naturally ranging throughout the subtropics of Japan and China. Warmer, wetter conditions and milder winters predicted by some climate change models are therefore likely to favour the spread and persistence of sika in Europe. An increase in tick abundance and prevalence with climate change is predicted (Gilbert, 2010), which might affect deer. Additionally it is predicted that there will be a decrease in deer body mass with climate change (Sheridan & Bickford, 2011), which might affect its grazing impact. Finally, changes in six deer phenological traits as a result of different plant growth under climate warming have been described (Moyes *et al.*, 2011), but the consequences of such changes for the species are unclear. Studies on related species reveal complex patterns, e.g. advanced breeding phenology in red deer (Moyes *et al.*, 2011), but no phenological response in roe deer (Plard *et al.*, 2014).
11. Documents information sources	**Acevedo P, Ward AI, Real R, Smith GC. 2010.** Assessing biogeographical relationships of ecologically related species using favourability functions: a case study on British deer. *Diversity and Distributions* **16:** 515-528. **Baiwy E, Schockert V, Branquart E. 2013.** Risk analysis of the sika deer, *Cervus nippon*, Risk analysis report of non-native organisms in Belgium. Cellule interdépartementale sur les Espèces invasives (CiEi), DGO3, SPW / Editions, 38 pages. **Biedrzycka A, Solarz W, Okarma H. 2012.** Hybridization between native and introduced species of deer in Eastern Europe. *Journal of Mammalogy* **93:** 1331-1341. **Carter N. 1984.** Bole scoring by sika deer (*Cervus nippon*) in England. *Deer* **6:** 77-78. **Demiaszkiewicz A. 2014.** Migrations and the introduction of wild ruminants as a source of parasite exchange and emergence of new parasitoses. *Annals of Parasitology* **60:** 25-30. **Demiaszkiewicz AW, Kuligowska I, Lachowicz J, Pyziel AM, Moskwa B.**

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Diaz A, Pinn E, Hannaford J. 2005. 14. Ecological Impacts of Sika Deer on Poole Harbour Saltmarshes. *Proceedings in Marine Science* **7:** 175-188.

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Moyes K, Nussey DH, Clements MN, Guinness FE, Morris A, Morris S, Pemberton JM, Kruuk LE, CLUTTON-BROCK TH. 2011. Advancing breeding phenology in response to environmental change in a wild red deer population. *Global Change Biology* **17:** 2455-2469.

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Plard F, Gaillard J-M, Coulson T, Hewison AM, Delorme D, Warnant C, Bonenfant C. 2014. Mismatch Between Birth Date and Vegetation Phenology Slows the Demography of Roe Deer. *PLoS biology* **12:** e1001828.

Sheridan JA, Bickford D. 2011. Shrinking body size as an ecological response to climate change. *Nature Climate Change* **1:** 401-406.

Solarz W, Okarma H. 2014. Management plan for sika deer *Cervus nippon* in Poland. Report for the General Directorate for Environmental Protection GDOŚ. Krakow, 79 pp.

Main experts	Wojciech Solarz Wolfgang Rabitsch Melanie Josefsson
Other contributing experts	Olaf Booy Belinda Gallardo
Notes	Additional information: In how many EU member states has this species been recorded? List them. Fourteen: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Netherlands, Romania, Poland, Sweden, United Kingdom In how many EU member states has this species currently established populations? List them. Eleven: Austria, Czech Republic, Denmark, France, Germany, Estonia, Ireland, Lithuania, Poland, Slovakia, United Kingdom In how many EU member states has this species shown signs of invasiveness? List them. Six: Czech Republic, Denmark, France, Ireland, Poland, United Kingdom In which EU Biogeographic areas could this species establish? Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic (Note: establishment and invasiveness in boreal and alpine areas as well as in Sweden and Finland is uncertain because of species sensitivity to deep snow cover as described above). EUNIS codes: E: Grassland and tall forb habitats, F3: Temperate and mediterraneo-montane scrub habitats, F4: Temperate shrub heathland, F8: Thermo-Atlantic xerophytic habitats, G: Woodland and forest habitats and other wooded land, I: Regularly or recently cultivated agricultural, horticultural and domestic habitats (Genovesi & Putman 2006 *Cervus nippon*. DAISIE). In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.

	Twenty six: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Nineteen: Belgium, Bulgaria, Croatia, Estonia, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden
Outcome	Compliant

Scientific name	*Corvus splendens*
Common name	Indian house crow
Broad group	Vertebrate
Number of and countries wherein the species is currently established	1: NL
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=49
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: House Crows were deliberately introduced into a number of countries for a variety of purposes, including biocontrol (e.g. caterpillars in Malaysia (Cramp *et al.*, 1980); livestock ticks in Oman (Ryall, 1994)) and to clean up refuse (e.g. Zanzibar (Ryall, 1994)). The species probably reduces the amount of human refuse in areas where waste management is inadequate, therefore outcompeting rats (CABI ISC, 2013). However, within Europe the opportunities for these purposes are lacking. In India the species is recognised as beneficial because it reduces numbers of invertebrate agricultural pests (Chakravarthy, 1988). Again, within Europe potential positive impact with this respect is unlikely. As a newcomer to the avifauna of Europe, House crow may be perceived as an attraction by birdwatchers and its exotic origin may be appealing

	also to the general public (Ryall, 2002, Ryall, 2003).
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning services: A number of crops and livestock present in the EU have been impacted elsewhere. In India, the House Crow is reported to raid crops such as wheat and maize, and to cause severe damage to fruit in orchards (Long, 1981), and to fields of oats and maize (Cramp *et al.*, 1980). Other crops damaged in India are ripening sunflower (Dhindsa *et al.*, 1991) and almonds (Bhardwaj, 1991). In Pakistan, the House Crow is regarded as a serious pest, consuming maize, sunflower and harvested wheat (Khan, 2003). In Mauritius, production of free range poultry was affected by predation on eggs and chicks (Puttoo & Archer, 2004). In France, carrion crows *Corvus corone* are one of a number of predators recorded as killing chickens being reared at free-range poultry units (Stahl *et al.*, 2002). Indian House Crows would represent an additional predation risk. Impacts on crops and livestock, however, will be mitigated through the species mostly residing in urban/semi-urban areas rather than rural. Throughout its range, the House Crow feeds primarily on human refuse, stolen scraps and road kills (Ryall, 1992). Regulating services: Further impacts are associated with public health issues arising from the House Crow's communal roosting and scavenging behaviours. Disease regulation - Indian House Crows are regarded as a public nuisance in a number of countries. The birds roost communally and can involve thousands of individuals (Cramp *et al.*, 1980). Such large roosts in urban areas create high levels of noise pollution and faecal contamination (Brook *et al.*, 2003, Jennings, 1992). Together with scavenging from refuse tips, streets and from human residences these behaviours present risks to public health. House Crows have been shown to carry organisms detrimental to human health, including *Salmonella*, *Escherichia coli* and *Campylobacter* (Ganapathy *et al.*, 2007, Jennings, 1992), and that of livestock, including Newcastle Disease (Roy *et al.*, 1998). The species is also a potential reservoir for West Nile Virus and avian influenza (Nyári *et al.*, 2006).
8. Includes status (threatened or protected) of species	The Indian House Crow is a voracious predator of eggs, chicks and adults of other bird species (Long, 1981, Puttoo & Archer, 2004, Yap & Sodhi, 2004); causes displacement of indigenous bird species through

or habitat under threat	competition and aggression (Brook *et al.*, 2003, Cramp *et al.*, 1980, Long, 1981, Puttoo & Archer, 2004). In its native and introduced range it is closely associated with people, taking advantage of scavenging opportunities provided by discarded food items and refuse dumps almost exclusively along coastal strips (Nyári *et al.*, 2006). Therefore, the protected habitats and/or species that could be impacted are in urban, semi-urban and peri-urban habitats with an emphasis on coastal areas. Impact on four red listed species (from GISD): *Falco punctatus* VU *Nesoenas mayeri* EN *Otus pembaensis* VU *Treron pembaensis* VU
9. Includes possible effects of climate change in the foreseeable future	The distribution of this species may be in the process of shifting because of the current global shifts in climates, which would broaden the species distribution at the poleward limits of its current distribution (Nyári *et al.*, 2006). Persistence of the small population at Hoek van Holland in the Netherlands is better explained by the degree of human development. This population is able to withstand winter temperatures down to -8°C thanks to human subsidy and acceptance of the local community (Ryall, 2003). High temperatures may negatively affect the parasite *Toxoplasma gondii* that affects House crow (Salant *et al.*, 2013). Releasing the pressure from this parasite may facilitate further spread of Indian House crow.
11. Documents information sources	**Bhardwaj S. 1991.** Indian house crow damage to almond in Himachal Pradesh, India. **Brook BW, Sodhi NS, Soh MC, Lim HC. 2003.** Abundance and projected control of invasive house crows in Singapore. *The Journal of wildlife management***:** 808-817. **CABI ISC. 2013.** *Corvus splendens*. Datasheet. Accessed on 15.12.2014 http://www.cabi.org/isc/datasheet/15463. **Chakravarthy A. 1988.** Bird predators of pod borers of field bean (Lablab niger Medick). *International Journal of Pest Management* **34:** 395-398. **Cramp S, Perrins CM, Brooks DJ. 1980.** *Handbook of the birds of Europe, the Middle East, and North Africa: the birds of the western*

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	Applied Ecology **39:** 204-216. **Yap CA, Sodhi NS. 2004.** Southeast Asian invasive birds: ecology, impact and management. *Ornithological Science* **3:** 57-67.
Main experts	Wojciech Solarz Wolfgang Rabitsch
Other contributing experts	Olaf Booy Belinda Gallardo Piero Genovesi
Notes	In how many EU member states has this species been recorded? List them. 3 - IE, NL, PL In how many EU member states has this species currently established populations? List them. 1 – NL In how many EU member states has this species shown signs of invasiveness? List them. 1 – NL In which EU Biogeographic areas could this species establish? Most likely the Mediterranean and Atlantic Coast, but possible in other regions except alpine and boreal. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Most likely the Mediterranean and Atlantic Coast, but possible in other regions except alpine and boreal. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Most likely to become invasive in Mediterranean and Black Sea (i.e. Spain, Portugal, Italy, Greece, France, Republic of Cyprus, Croatia, Malta,

	Bulgaria, Romania) Potential to establish in: Austria, Belgium, Czech Republic, Denmark, Germany, Hungary, Ireland, Luxembourg, Netherlands, Poland, Slovakia, Slovenia and the UK. Unlikely to establish in: Sweden, Estonia, Finland, Latvia, Lithuania.
Outcome	Compliant

Scientific name	*Crassostrea gigas*
Common name	Pacific Oyster
Broad group	Invertebrate
Number of and countries wherein the species is currently established	16: BE, DK, UK, HR, FR, DE, GR, IT, MT, NL, PT, RO, SI, ES, SE, IE
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=647
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Wild populations of *C. gigas* are harvested by local communites as a food item and for economic benefit (Cognie *et al.*, 2006). This species is also used in aquaculture.
6. Can broadly assess environmental impact with respect to ecosystem services	*Crassostrea gigas* has many and considerable impacts on ecosystem functioning and services with the ability to significantly alter trophic webs in the vicinity of dense populations reviewed in (Katsanevakis et al., 2014). It has been shown that there can be an increase in species richness, abundance, biomass, and diversity in *C. gigas* reefs in comparison to *M. edulis* reefs (Markert *et al.*, 2010).
8. Includes status (threatened or	Likely to impact habitats and species within SAC reefs and large shallow inlets and bays.

protected) of species or habitat under threat	
9. Includes possible effects of climate change in the foreseeable future	Natural spread is likely to occur in the future, whether by natural spread linked to climate change or accidental introduction through human activities, e.g. leisure boats, marinas. Given the quantity of suitable habitat in Europe and increasing suitability of conditions for reproduction (as seas become warmer with climate change), establishment is very likely. In 1966, oyster farmers were told that the introduction of the Pacific oyster was acceptable since water temperatures in The Netherlands were assumed to be too low for this species to be able to reproduce, as had been the case with the closely related Portuguese oyster *C. angulata* (Dijkema, 1997). However, the Pacific oyster soon proved to be able to reproduce in Dutch waters. In 1971, young *C. gigas* of approximately one year old were collected from the harbour of Zierikzee by F. Kerckhof. In 1975, Pacific oyster spat were observed to have settled onto mussel shells and some intertidal mussel beds. In 1976 and 1982 extensive spatfalls were observed, which were attributed to prolonged periods of high water temperatures. Although in Scandinavia water temperatures had been assumed to be too low for reproduction of *C. gigas*, as had been the case in The Netherlands, Pacific oysters are now naturally reproducing in Danish, Swedish and Norwegian waters. The recent success of *C. gigas* in Scandinavia and northern Germany appears to be related to the occurrence of exceptionally warm summers and mild winters during the last decade (Diederich *et al.*, 2005, Wrange *et al.*, 2010). Further invasion in the north is considered likely but will depend on high late-summer water temperatures. The Pacific oyster was already adapted to a wide range of environmental conditions, and appears able to quickly adapt to new habitats. This is confirmed by its ability to sustain a wide range of environmental conditions. The oysters can survive water temperatures up to 40 °C (Shamseldin *et al.*, 1997) and at low tide air temperatures as low as − 5 °C (Korringa, 1952) and even lower, depending on the salinity of the water enclosed in their shells (> 75% survival at 30 psu, at − 12 °C air temperature; exposure during 7 days, 6 h per day, mimicking tidal emersion). Growth occurs between 10–40 °C and 10–30 psu, and

	spawning between 16–30 °C and 10–30 psu. Larvae can sustain temperatures between 18 and 35 °C and salinities between 19 and 35 psu (Mann, 1979, Rico-Villa *et al.*, 2009). A global increase in temperature of 2°C is likely to allow for the further northerly increase in range for invasive *C. gigas* populations as a temperature of 19°C is required for spawning (Fabioux *et al.*, 2005, Mann, 1979). Increased pCO_2 and acidification projected by 2030 affected calcification larvae development. Consequently, only 5% developed into normal veligers (Kurihara *et al.*, 2007, Lannig *et al.*, 2010). It has been suggested that warming and acidification will adversely affect this species (Lannig *et al.*, 2010).
11. Documents information sources	**Cognie B, Haure J, Barillé L. 2006.** Spatial distribution in a temperate coastal ecosystem of the wild stock of the farmed oyster *Crassostrea gigas* (Thunberg). *Aquaculture* **259:** 249-259. **Diederich S, Nehls G, van Beusekom JE, Reise K. 2005.** Introduced Pacific oysters (*Crassostrea gigas*) in the northern Wadden Sea: invasion accelerated by warm summers? *Helgoland Marine Research* **59:** 97-106. **Dijkema R. 1997.** Molluscan fisheries and culture in the Netherlands. *NOAA Technical Report NMFS* **129:** 115-135. **Fabioux C, Huvet A, Le Souchu P, Le Pennec M, Pouvreau S. 2005.** Temperature and photoperiod drive *Crassostrea gigas* reproductive internal clock. *Aquaculture* **250:** 458-470. **Korringa P. 1952.** Recent advances in oyster biology. *Quarterly review of biology*: 266-308. **Kurihara H, Kato S, Ishimatsu A. 2007.** Effects of increased seawater pCO2 on early development of the oyster Crassostrea gigas. *Aquatic Biology* **1:** 91-98. **Lannig G, Eilers S, Pörtner HO, Sokolova IM, Bock C. 2010.** Impact of ocean acidification on energy metabolism of oyster, *Crassostrea gigas*—changes in metabolic pathways and thermal response. *Marine drugs* **8:** 2318-2339. **Mann R. 1979.** Some biochemical and physiological aspects of growth and gametogenesis in *Crassostrea gigas* and *Ostrea edulis* grown at sustained elevated temperatures. *Journal of the Marine Biological Association of the United Kingdom* **59:** 95-110. **Markert A, Wehrmann A, Kröncke I. 2010.** Recently established *Crassostrea*-reefs versus native *Mytilus*-beds: differences in ecosystem engineering affects the macrofaunal communities (Wadden Sea of Lower Saxony, southern German Bight). *Biological Invasions* **12:** 15-32. **Rico-Villa B, Pouvreau S, Robert R. 2009.** Influence of food density and

	temperature on ingestion, growth and settlement of Pacific oyster larvae, *Crassostrea gigas*. *Aquaculture* **287:** 395-401. **Shamseldin A, Clegg JS, Friedman CS, Cherr GN, Pillai M. 1997.** Induced thermotolerance in the Pacific oyster, *Crassostrea gigas*. **Wrange A-L, Valero J, Harkestad LS, Strand Ø, Lindegarth S, Christensen HT, Dolmer P, Kristensen PS, Mortensen S. 2010.** Massive settlements of the Pacific oyster, *Crassostrea gigas,* in Scandinavia. *Biological Invasions* **12:** 1145-1152.
Main experts	Argyro Zenetos Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan Olaf Booy
Notes	Additional information Risk assessment according to ENSARS: Medium Overall 2.2 (2.4) Introd.2.7 (3.0) moderately high risk Establ.2.0 (2.5) for medium risk; Dispersal 2.0 (1.8) for medium risk; Impact 2.2 (2.2) for medium risk; In how many EU member states has this species currently established populations? List them. Sweden, Ireland, Germany, Belgium, Denmark, Netherlands, Portugal, Spain, France, United Kingdom, Italy, France, Malta, Slovenia, Romania In which EU Biogeographic areas could this species establish? Baltic Sea, North Sea, Celtic, Iberian, Mediterranean, Black Sea In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Sweden, Ireland, Germany, Belgium, Denmark, Netherlands, Portugal, Spain, France, United Kingdom, Italy, France, Malta, Slovenia, Ukraine, Romania Greece, Croatia In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List

	them. All member states. Near Neighbours where it occurs: Russia, Norway (Norwegian shelf) and Ukraine
Outcome	Compliant but Pacific oyster is in annex IV of Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture. This means that it is excluded from the scope of the IAS regulation (see art 2.e)

Scientific name	*Crassula helmsii*
Common name	Australian swamp stonecrop
Broad group	Plant
Number of and countries wherein the species is currently established	11: AT, BE, DE, DK, ES, FR, IE, IT, NL, PT, UK
Risk Assessment Method	EPPO, GB NNRA
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12703_PRA_Crassula_helmsii_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12801%20PRA%20report%20CSBHE.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=237
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Crassula helmsii* is traded and imported for ornamental purposes (Brunel, 2009).
6. Can broadly assess environmental impact with respect to	*Crassula helmsii* may affect provisioning, regulating and cultural services. It interferes with irrigation systems (Hassan & Ricciardi, 2014).

ecosystem services	
8. Includes status (threatened or protected) of species or habitat under threat	Impact on threatened species and habitats: dense populations observed in Natura 2000 habitats (e.g. NL). Threat to species from *Litorello eleocharitetumacicularis* association and other rare plant species. Impact on newts (incl. in GB NNRA); Impact on *Pilularia globulifera* NT (from GISD 2014)(Robert *et al.*, 2013a).
9. Includes possible effects of climate change in the foreseeable future	No change after climate change is anticipated in the Atlantic region (Kelly *et al.*, 2014). *Crassula helmsii* has broad climatic amplitude (it occurs in Australia, New Zealand and has established in USA and in several European Countries (Belgium, France, Germany, the Netherlands and United Kingdom). In the southern hemisphere, *C. helmsii* is present in areas that have levels of precipitation from 100-550 mm in summer (November - April) and 200-3000 mm in winter (May - October). Its temperature requirements are restricted to a summer range of 20-25°C and a winter range of 0-15°C including extended periods under snow. In its native range it inhabits a wide range of climatic variation, from a mean temperature of 30°C in summer to -6°C in winter. No information is available to assess its survival capacity in extreme conditions (e.g. very cold conditions).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Robert H, Lafontaine R-M, Beudels-Jamar RC, Delsinne T. 2013.** Risk analysis of the Australian swamp stonecrop *Crassula helmsii* (Kirk) Cockayne. - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 37 p. See also: - The Belgian risk analysis report - The Irish risk analysis report
Main experts	Johan van Valkenburg Etienne Branquart

Other contributing experts	Belinda Gallardo Piero Genovesi
Notes	General conclusion (EPPO, GB): high risk in the Atlantic area. Area at risk: Atlantic area and possibly also in other bioregions. Currently established in 8-11 different countries : AT, BE, DE, DK, (ES), FR, IE, (IT), NL, (PT) and UK. Other countries may be invaded in the future in those bioregions. Establishment capacity is uncertain in Mediterranean region and central Europe. Data for establishment in Portugal (invalid record), Spain and Italy (http://crassulaceae.net/crassula/43-speciescrassula/138-native-crassula-in-italy-uk/ grey literature mentioning localised presence near Trieste in ponds on karst without proper voucher material) should be validated based on primary sources. Some countries not yet invaded in EU; A species of commonly invaded habitats in the north western Europe is Pillularia globulifera that has an NT status (http://www.iucnredlist.org/details/167887/0)
Outcome	Compliant

Scientific name	*Crepidula fornicata*
Common name	Slipper Limpet
Broad group	Invertebrate
Number of and countries wherein the species is currently established	12: BE, DK, UK, FR, DE, GR, IT, MT, NL, ES, SE, IE
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=754
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope,	Socio-economic benefits: subject of an extensive review (Katsanevakis *et al.*, 2014) "it reduces predation pressure to basibionts, provides additional substrate for other epibenthic species, adds heterogeneity to habitat structure, reduces parasite attacks on basibionts, may improve water quality and reduce toxic algal blooms, and may increase diversity, biomass and abundance of zoobenthic communities"

socio-economic benefits)	
6. Can broadly assess environmental impact with respect to ecosystem services	High density populations of *C. fornicata* are known to have ecosystem engineering effects, by altering phytoplankton communities, trophic levels and effecting sediment deposition (Thieltges *et al.*, 2006). A review of the main ecosystem service effects by (Katsanevakis *et al.*, 2014) lists disturbance to fishery and aquaculture activates and increased costs; reduced recruitment to benthic fish species; fouling of underwater structures; and most notably, competition and resulting reduced growth of *Mytilus edulis*.
8. Includes status (threatened or protected) of species or habitat under threat	Likely to impact habitats and species within SAC reefs and large shallow inlets and bays.
9. Includes possible effects of climate change in the foreseeable future	The infestation density of *C. fornicata* may be limited by high mortalities associated with cold winter temperatures in Northern Europe (Thieltges *et al.*, 2004). Mortality increased from 11-14% in areas without winter frost to 56-97% in frost areas. The authors conclude that milder winters may allow for an increase in the abundance of northern populations combined with a northward shift. *Crepidula fornicata* was found to expand its distribution in the English Channel possibly in relation to climate change (Hinz *et al.*, 2011). According to this study, the species has increased its coverage from 14 to 44% in the period between 1958 and 2006. A global increase in temperature of 2°C is likely to allow for the northerly expansion of *C. fornicata* range and population density within the Risk Assessment Area as low winter temperatures have been identified as a limiting factor to populations in German, Danish and Norwegian waters (Thieltges *et al.*, 2004).
11. Documents information sources	**Hinz H, Capasso E, Lilley M, Frost M, Jenkins S. 2011.** Temporal differences across a bio-geographical boundary reveal slow response of sub-littoral benthos to climate change. *Marine Ecology Progress Series* **423:** 69-82. **Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014.** Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-

	European review. *Aquatic Invasions* **9:** 391-423. **Thieltges DW, Strasser M, Reise K. 2006.** How bad are invaders in coastal waters? The case of the American slipper limpet *Crepidula fornicata* in western Europe. *Biological Invasions* **8:** 1673-1680. **Thieltges DW, Strasser M, van Beusekom JE, Reise K. 2004.** Too cold to prosper—winter mortality prevents population increase of the introduced American slipper limpet *Crepidula fornicata* in northern Europe. *Journal of Experimental Marine Biology and Ecology* **311:** 375-391. See also: - Irish risk analysis report
Main experts	Argyro Zenetos Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan
Notes	Non-native species Application based Risk Analysis (NAPRA) There are many pathways via which *C. fornicata* has the potential to enter. Of these pathways, contaminated molluscan shellfish and vessel hull fouling are likely to be the most threatening, with the former known to be the primary cause of entry in Europe. The species wide tolerance of environmental conditions is likely to aid its survival during transport. The threat of entry via hull fouling of vessels is likely to be dependent on slow moving vessels from infested locations. In which EU Biogeographic areas could this species establish? Iberian, Celtic, North Sea-Nnot BALTIC SEA or BLACK SEA In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Atlantic and Mediterranean France, Atlantic Spain; Denmark, Sweden, Ireland, Germany, Netherlands, Denmark, Belgium, United Kingdom, Greece, Italy, Malta, Cyprus, Slovenia In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List

	them. Italy, Malta, Cyprus, Slovenia.
Outcome	Compliant

Scientific name	*Didemnum vexillum*
Common name	Carpet Sea-squirt
Broad group	Invertebrate
Number of and countries wherein the species is currently established	6: ES, FR, NL, UK, IR, IT
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=238
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: not reported.
6. Can broadly assess environmental impact with respect to ecosystem services	In "non-European regions, where *D. vexillum* is invasive, it had a severe impact on the native ecosystems by overgrowing large areas of the bottom" suffocating virtually every organism (Gittenberger, 2010b). It is likely that if densities increase in Europe then these problems will come to the fore.
8. Includes status (threatened or protected) of species or habitat under threat	*Didemnum vexillum* is found in a number of SACs within Europe, with two notable examples from Ireland, the Malahide Estuary SAC 000205 (Minchin and Sides, 2006) and Clew Bay Complex SAC 001482 (Kelly and Maguire, 2008), both home to a number of listed bird and plant species as long as protected habitats. It also has significant negative impacts on cultured or commercially important wild shellfish (Gittenberger, 2010a).
9. Includes possible effects of climate	*Didemnum vexillum* colonies can tolerate water temperatures of -2 to 24℃ and daily changes of up to 11℃ (Gittenberger, 2007). At high

change in the foreseeable future	summer temperatures, especially above 20℃, colonies decline and growth speed decreases (Daley & Scavia, 2008, Gittenberger, 2007, McCarthy *et al.*, 2007). It is therefore unlikely that climate change resulting from global warming will automatically increase the invasion potential of this ascidian. At temperatures below 8-10℃ colony growth stops. The suitable ranges for *D. vexillum* included temperatures between 5–31 °C (although reported thermal tolerance in the field reported as only up to 24℃ (Valentine *et al.*, 2007)) and salinities from 10–33% regardless of season (Herborg *et al.*, 2009). *Didemnum vexillum* showed substantially less mortality under moderate (−7 units) and severe (−14 units) hypo-salinity than the native *D. listerianum* (Lenz *et al.*, 2011). While it is unknown which physiological adaptation mediates the tolerance in *D. vexillum*, it should constitute a competitive advantage for this recently introduced species if precipitation rates will increase in coming years as it is predicted for Wales (Farrar *et al.*, 2000). Non-native tunicates, including *D. vexillum*, all experienced 100% mortality in the heat-wave (24.5 ^{o}C) treatment (i.e. 0% cover for *D. vexillum* on day 5). Non-native tunicates recovered faster than native tunicates; abundances of all three non-native tunicate species on heat-wave plates were not significantly different from ambient levels by 35 days (Sorte *et al.*, 2010).
11. Documents information sources	**Daley BA, Scavia D. 2008.** An integrated assessment of the continued spread and potential impacts of the colonial ascidian, *Didemnum* sp. A, in US waters. **Farrar J, Vaze P, Hulme M, Reynolds B. 2000.** Wales: Changing Climate, Challenging Choices—A Scoping Study of Climate Change Impacts in Wales. *University of Wales, Bangor, ECOTEC Research & Consulting, Institute of Terrestrial Ecology, Bangor, University of East Anglia*. **Gittenberger A. 2007.** Recent population expansions of non-native ascidians in The Netherlands. *Journal of Experimental Marine Biology and Ecology* **342:** 122-126. **Gittenberger A. 2010a.** Risk analysis of the colonial sea-squirt Didemnum vexillum Kott, 2002 in the Dutch Wadden Sea, a UNESCO World Heritage Site. *Risk analysis of the colonial sea-squirt Didemnum*

	vexillum *Kott, 2002 in the Dutch Wadden Sea, a UNESCO World Heritage Site.* **Gittenberger A. 2010b.** Risk analysis of the colonial sea-squirt *Didemnum vexillum* Kott, 2002 in the Dutch Wadden Sea, a UNESCO World Heritage Site. **Herborg LM, O'Hara P, Therriault TW. 2009.** Forecasting the potential distribution of the invasive tunicate *Didemnum vexillum*. *Journal of Applied Ecology* **46:** 64-72. **Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014.** Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* **9:** 391-423. **Lenz M, da Gama BA, Gerner NV, Gobin J, Gröner F, Harry A, Jenkins SR, Kraufvelin P, Mummelthei C, Sareyka J. 2011.** Non-native marine invertebrates are more tolerant towards environmental stress than taxonomically related native species: results from a globally replicated study. *Environmental research* **111:** 943-952. **McCarthy A, Osman RW, Whitlatch RB. 2007.** Effects of temperature on growth rates of colonial ascidians: A comparison of *Didemnum* to *Botryllus schlosseri* and *Botrylloides violaceus*. *Journal of Experimental Marine Biology and Ecology* **342:** 172-174. **Sorte CJ, Fuller A, Bracken ME. 2010.** Impacts of a simulated heat wave on composition of a marine community. *Oikos* **119:** 1909-1918. **Valentine PC, Collie JS, Reid RN, Asch RG, Guida VG, Blackwood DS. 2007.** The occurrence of the colonial ascidian *Didemnum* sp. on Georges Bank gravel habitat—Ecological observations and potential effects on groundfish and scallop fisheries. *Journal of Experimental Marine Biology and Ecology* **342:** 179-181.
Main experts	Argyro Zenetos Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan
Notes	Canadian risk assessment includes uncertainty of vector and impact Impact on biodiversity: High – likely Canadian RA Impact on MPAs: moderate-likely Impact on shellfish: high almost certain

	Impact on fishing: moderate-likely Impact on vessels/mooring: moderate-likely to almost certain Impact on recreational low In how many EU member states has this species been recorded? Spain 2008 Established Ireland 2005 invasive United Kingdom 2005 invasive Netherlands 1991 Established France 1998 Established Italy 2010 established In which EU Biogeographic areas could this species establish? North, Celtic, Iberian, Mediterranean In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Mediterranean France, Spain, Belgium, Greece, Slovenia, Croatia In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Mediterranean France, Spain, Belgium, Greece, Slovenia, Croatia
Outcome	Compliant

Scientific name	*Eichhornia crassipes*
Common name	Water hyacinth
Broad group	Plant
Number of and countries wherein the species is currently established	5: ES, FR, IT, PT, RO
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-

	14407%20PRA%20record%20Eichhornia%20crassipes%20EICCR.pdf http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14408_PRAreport_Eichhornia.pdf
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Eichhornia crassipes* is traded and imported for ornamental purposes (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	*Eichhornia crassipes* may affect provisioning, regulating and cultural services. It interferes with irrigation systems, boating, fishing, etc (Hassan & Ricciardi, 2014).
8. Includes status (threatened or protected) of species or habitat under threat	Whereas in Asia and Africa numerous species are under threat by the dense mats produced by *E. crassipes* http://193.206.192.138/gisd/species.php?sc=70. In the Mediterranean area so far only eutrophic and anthropogenic systems have been affected. Impact on Red List assessed species 21: EX = 1; CR = 4; EN = 3; VU = 5; NT = 4; LC = 4 (from GISD 2014); • *Allotoca diazi CR* • *Aythya innotata CR* • *Aythya nyroca NT* • *Biomphalaria tchadiensis EN* • *Chloropeta gracilirostris VU* • *Citharidium ansorgii LC* • *Cyprinus intha EN* • *Dendrocygna bicolor LC* • *Haliaeetus leucoryphus VU* • *Microrasbora rubescens EN* • *Mutela franci VU* • *Ottelia scabra NT* • *Oxyura maccoa NT* • *Pollimyrus petricolus LC* • *Puntius compressiformis CR* • *Rhodonessa caryophyllacea CR*

	• *Rynchops albicollis VU* • *Steatocranus irvinei NT* • *Tachybaptus pelzelnii VU* • *Tachybaptus rufolavatus EX* • *Villorita cyprinoides LC*
9. Includes possible effects of climate change in the foreseeable future	Risk is likely to increase in the Atlantic area (Kelly *et al.*, 2014). However the main uncertainty relates to the climatic requirements of the species, especially the capacity of the species to be cold tolerant, influencing its ability to establish in more temperate countries, e.g. on the Atlantic coast in France and England. It is not known whether the plant could set seeds during summer in these areas, and whether the crown could survive, protected by dead parts of the plant. Managers in the northeastern United States are concerned that aquatic invasive species such as water hyacinth (*E. crassipes*) will be able to overwinter if temperatures increase, snowfall is reduced, the frequency of freeze–thaw cycles increase or seasonal ice cover melts earlier in the year. Milder winters would not only increase survival but also create longer growing seasons, potentially increasing reproductive output (Hellmann *et al.*, 2008). For example, the geographic distribution of water hyacinth (*E. crassipes*) is currently limited by cold, hard freezes, or ice cover (Grodowitz *et al.*, 1991, Owens & Madsen, 1995); in these areas hand pulling is sufficient control. If warmer winter temperatures allow these plants to overwinter, management will need to be more aggressive, sustained, and expensive (Hellmann *et al.*, 2008). Water hyacinth has invaded freshwater systems in over 50 countries on five continents and, according to recent climate change models, its distribution may expand into higher latitudes as temperatures rise (Rahel & Olden, 2008, Rodriguez - Gallego *et al.*, 2004). *Eichhornia crassipes* is reported to be winter hardy, but sensitive to frost. Frosts kill the leaves and upper petioles which protect the rhizome, but prolonged cold temperatures, below 5 ^{o}C, may kill the rhizome resulting in death of the plants (Owens and Madsen, 1995). Kasselmann (1995) reported that its minimum growth temperature is 12 ^{o}C, its optimum growth temperature is 25-30 °C, and its maximum growth temperature is 33-35 ^{o}C. Optimal growth occurs at temperatures of 28 to 30 ^{o}C, while growth ceases when water temperatures drop below 10 ^{o}C and it is retarded above 34 ^{o}C (Owens & Madsen, 1995).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213.

	Grodowitz MJ, Stewart RM, Cofrancesco AF. 1991. Population dynamics of waterhyacinth and the biological control agent *Neochetina eichhorniae* (Coleoptera: Curculionidae) at a southeast Texas location. *Environmental entomology* **20:** 652-660. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Hellmann JJ, Byers JE, Bierwagen BG, Dukes JS. 2008.** Five potential consequences of climate change for invasive species. *Conservation Biology* **22:** 534-543. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Owens CS, Madsen J. 1995.** Low temperature limits of waterhyacinth. *Journal of Aquatic Plant Management* **33:** 63-68. **Rahel FJ, Olden JD. 2008.** Assessing the effects of climate change on aquatic invasive species. *Conservation Biology* **22:** 521-533. **Rodriguez-Gallego LR, Mazzeo N, Gorga J, Meerhoff M, Clemente J, Kruk C, Scasso F, Lacerot G, García J, Quintans F. 2004.** The effects of an artificial wetland dominated by free-floating plants on the restoration of a subtropical, hypertrophic lake. *Lakes & Reservoirs: Research & Management* **9:** 203-215.
Main experts	Johan van Valkenburg Etienne Branquart
Other contributing experts	Belinda Gallardo Piero Genovesi
Notes	EPPO DSS: high risk in Mediterranean. Area at risk: Mediterranean and Black Sea regions with some countries within these regions remaining uninvaded. Medium uncertainty for establishment capacity in the Atlantic area.
Outcome	Compliant

Scientific name	*Elodea canadensis*
Common name	Canadian water/pondweed

Broad group	Plant
Number of and countries wherein the species is currently established	21: AT, BE, BG, CZ, DE, DK, EE, FI, FR, HU, IE, IT, LT, LU, LV, NL, PL, PT, RO, SE, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=617
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Elodea canadensis* is traded for ornamental purposes, but not imported anymore (local production) (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	Where *Elodea canadensis* persists in dense populations, the plant may affect provisioning, regulating and cultural services by fouling of water supply systems, crowding of recreational waterways, effect on angling, watersports and boating (Hassan & Ricciardi, 2014).
8. Includes status (threatened or protected) of species or habitat under threat	May be found in protected habitats but probably not at dense populations. Dense mats only found in anthropogenic habitats recently colonized (GB NNRA).
9. Includes possible effects of climate change in the foreseeable future	Under greenhouse conditions, the June/July growth of individually potted *E. canadensis* over temperatures ranging from 12 to 32 °C was monitored (Barko *et al.*, 1982, Barko & Smart, 1983). A general positive relationship between total biomass production and temperature was demonstrated. Greenhouse warming may result in earlier onset of growth and possible dominance of those species for which germination and the resumption of growth are primarily controlled by a rise in temperature. This phenomenon is reported for populations of *E. canadensis*. Several studies in waters influenced by thermal discharge support this idea, at least in part. In such systems an increase in the abundance of aquatic macrophytes at the cost of other submerged macrophytes is reported

	(Haag, 1979). The emergent macrophytes such as *E. canadensis*, emerged earlier and grew better in the warmer conditions of the greenhouse pond (maintained at 2-3C higher than ambient) compared with those in the reference pond. The difference in above-ground biomass throughout the growing seasons was >2 fold and after three experimental growing seasons the difference in below-ground biomass of macrophytes was 2.5-fold between the ponds (Kankaala *et al.*, 2000). The relative growth rate of both species was strongly affected by growth conditions and increased by up to 4·5 times with increased temperature and inorganic carbon availability (Olesen & Madsen, 2000). In general, growth rates increased with temperature with a Q10 varying from 2.3 to 3.5. However, at 5°C, growth was nearly arrested (Madsen & Brix, 1997). In ice-free areas near power plant outfalls it was found that *E. canadensis* dominated other species, which were not active during winter because their dormancy mechanisms were regulated by environmental cues other than temperature (Brock & van Vierssen, 1992, Haag, 1979). Decreasing impact in Ireland (Kelly *et al.*, 2014).
11. Documents information sources	**Barko J, Hardin D, Matthews M. 1982.** Growth and morphology of submersed freshwater macrophytes in relation to light and temperature. *Canadian Journal of Botany* **60:** 877-887. **Barko J, Smart R. 1983.** Effects of organic matter additions to sediment on the growth of aquatic plants. *The journal of Ecology*: 161-175. **Brock TC, van Vierssen W. 1992.** Climatic change and hydrophyte-dominated communities in inland wetland ecosystems. *Wetlands Ecology and Management* **2:** 37-49. **Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Haag RW. 1979.** The ecological significance of dormancy in some rooted aquatic plants. *The journal of Ecology*: 727-738. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Kankaala P, Ojala A, Tulonen T, Haapamäki J, Arvola L. 2000.** Response of littoral vegetation on climate warming in the boreal zone; an experimental simulation. *Aquatic Ecology* **34:** 433-444. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Madsen TV, Brix H. 1997.** Growth, photosynthesis and acclimation by two submerged macrophytes in relation to temperature. *Oecologia* **110:** 320-327. **Olesen B, Madsen TV. 2000.** Growth and physiological acclimation to

	temperature and inorganic carbon availability by two submerged aquatic macrophyte species, *Callitriche cophocarpa* and *Elodea canadensis*. *Functional Ecology* **14:** 252-260. See also: - Irish risk analysis report
Main experts	Johan van Valkenburg Etienne Branquart
Other contributing experts	Belinda Gallardo
Notes	GB NNRA medium risk but NOT VALIDATED BECAUSE OF INFORMATION GAPS. EPPO has not risk assessed this species because it is widespread in Europe. Some experts considered this species should be downgraded to a low risk because of decreasing populations (unknown causes) and replacement/outcompetition by other non-native Hydrocharitaceae. Included in the NL red list of plants. The GB NNRA risk assessment is under review in GB, which is taking into account new information relating to impact. Comments and changes to the original GBNNRA have been initiated but have not yet been included or validated within the GB NNRA. Area at risk: already colonized most of potential area
Outcome	**NOT COMPLIANT** (major information gaps)

Scientific name	*Eriocheir sinensis*
Common name	Chinese mittencrab
Broad group	Invertebrate
Number of and countries wherein the species is currently established	16: BE, CZ, DE, DK, EE, ES, FI, FR, IE, LV, LT, NL, PL, PT, SE, UK
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=51

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Adult *E. sinensis* which are taken as by-catch are sold to ethnic communities that have a tradition of consuming them (DAISIE 2013). Mitten crabs have been used as live fish bait, for fish meal production, as agricultural fertilizer, and for cosmetic products (Dittel & Epifanio, 2009) (DAISIE 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	*Eriocheir sinensis* is a known ecosystem engineer, effecting river bank stability through its burrowing activity. It can damage commercial fishing gear and consume fish caught in nets (Clark *et al.*, 1998, Katsanevakis *et al.*, 2014).
8. Includes status (threatened or protected) of species or habitat under threat	Burrowing activity may cause habitat damage to sandbanks, tidal mudflats and sandflats, reefs, estuaries and rivers within SACs. No specific information on damage to species but mitten crab allegedly prey on a range of fish species eggs including *Salmo salar* but data is limited (Culver, 2005).
9. Includes possible effects of climate change in the foreseeable future	In the Far East *E. sinensis* is the second intermediate host of the oriental lung fluke, *Paragonimus westermanii*, and if the crab is eaten uncooked the parasite can infect humans, causing the disease paragonimiasis. However, establishment of this lung disease in the north of EU is thought unlikely because *P. westermanii* is specific to a primary intermediate host of aquatic snails assigned to the Thiaridae, and the climate is too cold for members of this gastropod family. A global increase in temperature of 2 °C is likely to allow for the northerly expansion of *E. sinensis* range within Europe as the optimal water temperature range for reproduction is between 15 – 18°C (Anger, 1991). A global predicted sea level rive of 2.7m, based on capping of temperatures at a 2 °C rise (Schaeffer *et al.*, 2012) will lead to the gradual increase in new habitats to colonise, as saline waters push further inland. Projections of climatic suitability for *E. sinensis* show noticeable changes in future climates, especially in relation to the loss of suitable areas along the Southern Atlantic and Mediterranean coasts of the Iberian Peninsula (Capinha *et al.*, 2012). For *E. sinensis*, forecasts suggest that the majority of the north and northwest of the Peninsula will remain climatically suitable in the future, but an overall loss of suitability is expected to occur

	in southern areas. Larval development and survival is temperature and salinity dependent, with survival in a range of salinities from 15 to 32 ppt and temperatures from 12 to 25 °C (Anger, 1991). Optimal survival occurs in salinities of 20–25 ppt and temperatures from 15 to 25 °C (Anger, 1991, Kim & Hwang, 1995). Complete mortality in the first zoea stage occurs at 9 °C (Anger, 1991).
11. Documents information sources	**Anger K. 1991.** Effects of temperature and salinity on the larval development of the Chinese mitten crab *Eriocheir sinensis* (Decapoda: Grapsidae). *Marine Ecology Progress Series* **72:** 103-110. **Capinha C, Anastácio P, Tenedório JA. 2012.** Predicting the impact of climate change on the invasive decapods of the Iberian inland waters: an assessment of reliability. *Biological Invasions* **14:** 1737-1751. **Clark PF, Rainbow PS, Robbins RS, Smith B, Yeomans WE, Thomas M, Dobson G. 1998.** The alien Chinese mitten crab, *Eriocheir sinensis* (Crustacea: Decapoda: Brachyura), in the Thames catchment. *Journal of the Marine Biological Association of the United Kingdom* **78:** 1215-1221. **Culver CS. 2005.** Assessing the potential for Chinese mitten crab predation on eggs and larvae of salmonids. *Marine Science Institute, University of California, Santa Barbara*. **Dittel AI, Epifanio CE. 2009.** Invasion biology of the Chinese mitten crab *Eriochier sinensis*: A brief review. *Journal of Experimental Marine Biology and Ecology* **374:** 79-92. **Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014.** Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* **9:** 391-423. **Kim CH, Hwang SG. 1995.** The complete larval development of the mitten crab *Eriocheir sinensis* H. Milne Edwards, 1853 (Decapoda, Brachyura, Grapsidae) reared in the laboratory and a key to the known zoeae of the Varuninae. *Crustaceana*: 793-812. **Schaeffer M, Hare W, Rahmstorf S, Vermeer M. 2012.** Long-term sea-level rise implied by 1.5 ^{o}C and 2 ^{o}C warming levels. *Nature Climate Change* **2:** 867-870.
Main experts	Melanie Josefsson Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan

	Argyro Zenetos
Notes	Additional information: In how many EU member states has this species been recorded? List them. Baltic Sea Estonia 1933 Casual Baltic Sea Lithuania 1926 Casual Celtic Seas United Kingdom 2010 Casual Celtic Seas Ireland 2006 Casual North Sea Sweden 1932 Casual North Sea Norway 1976 Casual FW only Ukraine 2002 Established Baltic Sea Latvia 1932 Established Baltic Sea Russia 1980 Established Baltic Sea Sweden 1932 Established Baltic Sea Finland 1933 Established Baltic Sea Germany 1932 Established Baltic Sea Poland 1928 Established Bay of Biscay & the Iberian coast Spain 1997 Established Bay of Biscay & the Iberian coast Portugal 1988 Established Black Sea Romania 1934,1997 Established Black Sea Ukraine 1998, 2005 Established Black Sea Bulgaria 2006 Unknown North Sea Germany 1915 Established North Sea Netherlands 1929 Established North Sea France 1930 Established North Sea Belgium 1933 Established North Sea United Kingdom 1935 Established North Sea Denmark 1927 invasive
Outcome	Compliant

Scientific name	*Fallopia japonica*
Common name	Japanese knotweed
Broad group	Plant
Risk Assessment Method	GB NNRA

Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=239
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Fallopia japonica* has been intentionally introduced used for ornamental purposes (Pyšek *et al.*, 2012), possible use as a source of resveratrol (Vrchotová *et al.*, 2007) for honeybees, biomass fuel and possible remediation of soil (Honzik *et al.*, 1999).
6. Can broadly assess environmental impact with respect to ecosystem services	No available information.
8. Includes status (threatened or protected) of species or habitat under threat	It occurs frequently in natural areas (Pyšek *et al.*, 2013) where it is recognized as a problematic plant.
9. Includes possible effects of climate change in the foreseeable future	Widespread distribution across Europe. The plant has mechanisms for adaptation to adverse conditions and the use of competition strategies to monopolize resources; a warmer wetter climate will suit it even more. This species is a pioneer colonist; it withstands drought, heat, cold, sulphurous soil, being buried and even salt spray by sea lochs. The future climate change scenario shows *F. japonica* expanding into the higher elevations of the central European mountains and increasing its northward extent considerably in western Norway as well as in Sweden and Finland and increasing its growth, as it prefers warmer wetter conditions in summer. The eastern distributional limit of *F. japonica* is also predicted to shift markedly eastward and is predicted to lie between the Baltic and the Urals. Parts of Iceland are also likely to become potentially available to the species. These changes represent to a large extent the limitations imposed

	upon the species by winter temperatures and the amplified temperature increases simulated by GCMs at high latitudes in the winter months. The species' present northern limit is in Fennoscandia, however, this is in part determined by its minimum GDD5 requirement and thus its simulated northward expansion in part reflects the year-round warming predicted at these latitudes. The species' retreat from much of central northern Europe and from southern and southwestern parts of its present range apparently is primarily a reflection of decreased moisture availability in the 2 × CO_2 scenario (Beerling *et al.*, 1995). Mean annual temperatures and the risk of summer droughts are likely to increase in Europe. Hence, it is predicted that seed rotting will be boosted because of higher winter temperatures and any seedlings present will suffer from summer droughts rather than late frosts. In contrast, as a late summer flowerer seed production should be favoured by the diminished risk of early frost owing to warmer temperatures as mentioned by Bailey et al. (2009). Sexual reproduction by the hybrid would increase its ability to spread and to adapt to new environmental conditions because of higher genetic variability, which causes further problems (Funkenberg *et al.*, 2012).
11. Documents information sources	**Beerling DJ, Huntley B, Bailey JP. 1995.** Climate and the distribution of *Fallopia japonica*: use of an introduced species to test the predictive capacity of response surfaces. *Journal of Vegetation Science* **6:** 269-282. **Funkenberg T, Roderus D, Buhk C. 2012.** Effects of climatic factors on *Fallopia japonica* sl seedling establishment: evidence from laboratory experiments. *Plant Species Biology* **27:** 218-225. **Honzik R, Vana J, Ustak S. 1999.** Heavy metal decontamination of soil by means of plants. Pflanzenbelastung auf kontaminierten Standorten: plant impact at contaminated sites. Internationaler Workshop am 1. und 2. Dezember 1997 am Fraunhofer-Institut für Umweltchemie und Ökotoxikologie, Schmallenberg.: Erich Schmidt Verlag GmbH & Co (Berlin), 183-190. **Pyšek P, Danihelka D, Sádlo J, Jr. C, Chyrtý M, Jarošík V, Kaplan Z, Hrahulec F, Moravcová L, Perg J, Štajerová K, Tichý L. 2012.** Catalogue of alien plants of the Czech Republic (2nd edition): checklist update, taxonomic diversity and invasion patterns. *Preslia* **84:** 155-255. **Pyšek P, Genovesi P, Pergl J, Monaco A, Wild J. 2013.** Plant Invasions of Protected Areas in Europe: An Old Continent Facing New Problems *Plant Invasions in Protected Areas*: Springer. 209-240. **Vrchotová N, Sera B, Triska J. 2007.** The stilbene and catechin content of

	the spring sprouts of Reynoutria species. *Acta Chromatographica* **19:** 21.
Main experts	Kelly Martinou - Jan Pergl
Notes	Taxonomy of the *Fallopia* is complex and not generally adhered to by field workers and there is significant difference in risk of the group of taxons *F. japonica* vs *F. sachalinensis* and their hybrid *F. bohemica*. *Fallopia sachalinensis* does not pose such a high risk (lower regeneration, growth, overall invasive potential, distribution) in comparison to *F. japonica* or the hybrid *F. bohemica*. If the species are taken separately, then it is possible to consider *F. japonica* and *F. bohemica* posing high risk. *Fallopia sachalinensis* can be considered of lower risk. Furthermore there are a high number of hybrids which backcross, so it is recommended to ensure that all possible taxa are considered.
Outcome	Compliant

Scientific name	*Fallopia sachalinensis*
Common name	Japanese knotweed
Broad group	Plant
Number of and countries wherein the species is currently established	25: AT, BE, BG, CZ, DE, DK, EE, ES, FI, FR, HR, HU, IE, IT, LT, LU, LV, NL, PL, PT, RO, SE, SI, SK, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=385
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Fallopia sachalinensis* has been intentionally introduced for ornamental purposes (Pyšek *et al.*, 2012) (DAISIE – www.europe-aliens.org), possible use as a source of resveratrol (Vrchotová *et al.*, 2007) for honeybees, biomass fuel and possible remediation of soil (Honzik *et al.*, 1999).

6. Can broadly assess environmental impact with respect to ecosystem services	No available information.
8. Includes status (threatened or protected) of species or habitat under threat	It occurs frequently in natural areas (Pyšek *et al.*, 2013) where it is recognized as a problematic plant.
9. Includes possible effects of climate change in the foreseeable future	The plant has mechanisms for adaptation to adverse conditions and the use of competition strategies to monopolize resources; a warmer wetter climate will be advantageous to this species. This species is a pioneer colonist; it withstands drought, heat, cold, sulfurous soil, being buried and even salt spray by sea lochs. Already established and widespread across Europe and climate change is likely to increase its growth, as it prefers warmer wetter conditions in summer.
11. Documents information sources	**Honzik R, Vana J, Ustak S. 1999.** Heavy metal decontamination of soil by means of plants. Pflanzenbelastung auf kontaminierten Standorten: plant impact at contaminated sites. Internationaler Workshop am 1. und 2. Dezember 1997 am Fraunhofer-Institut für Umweltchemie und Ökotoxikologie, Schmallenberg.: Erich Schmidt Verlag GmbH & Co (Berlin), 183-190. **Pyšek P, Danihelka D, Sádlo J, Jr. C, Chyrtý M, Jarošík V, Kaplan Z, Hrahulec F, Moravcová L, Perg J, Štajerová K, Tichý L. 2012.** Catalogue of alien plants of the Czech Republic (2nd edition): checklist update, taxonomic diversity and invasion patterns. *Preslia* **84:** 155-255. **Pyšek P, Genovesi P, Pergl J, Monaco A, Wild J. 2013.** Plant Invasions of Protected Areas in Europe: An Old Continent Facing New Problems *Plant Invasions in Protected Areas*: Springer. 209-240. **Vrchotová N, Sera B, Triska J. 2007.** The stilbene and catechin content of the spring sprouts of Reynoutria species. *Acta Chromatographica* **19:** 21.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Belinda Gallardo
Notes	Taxonomy of the *Fallopia* is complex and not generally adhered to by field

	workers and there is significant difference in risk of the group of taxons *F. japonica* vs *F. sachalinensis* and their hybrid *F. bohemica* and indeed other hybrids. *Fallopia sachalinensis* does not pose such a high risk (lower regeneration, growth, overall invasive potential, distribution) in comparison to *F. japonica* or the hybrid *F. bohemica*. If the risk assessment is done for each species separately, then it is possible to join *F. japonica* and F. × *bohemica*, posing high risk together. *Fallopia sachalinensis* can be assessed separately because of lower impact and associated invasion risk. As there is high number of hybrids and backcrossing within the genus leading to wrong identification, it is recommended to ensure that all possible taxa are covered and consider all species as high risk.
Outcome	Compliant

Scientific name	*Heracleum mantegazzianum*
Common name	Giant hogweed
Broad group	Plant
Number of and countries wherein the species is currently established	18: AT, BE, CZ, DE, DK, EE, FI, FR, HU, IE, IT, LV, LU, NL, PL, SE, SK, UK
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14470%20PRA%20Heracelum%20mantegazzianum.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Heracleum mantegazzianum* is used by beekeepers and livestock feeding (it contains high amounts of sugar, it is not suitable for sillage due to its high water content).
Main experts	Kelly Martinou Jan Pergl

Notes	This species was not scored by EPPO DSS because the species is already widespread in Europe. *Heracleum mantegazzianum* is a widely studied species in its invaded range and there is much information about its biology, ecology and management compare to its closely related species *H. sosnowskyi* and *H. persicum*. Information needed for scoring is added to the appendix. The EPPO DSS for *H. sosnowskyi* can be used for this species.
Outcome	**NOT COMPLIANT** because of major information gaps

Scientific name	*Heracleum persicum*
Common name	Persian hogweed
Broad group	Plant
Number of and countries wherein the species is currently established	3: DK, FI, SE
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14472%20PRA%20Heracleum%20persicum.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15076%20PRA%20report%20Heracleumpersicum%20rev%20post%20WPPR.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: ornamental planting and rare use by beekeepers. For livestock feeding it is not suitable due to smell of plant which is translated to milk and meat.
Main experts	Kelly Martinou Jan Pergl
Notes	No additional comments
Outcome	Compliant

Scientific name	*Heracleum sosnowskyi*
Common name	Sosnowski's hogweed
Broad group	Plant
Number of and countries wherein the species is currently established	5: EE, FI, HU, LT, LV, PL
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14471%20PRA%20Heracleum%20sosnowskyi.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15075%20PRA%20report%20Heracleumsosnowskyi%20post%20WPPR.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: *Heracleum sosnowskyi* has use for ornamental planting, beekeepers, livestock feeding (high amount of sugar, not suitable for sillage due to high content of water).
Notes	No additional comments.
Main experts	Kelly Martinou Jan Pergl
Outcome	Compliant

Scientific name	*Hydrocotyle ranunculoides*
Common name	Floating pennywort
Broad group	Plant
Number of and countries wherein the species is currently established	9: BE, DE, ES, FR, IE, IT, NL, PT, UK
Risk Assessment Method	EPPO, GB NNRA

Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15108%20PRA%20Hydrocotyle%20ranunculoides%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15161%20PRA%20Report%20Hydrocotyle%20ranunculoides.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=240
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Hydrocotyle ranunculoides* was traded and imported for ornamental purposes. However, it is now restricted in several European countries as a consequence of trade regulation or codes of conduct designed to decrease invasion risks (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	This plant may affect provisioning, regulating and cultural services by fouling of water supply systems and drainage, crowding of recreational waterways, effect on angling, watersports and boating where it makes dense populations (Hassan & Ricciardi, 2014).
8. Includes status (threatened or protected) of species or habitat under threat	Impact on threatened species and habitats: form dense populations in Natura 2000 habitats (Robert *et al.*, 2013b).
9. Includes possible effects of climate change in the foreseeable future	No change predicted in Atlantic regions (Kelly *et al.*, 2014). According to the Climex simulation, the Atlantic and Mediterranean areas of the EPPO region that are characterized by mild winters are the most at risk. According to the climatic prediction, additional countries are at risk (e.g.: Mediterranean countries, Black Sea area). In Europe, plants grow slowly in spring and form small, up to 10 cm² large leaves. The plants flower and produce fruits between May and October. The maximal growth rate is reached during June and July (Hussner & Lösch, 2007). The species is reported to tolerate a wide range of temperatures, from 0°C up to 30°C of water temperatures. According to the climate calculations of Ackerly lab California Flora Climate Database (http://loarie.stanford.edu/calflora/index.php) which are based on mean climatic data where the species is recorded, the following information are available for temperatures:

	- mean daily air temperature (Annual based on 18-year mean) = 14.31 °C - minimum daily air temperature (Annual based on 18-year mean) = 1.58 °C - maximum daily air temperature (Annual based on 18-year mean) = 30.82 °C According to Hussner and Lösch (2007), optimal CO2 exchange (linked with photosynthesis) is between 25 and 32°C, meaning that optimal growth would occur at these temperatures; at 35°C, the gas exchanges dropped. Its presence in tropical America, in Africa and western Asia (Lebanon, Syria) shows however that *H. ranunculoides* could be present at higher temperatures. In Western Europe populations may be strongly reduced during cold winters, but recovery occurs quickly in the following season.
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Hussner A, Lösch R. 2007.** Growth and photosynthesis of *Hydrocotyle ranunculoides* L. fil. in Central Europe. *Flora-Morphology, Distribution, Functional Ecology of Plants* **202:** 653-660. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Robert H, Lafontaine R-M, Beudels-Jamar RC, Delsinne T. 2013.** Risk analysis of the Water Pennywort *Hydrocotyle ranunculoides* (L.F., 1781). - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 59 p. See also: - The Belgian risk analysis report - The Irish risk analysis report
Main experts	Johan van Valkenburg Etienne Branquart
Other contributing experts	Belinda Gallardo
Notes	EPPO DSS and GB NNRA: high risk in the Atlantic and Mediterranean

	areas. Area at risk: Atlantic, Mediterranean and Black Sea regions. Some countries not yet invaded in relevant bioregions.
Outcome	Compliant

Scientific name	*Lagarosiphon major*
Common name	Curly waterweed
Broad group	Plant
Number of and countries wherein the species is currently established	10: AT, BE, DE, ES, FR, IE, IT, NL, PT, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=241
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Lagarosiphon major* is traded and imported for ornamental purposes (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	May affect provisioning, regulating and cultural services (Lafontaine *et al.*, 2013a, Matthews *et al.*, 2012).
8. Includes status (threatened or protected) of species or habitat under threat	Adversely impacts Chara communities (see Ireland Risk Assessment). Also include effects on Loch Corib in Ireland (Caffrey *et al.*, 2010).
9. Includes possible effects of climate	Increased warming could increase risk of collapse of submerged plant communities, and there could be a switch towards phytoplankton

change in the foreseeable future	communities increasingly dominated by cyanophytes (Mckee *et al.*, 2002, Moss *et al.*, 2003). In contrast, the plant community proved resilient (McKee *et al.*, 2003, Mckee *et al.*, 2002). There was no switch to phytoplankton dominance, even at the highest nutrient levels in the presence of fish. In another mesocosm experiment involving a 3℃ temperature increase and 0.5 mg N l-1 enrichment, the proportion of warm-water exotics like L. major increased (McKee *et al.*, 2003) Additionally *L. major* was the major beneficiary of continuous warming in a mesocosm experiment designed to test the effect of simulated climate warming (Mckee *et al.*, 2002). Risk increase in the Atlantic region (Kelly *et al.*, 2014).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Caffrey JM, Millane M, Evers S, Moron H, Butler M. 2010.** A novel approach to aquatic weed control and habitat restoration using biodegradable jute matting. *Aquatic Invasions* **5:** 123-129. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Lafontaine R-M, Beudels-Jamar RC, Delsinne T, Robert H. 2013.** Risk analysis of the Curly Waterweed *Lagarosiphon major* (Ridley) Moss. - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 57 p. **Matthews J, Beringen R, Collas F, Koopman K, Odé B, Pot R, Sparrius L, van Valkenburg J, Verbrugge L, Leuven R. 2012.** Knowledge document for risk analysis of the non-native Curly Waterweed (*Lagarosiphon major*) in the Netherlands. *Reports Environmental Science* **414**. **McKee D, Atkinson D, Collings S, Eaton J, Gill A, Harvey I, Hatton K, Heyes T, Wilson D, Moss B. 2003.** Response of freshwater microcosm communities to nutrients, fish, and elevated temperature during winter and summer. *Limnology and Oceanography* **48:** 707-722. **Mckee D, Hatton K, Eaton JW, Atkinson D, Atherton A, Harvey I, Moss B. 2002.** Effects of simulated climate warming on macrophytes in freshwater microcosm communities. *Aquatic Botany* **74:** 71-83. **Moss B, McKee D, Atkinson D, Collings S, Eaton J, Gill A, Harvey I, Hatton K, Heyes T, Wilson D. 2003.** How important is climate? Effects of

	warming, nutrient addition and fish on phytoplankton in shallow lake microcosms. *Journal of Applied Ecology* **40:** 782-792. See also: - The Irish risk analysis report
Main experts	Johan van Valkenburg Etienne Branquart
Other contributing experts	Belinda Gallardo
Notes	GBNNRA: high risk in the Atlantic area. Area at risk: Atlantic, Mediterranean and Black Sea regions. Some countries not yet invaded in relevant bioregions.
Outcome	Compliant

Scientific name	*Lithobates (Rana) catesbeianus*
Common name	North American bullfrog
Broad group	Vertebrate
Number of and countries wherein the species is currently established	7: BE, DE, GR, FR, IT, NL, UK
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=56
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits are limited to the harvest and trade of animals for food (legs eaten, sold as gourmet, but does not appear to be economically profitable and limited extent) and as pet (including for garden ponds). This species is farmed for food in some areas outside Europe, and small number of the European introductions were originally due to import for food (and subsequent escape from farms) (Adriaens *et al.*, 2013). Translocations into private wetlands as a pet or source of food are problematic (Albertini & Lanza, 1987, Yiming *et al.*, 2006). http://www.issg.org/database/species/ecology.asp?si=80&fr=1&sts=sss&l

	ang=EN
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	The species may have a major impact on many species of threatened native amphibians due to the role as vector of the chytrid fungus, as predator, and as competitor (including sexual competition) From GISD: In the USA the bullfrog is known to prey on the following endangered amphibians: Amargosa Toad (*Anaxyrus nelsoni)*; California tiger salamander (*Ambystoma californiense*); Chiricahua leopard frog (*Lithobates chiricahuensis*); the California red-legged frog (*Rana draytonii*); and the Oregon spotted frog (*Rana pretiosa*) From IUCN Red List: Outside its native range, this species is considered a pest. It has been observed predating on native species in Puerto Rico, including on *Leptodactylus albilabris*, and is a potential predator of other native species throughout its introduced range. It is a possible vector of pathogens.
6. Can broadly assess environmental impact with respect to ecosystem services	Negative impact on native biodiversity, commercial fisheries, human enjoyment of wildlife following disruption of native biodiversity; possibly others including regulating services. Several field studies portray tadpoles as ‘‘ecosystem engineers’’ that alter the biomass, structure and composition of algal communities. High food intake (Pryor, 2003) and high population densities (up to thousands of individuals per m^2 (Pryor, 2003) suggest that tadpoles have considerable impact on nutrient cycling and primary production in freshwater ecosystems. http://www.issg.org/database/species/ecology.asp?si=80&fr=1&sts=sss&lang=EN
7. Broadly assesses adverse socio-economic impact	An attempt has been made to determine the cost to control of *R. catesbeiana* in Germany (Reinhardt *et al.*, 2003). In this country the presence of the bullfrog was limited to a few populations. However, the foreseen annual cost to implement control measures on only five ponds (mainly by means of electrofishing) is 270,000 euro. The total cost would rise to euro 4.4 billion (and obviously the ecological harm would likewise increase commensurately) in the event that this species spreads throughout Germany (Reinhardt *et al.*, 2003).

8. Includes status (threatened or protected) of species or habitat under threat	Very likely to have an impact on some protected amphibians via disease transmission, predation or competition. This could include amphibians listed on Annex IVa of the Habitats Directive (to say explicitly which species are at particular risk would take further analysis). Given that North American bullfrogs introduced into Europe have been found to prey on a wide range of taxa (notably invertebrates, amphibians, reptiles and mammals), it is possible that they could impact on these taxa via predation if introduced to a site supporting vulnerable populations. Unlikely to have a direct impact on protected habitats. The ability of the North American bullfrog to act as a vector for chytrid fungus is highly important. Infection prevalence was exceptionally high in Spain and Switzerland. In Spain, ongoing chytridiomycosis-driven declines of midwife toads (*Alytes obstetricans*) and salamanders (*Salamandra salamandra*) have been documented since 1997 and 1999, respectively (Fisher & Garner, 2007, Garner *et al.*, 2006). Most of European amphibians will be affected by chytrid fungus. According to GISD worldwide at least 512 species are affected by chytrid fungus (Red List assessed species 512: EX = 8; CR = 196; EN = 126; VU = 63; NT = 29; DD = 36; LC = 54). Introduced bullfrogs compete with endemic species (Hanselmann *et al.*, 2004). Unlike many other frogs, bullfrogs can coexist with predatory fish (Casper & Hendricks, 2005), giving bullfrogs a competitive advantage. Tadpoles of *L. catesbeianus* feed upon eggs and larvae of the endangered Razorback Sucker (*Xyrauchen texanus*) in laboratory conditions (Kraus, 2009), and their densities in artificial habitats can depress fish larvae recruitment (Kraus, 2009). http://www.issg.org/database/species/impact_info.asp?si=80&fr=1&sts=sss&lang=EN *Rana catesbeiana* consumes native frogs, salamanders, turtles, ducklings. It is important to note that additional introductions on alien sunfish can increase bullfrog tadpole survival, increasing the abundance of bullfrogs and their impacts. Impact on Red List assessed species 35: EX = 1; CR = 4; EN = 9; VU = 5; NT =

	3; DD = 2; LC = 11 (from GISD 2014); *Allobates ranoides EN* *Alytes obstetricans LC* *Ambystoma velasci LC* *Anaxyrus californicus EN* *Anaxyrus nelsoni EN* *Ansonia inthanon DD* *Aromobates mayorgai EN* *Aromobates meridensis CR* *Atelopus carbonerensis CR* *Bolitoglossa spongai EN* *Bufo bufo LC* *Centrolene quindianum VU* *Crossodactylus schmidti NT* *Dendropsophus mathiassoni LC* *Dendropsophus meridensis EN* *Epipedobates espinosai DD* *Erinna newcombi VU* *Lithobates fisheri EX* *Lithobates onca EN* *Lithobates palmipes LC* *Lithobates pipiens LC* *Lithobates subaquavocalis CR* *Lithobates tarahumarae VU* *Lithobates vaillanti LC* *Opisthotropis kikuzatoi CR* *Pelophylax cretensis EN* *Rana aurora LC* *Rana boylii NT* *Rana pretiosa VU* *Rhaebo caeruleostictus EN* *Salamandra salamandra LC* *Spea hammondii NT* *Thamnophis atratus LC* *Thamnophis gigas VU* *Thamnophis rufipunctatus LC*
9. Includes possible effects of climate	No data available for Europe only for South America (Nori *et al.*, 2011). Scenarios of future land-use suggest that suitability will remain similar in

change in the foreseeable future	the next years (Ficetola *et al.*, 2010). It is likely that the risk of establishment and spread would increase as a result of climate change, if the latter caused higher summer temperatures and/or waterbodies having longer hydroperiods. Finally, the ongoing climatic changes at global scale can modify the suitability of some areas for bullfrog; for example, global warming can cause an expansion of suitable areas towards higher latitude (Ficetola *et al.*, 2007). http://www.issg.org/database/species/ecology.asp?si=80&fr=1&sts=sss&lang=EN
11. Documents information sources	**Adriaens T, Devisscher S, Louette G. 2013.** Risk analysis of American bullfrog *Lithobates catesbeianus* (Shaw). Risk analysis report of non-native organisms in Belgium. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.41). Instituut voor Natuur- en Bosonderzoek, Brussel. **Albertini G, Lanza B. 1987.** *Rana catesbeiana* Shaw, 1802 in Italy. *Alytes* **6:** 117-129. **Casper G, Hendricks R. 2005.** *Rana catesbeiana* Shaw, 1802. American bullfrog. *Amphibian declines: the conservation status of United States species. University of California Press, Berkeley*: 540-546. **Ficetola GF, Maiorano L, Falcucci A, Dendoncker N, Boitani L, PADOA ‐ SCHIOPPA E, Miaud C, Thuiller W. 2010.** Knowing the past to predict the future: land ‐ use change and the distribution of invasive bullfrogs. *Global Change Biology* **16:** 528-537. **Ficetola GF, Thuiller W, Miaud C. 2007.** Prediction and validation of the potential global distribution of a problematic alien invasive species—the American bullfrog. *Diversity and Distributions* **13:** 476-485. **Fisher MC, Garner TW. 2007.** The relationship between the emergence of *Batrachochytrium dendrobatidis*, the international trade in amphibians and introduced amphibian species. *Fungal Biology Reviews* **21:** 2-9. **Garner TW, Perkins MW, Govindarajulu P, Seglie D, Walker S, Cunningham AA, Fisher MC. 2006.** The emerging amphibian pathogen *Batrachochytrium dendrobatidis* globally infects introduced populations of the North American bullfrog, *Rana catesbeiana*. *Biology letters* **2:** 455-459. **Hanselmann R, Rodrıguez A, Lampo M, Fajardo-Ramos L, Alonso Aguirre A, Marm Kilpatrick A, Paul Rodríguez J, Daszak P. 2004.** Presence of an emerging pathogen of amphibians in introduced bullfrogs *Rana catesbeiana* in Venezuela. *Biological Conservation* **120:** 115-119. **Kraus F. 2009.** Global trends in alien reptiles and amphibians. *Aliens: The Invasive Species Bull* **28:** 13-18.

	Nori J, Urbina-Cardona JN, Loyola RD, Lescano JN, Leynaud GC. 2011. Climate change and American Bullfrog invasion: what could we expect in South America? *PloS one* **6:** e25718. **Pryor GS. 2003.** Growth rates and digestive abilities of bullfrog tadpoles (*Rana catesbeiana*) fed algal diets. *Journal of Herpetology***:** 560-566. **Reinhardt F, Herle M, Bastiansen F, Streit B. 2003.** *Economic impact of the spread of alien species in Germany*. Umweltbundesamt Berlin. **Yiming L, Zhengjun W, Duncan RP. 2006.** Why islands are easier to invade: human influences on bullfrog invasion in the Zhoushan archipelago and neighboring mainland China. *Oecologia* **148:** 129-136.
Main experts	Merike Linnamagi Wolfgang Rabitsch
Other contributing experts	Olaf Booy Riccardo Scalera Piero Genovesi
Notes	The species is CITES-listed, to ensure a coherent legal framework and uniform rules on IAS at Union level, the listing of those IAS as IAS of Union concern should be considered as a matter of priority. In how many EU member states has this species been recorded? List them. 10: Austria; Belgium; Denmark; France; Germany; Greece; Italy; Netherlands; Spain; United Kingdom (Note: some records are historic and so it is possible that the species probably does not still occur in all of these MS). In how many EU member states has this species currently established populations? List them. Belgium, France, Italy, Netherlands, UK, Germany, Greece. In how many EU member states has this species shown signs of invasiveness? List them. UK, France, Italy, Netherlands In which EU Biogeographic areas could this species establish? See Ficetola et al. (2007 and 2010) In how many EU Member States could this species establish in the future

	[given current climate] (including those where it is already established)? List them. See above – potentially many MS, although establishment is more likely in central and southern countries. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. See above – it could be invasive in many central and southern MS.
Outcome	Compliant

Scientific name	*Ludwigia grandiflora*
Common name	Water-primrose
Broad group	Plant
Number of and countries wherein the species is currently established	8: BE, DE, ES, FR, IE, IT, NL, UK,
Risk Assessment Method	EPPO, GB NNRA
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-16827%20PRA%20Ludwigia_grandiflora%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-17142%20PRA%20%20report%20Ludwigia%20grandiflora.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=477
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Traded and imported for ornamental purposes. It is not the case any more in several European countries as a consequence of trade regulation or codes of conduct designed to decrease invasion risks (Brunel, 2009).
6. Can broadly assess environmental impact	May affect provisioning, regulating and cultural services by fouling of water supply systems and drainage, crowding of recreational waterways,

with respect to ecosystem services	effect on angling, water sports and boating where it makes dense populations (Hassan & Ricciardi, 2014, Vanderhoeven, 2013) (EPPO and GB NNRA).
8. Includes status (threatened or protected) of species or habitat under threat	Dense populations can establish in protected habitats (EPPO DSS).
9. Includes possible effects of climate change in the foreseeable future	Strong increase of risk in the Atlantic region (Kelly *et al.*, 2014).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Vanderhoeven S. 2013.** Risk analysis of *Ludwigia grandiflora*, Risk analysis report of non-native organisms in Belgium. Cellule interdépartementale sur les Espèces invasives (CiEi), DGO3, SPW / Editions, 36 pages.
Main experts	Johan van Valkenburg Etienne Branquart
Notes	EPPO DSS and GB NNRA: high risk in Atlantic and Mediterranean. Area at risk: Atlantic, Black Sea and Mediterranean regions. Uncertainty about establishment capacity in the Continental region.
Outcome	Compliant

Scientific name	*Ludwigia peploides*
Common name	Floating primrose-willow
Broad group	Plant

Number of and countries wherein the species is currently established	6: BE, ES, FR, GR, IT, NL
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-16828%20PRA%20Ludwigia_peploides%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-17143%20PRA%20%20report%20Ludwigia%20peploides.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Traded and imported for ornamental purposes. It is not the case any more in several European countries as a consequence of trade regulation or codes of conduct designed to decrease invasion risks (Brunel, 2009).
6. Can broadly assess environmental impact with respect to ecosystem services	May affect provisioning, regulating and cultural services by fouling of water supply systems and drainage, crowding of recreational waterways, effect on angling, water sports and boating where it makes dense populations (Hassan & Ricciardi, 2014) (EPPO DSS and GB NNRA).
8. Includes status (threatened or protected) of species or habitat under threat	Impact on threatened species and habitats: dense populations in protected habitats (see EPPO DSS) (Lafontaine *et al.*, 2013a).
9. Includes possible effects of climate change in the foreseeable future	Strong increase of risk in the Atlantic region (Kelly *et al.*, 2014).
11. Documents information sources	**Brunel S. 2009.** Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment*

	12: 218-223. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Lafontaine R-M, Beudels-Jamar RC, Delsinne T, Robert H. 2013.** Risk analysis of the Curly Waterweed *Lagarosiphon major* (Ridley) Moss. - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 57 p.
Main experts	Johan van Valkenburg Etienne Branquart
Notes	EPPO DSS, GB NNRA: high risk in Atlantic and Mediterranean. Validated. Area at risk: Atlantic, Black Sea and Mediterranean regions. Uncertainty about establishment capacity in the Continental region.
Outcome	Compliant

Scientific name	*Lysichiton americanus*
Common name	American skunk cabbage
Broad group	Plant
Number of and countries wherein the species is currently established	9: BE, , DK, DE, FI, FR, IE, NL, SE, UK
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15078%20PRA%20Lysichiton%20americanus%20final%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15077%20PRA%20report%20Lysichiton%20americanus.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefit: Traded as a pond plant in several European countries (Johan van Valkenburg personal communication).

6. Can broadly assess environmental impact with respect to ecosystem services	No strong effect on ecosystem services has been documented so far.
8. Includes status (threatened or protected) of species or habitat under threat	Strong impact (see EPPO DSS).
9. Includes possible effects of climate change in the foreseeable future	Climate change effects on plant distribution not documented.
Main experts	Johan van Valkenburg Etienne Branquart
Notes	EPPO: medium risk (because moderate spread capacity) although spread documented in UK. Area at risk: Alpine and Atlantic areas. Already established in some countries of those two regions: BE, CH, DK, DE, FI, FR, IE, NL, SE, UK; GB NNRA not available yet
Outcome	Compliant

Scientific name	*Mephitis mephitis*
Common name	Skunk
Broad group	Vertebrate
Number of and countries wherein the species is currently established	1: DE?
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=758
1. Description (Taxonomy, invasion	Socio-economic benefits not found.

history, distribution range (native and introduced), geographic scope, socio-economic benefits)	
6. Can broadly assess environmental impact with respect to ecosystem services	None reported.
8. Includes status (threatened or protected) of species or habitat under threat	None reported
9. Includes possible effects of climate change in the foreseeable future	In its natural range the species occurs in a range of climatic zones, from warm temperate to cool temperate, and in a range of habitats. No specific lab experiments or climate matching exist for this species. Its distribution might be partially affected by variation in a range of viruses. Since it is a species highly associated to urban habitats (Ordeñana *et al.*, 2010), it might benefit from climate change and increased urban disturbance. Skunks undergo winter dormancy (Mutch & Aleksiuk, 1977). Milder winters after climate change might increase its activity and capacity for spread and impact. The use of daily torpor and social thermoregulation in northern populations of striped skunks represent different mechanisms to minimize energetic costs and increase individual fitness in response to unfavorable environmental conditions, suggesting the species is able to adapt to very variable conditions (Ten Hwang *et al.*, 2007).
11. Documents information sources	**Mutch GR, Aleksiuk M. 1977.** Ecological aspects of winter dormancy in the striped skunk (*Mephitis mephitis*). *Canadian Journal of Zoology* **55:** 607-615. **Ordeñana MA, Crooks KR, Boydston EE, Fisher RN, Lyren LM, Siudyla S, Haas CD, Harris S, Hathaway SA, Turschak GM. 2010.** Effects of urbanization on carnivore species distribution and richness. *Journal of Mammalogy* **91:** 1322-1331. **Ten Hwang Y, Larivière S, Messier F. 2007.** Energetic consequences and ecological significance of heterothermy and social

	thermoregulation in striped skunks (*Mephitis mephitis*). *Physiological and Biochemical Zoology* **80:** 138-145.
Main experts	Piero Genovesi Melanie Josefsson
Other contributing experts	Belinda Gallardo
Notes	NOT VALIDATED the RA would benefit from specific data from other EU countries, not clear whether the overall result (LOW IMPACT) would change (records of occurrence – but no established populations so far - are known for FR, NL, DE).
Outcome	**NOT COMPLIANT** because of major information gaps

Scientific name	*Muntiacus reevesii*
Common name	Muntjac deer
Broad group	Vertebrate
Number of and countries wherein the species is currently established	4: BE, IE, NL, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=386
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Muntjac are increasingly viewed as an important quarry by hunters in England (Smith-Jones *et al.*, 2004). In the absence of Muntjac, this benefit would continue to be provided by other deer species.
6. Can broadly assess environmental impact with respect to	Food crops – Muntjac may consume and flatten cereal crops. Raw materials and carbon sequestration – repeated browsing of coppice by muntjac can retard or prevent tree growth (Cooke, 1998).

ecosystem services	Cultural – Complete removal of ground layer vegetation has significantly reduced the biodiversity value of nature reserves in the east of England (Cooke & Farrell, 2001). Muntjac may be a reservoir of bovine tuberculosis for livestock (Ward & Smith, 2012). Additional severe impacts on Ecosystem Services: can impact forest, and damage gardens and horticulture industry. Also vehicle collisions are a major problem.
8. Includes status (threatened or protected) of species or habitat under threat	Lowland deciduous woodlands and all biodiversity that depends on ground and shrub-layer vegetation (Putman & Moore, 1998).
9. Includes possible effects of climate change in the foreseeable future	Already established in areas with colder climate than native range. Likely to increase with climate change. Muntjac have expanded their range in the UK at an annual rate of 8.2% in recent years, and are predicted to be capable of spreading throughout the majority of England and Wales (Acevedo *et al.*, 2010). They favour warm climates, naturally ranging throughout the forests of subtropical China and Taiwan, but can survive the temperate winters of England. Warmer, wetter conditions and milder winters predicted by some climate change models are likely to favour the spread and persistence of muntjac in Europe. Although native to sub-tropical forests, Muntjac have adapted very well to the ecoclimatic zones of southern Britain. Prolonged periods of snow/frozen ground resulted in high mortality in the winter of 1962/63 (Chapman *et al.*, 1994). Northern Britain, being generally colder and with a shorter growing season for ground vegetation than more southern regions, is likely to be less favourable. Milder winters are likely to favour this aseasonal breeder. With a warming climate exotic deer as reservoirs of diseases may play a role in future UK livestock and wildlife disease management, thus the impact on native species can be expected to increase (Böhm *et al.*, 2007). Warmer winters and springs has been correlated with increased recruitment and overwinter survival of deer, and is related to the increase of exotic deer particularly at high latitudes (Fuller & Gill, 2001).
11. Documents information sources	**Acevedo P, Ward AI, Real R, Smith GC. 2010.** Assessing biogeographical relationships of ecologically related species using favourability functions: a case study on British deer. *Diversity and Distributions* **16:** 515-528.

	Baiwy, E. ; Schockert, V. ; Branquart, E. (2013) Risk analysis of the Reeves' muntjac Muntiacus reevesi, Risk analysis report of non-native organisms in Belgium. Cellule interdépartementale sur les Espèces invasives (CiEi), DGO3, SPW / Editions, 36 pages. **Böhm M, White PC, Chambers J, Smith L, Hutchings M. 2007.** Wild deer as a source of infection for livestock and humans in the UK. *The Veterinary Journal* **174:** 260-276. **Chapman N, Harris S, Stanford A. 1994.** Reeves' Muntjac Muntiacus reevesi in Britain: their history, spread, habitat selection, and the role of human intervention in accelerating their dispersal. *Mammal Review* **24:** 113-160. **Cooke A. 1998.** Survival and regrowth performance of coppiced ash (*Fraxinus excelsior*) in relation to browsing damage by muntjac deer (*Muntiacus reevesi*). *Quarterly Journal of Forestry* **92:** 286-290. **Cooke A, Farrell L. 2001.** Impact of muntjac deer (*Muntiacus reevesi*) at Monks Wood National Nature Reserve, Cambridgeshire, eastern England. *Forestry* **74:** 241-250. **Fuller R, Gill R. 2001.** Ecological impacts of increasing numbers of deer in British woodland. *Forestry* **74:** 193-199. **Putman R, Moore N. 1998.** Impact of deer in lowland Britain on agriculture, forestry and conservation habitats. *Mammal Review* **28:** 141-164. **Smith-Jones C, Smith-Jones C, Boon A. 2004.** *Muntjac: Managing an Alien Species*. COCH Y BONDDU BOOKS. **Ward AI, Smith GC. 2012.** Predicting the status of wild deer as hosts of *Mycobacterium bovis* infection in Britain. *European Journal of Wildlife Research* **58:** 127-135. See also: - The Belgian risk analysis report - The Irish risk analysis report
Main experts	Piero Genovesi Melanie Josefsson
Other contributing experts	Olaf Booy Riccardo Scalera

	Belinda Gallardo
Notes	In how many EU member states has this species been recorded? List them. Five: Belgium, France, Ireland, Netherlands, United Kingdom In how many EU member states has this species currently established populations? List them. Two: Ireland, United Kingdom In how many EU member states has this species shown signs of invasiveness? List them. One: United Kingdom In which EU Biogeographic areas could this species establish? Atlantic, Continental (sub-optimal) In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Nine: Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Slovenia, Spain, Portugal, United Kingdom In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Three: Belgium, France, Netherlands The risk assessment would benefit from specific data from other European countries (IR, BE and NL? FR?), but the overall result would not change. See risk assessments for BE and IR.
Outcome	Compliant

Scientific name	*Myocastor coypus*
Common name	Coypu
Broad group	Vertebrate
Number of and	22: AT, BE, BG, HR, CZ, DK, FI, FR, GR, DE, IT, IE, LV, NL, LU, PL, RO, SL, ES,

countries wherein the species is currently established	SE, SK, UK
Risk Assessment Method	New following GB NNRA protocol
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Of interest in the past, no known socio-economic benefits at present.
6. Can broadly assess environmental impact with respect to ecosystem services	In recent review this species was highlighted as effecting the highest number of ecosystem services (Vilà *et al.*, 2011). (3S, 1P, 3R, 2C - The number of impacts is indicated by S: supporting, P: provisioning, R: regulating, and C: cultural services).
8. Includes status (threatened or protected) of species or habitat under threat	Impact on Red List species (GISD 2014): *Acheilognathus longipinnis* VU *Arvicola sapidus* VU *Desmana moschata* VU *Libellula angelina* CR *Narcissus triandrus* LC *Porphyrio porphyrio* LC
9. Includes possible effects of climate change in the foreseeable future	Likely increasing impacts, considering that this is a neotropical species, that established in several Mediterranean countries, and is established in Sicily and Sardinia (Zenetos *et al.*, 2009).
11. Documents information sources	Global Invasive Species Database (2014). Downloaded from http://193.206.192.138/gisd/search.php on 09-12-2014 **Vila M, Espinar JL, Hejda M, Hulme PE, Jarosik V, Maron JL, Pergl J, Schaffner U, Sun Y, Pysek P. 2011.** Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. *Ecology Letters* **14:** 702-708. **Zenetos A, Pancucci-Papadopoulou M, Zogaris S, Papastergiadou E, Vardakas L, Aligizaki K, Economou AN, Thessaloniki AUo. 2009.**

	Aquatic alien species in Greece(2009): tracking sources, patterns and effects on the ecosystem. *Journal of Biological Research. Scientific Annals of the School of Biology* **12:** 135-172.
Main experts	Piero Genovesi
Notes	No additional comments
Outcome	Compliant

Scientific name	*Myiopsitta monachus*
Common name	Monk parakeet
Broad group	Vertebrate
Number of and countries wherein the species is currently established	8: BE, CZ?, ES, FR, DE, IT, NL, UK
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=52
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Monk parakeets are kept in zoos (Topola, 2014). The ISIS database roughly estimates that there are approximately 640 individuals kept in 50 European institutions (ISIS, 2014). The species is also kept as pet (Strubbe & Matthysen, 2009), thus generating some revenue for pet trade. Monk parakeets have an aesthetic appeal to bird-watchers and members of the wider general public. Records of predation on Monk parakeets by rats may reduce the impact of invasive alien predators on native fauna, thus generating some benefits from the biodiversity and socio-economic points of view. However, this requires experimental qualitative and quantitative evidence (Menchetti & Mori, 2014). From GISD (http://www.issg.org/database/welcome/): Known for their beauty and intelligence, *Myiopsitta monachus* (monk parakeets) are a popular pet, especially in North America, since the 1960's. From IUCN Red List:

	The species has been heavily traded: since 1981 when it was listed on CITES Appendix II, 710,686 wild-caught individuals have been recorded in international trade (UNEP-WCMC CITES Trade Database, January 2005).
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning services: Monk parakeets cause crop damages in many European countries, but without any quantification (Dubois, 2007, Spano & Truffi, 1986). The species feeds in orchards (Batllori & Nos, 1985, Caruso & Scelsi, 1993, Dangoisse, 2009, Zocchi *et al.*, 2009) and cultivated fields (corn, vine, *Hordeum* spp., *Pisum sativum*, *Pistacia vera*) (Borgo *et al.*, 2005, Tayleur, 2010) even if other plants are present within a study area. Habitat services: Droppings under roosting sites may inhibit native flora seed dispersal and alter the floral herbaceous component (Fletcher & Askew, 2007, Menchetti & Mori, 2014). The same mechanism may favour the spread of invasive alien plants (Runde *et al.*, 2007). Regulating services: Monk parakeets can carry several diseases that could be passed on to wild birds and poultry (Newcastle Disease) and humans (psittacosis) (Stafford, 2003). No outbreaks have yet been reported or attributed to this pathway of transmission. Cultural services: In urban settings, some residents feel that the large nests are unsightly and the noise that Monk parakeets can produce may be a serious nuisance (Stafford, 2003). From GISD (http://www.issg.org/database/welcome/): In its native range, *M. monachus* is considered a significant agricultural pest, often causing damage to field crops and orchards. There have also been reports of transmission lines short-circuited by nesting birds. In its introduced range, impacts are mainly associated with nesting behaviours. Monk parakeets build large bulky nests on communication towers and electric utilities such as distribution poles and transmission towers. On communication towers they are simply a maintenance problem and do not affect communications. However nests on electric utilities can cause outages and fires, as the large nests can complete electric circuits. This problem is pronounced in wet weather. Monk parakeet nests can cause significant effects to electric utilities including decrease in electric

	reliability, equipment damage, and lost revenue from nest and bird caused power outages, increase in operation and maintenance costs associated with nest removal and repair of damaged structures as well as public safety concerns. Costs associated with monk parakeets can be quite considerable. For example, during a five-month period in 2001 in South Florida 198 outages related to monk parakeets were logged. Lost revenue from electric power sales was $24,000 and the cost for repair of outages was estimated at $221,000. However in the introduced range *M. monachus* has not caused the agricultural devastation predicted, nor has there been any solid evidence that native fauna are negatively affected by their establishment. There is also the possibility that monk parakeets will spread plant diseases by transporting infected planting material to uninfected trees. For example, in Florida citrus canker is a major concern. There has also been some speculation that growing urban populations of *M. monachus* could become source populations for surrounding areas. The birds are widely admired by city dwellers who see little other wildlife. It is also stated that "In addition to being a fruit crop pest in South America, it has great potential for dissemination of Newcastle disease. It also cuts trigs and buds from ornamental trees. They are one of the most raucous of birds." (Fletcher & Askew, 2007)
8. Includes status (threatened or protected) of species or habitat under threat	From Belgium there are reports of noisy and physical intimidations against protected raptors (e.g. Kestrel *Falco tinnunculus* and Little owl *Athene noctua*) in the surrounding of the nests of the parakeets (Dangoisse, 2009). Monk parakeets frequently dominate avian feeding areas; such feeding areas are likely to be in urban and sub-urban areas where introduced colonies are formed as a result of escapes/releases. It is also reported that Monk parakeets had been observed killing native birds and it is likely that competition for food would limit resources available for native species.
9. Includes possible effects of climate change in the foreseeable future	Monk parakeets are native to subtropical and temperate South America where they inhabit grassland, scrub and forest regions (Long, 1981). They have successfully colonised subtropical and temperate North America as well as many temperate European countries with similar ecoclimatic conditions to the risk assessment area (Munoz and Real, 2006). Locations of monk parakeets are scattered and in disparate climatic conditions and evidence of the species expanding its range beyond the localities where it was released or escaped is generally lacking. For these reasons it does not seem likely that the present distribution of the species

	in Europe is determined by climatic requirements or tolerances (Huntley *et al.*, 2007). Other results suggest that in the future parakeet establishment probability may increase because climate warming is likely reduce the number of frost days (Strubbe & Matthysen, 2009). However, the same authors claim that parakeet distributions may not be as strictly governed by climate as is the case for other taxa, such as plants (Strubbe & Matthysen, 2009). Climate warming has the potential to enhance the invasion success of Monk parakeets through the latter stages of the invasion process (establishment and spread), through: (i) improving the climatic match between its introduced and native range, and (ii) through direct (e.g. thermal effects) and indirect changes (land management) to habitats and land use. In agriculture, predicted changes in crop type and regional patterns of crop planting and harvesting will alter the landscape for birds in terms of resource availability. For example, in northern Europe there may be an increase in the growing of grapes, other soft fruits and produce (e.g. sunflowers) currently concentrated in warmer, drier southern regions. Increase in the coverage of such crops and their introduction further north will provide enhanced foraging opportunities for birds, including invasive alien species such as monk parakeets which already forage on these or similar crops in their present range. Monk parakeet is tolerant to low air temperature and shows no sign of hypothermia at -8°C (Weathers & Caccamise, 1975). The species was also very resistant to high temperatures, up to 44°C. Broad climatic tolerance has been thus suggested to explain the species expansion in North America (Weathers & Caccamise, 1975). Results are suggestive of a possible role for year of introduction, as there is a tendency for monk parakeets to have a higher establishment probability when introduced more recently. This could signify that environmental conditions have recently become more suitable for the establishment of parakeets (e.g. because of warming as a result of climate change).

11. Documents information sources	**Batllori X, Nos R. 1985.** Presencia de la cotorrita gris (*Myiopsitta monachus*) y de la cotorrita de collar (*Psittacula krameri*) en el área metropolitana de Barcelona. *Misc. Zool* **9:** 407-411. **Borgo E, Galli L, Spanò S. 2005.** *Atlante ornitologico della città di Genova:(1996-2000)*. Università degli Studi. **Caruso S, Scelsi F. 1993.** Nidificazione del Pappagallo monaco, *Myiopsitta monachus*, a Catania. *Rivista italiana di Ornitologia* **63:** 213-215. **Dangoisse G. 2009.** ÉTUDE DE LA POPULATION DE CONURES VEUVES. **Dubois PJ. 2007.** Les oiseaux allochtones en France: statut et interactions avec les espèces indigènes. *Ornithos* **14:** 329-364. **Fletcher M, Askew N. 2007.** Review of the status, ecology and likely future spread of parakeets in England. *York: Central Science Laboratory*. **Huntley B, Green RE, Collingham YC, Willis SG. 2007.** *A climatic atlas of European breeding birds*. Lynx Edicions Barcelona. **ISIS. 2014.** International Species Information System. Accessed 19.12.2014. **Menchetti M, Mori E. 2014.** Worldwide impact of alien parrots (Aves Psittaciformes) on native biodiversity and environment: a review. *Ethology Ecology & Evolution* **26:** 172-194. **Runde DE, Pitt WC, Foster J. 2007.** Population ecology and some potential impacts of emerging populations of exotic parrots. *Managing Vertebrate Invasive Species*: 42. **Spano S, Truffi G. 1986.** Il Parrocchetto dal collare, *Psittacula krameri*, allo stato libero in Europa, con particolare riferimento alle presenze in Italia, e primi dati sul Pappagallo monaco, *Myiopsitta monachus*. *Rivista italiana di Ornitologia* **56:** 231-239. **Stafford T. 2003.** Pest risk assessment for the monk parakeet in Oregon. *Oregon Department of Agriculture*. **Strubbe D, Matthysen E. 2009.** Establishment success of invasive ring‐necked and monk parakeets in Europe. *Journal of Biogeography* **36:** 2264-2278. **Tayleur JR. 2010.** A comparison of the establishment, expansion and potential impacts of two introduced parakeets in the United Kingdom. *BOU Proceedings-The Impacts of Non-native Species*: 1-12. **Topola R. 2014.** *Polish Zoo and Aquarium Yearbook. Warszawa* **Weathers WW, Caccamise DF. 1975.** Temperature regulation and water requirements of the monk parakeet, *Myiopsitta monachus*. *Oecologia* **18:** 329-342. **Zocchi A, Battisti C, Santoro R. 2009.** Note sul pappagallo monaco *Myiopsitta monachus* a Roma (Villa Pamphili). *Rivista italiana di Ornitologia* **78:** 135-137.
Main experts	Wojciech Solarz Wolfgang Rabitsch
Other contributing	Olaf Booy

experts	Riccardo Scalera Belinda Gallardo
Notes	In how many EU member states has this species shown signs of invasiveness? List them. Two: UK, ES (possibly others) In which EU Biogeographic areas could this species establish? All except possibly alpine and boreal (but note established in Chicago, USA). In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. All In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. All
Outcome	Compliant

Scientific name	*Myriophyllum aquaticum*
Common name	Parrot's feather
Broad group	Plant
Number of and countries wherein the species is currently established	9: AT, BE, DE, FR, IE, IT, NL, PT, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=274
1. Description (Taxonomy, invasion history, distribution range (native and	Socio-economic benefits. Plant is traded and imported for ornamental purposes (Brunel, 2009).

introduced), geographic scope, socio-economic benefits)	
6. Can broadly assess environmental impact with respect to ecosystem services	Ecosystem services: the plant may affect provisioning, regulating and cultural services by interfering with irrigation systems and water supply systems, crowding of recreational waterways, limiting boating and angling activities (Hassan & Ricciardi, 2014) (GB NNRA).
8. Includes status (threatened or protected) of species or habitat under threat	Impact on threatened species and habitats: occurs in Natura 2000 sites, where it can make dense populations (Johan van Valkenburg, personal communication).
9. Includes possible effects of climate change in the foreseeable future	The plant originates from South America and is known not to tolerate very cold winters present in continental Europe. However, it is known to survive most winters in the UK in its current area of distribution. Personal observation suggests that emergent biomass is relatively susceptible to frosts, but submerged biomass tends to tolerate colder conditions, if not encased in ice. This allows regeneration from submerged material in the following spring. However, regrowth from submerged material is slower than from material with emergent biomass that survives over winter. An experimental population survived encasement in ice and overnight temperature of -14.9 ^{o}C in January 2010. This population was still viable and producing green shoots as of 1st March 2010. It appears that this species is tolerant of much colder temperatures than previously observed. (Newman, Personal observtaion). The inability to store phosphate in rhizomes overwinter may limit its distribution in colder areas with oligotrophic water, but overwintering in eutrophic ponds is possible due to compensation in continued P supply in the following spring (Barko & Smart, 1983, Sytsma & Anderson, 1993). Climate matching exists for a similar species: *M. heterophyllum* in Uk for current conditions (Gallardo & Aldridge, 2013a). The study suggests certain limitation by minimum annual temperature of this species, which suggest climate change may allow it to shift northwards. Increase in the Atlantic area (Kelly *et al.*, 2014).
11. Documents information sources	**Barko J, Smart R. 1983.** Effects of organic matter additions to sediment on the growth of aquatic plants. *The journal of Ecology*: 161-175.

	Brunel S. 2009. Pathway analysis: aquatic plants imported in 10 EPPO countries. *EPPO Bulletin* **39:** 201-213. **Gallardo B, Aldridge DC. 2013.** The 'dirty dozen': socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland. *Journal of Applied Ecology* **50:** 757-766. **Hassan A, Ricciardi A. 2014.** Are non-native species more likely to become pests? Influence of biogeographic origin on the impacts of freshwater organisms 3. *Frontiers in Ecology and the Environment* **12:** 218-223. **Kelly R, Leach K, Cameron A, Maggs CA, Reid N. 2014.** Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions*. **Lafontaine, R.-M., Beudels-Jamar, R.C., Delsinne, T., Robert, H. (2013).** Risk analysis of the Parrotfeather Myriophyllum aquaticum (Vell.) Verdc. - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 40 p. **Sytsma MD, Anderson L. 1993.** Biomass, nitrogen, and phosphorus allocation in parrotfeather (*Myriophyllum aquaticum*). *Journal of Aquatic Plant Management* **31:** 244-248. See also : - The Belgian risk analysis report - The Irish risk analysis report - The Q-Bank data sheet
Main experts	Johan van Valkenburg - Etienne Branquart
Notes	GB NNRA: High risk in the Atlantic region. Area at risk: Atlantic region and probably also the Mediterranean and Continental regions. Already established in 9 EU countries: AT, BE, DE, FR, IE, IT, NL, PT, UK
Outcome	Compliant

Scientific name	*Nasua nasua*
Common name	Coati
Broad group	Vertebrate

Number of and countries wherein the species is currently established	1: ES
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=759
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: limited but as a pet in private collections and zoos.
6. Can broadly assess environmental impact with respect to ecosystem services	None reported.
8. Includes status (threatened or protected) of species or habitat under threat	Impact on red listed species (GISD 2014). *Sephanoides fernandensis* CR *Puffinus creatopus*, *Pterodroma defilippiana* VU Feral cats and coatis are blamed for the possible extinction of *Pterodroma defilippiniana* on Robinson Crusoe Island. In Pacific islands has caused serious impacts on seabird colonies (Manzano 2009) e.g. from GISD http://www.issg.org/database/welcome/ • Juan Fernandez Islands (Chile) The 'Critically Endangered (CR)' Juan Fernandez firecrown (*Sephanoides fernandensis*) is endemic to the Juan Fernández Islands, Chile. Habitat degradation and loss has been the primary cause for population declines. Clearance of vegetation by humans since the 16th century, and the impacts of introduced herbivores especially rabbits (*Oryctolagus cuniculus*) has limited the availability of food sources. Habitat alteration

	due to the spread of alien invasive plant species (elm-leaf blackberry (*Rubus ulmifolius*), maqui (Aristotelia chilensis) and murtilla (*Ugni molinae*)), and predation by introduced mammals (rats (*Rattus* spp.), cats (*Felis catu*s) and coatis (*Nasua nasua*) are the other two causes for decline in population numbers (BirdLife International 2012). Robinson Crusoe Island (Chile) The Pink-footed Shearwater (*Puffinus creatopus*) is listed as 'Vulnerable (VU)' in the IUCN Red List of Threatened Species. It breeds only on Robinson Crusoe Island and Santa Clara Island of the Juan Fernandez group; Isla Mocha and Isla Guafo (recent evidence). Major threats to this species include habitat degradation due to herbivory and trampling, and predation by introduced mammals. IAS threats on Robinson Crusoe Island include predation by cats (*Felis catus*), rats (*Rattus* spp.) and coaties (*Nasua nasua*) and habitat degradation due to herbivory and trampling of rabbits (*Oryctolagus cuniculus*), cattle (*Bos taurus*) and goats (*Capra hircus*) causing erosion and burrow loss. On Isla Mocha predation by rats maybe an issue. Rabbits have been eradicated on Santa Clara. Other threats include entanglement in fishing gear and impact of longline fishing activities (BirdLife International 2012c). Defilippe's Petrel (*Pterodroma defilippiana*) is listed as 'Vulnerable (VU)' in the IUCN Red List of Threatened Species. It has a small breeding range at three or four locations on islands off the coast of Chile- In the Des Venturadas Islands- San Ambrosio and San Felix and in the Juan Fernandez Islands - on Santa Clara. It is believed to be extirpated on Robinson Crusoe Is. due to predation by feral cats (*Felis catus*) and coaties (*Nasua nasua*); on San Felix predation by cats are believed to have caused extensive mortality (BitdLife International 2012d)
9. Includes possible effects of climate change in the foreseeable future	The majority of the coati's native range is tropical or sub-tropical, between the tropics of Cancer and Capricorn, but they can be found at higher altitudes within this area It would appear to be able to at least survive for some period in more temperate climates although there is no evidence of breeding out of captivity or ability to thrive in Europe. They have not naturally expanded north or south from the more tropical areas in the Americas indicating that establishment in Europe could well be problematic. Despite high adaptability, it was stated that coatis are basically tropical woodland and forest animals whose distribution is

	limited by aridity, cold, unsuitable plant cover and food supply (Kaufmann *et al.*, 1976). However, cold was not found to be a limiting factor due to good thermoregulatory capacities, at least for adult coatis (Chevillard-Hugot *et al.*, 1980). Likely increased impact with climate change.
11. Documents information sources	**Chevillard-Hugot M-C, Müller E, Kulzeri E. 1980.** Oxygen consumption, body temperature and heart rate in the coati (*Nasua nasua*). *Comparative Biochemistry and Physiology Part A: Physiology* **65:** 305-309. **Kaufmann JH, Lanning DV, Poole SE. 1976.** Current status and distribution of the coati in the United States. *Journal of Mammalogy***:** 621-637. Global Invasive Species Database (2014). Downloaded from http://193.206.192.138/gisd/search.php on 09-12-2014
Main experts	Piero Genovesi - Melanie Josefsson
Other contributing experts	Riccardo Scalera, Belinda Gallardo
Notes	NOT VALIDATED. The risk assessment would benefit from specific data from other European countries, particularly Spain (Mallorca) where the species has been is introduced, but also from other countries where the species might be introduced in the future (it is kept in zoo and private collection, and also as a pet).
Outcome	**NOT COMPLIANT** because of major information gaps

Scientific name	*Orconectes limosus*
Common name	Spiny-cheek Crayfish
Broad group	Invertebrate
Number of and countries wherein the species is currently established	9: AT, UK, FR, DE, IT, LV, LT, NL, PL
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=53
1. Description (Taxonomy, invasion history, distribution	Other EU countries where the species is found (8): Belgium, Croatia, Czech Republic, Hungary, Luxemburg, Romania, Serbia, Slovakia, Spain (Holdich *et al.*, 2009, Kouba *et al.*, 2014).

range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Potential use by fishery managers as a food supplement in UK. Rarely used in the pet trade (Chucholl, 2013).
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional	The crayfish introductions in some cases have been accidental (e.g., through canals, escapes from holding facilities), but most have been deliberate (for aquaculture, legal and illegal stocking, and live food trade, as aquarium pets and live bait, for snail and weed control, and as supplies for science classes) (Gherardi, 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	The impact of *Orconectes* Species (*Orconectes immunis*, calico crayfish; *O. limosus*, spinycheek crayfish; *O. virilis*, northern crayfish; and O. juvenilis, Kentucky River crayfish) on ecosystem services has been assessed (Lodge *et al.*, 2012). Provisioning services: The earliest introductions of the *Orconectes* spp. to the Palearctic were probably for human consumption, including the early introduction of *O. limosus* to Europe in 1890. However, the *Orconectes* spp. are not as highly valued as food as signal crayfish or native crayfishes, and the spread of at least one, *O. limosus*, has been unintentional as a hitchhiker with fish stocks. Supporting services: *Orconectes* spp. are well known for causing major changes in community structure, especially via large reductions in macrophytes (*O. virilis*, *O. immunis*,). In addition, unlike some native Palearctic crayfishes, *O. immunis* digs deep burrows, causing changes in sediments and allowing it to inhabit shallower habitats than native species (Chucholl, 2013). Regulating services: Burrowing in dikes by *O. virilis* increases maintenance costs and the risk of flooding. Cultural services: There is no evidence that *Orconectes* spp. provide any cultural services not previously provided by native crayfishes; to the contrary, like red swamp crayfish and signal crayfish, *Orconectes* spp. contribute to the decline of cultural values previously provided by native

	crayfishes by vectoring crayfish plague (Lodge *et al.*, 2012).
8. Includes status (threatened or protected) of species or habitat under threat	The occurrence of *A. astacus* (VU, IUCN) and *O. limosus* in a number of lakes in Poland has been documented (Holdich *et al.*, 2009), and suggests that *O. limosus* is gradually displacing *A. astacus* by direct competition rather than disease. In Croatia the rapid spread of *O. limosus* through the Danube River catchment has adverse effects on the populations of *A. leptodactylus* (LC, IUCN) (Holdich *et al.*, 2009). *Orconectes limosus* has extended its distribution in the Danube River catchment and was recorded for the first time in the Romanian sector in 2008 (Pârvulescu *et al.*, 2009). From 2009 to 2011, the relative abundances of *O. limosus* steadily increased, while the native *A. leptodactylus* dramatically decreased in abundance. Currently, 70-90% of *A. leptodactylus* have been replaced by *O. limosus*. The presence of *A. astaci* DNA was detected in at least 32% of the invasive and 41% of the native crayfish coexisting in the Danube River. Furthermore, *A. astaci* was also detected in *A. leptodactylus* captured about 70 km downstream of the *O. limosus* invasion front. *O. limosus* expanded downstream at a rate of ca. 15 km per year. Assuming a steady rate of expansion, *O. limosus* may invade the highly protected Danube Delta area (UNESCO Biosphere Reserve and World heritage site) in the next years, even without long-distance dispersal (Pârvulescu *et al.*, 2012) (Pârvulescu, personal communication). The crayfish plague pathogen has already been detected in local populations in the Danube Delta, as neither crayfish mass mortalities nor alien crayfish species have been reported from the region (Schrimpf *et al.*, 2012). It was suggested that *Aphanomyces astaci* may have reached the Delta by long-range passive dispersal of infected hosts or pathogen spores, or by gradually infecting populations of native crayfish in upstream regions of the Danube in a stepping-stone manner, or may have already persisted there (Schrimpf *et al.*, 2012). In any case, the presence of this pathogen in the Lower Danube River may become a threat to conservation of European crayfish and to freshwater biodiversity in many regions of southeastern Europe, at present considered “crayfish plague-free”. Furthermore, in the section from Iron Gate II (rkm 863) to Calarasi-Silistra (rkm 375) alone, there are more than 35 Natura 2000 Sites of Community Importance (SCI) (5 on Romanian side and 30 on Bulgarian side)

	(http://natura2000.moew.government.bg/, http://natura2000.ro/), which may be affected by the invasion of *O. limosus* and the crayfish plague pathogen.
9. Includes possible effects of climate change in the foreseeable future	Climate matching: effect of climate, invasive species, and disease on the distribution of native European crayfishes has been examined (Capinha *et al.*, 2013). The model included the native crayfish in Europe and three North American plague-carrying crayfish species (*O. limosus*, *P. leniusculus*, and *P. clarkii*). The authors anticipate that *P. clarkii*, but not the other invasive alien crayfish, will enlarge its distribution range in both accessible (areas within basins where a given species is currently established) and inaccessible areas. This result has been confirmed by a behavioral study that analyzed antagonism, at different temperatures, of dyads composed of the same three species (Gherardi, 2013). All other conditions being equal, *P. clarkii* was dominant over the other species at the highest temperature analyzed (27°C), which corresponds to the maximum temperature expected at the latitudes of the study area (central France) in the next 80 years under the more pessimistic greenhouse gas-emission scenario. On the contrary, at that temperature, *O. limosus* will become less active, which may be a strategy to avoid thermal shocks, and *P. leniusculus*, being likely more vulnerable to high temperatures, will become less competitive. *Procambarus clarkii* is thus expected to exclude the other crayfish from the areas of syntopy and to dominate the future European watersheds. Ultimately, this might lead to impoverished biodiversity, simplified food webs, and altered ecosystem services (Gherardi, 2013). Tolerance experiments: increased temperature may increase metal toxicity and mortality of ectotherms, including *Orconectes* spp (Sokolova & Lannig, 2008). The data indicate that rising global temperatures associated with climate change can have the potential to increase the sensitivity of aquatic animals to heavy metals in their environment (Khan *et al.*, 2006). Critical thermal minima and maxima for a similar species, *O. rusticus*, are calculated as 9.7 and 14.7 ^{o}C, respectively. Observation: Crayfish populations appear to be highly resistant, if not positively responsive, to drought conditions (Flinders & Magoulick, 2005).
11. Documents information sources	**Capinha C, Larson ER, Tricarico E, Olden JD, Gherardi F. 2013.** Effects of climate change, invasive species, and disease on the distribution of

native European crayfishes. *Conservation Biology* **27:** 731-740.

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Khan M, Ahmed S, Catalin B, Khodadoust A, Ajayi O, Vaughn M. 2006. Effect of temperature on heavy metal toxicity to juvenile crayfish, *Orconectes immunis* (Hagen). *Environmental toxicology* **21:** 513-520.

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Pârvulescu L, Paloş C, Molnar P. 2009. First record of the spiny-cheek crayfish *Orconectes limosus* (Rafinesque, 1817)(Crustacea: Decapoda: Cambaridae) in Romania. *North-Western Journal of Zoology* **5:** 424-428.

Pârvulescu L, Schrimpf A, Kozubíková E, Cabanillas Resino S, Vrålstad T, Petrusek A, Schulz R. 2012. Invasive crayfish and crayfish plague on the move: first detection of the plague agent *Aphanomyces astaci* in the Romanian Danube. *Diseases of Aquatic Organisms* **98:** 85.

Schrimpf A, Pârvulescu L, Copilas-Ciocianu D, Petrusek A, Schulz R. 2012. Crayfish plague pathogen detected in the Danube Delta- a potential

	threat to freshwater biodiversity in southeastern Europe. *Aquatic Invasions* **7:** 503-510. **Sokolova IM, Lannig G. 2008.** Interactive effects of metal pollution and temperature on metabolism in aquatic ectotherms: implications of global climate change. *Climate research (Open Access for articles 4 years old and older)* **37:** 181. See also the Irish risk analysis report (http://nonnativespecies.ie/risk-assessments/).
Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Belinda Gallardo Lucian Parvulescu
Notes	The spiny-cheek crayfish *Orconectes limosus* has been reported from 17 EU countries. Currently it is expanding rapidly its range to South and East Europe, especially through the Danube River, being real and potential threat to the native populations of *Astacus leptodactylus* in the main channel, *Astacus astacus* and *Austropotamobius torrentium* in the tributaries. There are no socio-economic benefits of the species reported in Europe, except as a food supplement in fishery. GB NNRA: medium risk and low level of uncertainty. Some recent data on more pathways of crayfish introduction in Europe, on the impact on ecosystem services, on the impact on protected species and habitats, and results of studies on the effects of climate change are added. Based on the collected information we suggest the risk assessment to be considered as compliant to the minimum standards with increased level of risk from medium to high in Europe scale.
Outcome	Compliant

Scientific name	*Orconectes virilis*
Common name	Virile Crayfish
Broad group	Invertebrate
Number of and countries wherein the species is currently established	1: NL

Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=868
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Taxonomy: Recent phylogeographic and phylogenetic studies revealed that *O. virilis* is actually a diverse species complex. The genetic analysis of European populations suggested that they represent a lineage distinct from *O. virilis* in a strict sense (Kouba *et al.*, 2014). Introduced range: 1: NL Other EU countries where the species is found: UK (Kouba *et al.*, 2014). Socio-economic benefits: The species has been commercially harvested within its native range, however it is not generally considered a crayfish of great economic importance (CABI ISC). Very rarely used in the pet trade in Europe (Chucholl, 2013).
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional	In some cases, introductions have been accidental (e.g., through canals, escapes from holding facilities), but most have been deliberate (for aquaculture, legal and illegal stocking, and live food trade, as aquarium pets and live bait, for snail and weed control, and as supplies for science classes) (Gherardi, 2013).
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	The virile crayfish is most likely responsible for the decline of macrophytes in a few canals in the Netherlands (Kouba *et al.*, 2014) but further studies confirming and quantifying its impacts on European ecosystems are lacking. There are numerous features reported for virile crayfish suggesting that this taxon may become an invader with substantial impact: early maturation, relatively high fecundity, short incubation and fast growth, high aggressiveness, extensive burrowing activity, and ability to withstand low temperature. Indeed, virile crayfish showed the potential to rapidly invade new waterbodies and outcompete native congeners in North America. However, it should be kept in mind that individual studies may refer to different lineages of the species complex, thus the

	performance of the one living in European waters should be evaluated in detail (Kouba *et al.*, 2014).
6. Can broadly assess environmental impact with respect to ecosystem services	The impact of *Orconectes* Species (*Orconectes immunis*, calico crayfish; *O. limosus*, spinycheek crayfish; *O. virilis*, northern crayfish; and O. juvenilis, Kentucky River crayfish) on ecosystem services was evaluated (Lodge *et al.*, 2012). Provisioning services: The earliest introductions of the *Orconectes* spp. to the Palearctic were probably for human consumption, including the early introduction of *O. limosus* to Europe in 1890. However, the *Orconectes* spp. are not as highly valued as food as signal crayfish or native crayfishes, and the spread of at least one, *O. limosus*, has been unintentional as a hitchhiker with fish stocks. Supporting services: *Orconectes* spp. are well known for causing major changes in community structure, especially via large reductions in macrophytes (*O. virilis*, *O. immunis*) (Ahern *et al.*, 2008). In addition, unlike some native Palearctic crayfishes, *O. immunis* digs deep burrows, causing changes in sediments and allowing it to inhabit shallower habitats than native species (Chucholl 2012). Regulating services: Burrowing in dikes by *O. virilis* increases maintenance costs and the risk of flooding (Ahern *et al.*, 2008). Cultural services: There is no evidence that *Orconectes* spp. provide any cultural services not previously provided by native crayfishes; to the contrary, like red swamp crayfish and signal crayfish, *Orconectes* spp. contribute to the decline of cultural values previously provided by native crayfishes by vectoring crayfish plague (Lodge *et al.*, 2012).
8. Includes status (threatened or protected) of species or habitat under threat	*Orconectes virilis* is reported as a threat to the Red List assessed *Austropotamobius* pallipes (EN) (IUCN Red List, GISD 2014). E.g. Red List assessed species 9: CR = 1; EN = 1; VU = 4; DD = 1; LC = 2; • *Austropotamobius* pallipes EN • *Cambarus elkensis VU* • *Catostomus clarkii LC* • *Catostomus insignis LC* • *Cyprinodon tularosa VU* • *Lithobates chiricahuensis VU* • *Orconectes wrighti VU* • *Pacifastacus fortis CR*

	• *Pyrgulopsis trivialis DD*
9. Includes possible effects of climate change in the foreseeable future	Observation. O *virilis* occurs naturally in many regions of the USA and Canada and has also been introduced into other regions in North America and into Chihuahua, Mexico . It is able to survive severe winters in its home range. In Europe it has become established at one site in the Netherlands and is beginning to spread (Pöckl *et al.*, 2006). It is now established in one area of the River Lee catchment in England (Ahern *et al.*, 2008). Crayfish populations appear to be highly resistant, if not positively responsive, to drought conditions (Adams & Engelhardt, 2009, Flinders & Magoulick, 2005). In the Yampa River, *O. virilis* showed a significant growth advantage with warming water temperatures, which may facilitate expansion of their range, abundance and ecological impact (Rahel & Olden, 2008, Whitledge & Rabeni, 2002). Virile crayfish was able to exploit the drought conditions in the Yampa River, increasing their abundance in explosive fashion. Crayfish in the Ozark Plateau of Missouri and Arkansas (U.S.A.) provide an example in which climate warming could favour a common species over species of conservation concern. A widespread species, *O. virilis*, occurs at the periphery of the Ozark Plateau (Rahel & Olden, 2008). *O. virilis* has a major growth advantage at warm temperatures, and there is concern that warming will allow this species to expand its range and cause the extinction of two endemic species. Tolerance experiments: Maximum daily food consumption rates has been shown to increase most steeply from 18 to 22℃ (Whitledge & Rabeni, 2002). Virile crayfish become more active above 15℃ (Rabeni, 1992, Richards *et al.*, 1996) and is likely to benefit from prolonged periods of sustained water temperatures over 16℃ after climate change. Higher water temperatures during the drought also likely improved their capacity for reproduction, recruitment, and range expansion (Rahel & Olden, 2008). The data indicate that rising global temperatures associated with climate change can have the potential to increase the sensitivity of aquatic animals to heavy metals in their environment (Khan *et al.*, 2006). *O. virilis* show a pronounced thermal acclimation response (Claussen, 1980), and other studies confirm crayfish are among the most heat tolerant species (Spoor, 1955). Other studies suggest increased susceptibility to water acidification, overall by post-moult crayfish. Warmer temperatures may decrease survival of *O. rusticus* juveniles but improve their growth rates, leading to enhanced fecundity and competitive ability (Mundahl &

	Benton, 1990). The study also suggests that the species success in expanding its range may depend, in part, on the species ability to adjust to new thermal conditions occupied by other species of crayfish.
11. Documents information sources	**Adams SN, Engelhardt KAM. 2009.** Diversity declines in Microstegium vimineum (Japanese stiltgrass) patches. *Biological Conservation* **142:** 1003-1010. **Ahern D, England J, Ellis A. 2008.** The virile crayfish, *Orconectes virilis* (Hagen, 1870)(Crustacea: Decapoda: Cambaridae), identified in the UK. *Aquatic Invasions* **3:** 102-104. **Chucholl C. 2013.** Invaders for sale: trade and determinants of introduction of ornamental freshwater crayfish. *Biological Invasions* **15:** 125-141. **Claussen DL. 1980.** Thermal acclimation in the crayfish, *Orconectes rusticus* and *O. virilis*. *Comparative Biochemistry and Physiology Part A: Physiology* **66:** 377-384. **Flinders C, Magoulick D. 2005.** Distribution, habitat use and life history of stream-dwelling crayfish in the Spring River drainage of Arkansas and Missouri with a focus on the imperiled Mammoth Spring crayfish (*Orconectes marchandi*). *The American midland naturalist* **154:** 358-374. **Gherardi F. 2013.** Crayfish as global invaders: distribution, impact on ecosystem services and management options. *Freshwater Crayfish* **19:** 177-187. **Khan M, Ahmed S, Catalin B, Khodadoust A, Ajayi O, Vaughn M. 2006.** Effect of temperature on heavy metal toxicity to juvenile crayfish, *Orconectes immunis* (Hagen). *Environmental toxicology* **21:** 513-520. **Kouba A, Petrusek A, Kozák P. 2014.** Continental-wide distribution of crayfish species in Europe: update and maps. *Knowledge and Management of Aquatic Ecosystems***:** 05. **Lodge DM, Deines A, Gherardi F, Yeo DC, Arcella T, Baldridge AK, Barnes MA, Chadderton WL, Feder JL, Gantz CA. 2012.** Global introductions of crayfishes: evaluating the impact of species invasions on ecosystem services. *Annual Review of Ecology, Evolution, and Systematics* **43:** 449-472. **Mundahl ND, Benton MJ. 1990.** Aspects of the thermal ecology of the rusty crayfish *Orconectes rusticus* (Girard). *Oecologia* **82:** 210-216. **Pöckl M, Holdich D, Pennerstorfer J. 2006.** Identifying native and alien

	crayfish species in Europe. *European project CRAYNET*. **Rabeni CF. 1992.** Trophic linkage between stream centrarchids and their crayfish prey. *Canadian Journal of Fisheries and Aquatic Sciences* **49:** 1714-1721. **Rahel FJ, Olden JD. 2008.** Assessing the effects of climate change on aquatic invasive species. *Conservation Biology* **22:** 521-533. **Richards C, Kutka F, McDonald M, Merrick G, Devore P. 1996.** Life history and temperature effects on catch of northern orconectid crayfish. *Hydrobiologia* **319:** 111-118. **Spoor W. 1955.** Loss and gain of heat-tolerance by the crayfish. *The Biological Bulletin* **108:** 77-87. **Whitledge GW, Rabeni CF. 2002.** Maximum daily consumption and respiration rates at four temperatures for five species of crayfish from Missouri, USA (Decopda, *Orconectes* spp.) *Crustaceana* **75:** 1119-1132.
Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Belinda Gallardo Piero Genovesi
Notes	The virile crayfish *Orconectes virilis* is the most widespread crayfish species in USA and Canada. In Europe its distribution is restricted - it was first recorded in 2004 and is found only in the Netherlands (where became widespread) and UK (only in the River Lee catchment). The species identity is not clear, recent phylogeographic and phylogenetic studies suggest that the European population represent a lineage distinct from *O. virilis* in North America in a strict sense. No socio-economic benefits of the species in Europe were reported. GB NNRA: medium risk and high level of confidence. Some recent information about the species environmental impact, impact on ecosystem services (of *Orconectes* species), and impact on threatened species, as well as results of studies on the effects of climate change are added. Based on the collected information we suggest the risk assessment to be considered as compliant to the minimum standards with increased level of uncertainty because of unclear species identity.
Outcome	Compliant

Scientific name	*Oxyura jamaicensis*
Common name	Ruddy duck
Broad group	Vertebrate
Number of and countries wherein the species is currently established	5: FR, IE, NL, SE, UK
Risk Assessment Method	GB NNRA
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Ruddy ducks are kept as for ornamental purposes, although it is very uncommon (Solarz personal communication). The species is also kept in zoos. The ISIS database roughly estimates that there are approximately 120 individuals kept in 19 European institutions (ISIS, 2014). Ruddy ducks have an aesthetic appeal to bird-watchers and members of the wider general public (Avifaunistic Commission - the Polish Rarities Committee, 2013, Lafontaine *et al.*, 2013b).
11. Documents information sources	**Avifaunistic Commission - the Polish Rarities Committee. 2013.** Rare birds recorded in Poland in 2012. *Ornis Polonica* **54:** 109-150. **ISIS. 2014.** International Species Information System. Accessed 19.12.2014. **Lafontaine R-M, Robert H, Delsinne T, Adriaens T, Devos K, Beudels-Jamar RC. 2013.** Risk analysis of the Ruddy Duck Oxyura jamaicensis (Gmelin, 1789). - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 33 p.
Main experts	Wojciech Solarz Wolfgang Rabitsch
Notes	No additional comments
Outcome	Compliant

Scientific name	*Pacifastacus leniusculus*
Common name	Signal Crayfish

Broad group	Invertebrate
Number of and countries wherein the species is currently established	18: AT, BE, CZ, DK, UK, FI, FR, DE, IT, LV, LT, NL, PL, PT, SI, ES, SE, GR
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=54
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Other EU countries where the species occurs (5): Croatia, Estonia, Greece, Luxenburg, Slovakia (Holdich *et al.*, 2009, Kouba *et al.*, 2014). Socio-economic benefits: In many countries, especially Sweden and Finland, the signal crayfish populations support a large, commercially and recreationally important, fishery (Ackefors, 1998). In Europe as a whole, a total of 355 tonnes of signal crayfish was estimated from capture fisheries in 1994 (Ackefors, 1998). This level has increased considerably, and in 2001 the Swedish catch was estimated to 1200 tonnes. Fishing statistics for crayfish in Sweden states total yield in 2013 was about 3.1 million € (28 972 000 SEK), which includes both signal crayfish and noble crayfish, but it is estimated that noble crayfish is up to 10% catch. This only considers fishing in public water bodies, not commercial rearing in ponds (Statistics Sweden, http://www.scb.se/Statistik/JO/JO1102/2013A01/JO1102_2013A01_JO56SM1401.pdf). Very rarely used in the pet trade in Europe (Chucholl, 2013).
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional	The crayfish introductions in some cases have been accidental (e.g., through canals, escapes from holding facilities), but most have been deliberate (for aquaculture, legal and illegal stocking, and live food trade, as aquarium pets and live bait, for snail and weed control, and as supplies for science classes) (Gherardi, 2013).
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns	Crayfish cause major environmental impacts in Europe by outcompeting native species and altering habitat structure. Alien crayfish, such as *Procambarus clarkii* and *Pacifastacus leniusculus*, are responsible for the largest range of impacts (i.e., crayfish plague dissemination, bioaccumulation of pollutants, community dominance, competition and

and processes	predation on native species, habitat modifications, food web impairment, herbivory and macrophyte removal) (Gherardi, 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning services. The signal crayfish is the most abundant crayfish in natural waters and aquaculture facilities in much of Europe because of the existence of commercial markets supplying this crayfish for human consumption (Holdich *et al.*, 2009). Because signal crayfish largely replaced native crayfish in Palearctic natural environments and in markets, the net impact of the species replacement on the marketplace is difficult to assess. What is clear is that, under the current circumstances, native crayfishes are much more highly valued; the 2010 market price of native *Astacus astacus* was double that of signal crayfish in Sweden (L. Edsman, personal communication). Supporting services. Like red swamp crayfish in warmer waters, signal crayfish also reduces the abundance of a wide range of native organisms in the cooler waters it inhabits in both the Palearctic and Oriental realms. In Scandinavia, signal crayfish reduces species richness and abundance of macrophytes and macroinvertebrates, and it reduces organic matter content of sediments (Holdich *et al.*, 2009). Competition with signal crayfish, and its interactions with predation, contribute to the displacement of native crayfishes in Japan (*Cambaroides japonicas*) and the western Palearctic realm (Holdich *et al.*, 2009). Regulating services. As a major vector of crayfish plague, signal crayfish introductions have caused the continued loss of populations of native crayfish. Although not typically a burrowing species in its native range, signal crayfish causes considerable damage to English river banks (A. Stancliffe-Vaughan, unpublished data). Cultural services. The loss of native crayfishes caused by signal crayfish in northern Europe, especially the loss of the noble crayfish (*Astacus astacus*) in Scandinavia, is perceived as a serious cultural blow (Lodge *et al.*, 2012).
8. Includes status (threatened or protected) of species or habitat under threat	The following Red List assesses species (6: EX = 1; EN = 1; VU = 1; DD = 2; LC = 1) are under threat because of the Signal Crayfish (GISD 2014): • *Astacus astacus* VU • *Astacus leptodactylus* LC • *Austropotamobius* pallipes EN • *Austropotamobius torrentium* DD

	• *Cambaroides japonicus DD* • *Pacifastacus nigrescens* EX The White-clawed crayfish *Austropotamobius pallipes* is affected by a range of threats, however the most widespread threat is that of the invasive alien crayfish species such as the Signal Crayfish (*Pacifastacus lenisculus*) and Red Swamp Crayfish (*Procambarus clarkii*), as well as the Crayfish Plague (*Aphanomyces astaci*). Invasive crayfish are aggressive predators for food and habitat, and often prey upon the White-clawed Crayfish (Füreder *et al.*, 2010, Kozák *et al.*, 2011). Significant declines are occurring across much of this species range: approximately ~52% decline over 10 years in England, ~52% decline between 1995 and 2003 within France, and a 99.5% decline estimated for a ten year period in the South Tyrol region of Italy. These countries once held the greatest abundance of this species (Füreder *et al.*, 2010). For example, the situation concerning *A. pallipes* is considered critical in South-West England, where *P. leniusculus* has become widespread and this has been at the expense of *A. pallipes*, mainly through outbreaks of crayfish plague since the 1980s. It has also colonised waters not suitable for *A. pallipes* (Holdich *et al.*, 2009). In France, a national survey conducted in 2006 shows the same trend and the situation of three indigenous species is considered alarming: *Austropotamobius torrentium* and *Astacus astacus* are close to extinction, and *A. pallipes*, with mortalities observed in 47 departments, can now only be found in the uppermost parts of the watersheds (Füreder *et al.*, 2010). These mortalities are due not only to disease, but also to the pressure of non-indigenous species, which are still expanding their range. Both *P. leniusculus* and *P. clarkii* showed their strongest geographical expansion during the 2001–2006 period. They appear to be ubiquitously very strong competitors; being more aggressive; resistant to disease, although there are outbreaks of disease at times associated with either a chronic or epizootic mortality; and are able to colonise varied environments. They are in the process of colonising new departments, new watersheds, and eliminating indigenous species (Holdich *et al.*, 2009).

	Italy is considered a "hot-spot" for the genetic diversity of the European crayfish genus *Austropotamobius*. The fragmentation of the *A. pallipes* complex populations is due to among other threats the diseases, notably crayfish plague carried by *P. leniusculus* and *P. clarkii*, and interspecific competition with the non-native crayfish species. In Italy, the decline is about 74% over the last 10 years (Holdich *et al.*, 2009). With the introduction of the two North American species into the Iberian peninsula, first, *P. clarkii* in 1973, and then *P. leniusculus* in 1974, the fate of *A. pallipes* was effectively sealed. Today this crayfish is believed extinct in Portugal and only remnant populations remain in Spain, chiefly in Atlantic regions of Asturias, Girona and Pais Vasco, Navarra, Castilla and Leon, Cuenca and Granada. As elsewhere when NICS have ousted ICS from the majority of their habitat, A. pallipes is now restricted in Spain to small headwater streams and springs (Holdich *et al.*, 2009). In Croatia *P. leniusculus* has adverse effects on the populations of *A. astacus* in the Mura River, where the species has disappeared from many sites. *Pacifastacus leniusculus* entered Croatia in 2008 via the Mura River, which borders Hungary and Slovenia and is expected to spread downstream toward the Drava River (Holdich *et al.*, 2009).
9. Includes possible effects of climate change in the foreseeable future	The effect of climate, invasive species, and disease on the distribution of native European crayfishes has been studied (Capinha *et al.*, 2013). They developed a model for the native crayfish in Europe and three North American plague-carrying crayfish species (*O. limosus*, *P. leniusculus*, and *P. clarkii*). The authors anticipate that *P. clarkii*, but not the other invasive alien crayfish, will enlarge its distribution range in both accessible (areas within basins where a given species is currently established) and inaccessible areas. This result has been confirmed by a behavioral study that analyzed antagonism, at different temperatures, of dyads composed of the same three species (Gherardi, 2013). All other conditions being equal, *P. clarkii* was dominant over the other species at the highest temperature analyzed (27°C), which corresponds to the maximum temperature expected at the latitudes of the study area (central France) in the next 80 years under the more pessimistic greenhouse gas-emission scenario. On the contrary, at that temperature, *O. limosus* will become less active, which may be a strategy to avoid thermal shocks, and *P. leniusculus*, being likely more vulnerable to high temperatures, will

	become less competitive. *Procambarus clarkii* is thus expected to exclude the other crayfish from the areas of syntopy and to dominate the future European watersheds. Ultimately, this might lead to impoverished biodiversity, simplified food webs, and altered ecosystem services (Gherardi, 2013). Observation: Signal crayfish originated in northwestern USA (Oregon/Washington), but has been very widely distributed across biogeographic regions within the USA, in Japan and across Europe from Spain and Portugal to Finland and other Baltic states and increasingly recorded in Eastern Europe (Souty-Grosset *et al.*, 2006). Signal crayfish are known to be tolerant of climatic conditions in all parts of Risk Assessment area and indeed can survive in hotter summers and colder winters in other parts of their indigenous and introduced range. Colder areas (Souty-Grosset *et al.*, 2006) include Estonia, Latvia, Sweden, Finland and from 2007 Norway too. Examples of warmer countries include Spain, Portugal, Italy, Greece. Higher fitness of *P. leniusculus* under warm climates when compared with other European native and invasive crayfishes has been reported (Lozán, 2000). Tolerance experiments: Results from tolerance experiments have shown that optimum temperature for the growth of three crayfishes ranges between 20 and 25°C, while temperatures above 38°C are lethal. However, *P. leniusculus* has a greater overall thermal tolerance and can not only survive and grow under conditions unsuitable for native crayfish, but will also grow faster (Firkins, 1993). Climate matching: However, climate matching indicates the opposite. After evaluating four different climate change scenarios, a predicted decrease in the area occupied by *P. leniusculus* between 18 and 30% was found (Gallardo & Aldridge, 2013b). Also, the potential distribution of *P. leniusculus* was predicted to shift towards the north-east (e.g. Sweden, Denmark, up to 67°N latitude).
11. Documents information sources	**Ackefors H. 1998.** The culture and capture crayfish fisheries in Europe. *World aquaculture* **29:** 18-24. **Capinha C, Larson ER, Tricarico E, Olden JD, Gherardi F. 2013.** Effects of climate change, invasive species, and disease on the distribution of native European crayfishes. *Conservation Biology* **27:** 731-740. **Chucholl C. 2013.** Invaders for sale: trade and determinants of

	introduction of ornamental freshwater crayfish. *Biological Invasions* **15:** 125-141. **Firkins I. 1993.** Environmental tolerances of three species of freshwater crayfish (Doctoral dissertation, University of Nottingham). . **Füreder L, Gherardi F, Holdich D, Reynolds J, Sibley P, Souty-Grosset C. 2010.** *Austropotamobius pallipes*. *IUCN 2010: IUCN Red List of Threatened Species. Version 2010.4*. **Gallardo B, Aldridge DC. 2013.** Evaluating the combined threat of climate change and biological invasions on endangered species. *Biological Conservation* **160:** 225-233. **Gherardi F. 2013.** Crayfish as global invaders: distribution, impact on ecosystem services and management options. *Freshwater Crayfish* **19:** 177-187. **Holdich D, Reynolds J, Souty-Grosset C, Sibley P. 2009.** A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Knowledge and Management of Aquatic Ecosystems*: 11. **Kouba A, Petrusek A, Kozák P. 2014.** Continental-wide distribution of crayfish species in Europe: update and maps. *Knowledge and Management of Aquatic Ecosystems*: 05. **Kozák P, Füreder L, Kouba A, Reynolds J, Souty-Grosset C. 2011.** Current conservation strategies for European crayfish. *Knowledge and Management of Aquatic Ecosystems*: 01. **Lodge DM, Deines A, Gherardi F, Yeo DC, Arcella T, Baldridge AK, Barnes MA, Chadderton WL, Feder JL, Gantz CA. 2012.** Global introductions of crayfishes: evaluating the impact of species invasions on ecosystem services. *Annual Review of Ecology, Evolution, and Systematics* **43:** 449-472. **Lozán JL. 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* **30:** 156-161. **Souty-Grosset C, Holdich DM, Noël PY, Reynolds J, Haffner P. 2006.** *Atlas of crayfish in Europe*. Muséum national d'Histoire naturelle. See also the Irish risk analysis report.
Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Belinda Gallardo Piero Genovesi Leopold Füreder
Notes	The signal crayfish *Pacifastacus leniusculus* is the most widespread non-native crayfish species in Europe, it is found in 22 EU countries. It is

	particularly widespread in Sweden, Finland and England. Currently it continues to expand its range in countries where already established and in new countries (Norway, Slovakia, Croatia and Estonia). In many countries, especially Sweden and Finland, the signal crayfish populations support a large, commercially and recreationally important, fishery. GB NNRA: high risk and high level of confidence. Additional information about the socio-economic benefits of the species is given, and some recent data on the species environmental impact, impact on ecosystem services, impact on protected species and habitats, and results of studies on the effects of climate change are added. Based on all collected information we suggest the risk assessment to be considered as compliant to the minimum standards with the same risk level in EU scale.
Outcome	Compliant

Scientific name	*Parthenium hysterophorus*
Common name	Whitetop Weed
Broad group	Plant
Number of and countries wherein the species is currently established	Not yet established in Europe.
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/14-19987_PRA_Parthenium_hysterophorus.docx http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/14-19988_PRA_report_Parthenium_hysterophorus.docx
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	Socio-economic benefit: *P. hysterophorus* could efficiently reduce heavy metal pollution in soil (Ahmad & Al-Othman, 2014).
6. Can broadly assess	*Parthenium hysterophorus* can affect the survival of earthworms that are

environmental impact with respect to ecosystem services	essential to soil formation (Rajiv *et al.*, 2014).
7. Broadly assesses adverse socio-economic impact	Data not available for Europe but inAustralia it costs farmers and pastoralists $A 100 million per year (Adkins & Shabbir, 2014). In Australia, this weed is a declared 'Weed of National Significance' and mainly occurs in Queensland where it has invaded *ca*. 600,000 km^2 of pasture land and has reduced beef production by *ca*. AU$100 million annually (Shabbir *et al.*, 2014)
8. Includes status (threatened or protected) of species or habitat under threat	No information.
9. Includes possible effects of climate change in the foreseeable future	The effects of climate change were shown to be neutral effect for this species (Shabbir *et al.*, 2014). In this study, they used *P. hysterophorus* and one of its biological control agents, the winter rust (*Puccinia abrupta* var. *partheniicola*) (Shabbir & Bajwa, 2006, Shabbir *et al.*, 2013) as a model system to investigate how the weed may respond to infection under a climate change scenario involving an elevated atmospheric CO_2 (550 umol mol-1) concentration. Under such a scenario, *P. hysterophorus* plants grew significantly taller (52%) and produced more biomass (55%) than under the ambient atmospheric CO_2 concentration (380 umol mol-1). Following winter rust infection, biomass production was reduced by 17% under the ambient and by 30% under the elevated atmospheric CO_2 concentration. The production of branches and leaf area was significantly increased by 62% and 120%, under the elevated as compared with ambient CO2 concentration, but unaffected by rust infection under either condition. The photosynthesis and water use efficiency (WUE) of *P. hysterophorus* plants were increased by 94% and 400%, under the elevated as compared with the ambient atmospheric CO_2 concentration. However, in the rust-infected plants, the photosynthesis and WUE decreased by 18% and 28%, respectively, under the elevated CO_2 and were unaffected by the ambient atmospheric CO_2 concentration. The results suggest that although *P. hysterophorus* will benefit from a future climate involving an elevation of the atmospheric CO_2 concentration, it is also likely that the winter rust will perform more effectively as a biological control agent under these same conditions.

11. Documents information sources	**Adkins S, Shabbir A. 2014.** Biology, ecology and management of the invasive Parthenium weed (*Parthenium hysterophorus* L.). *Pest. Management Science* **70:** 1023-1029. **Ahmad A, Al-Othman AA. 2014.** Remediation rates and translocation of heavy metals from contaminated soil through *Parthenium hysterophorus*. *Chemistry and Ecology* **30:** 317-327. **Rajiv P, Rajeshwari S, Rajendran V. 2014.** Impact of Parthenium weeds on earthworms (*Eudrilus eugeniae*) during vermicomposting. *Environmental Science and Pollution Research* **21:** 12364-12371. **Shabbir A, Bajwa R. 2006.** Distribution of parthenium weed (*Parthenium hysterophorus* L.), an alien invasive weed species threatening the biodiversity of Islamabad. *Weed Biology and Management* **6:** 89-95. **Shabbir A, Dhileepan K, Khan N, Adkins SW. 2014.** Weed–pathogen interactions and elevated CO2: growth changes in favour of the biological control agent. *Weed Research* **54:** 217-222. **Shabbir A, Dhileepan K, O'Donnell C, Adkins SW. 2013.** Complementing biological control with plant suppression: Implications for improved management of parthenium weed (*Parthenium hysterophorus* L.). *Biological Control* **64:** 270-275.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis Belinda Gallardo
Notes	The species is considered as an emerging invader in the EPPO region. It has been recorded so far in Israel, Egypt, Poland and Belgium. Dry land cropping and grazing systems in the Mediterranean are likely habitats for this species to establish.
Outcome	Compliant

Scientific name	*Persicaria perfoliata (Polygonum perfoliatum)*
Common name	Asiatic tearthumb or Mile-a-minute weed
Broad group	Plant
Number of and countries wherein the species is currently established	Not established in the EU
Risk Assessment Method	EPPO

Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13387rev%20PRA%20POLPF%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13604_PRAreportPOLPF.dochttp://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13604_PRAreportPOLPF.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	In native Asia *P. perfoliata* has been used as an herbal medicine for over 300 years, or as an edible wild fruit. Two protein kinase C inhibitors (PKC), vanicosides A and B, five diferuloyl esters of sucrose, and feruloylsucroses have been isolated from the plants, showing potential for use in medicine such as anticancer agents. Nine components were recently isolated from the methanol extract of the plant and evaluated for their antioxidant activity, among which, alpha-tocopherol and methyl trans-ferulate showed significant effects. In addition, five phenolic acids, caffeic acid, p-coumaric acid, p-hydroxybenzoic acid, protocatechuic acid, and vanillic acid were isolated from the aqueous extracts of the plant. They are allelopathic substances that have potential in controlling crop weeds. http://www.cabi.org/isc/datasheet/109155
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	Mile-a-minute exhibited lower biomass, flowered earlier and had greater reproductive output than plants from the native range (Guo *et al.*, 2011). Compared with native populations, plants from invasive populations had lower tannin content, but exhibited higher prickle density on nodes and leaves. Thus partially supporting the EICA hypothesis. When exposed to the monophagous insect, *Rhinoncomimus latipes* and the *oligophagous insects, Gallerucida grisescens* and *Smaragdina nigrifrons*, more damage by herbivory was found on invasive plants than on natives. *R. latipes, G. grisescens* and *S. nigrifrons* had strong, moderate and weak impacts on the growth and reproduction of mile-a-minute, respectively. The results indicate that mile-a-minute may have evolved a higher reproductive capacity in the introduced range, and this along with a lack of oligophagous and monophagous herbivores in the new range may have contributed to its invasiveness.
11. Documents information sources	**Guo WF, Zhang J, Li XQ, Ding JQ. 2011.** Increased reproductive capacity and physical defense but decreased tannin content in an invasive plant. *Insect Science* **18:** 521-532. http://www.cabi.org/isc/datasheet/109155

Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis
Notes	IRELAND RISK ASSESSMENT: http://nonnativespecies.ie/risk-assessments/ According to the EPPO report this IAS has restricted distribution in the EPPO region (Currently in Russia –Native in Siberia and Turkey- alien) but it is highly invasive in the US. Central European countries are more likely to be at risk than Mediterranean countries. Habitats at risk are cultivated systems such as the edges of pastures but also freshwater systems such as stream banks. It can affect tree plantations and nurseries and freshwater systems and its probability of entry is moderately high and the potential economic damage is medium to high. Possible pathway are plants in which growing media is from countries where *P. perfoliata* exists.
Outcome	Compliant

Scientific name	*Potamopyrgus antipodarum*
Common name	New Zealand Mudsnail
Broad group	Invertebrate
Number of and countries wherein the species is currently established	22: AT, BE, CZ, DK, UK, EE, FI, FR, DE, IR, IT, LV, LT, NL, IR, PO, RO, SI, SE, ES, GR, BU
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=619
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic	Socioeconomic benefits: Can be used to test anthropogenic toxins (Duft *et al.*, 2003a, Duft *et al.*, 2003b).

benefits)	
6. Can broadly assess environmental impact with respect to ecosystem services	Reported impacts of the species (on nutrient cycles, native fauna, fish health) are mostly relevant to freshwater bodies. Possible economic effects include contamination of drinking water (Weeks *et al.*, 2007), biofouling, threat to recreational fishing industry, increased vulnerability of native threatened or endangered fauna (resulting in costs for protection, research etc), monitoring, control, containment and education costs (Proctor *et al.*, 2007). Currently there is no evidence that these effects have taken place in the UK. GB NNRA gives direct negative economic effect of the organism, minor with medium uncertainty.
8. Includes status (threatened or protected) of species or habitat under threat	At high densities, *P. antipodarum* can dominate secondary production and is capable of increasing it to some of the highest values ever reported among stream invertebrates (194 g of ash free dry mass/m2/year) (Hall Jr *et al.*, 2006). This allows *P. antipodarum* to alter the overall nitrogen fixation rate of an ecosystem by consuming a high proportion of green algae, which causes an increase of nitrogen-fixing diatoms (Richardson *et al.*, 2009). Some studies show domination of mollusc communities by this species (Gérard *et al.*, 2003, Lewin & Smoliński, 2006) and also a reduction in the growth of native molluscs (Richardson *et al.*, 2009) due to competition for space and food.
9. Includes possible effects of climate change in the foreseeable future	*Potamopyrgus antipodum* has been found in waters only at temperatures below 28°C. Experimental work indicates that 28°C represents the temperature at which snail activity is first curtailed when temperatures are progressively raised. When temperature was raised 1°C/24 hours, heat death occurred at 30-32°C.
11. Documents information sources	**Alonso Á, Castro-Díez P. 2012.** The exotic aquatic mud snail *Potamopyrgus antipodarum* (Hydrobiidae, Mollusca): state of the art of a worldwide invasion. *Aquatic sciences* **74:** 375-383. **Duft M, Schulte-Oehlmann U, Weltje L, Tillmann M, Oehlmann J. 2003.** Stimulated embryo production as a parameter of estrogenic exposure via sediments in the freshwater mudsnail *Potamopyrgus antipodarum*. *Aquatic Toxicology* **64:** 437-449. **Duft M, Schulte‐Oehlmann U, Tillmann M, Markert B, Oehlmann J. 2003.** Toxicity of triphenyltin and tributyltin to the freshwater mud snail *Potamopyrgus antipodarum* in a new sediment biotest. *Environmental Toxicology and Chemistry* **22:** 145-152. **Gérard C, Blanc A, Costil K. 2003.** *Potamopyrgus antipodarum* (Mollusca:

	Hydrobiidae) in continental aquatic gastropod communities: impact of salinity and trematode parasitism. *Hydrobiologia* **493:** 167-172. **Hall Jr RO, Dybdahl MF, VanderLoop MC. 2006.** Extremely high secondary production of introduced snails in rivers. *Ecological Applications* **16:** 1121-1131. **Lewin I, Smoliński A. 2006.** Rare and vulnerable species in the mollusc communities in the mining subsidence reservoirs of an industrial area (The Katowicka Upland, Upper Silesia, Southern Poland). *Limnologica-Ecology and Management of Inland Waters* **36:** 181-191. **Proctor T, Kerans B, Clancey P, Ryce E, Dybdahl M, Gustafson D, Hall R, Pickett F, Richards D, Waldeck R. 2007.** National Management and Control Plan for the New Zealand Mudsnail (*Potamopyrgus antipodarum*). *Aquatic Nuisance Species Task Force. Website: http://www. anstaskforce. gov/Documents/NZMS_M&C_Draft_8-06. pdf.* **Richardson J, Arango CP, Riley LA, Tank JL, Hall RO. 2009.** Herbivory by an invasive snail increases nitrogen fixation in a nitrogen-limited stream. *Canadian Journal of Fisheries and Aquatic Sciences* **66:** 1309-1317. **Weeks MA, Leadbeater BS, Callow ME, Bale JS, Barrie Holden J. 2007.** Effects of backwashing on the prosobranch snail *Potamopyrgus jenkinsi* Smith in granular activated carbon (GAC) adsorbers. *Water research* **41:** 2690-2696. Canadian risk assessment (http://www.dfo-mpo.gc.ca/Library/344229.pdf) The overall risk posed to Canadian aquatic ecosystems by New Zealand mud snail was determined to be low to moderate but with very high uncertainty.
Main experts	Frances Lucy Argyro Zenetos
Other contributing experts	Rory Sheehan
Notes	This successful early colonizer is tolerant of a wide range of environmental conditions and has a high parthenogenetic reproductive capacity, which may lead to the establishment of very dense populations of thousands individuals m^2 [several authors reported densities up to 500,000 individuals m^2 in invaded habitats or even up to 800,000 individuals m^2 (Alonso & Castro-Díez, 2012)].

	Distribution Bay of Biscay & the Iberian coast Spain 1950 Unknown North Sea Netherlands 1913 Unknown North Sea Sweden Unknown North Sea France 1984 Casual FW only Italy 1961 Established FW only Spain 1985 Established FW only Greece 1996 Established Baltic Sea Lithuania 1887 Established Baltic Sea Poland 1933 Established Baltic Sea Germany 1908 Established Baltic Sea Estonia >1850 Established Baltic Sea Sweden 1887 Established Baltic Sea Finland 1880s Established Baltic Sea Latvia 1900 Established Bay of Biscay & the Iberian coast France 1954 Established Black Sea Romania 1940s Established Black Sea Bulgaria 1952 Established Celtic Seas Ireland <1900 Established North Sea Denmark 1914 Established North Sea United Kingdom 1859 Established North Sea Belgium 1927 Established North Sea Germany 1900 Established Bay of Biscay & the Iberian coast Portugal 1978 Unknown North Sea Norway 1952 Unknown
Outcome	Compliant

Scientific name	*Procambarus clarkii*
Common name	Red Swamp Crayfish
Broad group	Invertebrate
Number of and countries wherein the species is currently established	10: AT, BE, DE, ES, FR, IT, NL, PL?, PT, UK
Risk Assessment	GB NNRA

Method	
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=46
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Other EU countries where the species is found (2): Austria, Cyprus (Holdich *et al.*, 2009). Currently established populations are found in the following EU member states: The majority of populations are found in Spain, Italy and France. Wild populations of the species also exist in: Portugal, Belgium, the Netherlands, Germany, Austria, Czech Republic and England. The species shows signs of invasiveness in the following EU member states: All EU member states recorded although levels of invasiveness may vary, but this may due to a lack of scientific evidence. The species can establish in the following EU Biogeographic areas: Atlantic, continental, Mediterranean, Macaronesia, Pannonian, Steppic, Black Sea, possibly Boreal. It could establish in the future [given current climate] (including those where it is already established) in the following EU member states: Portugal, Belgium, the Netherlands, Germany, Austria, Czech Republic and the UK. This species could become invasive in the future [given current climate] (where it is not already established) in the following MS: Poland, Slovakia, Slovenia, Greece, Romania, Croatia, Bulgaria. Socio-economic benefits: *P. clarkii* is used as human food for domestic consumption and/or export. The red swamp crawfish has also been introduced as food for fishes, and for other species (Gherardi, 2013). In addition, *P. clarkii* has become one of the most popular crayfish species in the European aquarium trade (Chucholl, 2013). The species is cultured and captured extensively for human consumption in its native range and introduced range e.g. Spain and China. In Andalucía (Spain) the local economy has been revitalised as a result of wild

	harvesting of *P. clarkii*. Production figures of between 3000-5000 tonnes per annum are likely under estimates. Exploitation in Italy has met with little success due to low demand. Production is very low in Europe however, in comparison to the USA and China (50,000 and 70,000 tonnes per annum respectively).
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional	In some cases, introductions have been accidental (e.g., through canals, escapes from holding facilities), but most have been deliberate (for aquaculture, legal and illegal stocking, and live food trade, as aquarium pets and live bait, for snail and weed control, and as supplies for science classes) (Gherardi, 2013).
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	Crayfish cause major environmental impacts in Europe by outcompeting native species and altering habitat structure. Alien crayfish, such as *P. clarkii* and *Pacifastacus leniusculus*, are responsible for the largest range of impacts (i.e., crayfish plague dissemination, bioaccumulation of pollutants, community dominance, competition and predation on native species, habitat modifications, food web impairment, herbivory and macrophyte removal) (Gherardi, 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	Summary of impacts of the red swamp crawfish *P. clarkii* on the four categories of ecosystem services (provisioning, regulating, supporting, and cultural services have been reviewed (Gherardi, 2013). *Procambarus clarkii* burrows extensively destabilising banks and increasing turbidity. The species also has significant negative effect on plants and animals causing changes to food web structure. Impacts on ecosystem services include (but are not limited to): • Supporting services- burrowing will lead to destabilisation of river banks and water ways may become shallower and therefore more susceptible to flooding and flood related damage. Significant changes in the entire ecosystem resulting from the introduction of *P. clarkii* may also impact on food supply. • Provisioning services- *P. clarkii* has had impact on rice production where burrowing has destabilised paddies and consumption of crops has reduced yield. Increased turbidity in potable water sources may lead to additional costs in purification, although this has not been documented. • Regulating services- *P. clarkii* are asymptomatic carriers of the crayfish plague, a pathogen which native European crayfish species are highly

	susceptible to, often causing 100% mortalities. *P. clarkii* also accumulates heavy metals and other pollutants which are transmitted to higher trophic levels. • Cultural services- impacts on whole ecosystems will decrease species abundance and richness, in addition to making waters unsightly, possibly effecting ecotourism. Fish communities are likely to decrease, impacting on angling. Long term changes in water ways through bank erosion and turbidity make impact on navigation.
8. Includes status (threatened or protected) of species or habitat under threat	The following Red List assesses species in Europe are under threat because of the Red Swamp Crayfish (IUCN Red List, GISD 2014): a) Gastropods • *Lymnaea stagnalis* LC b) Crayfish species: • *Astacus astacus VU* • *Astacus leptodactylus LC* • *Austropotamobius pallipes EN* • *Austropotamobius torrentium DD* The White-clawed crayfish *Austropotamobius pallipes* is affected by a range of threats, however the most widespread threat is that of the invasive alien crayfish species such as the Signal Crayfish (*Pacifastacus lenisculus*) and Red Swamp Crayfish (*Procambarus clarkii*), as well as the Crayfish Plague (*Aphanomyces astaci*). Invasive crayfish are aggressive predators for food and habitat, and often prey upon the White-clawed Crayfish (Füreder *et al.*, 2010). Significant declines are occurring across much of this species range: approximately ~52% decline over 10 years in England, ~52% decline between 1995 and 2003 within France, and a 99.5% decline estimated for a ten year period in the South Tyrol region of Italy. These countries once held the greatest abundance of this species (Füreder *et al.*, 2010). For example, the situation concerning *A. pallipes* is considered critical in South-West England, where *P. leniusculus* has become widespread and this has been at the expense of *A. pallipes*, mainly through outbreaks of

	crayfish plague since the 1980s. It has also colonised waters not suitable for *A. pallipes* (Holdich *et al.*, 2009). In France, a national survey conducted in 2006 shows the same trend and the situation of three indigenous species is considered alarming: *Austropotamobius torrentium* and *Astacus astacus* are close to extinction, and *A. pallipes*, with mortalities observed in 47 departments, can now only be found in the uppermost parts of the watersheds (Holdich *et al.*, 2009). These mortalities are due not only to disease, but also to the pressure of non-indigenous species, which are still expanding their range. Both *P. leniusculus* and *P. clarkii* showed their strongest geographical expansion during the 2001–2006 period. They appear to be ubiquitously very strong competitors; being more aggressive; resistant to disease, although there are outbreaks of disease at times associated with either a chronic or epizootic mortality; and are able to colonise varied environments. They are in the process of colonising new departments, new watersheds, and eliminating indigenous species (Holdich *et al.*, 2009). Italy is considered a “hot-spot” for the genetic diversity of the European crayfish genus *Austropotamobius*. The fragmentation of the *A. pallipes* complex populations is due to among other threats the diseases, notably crayfish plague carried by *P. leniusculus* and *P. clarkii*, and interspecific competition with the non-native crayfish species. In Italy, the decline is about 74% over the last 10 years (Holdich *et al.*, 2009). With the introduction of the two North American species into the Iberian peninsula, first, *P. clarkii* in 1973, and then *P. leniusculus* in 1974, the fate of *A. pallipes* was effectively sealed. Today this crayfish is believed extinct in Portugal and only remnant populations remain in Spain, chiefly in Atlantic regions of Asturias, Girona and Pais Vasco, Navarra, Castilla and Leon, Cuenca and Granada. As elsewhere when NICS have ousted ICS from the majority of their habitat, *A. pallipes* is now restricted in Spain to small headwater streams and springs (Holdich *et al.*, 2009). c) Fish species • *Aphanius baeticus* LC (restricted to the lower Guadalquivir region and in streams located on the southern Atlantic slope of Spain, including Coto Donana National Park)

	d) Amphibians - predation • *Alytes cisternasii* NT (restricted to southern and eastern Portugal and western and central Spain) • *Discoglossus galganoi* LC (endemic to the Iberian Peninsula - Portugal and most of western Spain) • *Discoglossus jeanneae* NT (endemic to isolated areas in southern, eastern and north-eastern Spain) • *Epidalea calamita* LC (found in southern, western and northern Europe, ranging from Portugal and Spain, north to Denmark, southern Sweden, and as far east as western Ukraine, Belarus, Latvia and Estonia) • *Hyla meridionalis* LC (the western Mediterranean) • *Lissotriton boscai* LC (restricted to the western part of the Iberian Peninsula) • *Lissotriton helveticus* LC (restricted to western Europe) • *Pelobates cultripes* NT (present in most of the Iberian Peninsula and southern France) • *Pelodytes ibericus* LC (endemic to southeastern Portugal and southern Spain) • *Pelodytes punctatus* LC (found in Portugal, Spain, France and Italy) • *Pleurodeles waltl* NT (central and southern Iberia) • *Rana latastei* VU (found in Italy, Switzerland, Slovenia, Croatia) • *Salamandra salamandra* LC (present across much of central, eastern and southern Europe) • *Triturus marmoratus* LC (found in much of northern Iberia, and central, southern and western France) • *Triturus pygmaeus* NT (endemic to the Iberian Peninsula) e) Bird species - competition • *Fulica cristata* LC (Spain) *P. clarkii* are ecosystem engineers having a wide ranging impact when found outside of their native range. For example in Chozas Lake (Spain) the introduction of *P. clarkii* show a significant change from a biodiverse clear water lake to a turbid water with significant loss of species abundance and richness (99% reduction in plant cover, 71% loss of macro-invertebrates, 83% reduction in amphibian species and 52% reduction in water fowl).

	P. clarkii are asymptomatic carriers of the crayfish plague, a pathogen which native European crayfish species are highly susceptible to, often causing 100% mortalities. *P. clarkii* also accumulates heavy metals and other pollutants which are transmitted to higher trophic levels. It is therefore likely that *P. clarkii* may have an impact on all freshwater protected habitats and species within the risk assessment area.
9. Includes possible effects of climate change in the foreseeable future	*P. clarkii* naturally occurs in southern America including Central America, preferring warmer climates, but tolerant of colder conditions. Increasing water temperature is likely to see an increase in the range of *P. clarkii* into northern territories. The effect of climate change on the world's distribution of *P. clarkii* by 2050 has been examined (Liu *et al.*, 2011). The authors developed a model under two greenhouse gas-emission scenarios and found that *P. clarkii*'s presence is negatively correlated with the minimum temperature of the coldest month but positively so with precipitation of the driest quarter and human footprint. A second result of this study is that Europe, particularly river basins at higher latitudes, will be more sensitive to this species, and thus necessitates additional concern under future climate change. A similar modeling exercise was developed (Capinha *et al.*, 2013) for the native crayfish in Europe and three North American plague-carrying crayfish species (*O. limosus*, *P. leniusculus*, and *P. clarkii*). The authors anticipate that only *P. clarkia* will enlarge its distribution range in both accessible (areas within basins where a given species is currently established) and inaccessible areas. This result has been confirmed by a behavioural study that analyzed antagonism, at different temperatures, of dyads composed of the same three species (Gherardi, 2013). All other conditions being equal, *P. clarkii* was dominant over the other species at the highest temperature analyzed (27°C), which corresponds to the maximum temperature expected at the latitudes of the study area (central France) in the next 80 years under the more pessimistic greenhouse gas-emission scenario. On the contrary, at that temperature, *O. limosus* will become less active, which may be a strategy to avoid thermal shocks, and *P. leniusculus*, being likely more vulnerable to high temperatures, will

	become less competitive. *Procambarus clarkii* is thus expected to exclude the other crayfish from the areas of syntopy and to dominate the future European watersheds. Ultimately, this might lead to impoverished biodiversity, simplified food webs, and altered ecosystem services (Gherardi, 2013). Observation. At least 2 generations per year are possible at low latitudes (up to 600 eggs brooded at a time). In northern Europe and arid areas there is usually only one generation per year. It is very versatile in its ecology, able to avoid climatic extremes by burrowing. Females can store sperm and breed at any time of year when conditions become favourable (Stucki, 2002, Stucki & Romer, 2001). Summer temperature of 22-30°C is optimal, but growth and reproduction possible in cooler conditions, e.g. in Netherlands (climatically equivalent to south and east England). Confirmed breeding in England in 2000. Can survive in much colder winter than in England, e.g. under ice in Germany (Holdich *et al.*, 2009, Holdich & Crandall, 2002), also introduced into northern USA (Idaho, Ohio). Much of England has conditions that are suitable for breeding, especially in the south and in warm years. In northern England, Wales and Scotland, *P. clarkii* could easily survive the winters, but the summers are cool and definitely suboptimal. It is likely that reproduction would be less in northern and western areas, but it should not be assumed that it could not occur. Embryo development is not arrested until temperature is below 10°C (Souty-Grosset *et al.*, 2006). Outcome of competition between *P. clarkii* and *P. leniusculus* will probably depend on local habitat and climate.
11. Documents information sources	**Capinha C, Larson ER, Tricarico E, Olden JD, Gherardi F. 2013.** Effects of climate change, invasive species, and disease on the distribution of native European crayfishes. *Conservation Biology* **27:** 731-740. **Chucholl C. 2013.** Invaders for sale: trade and determinants of introduction of ornamental freshwater crayfish. *Biological Invasions* **15:** 125-141. **Füreder L, Gherardi F, Holdich D, Reynolds J, Sibley P, Souty-Grosset C. 2010.** *Austropotamobius pallipes*. *IUCN 2010: IUCN Red List of Threatened Species. Version 2010.4*. **Gherardi F. 2013.** Crayfish as global invaders: distribution, impact on ecosystem services and management options. *Freshwater Crayfish* **19:** 177-187. **Holdich D, Reynolds J, Souty-Grosset C, Sibley P. 2009.** A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Knowledge and Management of Aquatic*

	Ecosystems: 11. **Holdich DM, Crandall K. 2002.** *Biology of freshwater crayfish*. Blackwell Science Oxford. **Liu X, Guo Z, Ke Z, Wang S, Li Y. 2011.** Increasing potential risk of a global aquatic invader in Europe in contrast to other continents under future climate change. *PloS one* **6:** e18429. **Souty-Grosset C, Holdich DM, Noël PY, Reynolds J, Haffner P. 2006.** *Atlas of crayfish in Europe*. Muséum national d'Histoire naturelle. **Stucki TP. 2002.** Differences in life history of native and introduced crayfish species in Switzerland. *Freshwater Crayfish* **13:** 463-476. **Stucki TP, Romer J. 2001.** Will *Astacus leptodactylus* displace *Astacus astacus* and *Austropotamobius torrentium* in Lake Ägeri, Switzerland? *Aquatic sciences* **63:** 477-489. See also: - The Belgian risk analysis report - The Irish risk analysis report
Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Olaf Booy Belinda Gallardo Piero Genovesi Leopold Füreder
Notes	The red swamp crayfish *Procambarus clarkii* was reported from more than 10 EU countries. Most heavily invaded are Portugal, Spain, Italy and The Netherlands. It is used for human consumption and has become one of the most popular crayfish species in the European aquarium trade. GB NNRA: high risk and low level of uncertainty. Information about the socio-economic benefits of the species is given, and recent data on the species environmental impact, impact on ecosystem services, impact on protected species and habitats, and results of studies on the effects of climate change are added. Based on all collected information we suggest the risk assessment to be considered as compliant to the minimum standards with the same risk level at European scale with GB.
Outcome	Compliant

Scientific name	*Procambarus spp.*

Common name	Marbled Crayfish
Broad group	Invertebrate
Number of and countries wherein the species is currently established	5: IT, DE, NL, SE, SK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=620
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Taxonomy: Using genetic and morphological comparisons, it has recently been shown that Marmorkrebs are the parthenogenetic form of *Procambarus fallax* (Hagen, 1870) and proposed the tentative scientific name *Procambarus fallax* f. *virginalis* (Martin *et al.*, 2010). The Marmorkrebs is unique because it is the only known decapod crustacean that obligatory reproduces by apomictic parthenogenesis: only females exist, which lay unfertilized eggs that develop into genetically identical offspring (Martin *et al.*, 2010, Scholtz *et al.*, 2003, Vogt *et al.*, 2004). No males have been found in the laboratory or in introduced, wild populations (Chucholl *et al.*, 2012, Seitz *et al.*, 2005) (Seitz et al. 2005, Jones et al. 2009, Janský, Mutkovič 2010). Introduced range: recently reviewed (Bohman *et al.*, 2013, Kouba *et al.*, 2014, Samardžić *et al.*, 2014). In how many EU member states has this species been recorded? List them. Italy, Netherlands, Slovakia, Sweden, and Germany. In how many EU member states has this species currently established populations? List them. Italy, Netherlands and Germany. This species could establish in the following EU Biogeographic areas: Atlantic, continental, Mediterranean, Macaronesia, Pannonian, Steppic, Black Sea, possibly Boreal.

	Without having a native range for comparison it is very difficult to say under which conditions this species will and will not survive. It may therefore be possible for this species to establish in Alpine and even Arctic regions. The species could establish and become invasive in the future [given current climate] (including those where it is already established) in potentially all EU member states. Socio-economic benefits: The Marmorkrebs is a popular pet species in Europe and North America (Chucholl, 2013) http://www.cabi.org The Marmorkrebs was suggested as laboratory model organism for development, epigenetics and toxicology. Its high number of genetically identical offspring and its undemanding nature are, among other peculiarities, ideal prerequisites for this role (Jirikowski *et al.*, 2010, Vogt, 2011, Vogt *et al.*, 2004). The species is widely cultured in the aquarium trade. No figures have been compiled on total value of the trade in this species.
6. Can broadly assess environmental impact with respect to ecosystem services	There are no known naturally occurring populations of this species, and few introduced populations to assess impact. However, it is parthenogenetic, requiring no males for reproduction (in fact no males have been found to date), it has high reproductive potential and feeds voraciously. If these species characteristics are considered in combination with the impact of other similar species (e.g. *Procambarus clarkii*), then Marbled crayfish could have a significant impact on ecosystem services, and potentially to more so than *P. clarkii*. Impacts on ecosystem services may include (but are not limited to): Supporting services: although not recorded in the wild there is evidence to suggest this species will burrow. Burrowing will lead to destabilisation of river banks and water ways may become shallower and therefore more susceptible to flooding and flood related damage. Significant changes in the entire ecosystem resulting from their introduction may also impact on food supply.

	Provisioning services: similar species have had impact on rice production where burrowing has destabilised paddies and consumption of crops has reduced yield. Increased turbidity in potable water sources may lead to additional costs in purification, although this has not been documented. Regulating services: the species has been demonstrated to be asymptomatic carriers of the crayfish plague, a pathogen which native European crayfish species are highly susceptible to, often causing 100% mortalities. Cultural services: it is likely that the species will impact on whole ecosystems, decreasing species abundance and richness, in addition to making waters unsightly, possibly effecting ecotourism. Fish communities are likely to decrease, impacting on angling. Long term changes in water ways through bank erosion and turbidity make impact on navigation.
8. Includes status (threatened or protected) of species or habitat under threat	Marmorkrebs most likely pose a serious threat to the indigenous European crayfish species because they may compete with other species for food and space, and they may transmit crayfish plague (Chucholl *et al.*, 2012, Chucholl & Pfeiffer, 2010). Direct aggressive interactions between Marmorkrebs and *P. clarkii* have been studied and it was concluded that Marmorkrebs have the potential to compete with other crayfish species. Furthermore, Marmorkrebs differ ecologically from the more K-selected indigenous European crayfish because Marmorkrebs have a fast growth rate, very high fecundity and an extended breeding period (Chucholl & Pfeiffer, 2010, Seitz *et al.*, 2005), all of which might give an additional competitive advantage to Marmorkrebs. The risk of devastating consequences for indigenous crayfish would dramatically increase if Marmorkrebs were infected with the causative agent of crayfish plague, *Aphanomyces astaci* Schikora, 1903: any contact between Marmorkrebs and the susceptible European crayfish would almost certainly result in mass mortalities among the susceptible species. This potential threat to indigenous crayfish is alarming, especially because at least two of the six established Marmorkrebs populations already endanger indigenous crayfish populations (Chucholl *et al.*, 2012). It is likely that *P. clarkii* and marbled crayfish will have similar impacts, with Marbled crayfish possibly having the greater impact as a result of the higher rate of reproduction. The assessment species may therefore have

	an impact on all freshwater protected habitats and species within the risk assessment area. *P. clarkii* are ecosystem engineers having a wide ranging impact when found outside of their native range. For example in Chozas Lake (Spain) the introduction of *P. clarkii* show a significant change from a biodiverse clear water lake to a turbid water with significant loss of species abundance and richness (99% reduction in plant cover, 71% loss of macro-invertebrates, 83% reduction in amphibian species and 52% reduction in water fowl). *P. clarkii* are asymptomatic carriers of the crayfish plague, a pathogen which native European crayfish species are highly susceptible to, often causing 100% mortalities. *P. clarkii* also accumulates heavy metals and other pollutants which are transmitted to higher trophic levels.
9. Includes possible effects of climate change in the foreseeable future	Quantitative predictions have been made through species distribution models (SDM), using nineteen climatic variables, for the three regions where Marmorkrebs currently pose the greatest conservation concern (Feria & Faulkes, 2011): Madagascar, Europe, and North America. Only a few regions in Europe were predicted to be suitable habitat for Marmorkrebs in three of the four models they ran. Using *P. fallax* data alone, no western European regions are predicted to be suitable habitat. When data on Marmorkrebs in Madagascar are used, relatively small areas of suitable habitat are predicted to exist in several countries, including Germany (where there have been several documented releases of Marmorkrebs and one confirmed population (Chucholl & Pfeiffer, 2010)) and the United Kingdom. The predicted habitat changes substantially when the model is trained using *P. fallax* locations, and both the Madagscar and European locations of Marmorkrebs. Almost all of Europe is predicted to be suitable habitat for Marmorkrebs, except southern Spain and Portugal. Observation: substantial cold tolerance, although its temperature optimum is high at 18-25°C. The recent finding of a well-developed population in a lake in the region of the upper Rhine would seem to indicate that it can survive central European winter conditions (Chucholl & Pfeiffer, 2010). Marmorkrebs is less likely to become established in cooler northern and western regions, although this may change with climate

	change.
11. Documents information sources	Bohman P, Edsman L, Martin P, Scholtz G (2013) The first Marmorkrebs (Decapoda: Astacida: Cambaridae) in Scandinavia. *Bioinvasions Rec,* **2**, 227-232. Chucholl C (2013) Invaders for sale: trade and determinants of introduction of ornamental freshwater crayfish. *Biological Invasions,* **15**, 125-141. Chucholl C, Morawetz K, Groß H (2012) The clones are coming–strong increase in Marmorkrebs [*Procambarus fallax* (Hagen, 1870) f. virginalis] records from Europe. *Aquatic Invasions,* **7**, 511-519. Chucholl C, Pfeiffer M (2010) First evidence for an established Marmorkrebs (Decapoda, Astacida, Cambaridae) population in Southwestern Germany, in syntopic occurrence with Orconectes limosus (Rafinesque, 1817). *Aquatic Invasions,* **5**, 405-412. Feria TP, Faulkes Z (2011) Forecasting the distribution of Marmorkrebs, a parthenogenetic crayfish with high invasive potential, in Madagascar, Europe, and North America. *Aquatic Invasions,* **6**, 55-67. Jirikowski G, Kreissl S, Richter S, Wolff C (2010) Muscle development in the marbled crayfish—insights from an emerging model organism (Crustacea, Malacostraca, Decapoda). *Development genes and evolution,* **220**, 89-105. Kouba A, Petrusek A, Kozák P (2014) Continental-wide distribution of crayfish species in Europe: update and maps. *Knowledge and Management of Aquatic Ecosystems*, 05. Martin P, Dorn NJ, Kawai T, Van Der Heiden C, Scholtz G (2010) The enigmatic Marmorkrebs (marbled crayfish) is the parthenogenetic form of *Procambarus fallax* (Hagen, 1870). *Contrib Zool,* **79**, 107-118. Samardžić M, Lucić A, Maguire I, Hudina S (2014) The first record of the Marbled Crayfish (*Procambarus fallax* (Hagen, 1870) f. *virginalis*) in Croatia. *Crayfish News,* **36**, 4. Scholtz G, Braband A, Tolley L *et al.* (2003) Ecology: Parthenogenesis in an outsider crayfish. *Nature,* **421**, 806-806. Seitz R, Vilpoux K, Hopp U, Harzsch S, Maier G (2005) Ontogeny of the Marmorkrebs (marbled crayfish): a parthenogenetic crayfish with unknown origin and phylogenetic position. *Journal of Experimental Zoology Part A: Comparative Experimental Biology,* **303**, 393-405. Vogt G (2011) Marmorkrebs: natural crayfish clone as emerging model for various biological disciplines. *Journal of biosciences,* **36**, 377. Vogt G, Tolley L, Scholtz G (2004) Life stages and reproductive components of the Marmorkrebs (marbled crayfish), the first parthenogenetic decapod crustacean. *Journal of Morphology,* **261**, 286-311.

Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Olaf Booy Belinda Gallardo Leopold Füreder
Notes	The marbled crayfish or Marmorkrebs *Procambarus* spp. was identified as *P. fallax* f. *virginalis* – a parthenogenetic form. The species was recorded in at least five EU countries (Germany, Italy, Netherlands, Sweden and Slovakia) and since 2010 has established populations in Germany, Slovakia and Italy. The records in Germany are increasing. The species is a popular pet species in Europe because of its attractive colouration, undemanding nature and obligatory asexual reproduction.
Outcome	Compliant

Scientific name	*Procyon lotor*
Common name	Raccoon
Broad group	Vertebrate
Number of and countries wherein the species is currently established	13: AT, BE, CZ, DE, DK, ES, FR, HU, LU, NL, PL, SI, SK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=621
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Raccoons are available in the pet trade and kept by private owners and zoological gardens in unknown numbers. According to the European Fur Breeders' Association (www.efba.eu) raccoons are no longer used in fur farming in Europe.
4. Has the capacity to assess multiple	A new pathway of introduction for raccoons has appeared, stowaways on ships and in transport containers from Germany to Scandinavia.

pathways of entry and spread in the assessment, both intentional and unintentional	
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning services: Raccoons have provided raw material (fur as ornamental resource) in the past, but farming is now prohibited or not profitable in Europe. Raccoons may have negative impact on food (farm and garden crops, fruit trees) (references in the GB NNRA). Regulating services: Raccoons are carriers of several pathogens and therefore may influence disease infection rates and may influence natural disease regulation (references in the GB NNRA). Cultural services: Raccoons are appreciated for aesthetic reasons by pet owners, but may cause recreation and mental/physical health issues in high densities in houses/urban areas (references in the GB NNRA).
8. Includes status (threatened or protected) of species or habitat under threat	At the global IUCN-red list level, there is no threatened species in Europe under pressure from raccoon (GISD 2014). However, there is a number of species of national concern (threatened or protected) that may suffer from raccoon predation (seabirds, waterfowl, amphibians) depending on specific (context-dependent) circumstances (e.g. high raccoon population numbers). Although highest densities are reached in urban and suburban areas, raccoons also occur in threatened or protected habitats, including Natura 2000-habitats (e.g. wetlands). Impacted Red List assessed species 7: EN = 1; VU = 1; NT = 2; LC = 3 (from GISD 2014): *Iguana delicatissima EN* *Meles anakuma LC* *Meles meles LC* *Natrix megalocephala VU* *Ommatotriton ophryticus NT* *Pelodytes caucasicus NT* *Rana macrocnemis LC*
9. Includes possible effects of climate change in the foreseeable future	This species has demonstrated great adaptability in respect of both climate and habitat. The raccoon ranges across the North American continent, but has also invaded Japan and established in a large part of Europe (Germany, Poland, France, Luxembourg, Netherlands, Belgium, Switzerland, Austria, Hungary, Belarus, Slovakia, Spain). The effects of

	global warming, which affects not only the availability and diversity of food but also the duration of the growing season (and thus temporal availability of food), probably helped raccoons colonize new areas in Canada (Larivière, 2004).
11. Documents information sources	**Larivière S. 2004.** Range expansion of raccoons in the Canadian prairies: review of hypotheses. *Wildlife Society Bulletin* **32:** 955-963. GISD 2014 Global Invasive Species Database (2014). Downloaded from http://193.206.192.138/gisd/search.php on 09-12-2014 (P. Genovesi, pers. comm.)
Main experts	Wolfgang Rabitsch Melanie Josefsson
Other contributing experts	Belinda Gallardo Piero Genovesi
Notes	GB NNRA: Medium risk and medium uncertainty
Outcome	Compliant

Scientific name	*Pseudorasbora parva*
Common name	Stone moroko
Broad group	Vertebrate
Number of and countries wherein the species is currently established	16: AT, BE, BG, CZ, DE, DK, GR, ES, FR, HU, IT, NL, PL, RO, SK, UK
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=243
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic	Additional EU countries where the species is found (3): Sweden (CABI), Croatia (GISIN), Slovenia (Gozlan *et al.*, 2010). The species has been recorded in the following: EU member: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden & United Kingdom (19)

benefits)	It is currently established populations in the following EU member states: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden & United Kingdom (18) This species has shown signs of invasiveness in the following EU member states: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden & United Kingdom (18) It could be established in the following EU Biogeographic area: Atlantic, Alpine, Continental, Pannonian, Mediterranean & Steppic The species could establish in the future [given current climate] (including those where it is already established) in the following EU MS: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden & United Kingdom (28) It could become invasive in the future [given current climate] (where it is not already established) in: Croatia, Cyprus, Estonia, Finland, Ireland, Latvia, Luxembourg, Malta, Portugal, Slovenia (10) Socio-economic benefits: Some commercially valuable fish species, such as the Chinese perch, are reported to pray on the topmouth gudgeon in the native range (China, Japan) (FishBase, http://www.fishbase.org). Feed item for commercially important species in aquaculture. Considered a model species for research.
4. Has the capacity to assess multiple pathways of entry and spread in the	The primary introduction pathways, in order of importance, are aquaculture, mainly associated to the species' hitch-hiking with Chinese carp species and common carp *Cyprinus carpio* (65%), recreational fishing (22%), ornamental fish trade (9%) and natural dispersal (1%). However,

assessment, both intentional and unintentional	natural dispersal represents the main secondary pathway (72%) followed by angling (25%) and the ornamental fish trade (3%). Based on the number of fish movements and introductions during the 1970 and early 1980's across European countries, and in particular of Chinese carp species, it is likely that the actual distribution of *P. parva* in its invasive range reflects a combination of 'stepping–stone' and 'diffusion' dispersal models (Gozlan *et al.*, 2010).
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning: Food (aquaculture) Inter-specific competition for food between *P. parva* and other cyprinid fish species resulted in food web structure changes causing increased economic costs for carp aquaculture ponds in the Czech Republic (Gozlan *et al.*, 2010) . Regulating: Pest and disease regulation Transmission of parasites – the species has an important role in the spread of diseases and parasites as a healthy carrier for a number of pathogens (Gozlan *et al.*, 2010). The only reported parasite specific to *P. parva* that has been reported is *Dactylogyrus squameus* and this has facilitated their dispersal to regions in Kazakhstan, Tajikistan, Uzbekistan, the Czech and Slovak Republics and Italy. The two most pathogenic parasites associated with *P. parva* in its invasive range are *Anguillicola crassus* and the rosette agent *Sphaerothecum destruens* (Gozlan *et al.*, 2010, Gozlan *et al.*, 2005). *Anguillicola crassus* is a parasitic nematode that occupies the swimbladder of eels with the capacity to cause high eel mortalities; *P. parva* acts as an intermediate host. In a location in France, 35% of *P. parva* were infected with *A. crassus* (Cesco *et al.*, 2001). The identification of *P. parva* as a healthy carrier for the intracellular parasite *S. destruens* is a concern as this pathogen has been responsible for mass mortalities of salmonid fishes in the USA (Arkush *et al.*, 2003) and has since been associated with the decline of native European fish species including sunbleak *Leucaspius delineatus* (Heckel 1843). Although the origin of *S. destruens* in Europe remains unclear (Gozlan *et al.*, 2010), it may have arrived with *P. parva* and consequently, the natural dispersal of *P. parva* throughout Eurasia may have facilitated their spread, posing a potential thread to cyprinid and

	salmonid populations. Supporting: Community, foodweb a) Predation and parasitism (Gozlan *et al.*, 2010) In water bodies of China and Germany, *P. parva* were reported to feed on eggs and larvae of native fish species. They are also reported to be a facultative parasite on other fish species when kept in high densities. Such behaviour was observed in aquaculture ponds of Moldavia where *P. parva* >1 year old were causing injuries reaching the musculature in *H. molitrix*, *A. nobilis* and *C. idella*, although feeding on tubificid worms (*Tubifex* spp.) was also observed. b) Competition for food with native fish species Inter-specific competition for food between *P. parva* and native fish species has been observed in water bodies of Belgium, Bulgaria (T. Trichkova personal communication), Czech Republic (J. Musil personal communication), Germany, Greece and Poland (Gozlan *et al.*, 2010). A stable isotope analysis revealed significant trophic overlap between *P. parva*, *R. rutilus* and *C. carpio*, a shift associated with significantly depressed somatic growth in *R. rutilus* (Britton *et al.*, 2010b). Supporting: Production High grazing pressure exerted by dense *P. parva* populations can also result in changes in the prevalent environmental conditions through top-down effects characterised by increased development of phytoplankton and accelerated eutrophication (Gozlan *et al.*, 2010). Supporting: Impact on native aquatic species diversity and density. Competes for food, predates upon juvenile native species, disease vector. Can alter ecosystem function and modify habitat. Threat to native/ endangered species. Provisioning: Reduction in aquaculture productivity. Regulating: Water use, disease and pest regulation. Cultural: Loss of recreational angling opportunities and reduced amenity

	values.
8. Includes status (threatened or protected) of species or habitat under threat	There is an evidence for dietary overlap between *P. parva* and three endemic species in Lake Mikri Prespa (north-western Greece): *Pelasgus prespensis* (EN, IUCN), *Cobitis meridionalis* (VU, IUCN) and *Alburnoides ohridanus* (VU, IUCN). It was reported that the population of *P. prespensis* has declined due to the introduction of alien species (*P. parva*, *Rhodeus amarus*) (Kottelat & Freyhof, 2007). A recent study on the feeding habits of topmouth gudgeon in the Hirfanli Reservoir, Central Anatolia, Turkey, reported a broad food preference (including fish eggs) and high feeding intensity of the introduced *P. parva*. Therefore, it was concluded that *P. parva* may have a competitive pressure on the native fish fauna in the reservoir - *Alburnus* cf. *escherichi* population which was dominant in the 1960s has disappeared (locally extinct) in the Hirfanli Reservoir; studies on food overlap between *P. parva* and the endemic *Aphanius danfordii* (CR, IUCN) has been undertaken (F. Güler Ekmekçi, personal communication). The first evidence of the parasite *Sphaerothecum destruens* being present in wild populations of topmouth gudgeon, with a prevalence of 67 to 74% was reported in the Netherlands. Sympatric populations of known susceptible fish species were found at the sampled sites, including species that feature in the national Red List (LNV 2004) (bitterling *Rhodeus amarus* and sunbleak *Leucaspius delineatus*). No information about infection rates of these native species by *S. destruens* is available yet, nor about the effects on their population size (Spikmans *et al.*, 2013). Hybridisation between *P. parva* and sunbleak *L. delineatus* (LC, IUCN), a threatened freshwater species that is in decline throughout Europe, has been demonstrated by artificial insemination illustrating gamete compatibility between two genres and a potential for natural hybridisation (Gozlan *et al.*, 2010).
9. Includes possible effects of climate change in the foreseeable future	Tolerance experience: Recent study evaluated the effect of elevated water temperature on an ecosystem after the invasion by topmouth gudgeon in order to create a possible scenario of climate change and the invasion of topmouth gudgeon (Záhorská *et al.*, 2013). Lake Licheńskie, which is part

	of the cooling system of the Konin and Pątnów power plants, was used as a model. The building of the cooling system caused an increase in the average temperatures from 5 to 7°C. The modifications of hydrological, thermal and trophic conditions impacted adversely the structure and development of zooplankton and fish communities. The coldwater species typical of the region, such as pikeperch, pike and perch disappeared, or occurred at very low densities. On the other hand, submerged vegetation formed by the invasive aquatic plants *Najas marina* and *Vallisneria spiralis* became abundant and the relative density of topmouth gudgeon increased. The authors assumed that because of the species high phenotypic plasticity in all parameters, from reproduction to morphology, its population would be successful even if the climate changes radically (Záhorská *et al.*, 2013). Observation: High phenotypic plasticity in fitness related traits such as growth, early maturity, fecundity, reproductive behaviour and the ability to cope with novel pathogens has predisposed *P. parva* to being a strong invader (Gozlan *et al.*, 2010). Climate matching: increase in climate suitability by 2050 is predicted (Britton *et al.*, 2010a). The predictive use of climate-matching models and an air and water temperature regression model suggested that there are six non-native fishes currently persistent but not established in England and Wales whose establishment and subsequent invasion would benefit substantially from the predicted warming temperatures. These included the common carp *Cyprinus carpio* and European catfish *Silurus glanis*, fishes that also exert a relatively high propagule pressure through stocking to support angling and whose spatial distribution is currently increasing significantly, including in open systems.
11. Documents information sources	**Arkush KD, Mendoza L, Adkison MA, Hedrick RP. 2003.** Observations on the life stages of *Sphaerothecum destruens* ng, n. sp., a mesomycetozoean fish pathogen formally referred to as the rosette agent. *Journal of Eukaryotic Microbiology* **50:** 430-438. **Britton J, Cucherousset J, Davies G, Godard M, Copp G. 2010.** Non‐native fishes and climate change: predicting species responses to warming temperatures in a temperate region. *Freshwater Biology* **55:** 1130-1141. **Britton JR, Davies GD, Harrod C. 2010.** Trophic interactions and consequent impacts of the invasive fish *Pseudorasbora parva* in a native aquatic foodweb: a field investigation in the UK. *Biological*

	Invasions **12:** 1533-1542. **Cesco H, Lambert A, Crivelli A. 2001.** Is *Pseudorasbora parva*, an invasive fish species (Pisces, Cyprinidae), a new agent of anguillicolosis in France? *Parasite* **8:** 75-76. **Gozlan RE, Andreou D, Asaeda T, Beyer K, Bouhadad R, Burnard D, Caiola N, Cakic P, Djikanovic V, Esmaeili HR. 2010.** Pan - continental invasion of Pseudorasbora parva: towards a better understanding of freshwater fish invasions. *Fish and Fisheries* **11:** 315-340. **Gozlan RE, St-Hilaire S, Feist SW, Martin P, Kent ML. 2005.** Biodiversity: disease threat to European fish. *Nature* **435:** 1046-1046. **Kottelat M, Freyhof J. 2007.** *Handbook of European freshwater fishes*. Publications Kottelat Cornol. **Spikmans F, van Tongeren T, van Alen TA, van der Velde G, den Camp H. 2013.** High prevalence of the parasite *Sphaerothecum destruens* in the invasive topmouth gudgeon *Pseudorasbora parva* in the Netherlands, a potential threat to native freshwater fish. *Aquat. Invasions* **8:** 355-360. **Záhorská E, Balážová M, Šúrová M. 2013.** Morphology, sexual dimorphism and size at maturation in topmouth gudgeon (*Pseudorasbora parva*) from the heated Lake Licheńskie (Poland). *Knowledge and Management of Aquatic Ecosystems***:** 07.
Main experts	Teodora Trichkova Merike Linnamagi
Other contributing experts	Belinda Gallardo Olaf Booy Guler Ekmekci
Notes	The topmouth gudgeon *Pseudorasbora parva* is widely spread in Europe, already reported from 19 EU countries. In order to fill the information gaps, recent data and data from other regions in Europe on the pathways of introduction, the impact on ecosystem services, impact on protected species and habitats, and results of studies on the effects of climate change are added.
Outcome	Compliant

Scientific name	*Psittacula krameri*
Common name	Rose-ringed parakeet
Broad group	Vertebrate

Number of and countries wherein the species is currently established	11: BE, DE, DK, EE, GR, FR, IT, NL, PT, SI, UK
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=55
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Ring-necked parakeets are kept in zoos (Topola, 2014). The ISIS database roughly estimates that there are approximately 260 individuals kept in 45 European institutions (ISIS, 2014).The species is also widely kept as pet (Strubbe & Matthysen, 2009), thus generating some revenue for pet trade. Ring-necked parakeets have an aesthetic appeal to bird-watchers and members of the wider general public (Avifaunistic Commission - the Polish Rarities Committee, 2013).
6. Can broadly assess environmental impact with respect to ecosystem services	Habitat services: Droppings under roosting sites may inhibit native flora seed dispersal and alter the floral herbaceous component (Menchetti & Mori, 2014). The same mechanism may favour the spread of invasive alien plants (Runde *et al.*, 2007). Provisioning services: Ring-necked parakeets cause damages in orchards (Batllori & Nos, 1985) and vineyards (Fletcher & Askew, 2007). Crop damages are reported in many European countries, but without any quantification (Andreotti *et al.*, 2001, Borgo *et al.*, 2005, Dubois, 2007, Spano & Truffi, 1986). Economic damage is initially likely to be on fruit and grain growing land close to urban areas, but it may be that continued expansion will mean that Ring-necked Parakeets reside in rural areas independent of urbanisation. Regulating services: Further impacts are associated with public health issues arising from the parakeets' communal roosting. Disease regulation - Ring-necked Parakeets are possible vectors for diseases such as Newcastle disease (Butler, 2003) (Butler, 2003) and

	cryptosporidium (Morgan *et al.*, 2000), both of which could affect poultry.
8. Includes status (threatened or protected) of species or habitat under threat	The Ring-necked Parakeet is a secondary cavity nester, occupying cavities that are either natural or have been excavated by other species (primary cavity nesters); parakeets favour similar types of cavity to some native European secondary cavity-nesting species There is evidence that the parakeet competes with other cavity nesters, both in its native and introduced range. In northern European countries, parakeets initiate nesting much earlier than native species and have relatively long incubation and nestling periods; cavities, therefore, may already be occupied when native species initiate their own breeding cycle. In Belgium, there is evidence that Ring-necked Parakeets compete with and suppress some populations of native secondary cavity nesters, e.g. nuthatch *Sitta europaea* (Strubbe & Matthysen, 2007). In contrast, no population-level impact was found on secondary-cavity nesters in England. One explanation for the current absence of such a relationship in the UK might be the higher density of available cavities. In England, Ring-necked parakeets have been shown to deter native species from garden-feeders (Scalera *et al.*, 2012). There is a record from Spain of a flock of 60 Ring-necked parakeets mobbing the Booted eagle (*Hieraaetus pennatus*, Annex I of the 2009/147/EC Birds Directive; (Hernández-Brito *et al.*, 2014)). In the same area, increase in Ring-necked parakeet population caused decline in Greater noctules (*Nyctalus lasiopterus*), a bat with a scattered distribution throughout Europe and classified as Vulnerable in Spain (Hernández-Brito *et al.*, 2014). Impact on bats was recorded also in Italy, where the parakeet was observed to enter a trunk cavity where an adult male individual of Leisler's bat (*Nyctalus leisleri*) was roosting. This species is included in in Annex IV of the 92/43/EC Habitats Directive. The parakeet attacked the bat and extruded it from the cavity. As a result of injuries on the head and abdomen, the bat died (Menchetti & Mori, 2014). Ring-necked parakeets breeding in wall cavities in Seville caused may threaten the colony of Lesser kestrels *Falco naumanni*, a falcon that suffered a drastic decline in Europe due to land-use changes and is included in Annex I of the 2009/147/EC Birds Directive. Conservation actions for this species include the provisioning of nest cavities, therefore

	the presence of the parakeets may hamper these efforts (Hernández-Brito *et al.*, 2014). Continuing growth in nesting Ring-necked parakeets may limit nest sites even for species using small-sized cavities, e.g. House sparrows *Passer domesticus*, whose European populations are now decreasing, thus drawing attention to its long-term conservation status (Hernández-Brito *et al.*, 2014). Ring-necked parakeet has been reported to attack and kill protected Little owls *Athene noctua* (Mori *et al.*, 2013).
9. Includes possible effects of climate change in the foreseeable future	It has successfully established breeding populations in 35 countries across five continents, adapting to a wide range of ecoclimatic and habitat conditions (Butler, 2003). The ring-necked parakeet is the world's most widely distributed parakeet, occurring in most of tropical Africa north of the moist forest zone and in much of southern Asia (Juniper & Parr, 1998), and consequently it must have a broad tolerance of climatic and environmental conditions. However, the ring-necked parakeet is a bird of tropical and subtropical low latitudes (Cramp, 1985), and there are indications that they may suffer during cold European winters. Indeed, Europe, most introductions in areas with over 50 frost days have failed (Strubbe & Matthysen, 2009). Thus, in colder regions, the spread of established parakeet populations could be impaired by low reproductive success. Global warming may reduce the climate mismatch and facilitate invasive spread of ring-necked parakeets in more northern European latitudes. Climate warming has the potential to enhance the invasion success of ring-necked parakeets through the latter stages of the invasion process (establishment and spread), through: (i) improving the climatic match between its introduced and native range, and (ii) through direct (e.g. thermal effects) and indirect changes (land management) to habitats and land use. For instance, in agriculture, predicted changes in crop type and regional patterns of crop planting and harvesting will alter the landscape for birds in terms of resource availability. For example, in northern Europe there may be an increase in the growing of grapes, other soft fruits and produce (e.g. sunflowers) currently concentrated in warmer, drier southern regions. Increase in the coverage of such crops in the south and

	their introduction further north will provide enhanced foraging opportunities for birds, including invasive species such as the ring-necked parakeet which already forage on these crops in their present range. Farming practices that adapt to global climate change and a warmer Europe facilitate the continued expansion of parakeet populations, amplifying the problems parakeets pose for European agro-economy (from ParrotNet: http://www.kent.ac.uk/parrotnet/).
11. Documents information sources	**Andreotti A, Baccetti N, Perfetti A, Besa M, Genovesi P, Guberti V. 2001.** Mammiferi ed Uccelli esotici in Italia: analisi del fenomeno, impatto sulla biodiversità e linee guida gestionali. Ministero dell'Ambiente e Istituto Nazionale per la Fauna Selvatica 'A. Ghigi', Ed. Quaderni di Conservazione della Natura 2. Rome, Italy: Ministero dell'Ambiente, Istituto Nazionale Fauna Selvatica. **Avifaunistic Commission - the Polish Rarities Committee. 2013.** Rare birds recorded in Poland in 2012. *Ornis Polonica* **54:** 109-150. **Batllori X, Nos R. 1985.** Presencia de la cotorrita gris (*Myiopsitta monachus*) y de la cotorrita de collar (*Psittacula krameri*) en el área metropolitana de Barcelona. *Misc. Zool* **9:** 407-411. **Borgo E, Galli L, Spanò S. 2005.** *Atlante ornitologico della città di Genova:(1996-2000)*. Università degli Studi. **Butler CJ. 2003.** Population biology of the introduced rose-ringed parakeet *Psittacula krameri* in UK. Unpublished PhD, University of Oxford. **Cramp S. 1985.** *Handbook of the birds of Europe, the Middle East, and North Africa: the birds of the western Palearctic. Vol. 4, Terns to woodpeckers*. Oxford University Press. **Dubois PJ. 2007.** Les oiseaux allochtones en France: statut et interactions avec les espèces indigènes. *Ornithos* **14:** 329-364. **Fletcher M, Askew N. 2007.** Review of the status, ecology and likely future spread of parakeets in England. *York: Central Science Laboratory*. **Hernández-Brito D, Carrete M, Popa-Lisseanu AG, Ibáñez C, Tella JL. 2014.** Crowding in the City: Losing and Winning Competitors of an Invasive Bird. *PloS one* **9:** e100593. **ISIS. 2014.** International Species Information System. Accessed 19.12.2014. **Juniper T, Parr M. 1998.** A Guide to the Parrots of the World. *A&C Black. Londres-Inglaterra*: 45-322. **Menchetti M, Mori E. 2014.** Worldwide impact of alien parrots (Aves Psittaciformes) on native biodiversity and environment: a review. *Ethology Ecology & Evolution* **26:** 172-194. **Morgan U, Xiao L, Limor J, Gelis S, Raidal S, Fayer R, Lal A, Elliot A, Thompson R. 2000.** *Cryptosporidium meleagridisin* an Indian ring - necked parrot (*Psittacu la krameri*). *Australian veterinary journal* **78:** 182-183. **Mori E, Di Febbraro M, Foresta M, Melis P, Romanazzi E, Notari A,**

	Boggiano F. 2013. Assessment of the current distribution of free-living parrots and parakeets (Aves: Psittaciformes) in Italy: a synthesis of published data and new records. *Italian Journal of Zoology* **80:** 158-167. **Runde DE, Pitt WC, Foster J. 2007.** Population ecology and some potential impacts of emerging populations of exotic parrots. *Managing Vertebrate Invasive Species*: 42. **Scalera R, Genovesi P, Essl F, Rabitsch W. 2012.** The impacts of invasive alien species in Europe. EEA Technical report no.16/2012. **Spano S, Truffi G. 1986.** Il Parrocchetto dal collare, *Psittacula krameri*, allo stato libero in Europa, con particolare riferimento alle presenze in Italia, e primi dati sul Pappagallo monaco, *Myiopsitta monachus*. *Rivista italiana di Ornitologia* **56:** 231-239. **Strubbe D, Matthysen E. 2007.** Invasive ring - necked parakeets *Psittacula krameri* in Belgium: habitat selection and impact on native birds. *Ecography* **30:** 578-588. **Strubbe D, Matthysen E. 2009.** Establishment success of invasive ring - necked and monk parakeets in Europe. *Journal of Biogeography* **36:** 2264-2278. **Topola R. 2014.** *Polish ZOO and Aquarium Yearbook. Warszawa*
Main experts	Wojciech Solarz Teodora Trichkova
Other contributing experts	Olaf Booy Riccardo Scalera Belinda Gallardo
Notes	In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. All except Sweden, Finland, Latvia, Estonia and Lithuania.
Outcome	Compliant

Scientific name	*Pueraria lobata*
Common name	Kudzu Vine
Broad group	Plant
Number of and countries wherein the species is currently established	1: CH, IT (only casual occurrences in both countries)
Risk Assessment	EPPO

Method	
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12701_PRA_Pueraria_lobata_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12802_PRA_report_PUELO.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: It can be used for bioethanol production. If economical harvesting and processing techniques could be developed, the kudzu within North America has the potential to supplement existing bioethanol feedstocks, whichcould be of significance to the rural economy of the southeastern USA (Sage *et al.*, 2009). Before isolating the starch (which is 99.6% starch with about 0.4% water), the whole roots also have a small amount of protein and are a reasonably good source of calcium, magnesium, iron, potassium, and zinc when compared to starchy foods such as wheat and sorghum. *Pueraria* has one major medicinal active component group: isoflavones that are often simply designated as puerarin, which is its main ingredient (chemical structure, right). Although several isoflavones have been isolated and characterized, there are five principal ones: puerarin, methylpuerarin, daidzein, daidzin, and daidzein glucopyranoside. See http://www.itmonline.org/articles/pueraria/pueraria.htm
6. Can broadly assess environmental impact with respect to ecosystem services	Effects on carbon sequestration through depletion the soil carbon stocks of invaded soils (Tamura & Tharayil, 2014)
8. Includes status (threatened or protected) of species or habitat under threat	Impact on Red List assessed species 6: CR = 1; VU = 1; LR/nt = 1; LR/lc = 3 (from GISD 2014): • *Sarracenia alata LR/nt* • *Sarracenia flava LR/lc* • *Sarracenia leucophylla VU* • *Sarracenia minor LR/lc* • *Sarracenia oreophila CR* • *Sarracenia psittacina LR/lc*
9. Includes possible effects of climate change in the	Weed can have an impact on climate change. The capacity of invasive alien plants to feed back to climate change by destabilizing native soil C stocks has been demonstrated (Tamura & Tharayil, 2014) and indicates

foreseeable future	that environments that promote the biochemical decomposition of plant litter would enhance the long-term storage of soil C. Further, concurrent influence of dominant plant species on both selective preservation and humification of soil organic matter has been highlighted. When *P. lobata* is grown under conditions of elevated CO_2, it produces more and longer stems and more biomass (Sasek & Strain, 1988). Furthermore, as global temperatures rise, the plant's range may extend northward because its growth is no longer limited by cold weather (Sasek & Strain, 1988, Weltzin *et al.*, 2003). This is confirmed by multiple studies that suggest an increase in the potential area of distribution of *P. lobata* by hundreds of km (Bradley *et al.*, 2010). Better growth and enhanced seedling establishment near the range limits further improve the chances for the species to invade adjacent new habitats that become more favorable after future climatic change. The CO_2 enrichment effects may have similar positive benefits on other species in these new habitats, decreasing the impacts of the vines. However, the competitive characteristics of kudzu make them strong competitors (Sasek & Strain, 1988).
11. Documents information sources	**Bradley BA, Wilcove DS, Oppenheimer M. 2010.** Climate change increases risk of plant invasion in the Eastern United States. *Biological Invasions* **12:** 1855-1872. **Sage RF, Coiner HA, Way DA, Brett Runion G, Prior SA, Allen Torbert H, Sicher R, Ziska L. 2009.** Kudzu [*Pueraria montana* (Lour.) Merr. Variety *lobata*]: A new source of carbohydrate for bioethanol production. *Biomass and bioenergy* **33:** 57-61. **Sasek TW, Strain BR. 1988.** Effects of carbon dioxide enrichment on the growth and morphology of kudzu (*Pueraria lobata*). *Weed Science*: 28-36. **Tamura M, Tharayil N. 2014.** Plant litter chemistry and microbial priming regulate the accrual, composition and stability of soil carbon in invaded ecosystems. *New phytologist* **203:** 110-124. **Weltzin JF, Belote RT, Sanders NJ. 2003.** Biological invaders in a greenhouse world: will elevated CO2 fuel plant invasions? *Frontiers in Ecology and the Environment* **1:** 146-153.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis Belinda Gallardo Piero Genovesi

Notes	According to the EPPO report this plant has been intentionally introduced in Italy and Switzerland. *Pueraria lobata* is already naturalized in Italy and the probability of establishment in other EPPO regions is high as *P. lobata* grows well under a wide range of conditions and in most soil types. Southern parts of the EPPO region are more at risk. The pathways that the plant is most likely to be introduced are for horticulture and agriculture such as livestock fodder. The main habitats that it can colonize are woodland edges or woodland with open canopies, riverbanks and road and rail networks.
Outcome	Compliant

Scientific name	*Rapana venosa*
Common name	Rapa Whelk
Broad group	Invertebrate
Number of and countries wherein the species is currently established	8: IT, SI, FR, NL, UK, BG, RO
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=622
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	*Rapana venosa* invasion within Europe has provided notable socio-economic benefits. A commercial fishery with a 13, 000 t landing in 2005 from Turkey and Bulgaria now exists, with exploitation to such a level that catch controls have been introduced. *R. venosa* catch is mainly exported with limited local consumption. A limited secondary industry is supported in the processing and sale of shells as decorative items (Katsanevakis *et al.*, 2014).
6. Can broadly assess environmental impact with respect to ecosystem services	Large scale invasions of *R. venosa* have considerable negative effects on ecosystem services through predation, such as “the species has a severe impact on all ecosystem services provided by mussel and oyster biogenic reefs, i.e. food provision, water purification, coastal protection, cognitive benefits, recreation, symbolic and aesthetic values, and life cycle maintenance” (Katsanevakis *et al.*, 2014).

8. Includes status (threatened or protected) of species or habitat under threat	Likely to impact habitats and species within SAC reefs and large shallow inlets and bays.
9. Includes possible effects of climate change in the foreseeable future	Native to the Sea of Japan and temperate Asian waters including the East China Sea. Non-native populations occur in the Black Sea, the Aegean and Adriatic seas, Uruguay, and the Chesapeake Bay area (eastern USA). In NW Europe, several specimens were discovered by the end of the 1990s in the Bay of Quiberon (Brittany, France) (Mann *et al.*, 2004). Native temperature range for adult: 4 - 27 °C. Egg capsule production by *R. venosa* in Chesapeake Bay was found to be influenced by seasonal and absolute water temperatures as well asseasonal day length cycles (Harding *et al.*, 2008). Egg capsule deposition began at water temperatures of ~18 °C in Chesapeake Bay, and similar thresholds have been reported in the native habitat of *R. venosa*. The authors predict a latitudinal range of 30 - 41 ° (N and S) as the reproductive range for *R. venosa* populations. Future increases in water temperature would enhance this species' ability to successfully establish in the risk assessment area. Literature suggests that water temperatures of at least 18 °C for extended periods are required for egg case deposition, hatching and larval development (Harding *et al.*, 2008). A global increase in temperature of 2°C is likely to allow for the northerly expansion of *Rapana venosa* range within the Risk Assessment Area as it has been observed to tolerate temperatures between 4 – 27℃ (Chung *et al.*, 2002).
11. Documents information sources	**Chung E, Kim S, Park K, Park G. 2002.** Sexual maturation, spawning, and deposition of the egg capsules of the female purple shell, *Rapana venosa* (Gastropoda: Muricidae). *Malacologia* **44:** 241-257. **Harding JM, Mann R, Kilduff CW. 2008.** Influence of environmental factors and female size on reproductive output in an invasive temperate marine gastropod *Rapana venosa* (Muricidae). *Marine biology* **155:** 571-581. **Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014.** Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* **9:** 391-423. **Mann R, Occhipinti A, Harding JM. 2004.** *Alien species alert: Rapana*

	venosa (veined whelk). International Council for the Exploration of the Sea.
Main experts	Argyro Zenetos Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan
Notes	In how many EU member states has this species been recorded? List them. Spain 2007 Casual Belgium 2005–2007 Casual France 1997 Established Netherlands 2005 Established United Kingdom 1991 Established Ukraine 1954 invasive Bulgaria 1946/1956 invasive Slovenia 1983 established Italy 1973 Invasive In how many EU member states has this species currently established populations? List them. France, Netherlands, United Kingdom, Bulgaria, Ukraine, , Slovenia, Italy In which EU Biogeographic areas could this species establish? All In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. France, Netherlands, United Kingdom, Bulgaria, Ukraine, , Belgium, France, Spain, Ireland, Slovenia, Croatia Italy, Greece In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Belgium, France, Spain, Ireland, Slovenia, Croatia
Outcome	Compliant

Scientific name	*Sargassum muticum*
Common name	Japweed, wireweed
Broad group	Plant
Number of and countries wherein the species is currently established	11: BE, DE, DK, ES, FR, IE, IT, NL, PT, SE, UK
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=57
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	A number of bioactive compounds have been extracted from *S. muticum* which may have potential for commercialisation. Dense stands have been shown to harbour a wide range of algae and invertebrates, promoting biodiversity (Katsanevakis *et al.*, 2014), with the potential to increase recreational fish populations
6. Can broadly assess environmental impact with respect to ecosystem services	The effects of *S. muticum* on ecosystem services are many, wide ranging and severe and are reviewed in (Katsanevakis *et al.*, 2014). These effects range from competition with native algae species; ecosystem engineering by increasing siltation rates with associated effects on benthic substrate; sequestration of nutrients with associated effects on nutrient cycles and availability; impediment and reduction of water flow; reduced O2 levels in dense stands; impediment of boating traffic, recreational activities, aquaculture and commercial fisheries; large diebacks can provide a public nuisance through the decomposition of vast amounts of *S. muticum*.
8. Includes status (threatened or protected) of species or habitat under threat	Likely to impact habitat and species within SAC Large shallow inlets and bays. Impact not necessarily negative.
9. Includes possible effects of climate change in the	*S. muticum* has a wide temperature tolerance and has colonised Atlantic European coasts from southern Norway and Sweden to Portugal; it is becoming more common in the Mediterranean Sea, but is largely absent

foreseeable future	from cold arctic waters. A global increase in temperature of 2°C is likely to allow for the northerly expansion of *S. muticum* range within the Risk Assessment Area as its optimal water temperature for growth is 25°C with high temperature unlikely to be a limiting factor in southern areas as a water of 30°C is tolerated (Hales & Fletcher, 1990). Experimental studies have further shown that *S. muticum* is eurythermal and able to tolerate and develop under a wide range of temperatures from 5 to 30 ℃ (Hales & Fletcher, 1990) but optimally at 25 ℃.
11. Documents information sources	**Hales J, Fletcher R. 1990.** Studies on the recently introduced brown alga *Sargassum muticum* (Yendo) Fensholt. V. Receptacle initiation and growth, and gamete release in laboratory culture. *Botanica marina* **33:** 241-250. **Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014.** Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* **9:** 391-423.
Main experts	Argyro Zenetos Frances Lucy
Other contributing experts	Belinda Gallardo Rory Sheehan
Notes	EXTRA INFORMATION In how many EU member states has this species been recorded? List them. Portugal 1989 Established Spain 1985 Established Ireland 1995 Established Norway 1984 Established Sweden 1985 Established United Kingdom 1971 Established Netherlands 1980 Established Belgium 1972 Established Atl France 1971 Established Med France 1980 Established Germany 1988 Established Denmark 1984 Invasive

	Italy 1992 Established In how many EU member states has this species currently established populations? List them. All above. In which EU Biogeographic areas could this species establish? Celtic, North, Iberia-Biscay, Mediterranean In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Greece, Slovenia, Croatia, Malta, Cyprus
Outcome	Compliant

Scientific name	*Sciurus carolinensis*
Common name	American Grey Squirrel
Broad group	Vertebrate
Number of and countries wherein the species is currently established	3: IE, IT, UK
Risk Assessment Method	New following GB NNRA
8. Includes status (threatened or protected) of species or habitat under threat	From the GISD 2014, 2 LR species: *Sciurus vulgaris,* and *Muscardinus avellanarius*
11. Documents information sources	Global Invasive Species Database (2014). Downloaded from http://193.206.192.138/gisd/search.php on 09-12-2014 See also: **Schockert V, Baiwy E, Branquart E. 2013.** Risk analysis of the gray squirrel, *Sciurus carolinensis*, Risk analysis report of non-native organisms in

	Belgium. Cellule interdépartementale sur les Espèces invasives (CiEi), DGO3, SPW / Editions, 43 pages.
Main experts	Piero Genovesi Melanie Josefsson
Other contributing experts	Sandro Bertolino Adriano Martinoli John Gurnell Peter Lurz Lucas Wauters
Notes	No additional comments
Outcome	Compliant

Scientific name	*Senecio inaequidens*
Common name	Narrow-leaved ragwort
Broad group	Plant
Number of and countries wherein the species is currently established	13 : AT, BE, CZ, DE, DK, ES, FR, HU, IT, LU, NL, SE, UK
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12954_PRA_SENIQ.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socioeconomic benefits unknown. Not suitable for grazing by livestock animals due to its toxicity (Dimande *et al.*, 2007). *Senecio inaequidens* is an important food plant for wild insect species in its introduced range (Schmitz & Werner, 2001) and may be a nectar source for honey bees. Over the last 20 years, *Senecio inaequidens* DC. (Asteraceae) has become one of the most successful invasive alien plants on ruderal sites in Central Europe. In order to assess the biocoenotic role of the originally South African plant, the authors conducted independent studies of the phytophagous insect fauna on various sites located primarily in North

	Rhine-Westphalia, Germany. Sixty-two species were found in total, including 34 Heteroptera, 11 Lepidoptera, 8 Homoptera, and 5 Coleoptera. Six species live in the plant, 4 of which that are normally restricted to other *Senecio* species having switched to the new host. The range of phytophagous insects on the alien plant is still small relative to the indigenous *S. jacobaea* and to plant species the newcomer competitively suppresses. While none of the phytophagous insects were able to effectively inhibit the growth of *S. inaequidens*, some Heteroptera are probably capable of reducing the amount of successful achenes. *S. inaequidens* originally colonizes skeletal sectors on steep, moist and grassy slopes, as well as sandy and gravelly banks of periodic streams.
11. Documents information sources	**Dimande AFP, Botha CJ, Prozesky L, Bekker L, Rosemann G, Labuschagne L, Retief E. 2007.** The toxicity of *Senecio inaequidens* DC. *Journal of the South African Veterinary Association* **78:** 121-129. **Schmitz G, Werner D. 2001.** The importance of the alien plant *Senecio inaequidens* DC.(Asteraceae) for phytophagous insects. *Zeitschrift für ökologie und Naturschutz* **9:** 153-160.
Main experts	Kelly Martinou Jan Pergl
Notes	No additional comments
Outcome	Compliant

Scientific name	*Sicyos angulatus*
Common name	Star-cucumber
Broad group	Plant
Number of and countries wherein the species is currently established	13: AT, BG, CZ, DE, GR , ES, FR, GR, HR, HU, IT, MD, PL, RO, RS, RU, SK, UE, UK
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15109rev_PRA_Sicyos_angulatus.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/10-16056_PRA_report_Sicyos_angulatus.doc

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socioeconomic benefits: Seven flavonol glycosides were isolated from Sicyos angulatus All flavonols were identified as 3,7-O-glycosides of quercetin and kaempferol. These flavonoids were isolated from the genus *Sicyos* for the first time. These flavonoids showed differences with other genera of same tribe the Sicyeae. Four of the seven flavonoids have various biological activities (Na *et al.*, 2013).
11. Documents information sources	**Na CS, Lee YH, Murai Y, Iwashina T, Kim TW, Hong SH. 2013.** Flavonol 3, 7-diglycosides from the aerial parts of *Sicyos angulatus* (Cucurbitaceae) in Korea and Japan. *Biochemical Systematics and Ecology* **48:** 235-237.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis
Notes	The risk assessments comply with the minimum standards set by the EU. According to the EPPO report the species is only recorded as a threat in France, Italy, Moldova and Spain, it is a weed of maize, soybean and sorghum, it is not a strong competitor but as a vine plant when it infests crops it makes them difficult to harvest.
Outcome	Compliant

Scientific name	*Solanum elaeagnifolium*
Common name	Silver-leaved Nightshade
Broad group	Plant
Number of and countries wherein the species is currently established	5 : CY, GR, ES, FR, GR, HR, IT, MK, RS
Risk Assessment Method	EPPO
Links	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12702_PRA_Solanum_elaeagnifolium_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13607%20PRA%20report%20SOLEL.doc

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Although typically considered a troublesome weed, silverleaf nightshade has been used in the preparation of food and clothing. The berries and seeds were used by Indian tribes of the southwestern United States. The Pimas added the crushed berries to milk when making cheese, and the Kiowas reportedly combined the seed with brain tissue and used the mixture for tanning hides. A protein-digesting enzyme similar to papain is thought to be the active ingredient in the seed and berries. Researchers in India have investigated silverleaf nightshade's potential as a source of drugs. Silverleaf nightshade is rich in solasodine, a chemical used in the manufacture of steroidal hormones. Fruits contain about 3.2% (g/g dry wt) solasodine (Boyd *et al.*, 1984). The steroidal alkaloid Solasodine used in the preparation of contraceptive and corticosteroid drugs has been commercially extracted from *S. elaeagnifolium* berries in India and Argentina, making it the most promising source among *Solanum* species investigated. Recent studies have identified other potential uses for *S. elaeagnifolium* as plant extracts have shown moluscicidal and nematicidal activity, as well as cancer-inhibiting activity.
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	Can act as a reservoir of TYLC virus in agricultural fields in Tunisia (Zammouri & Mnari-Hattab, 2014).
6. Can broadly assess environmental impact with respect to ecosystem services	Pollination services have shown to be affected (Tscheulin & Petanidou, 2013). Invasive plants can impact biodiversity and ecosystem functioning by displacing native plants and crop species due to competition for space, nutrients, water and light. The presence of co-flowering invasives has also been shown to affect some native plants through the reduction in pollinator visitation or through the deposition of heterospecific pollen on the native's stigmas leading to stigma clogging. The authors examined the impact of the invasive plant *Solanum elaeagnifolium* Cavanilles (silver-leafed nightshade), native to South and Central America and South-western parts of North America, on the seed set of the native *Glaucium flavum* Crantz (yellow-horned poppy) on Lesvos Island, Greece. To do this they measured seed set and visitation rates to *G. flavum* before and after the placement of potted individuals of the invasive near the native plants.

	In addition, they hand-crossed *G. flavum* flowers with super-optimal amounts of conspecific pollen, bagged flowers to measure the rate of spontaneous selfing, and applied self-pollen to measure self-compatibility of *G. flavum*. The hand-selfing treatment resulted in very low seed set, which indicates that *G. flavum* is to a large degree self-incompatible and highlights the plant's need for insect-mediated outcrossing. They showed that the presence of the invasive significantly enhanced pollen limitation, although the overall visitation rates were not reduced and that this increase was due to a reduction in honeybee visitation in the presence of the invasive resulting in reduced pollination.
11. Documents information sources	**Boyd J, Murray D, Tyrl R. 1984.** Silverleaf nightshade, *Solarium elaeagnifolium*, origin, distribution, and relation to man. *Economic botany* **38:** 210-217. **Tscheulin T, Petanidou T. 2013.** The presence of the invasive plant *Solanum elaeagnifolium* deters honeybees and increases pollen limitation in the native co-flowering species *Glaucium flavum*. *Biological Invasions* **15:** 385-393. **Zammouri S, Mnari-Hattab M. 2014.** First report of *Solanum elaeagnifolium* as natural host of tomato yellow leaf curl virus species (TYLCV and TYLCSV) in Tunisia. *Journal of Plant Pathology* **1**.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Ioannis Bazos Alexandros Galanidis
Notes	According to the EPPO report it is invasive in many countries and it was unintentionally introduced to Europe and now widespread in Croatia, Greece and Spain. It colonizes anthropogenic made habitats such as road sides but also pastures and grasslands as well as riverbanks. It has been found to infest crops and cause serious damage in Morocco 47% damage in maize and 78% in cotton.
Outcome	Compliant

Scientific name	*Solidago nemoralis*
Broad group	Plant

Number of and countries wherein the species is currently established	Not established in Europe
Risk Assessment Method	EPPO
Links	https://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/04-11150%20PRAss_Report%20sol_nem3.doc
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits not recorded from EU. Weed in some parts of US. This plant grows in forests, woods, prairies, grasslands, and disturbed areas such as old fields and roadsides. It forms groundcover in dry, harsh, sunny conditions. As a ground cover it is often used in native landscapes, rock gardens, butterfly gardens and meadow plantings. It could also be used in flower mixes. A wide range of insects visit the flowers for pollen and nectar, including long-tongued bees, short-tongued bees, Sphecid and Vespid wasps, flies, butterflies, moths and beetle. Habitats include: meadows, dry open woods, upland Control prairies, pastures, savannas, fallow fields, thickets, roadsides, railroads, eroded slopes, and sand dunes
6. Can broadly assess environmental impact with respect to ecosystem services	Positive effect: some medicinal use, but not environmental. Maybe positive effects to pollinators. For horticulture trade. Negative: possible weed of crop fields. Positive/negative: sand dunes stabilization/ transformer species.
8. Includes status (threatened or protected) of species or habitat under threat	Not anticipated because the plant grows on disturbed areas or early successional habitats where there are already high numbers of neophytes but on sand dunes may affect negatively endemic and rare species.
9. Includes possible effects of climate change in the foreseeable future	This species is widely distributed from Georgia to Texas, north to Nova Scotia and Alberta Canada in USDA cold hardiness zones 2 – 9. Wide range of climate (-2 to -40°C), therefore it can occur in Europe from Mediterranean to northern areas of EU. For a similar species, *Solidago rigida*, increased CO_2 and N reduced incidence of leaf spot disease, increased total biomass and total plant N

	(Strengbom & Reich, 2006). It was concluded that soil N supply is probably an important constraint on global terrestrial responses to elevated CO_2 (Reich *et al.*, 2006).
11. Documents information sources	**Reich PB, Hobbie SE, Lee T, Ellsworth DS, West JB, Tilman D, Knops JM, Naeem S, Trost J. 2006.** Nitrogen limitation constrains sustainability of ecosystem response to CO2. *Nature* **440:** 922-925. **Strengbom J, Reich PB. 2006.** Elevated [CO2] and increased N supply reduce leaf disease and related photosynthetic impacts on *Solidago rigida*. *Oecologia* **149:** 519-525.
Main experts	Kelly Martinou Jan Pergl
Other contributing experts	Belinda Gallardo
Notes	No additional comments
Outcome	Compliant

Scientific name	*Tamias sibiricus*
Common name	Siberian chipmunk
Broad group	Vertebrate
Number of and countries wherein the species is currently established	6: Austria (now extinct), Belgium, France, Germany, Italy, The Netherlands and Switzerland
Risk Assessment Method	GB NNRA
Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=58
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefit: Limited trade as a pet.
6. Can broadly assess environmental impact with respect to	No information found.

ecosystem services	
8. Includes status (threatened or protected) of species or habitat under threat	No information found.
9. Includes possible effects of climate change in the foreseeable future	Populations of *T. sibiricus* have become established in comparable temperate parts of central, southern and northern Europe including Austria (now extinct), Belgium, France, Germany, Italy, The Netherlands and Switzerland (Long, 2003, Mitchell-Jones *et al.*, 1999). Current native distribution stretches across a large part of northern Asia, and reaches as far west as Finland.
11. Documents information sources	**Long JL. 2003.** *Introduced Mammals of the World: their history, distribution and influence*. CABI Publishing: Oxford. **Mitchell-Jones AJ, Amori G, Bogdanowicz W, Krystufek B, Reijnders P, Spitzenberger F, Stubbe M, Thissen J, Vohralik V, Zima J. 1999.** The atlas of European mammals. See also the Irish risk analysis report
Main experts	Piero Genovesi Melanie Josefsson
Other contributing experts	Belinda Gallardo
Notes	
Outcome	Compliant

Scientific name	*Threskiornis aethiopicus*
Common name	Sacred ibis
Broad group	Vertebrate
Number of and countries wherein the species is currently established	6: FR, IT, NL, PT, ES, GR
Risk Assessment Method	GB NNRA

Links	http://www.nonnativespecies.org/downloadDocument.cfm?id=59
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: Sacred ibises are kept in zoos (Clergeau & Yésou, 2006, Smits *et al.*, 2010, Topola, 2014) and other collections, thus generating some revenue for zoos and pet trade. The ISIS database roughly estimates that there are approximately 1170 individuals kept in 101 European institutions (ISIS, 2014). The species may have an aesthetic appeal to bird-watchers and members of the wider general public (Avifaunistic Commission - the Polish Rarities Committee, 2013). In France, Sacred Ibis have been documented consuming invasive Red swamp crayfish *Procambarus clarkii* (Marion, 2013), thus possibly reducing impact of this species upon biodiversity and economy.
6. Can broadly assess environmental impact with respect to ecosystem services	Provisioning services: Sacred Ibis have a broad dietary range including species that might be reared for human consumption (Clergeau *et al.*, 2010). Fisheries - Sacred Ibises are omnivorous, but largely predatory, with a diet that includes fish and molluscs. Sacred Ibis, therefore, could be an additional predator at fisheries (Clergeau *et al.*, 2010). Regulating services: Further impacts are associated with public health issues arising from the species scavenging behavior (Yésou & Clergeau, 2005). Disease regulation - Sacred Ibis could cause nuisance or environmental health concerns by scavenging from rubbish bins in areas of human habitation; as has happened in France (Clergeau & Yésou, 2006). It is possible that they may also carry disease which could be harmful to poultry, native fauna and humans.
8. Includes status (threatened or protected) of species or habitat under threat	Sacred Ibises are omnivorous, but largely predatory, feeding on amphibians, crustaceans, small rodents, molluscs, fish, earthworms, insects and the eggs and chicks of other bird species (Cramp *et al.*, 1983, Robert *et al.*, 2013c) and may therefore threaten native fauna of these types. Sacred Ibises can have serious impacts on other bird species due to predation of eggs and chicks. Colonial-nesting species such as terns and seabirds are particularly vulnerable. In South Africa, where they are native, predation of eggs and chicks has been shown to be one of the most serious

	causes of mortality in seabird colonies. With the current information, no estimates of the extent of the ecological impact of the Sacred ibis can be made with adequate certainty (Smits *et al.*, 2010). In France Sacred Ibises have been recorded to predate the eggs or chicks of a wide range of bird species including Sandwich tern (*Sterna sandvicensis = Thalasseus sandvicensis*) included in Annex I of the 2009/147/EC Birds Directive (Clergeau *et al.*, 2010, Clergeau & Yésou, 2006, Vaslin, 2005). In one incident, two Sacred Ibises were recorded to take all the eggs from a 30-nest Sandwich Tern colony in a few hours, causing the terns to desert the colony for the rest of the season, and similar incidents have been recorded with other tern species (Yésou & Clergeau, 2005). Another Annex I species affected by Sacred ibises is Little egrets (Egretta garzetta) that can be outcompeted for nest sites (Kayser *et al.*, 2005). In contrast, a fourteen year study in France reported that Sacred ibis diet was essentially composed of invertebrates, and that vertebrates constituted very accidental preys, and no bird species were really threatened by such predation (Marion, 2013). In the Netherlands Sacred Ibis has settled already in the Natura 2000-site Botshol and most wetlands with a Natura 2000 status are prone to be colonised (Smits *et al.*, 2010). Vegetation at colonised sites may suffer from eutrophication (Yésou & Clergeau, 2005).
9. Includes possible effects of climate change in the foreseeable future	Sacred ibises were introduced to locations colder than their native range and seem to have expanded into even colder areas (Strubbe & Matthysen, 2014). Climate change has the potential to enhance the invasion success of Sacred Ibis through the latter stages of the invasion process (establishment and spread), through: (i) improving the climatic match between its introduced and native range and (ii) through direct (e.g. thermal effects) and indirect changes (land management) to habitats and land use. The action of climate warming on the life history traits of such species, however, is not necessarily straightforward. For Sacred Ibis breeding performance is higher in temperate Western France than those estimates

	published for its warmer native Africa (Clergeau & Yésou, 2006).
11. Documents information sources	**Avifaunistic Commission - the Polish Rarities Committee. 2013.** Rare birds recorded in Poland in 2012. *Ornis Polonica* **54:** 109-150. **Clergeau P, Reeber S, Bastian S, Yesou P. 2010.** Le profil alimentaire de l'Ibis sacré *Threskiornis aethiopicus* introduit en France métropolitaine: espèce généraliste ou spécialiste? *Revue d'écologie* **65:** 331-342. **Clergeau P, Yésou P. 2006.** Behavioural flexibility and numerous potential sources of introduction for the sacred ibis: causes of concern in western Europe? *Biological Invasions* **8:** 1381-1388. **Cramp S, Simmons KL, editors, Brooks D, Collar N, Dunn E, Gillmor R, Hollom P, Hudson R, Nicholson E, Ogilvie M. 1983.** *Handbook of the birds of Europe, the Middle East and North Africa. The birds of the Western Palearctic: 3. Waders to gulls*. **ISIS. 2014.** International Species Information System. Accessed 19.12.2014. **Kayser Y, Clément D, Gauthier-Clerc M. 2005.** L'ibis sacré *Threskiornis aethiopicus* sur le littoral méditerranéen français: impact sur l'avifaune. *Ornithos* **12:** 84-86. **Marion L. 2013.** Is the Sacred ibis a real threat to biodiversity? Long-term study of its diet in non-native areas compared to native areas. *Comptes rendus biologies* **336:** 207-220. **Robert H, Lafontaine R-M, Delsinne T, Beudels-Jamar RC. 2013.** Risk analysis of the Sacred Ibis Threskiornis aethiopicus (Latham 1790). - Risk analysis report of non-native organisms in Belgium from the Royal Belgian Institute of Natural Sciences for the Federal Public Service Health, Food chain safety and Environment. 35 p. **Smits RR, van Horssen P, van der Winden J. 2010.** A risk analysis of the sacred ibis in The Netherlands Including biology and management options of this invasive species. Bureau Waardenburg bv / Plantenziektenkundige Dienst, Ministerie van LNV. **Strubbe D, Matthysen E. 2014.** Patterns of niche conservatism among non-native birds in Europe are dependent on introduction history and selection of variables. *Biological Invasions* **16:** 759-764. **Topola R. 2014.** *Polish ZOO and Aquarium Yearbook. Warszawa* **Vaslin M. 2005.** Prédation de l'Ibis sacré *Threskiornis aethiopicus* sur des colonies de sternes et de guifettes. *Ornithos* **12:** 106-109. **Yésou P, Clergeau P. 2005.** Sacred Ibis: a new invasive species in Europe. *Birding World* **18:** 517-526.
Main experts	Wojciech Solarz Wolfgang Rabitsch
Other contributing experts	Olaf Booy Belinda Gallardo Leopold Füreder

Notes	In how many EU member states has this species been recorded? List them. 7 – FR, IT, NL, PL, PT, ES, GR In how many EU member states has this species currently established populations? List them. 6 (from table) In how many EU member states has this species shown signs of invasiveness? List them. 3 – FR, ES, IT In which EU Biogeographic areas could this species establish? Most likely the Mediterranean and Atlantic Coast, but possible in other regions except alpine and boreal. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them. Most likely the Mediterranean and Atlantic Coast, but possible in other regions except alpine and boreal. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. Most likely to become invasive in Mediterranean and Black Sea (i.e. Spain, Portugal, Italy, Greece, France, Republic of Cyprus, Croatia, Malta, Bulgaria, Romania) Potential to establish in: Austria, Belgium, Czech Republic, Denmark, Germany, Hungary, Ireland, Luxembourg, Netherlands, Poland, Slovakia, Slovenia and the UK. Unlikely to establish in: Sweden, Estonia, Finland, Latvia, Lithuania.
Outcome	Compliant

Scientific name	*Vespa velutina*

Common name	Asian hornet
Broad group	Invertebrate
Number of and countries wherein the species is currently established	4: ES, FR, IT, PT
Risk Assessment Method	GB NNRA
Links	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=643
1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	Socio-economic benefits: None known.
6. Can broadly assess environmental impact with respect to ecosystem services	*Vespa velutina* predates managed honey bees, which provide pollination services to commercial crops and natural landscapes. This hornet also predates a wide variety of other beneficial insect species, including unmanaged pollinators (e.g. other Hymenoptera, hoverflies) (Rome *et al.*, 2011, Villemant *et al.*, 2011a). Provisioning services: The possible negative effect on pollination (primary service) may translate into loss of crop/fruit production and honey yields (secondary service). Regulating services: The Asian hornet preys on honeybees and other wild pollinators such as bumble bees, which can have a negative impact on production. Cultural services: Although hornets usually are defensive, they may be considered a nuisance to recreational activities, cause mental and physical health issues.
8. Includes status (threatened or	Honeybees are protected in several European countries and covered by different legislation (e.g. legislation on animal health certification and

protected) of species or habitat under threat	requirements for the movement of bees between Member States, Directive 92/65/EEC; including also other invasive alien species, *Aethina tumida, Varroa destructor*). The Asian hornet colonizes urban, sub-urban, agricultural and wooded areas, but rarely also can be found in unmanaged environments (e.g. marshlands), which may include protected habitats.
9. Includes possible effects of climate change in the foreseeable future	Unpredictable. However, could expect that northern parts of Europe might become more susceptible to establishment. Although the native range of *V. velutina* is within NE India, S. China and Taiwan and Indonesia, even in such tropical regions this species nests in cooler highland regions, which are climatically similar to Southern Europe (Martin, 1995, Starr, 1992). *Vespa* species are very effective at regulating the temperature within their nests, protecting adults and brood from ambient temperature extremes (Martin, 1995); they can maintain a constant nest temperature around 30°C, even if temperatures outside the hive may be 20°C lower. Under laboratory conditions, *V. velutina* has been shown to complete its lifecycle under a wide range of conditions (14-25°C) (Dong & Wang, 1989). Models predict that large parts of Europe are climatically suitable for the species (Barbet-Massin *et al.*, 2013, Rome *et al.*, 2009, Villemant *et al.*, 2011a), and an increase in the climatic suitability for the species in the Northern hemisphere is predicted, especially close to the already invaded range in Europe, in Spain and in Central and Eastern Europe – from Switzerland to Hungary up to Southern Sweden. Standard deviations of the results obtained from the 13 different climate scenarios confirmed the low uncertainty of models to predict an increase in invasion risk across Central and Eastern Europe, close to the already invaded European range. These regions hold among the highest densities of bee-hives in Europe, and could suffer from the potential predation of the putative invading hornet on pollinators. When considering all known occurrences of *V. v. nigrithorax* in the native and invaded ranges, models revealed that many countries of Western Europe exhibit a high probability of being invaded with a higher risk along the Atlantic and northern Mediterranean coasts. Coastal areas of the Balkan Peninsula, Turkey and Near East appear also suitable and could potentially be colonised later.
11. Documents information sources	**Barbet-Massin M, Rome Q, Muller F, Perrard A, Villemant C, Jiguet F. 2013.** Climate change increases the risk of invasion by the yellow-legged hornet. *Biological Conservation* **157:** 4-10. **Choi MB, Martin SJ, Lee JW. 2011.** Distribution, spread and impact of the

	invasive hornet *Vespa velutina* in South Korea. *Entomological Research* **41:** 276-276. **Dong D, Wang W. 1989.** A preliminary study on the biology of wasps *Vespa velutina auraria* Smith and *Vespa tropica ducalis* Smith. . **Ibáñez-Justicia A, Loomans A. 2011.** Mapping the potential occurrence of an invasive species by using CLIMEX: case of the Asian hornet (*Vespa velutina nigrithorax*) in The Netherlands. *Proc Neth Entomol Soc Meet* **22:** 39-46. **Martin SJ. 1995.** Hornets (Hymenoptera: Vespidae) of Malaysia. . *Malayan Nature Journal* **49:** 71-82. **Monceau K, Bonnard O, Thiéry D. 2014.** *Vespa velutina*: a new invasive predator of honeybees in Europe. *Journal of Pest Science* **87:** 1-16. **Rome Q, Gargominy O, Jiguet F, Muller F, Villemant C. 2009.** Using maximum entropy (MAXENT) models to predict the expansion of the invasive alien species *Vespa velutina* var. *nigrithorax* Du Buysson, 1905 (Hym.: Vespidae), the Asian hornet. *Europe. In: Apimondia*: 15-20. **Rome Q, Perrard A, Muller F, Villemant C. 2011.** Monitoring and control modalities of a honeybee predator, the yellow-legged hornet *Vespa velutina nigrithorax* (Hymenoptera: Vespidae). *Aliens: The Invasive Species Bulletin* **31:** 7-15. **Starr CK. 1992.** The social wasps (Hymenoptera: Vespidae) of Taiwan. *Bulletin of the National Museum of Natural Science* **3:** 93-138. **Villemant C, Barbet-Massin M, Perrard A, Muller F, Gargominy O, Jiguet F, Rome Q. 2011a.** Predicting the invasion risk by the alien bee-hawking Yellow-legged hornet *Vespa velutina nigrithorax* across Europe and other continents with niche models. *Biological Conservation* **144:** 2142-2150. **Villemant C, Muller F, Haubois S, Perrard A, Darrouzet E, Rome Q. 2011b.** Bilan des travaux (MNHN et IRBI) sur l'invasion en France de *Vespa velutina*, le frelon asiatique prédateur d'abeilles. *Proceedings of the Journée Scientifique Apicole–11 February*: 3-12. **Villemant C, Perrard A, Rome Q, Gargominy O, Haxaire J, Darrouzet E, Rortais A. 2008.** A new enemy of honeybees in Europe: the invasive Asian hornet *Vespa velutina*. XXth International Congress of Zoology – Paris, 26-29 August 2008. http://inpn.mnhn.fr/gargo/Vespa%20velutina%20ICZ%202008.pdf.
Main experts	Wolfgang Rabitsch Piero Genovesi
Other contributing experts	Olaf Booy Belinda Gallardo
Notes	

	In how many EU member states has this species been recorded? List them. 6 member states (MS): France (since 2003/2004), Spain (since 2010), Belgium (2011), Portugal (since 2012), Italy (since 2013), Germany (2014) In how many EU member states has this species currently established populations? List them. Certain establishment in 4 MS: France, Spain, Portugal, Italy Establishment in 2 MS uncertain: flying male recorded present in Belgium in 2011 but not reported in 2012 - not believed established; only recently recorded present in Germany (August/September 2014) – no data on establishment available yet. In how many EU member states has this species shown signs of invasiveness? List them. Certain spread in 4 MS (highly invasive): France, Spain, Portugal, Italy Spread in 2 MS uncertain: observed in Belgium in 2011 but not in 2012 therefore not believed to have spread; only recently recorded present in Germany (August/September 2014) – no data on invasiveness available yet. In which EU Biogeographic areas could this species establish? The GB risk assessment (overall conclusion Medium Risk and Medium Uncertainty) is validated. Missing information was added. *Vespa velutina* has established in urban and rural environments. Shows a preference for peri urban/urban locations: Based on observations of invasive populations of this species in both France and south Korea, mature nests are distributed in the environment as follows: *Habitat type in France: Urban/periurban - 49% (of nests) Agricultural areas - 43% Forest - 7% “Milieu humides” (i.e. wetlands?) e.g. estuaries, marshes - 1% **Habitat type S. Korea: Forest (only ‘green’; no urbanisation) - 20% (of hornet community on wing)

Forest edge (green:urbanisation 3:1) – 29%
Large urban parks (green:urbanisation 1:1) – 40%
Local urban parks (green:urbanisation 1:3) – 65%
Urban centre (only urbanised; no ‘green’) – 92%

*Nest heights: >10m above ground - 75% (of nests)
Between 2-10m above ground - 21%
<2m above ground - 3%

***Substrate: Trees - 90% (of nests)
Buildings (verandas, terraces, barns, municipal buildings etc) – 10%
underground rarely - <1%?

***Types of tree: Oaks 25% (of nests)
Poplars 19%
Acacias 13%
Conifers 11%
Birch ?%
Bushes (Laurel) 1%
Fruit trees (Plum, Pear, Sour cherry) 1%

Proximity to water: Strong correlation between hornet presence and proximity to hydrographic network (water = a requirement for nest building).

*French population, based on 4,107 nests (Villemant *et al.*, 2011b)
**South Korean population (Choi *et al.*, 2011)
***French population, based on studies of 550 nests (Villemant *et al.*, 2008)

In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.

Unknown. However, it has been stated (Monceau *et al.*, 2014) that “different simulations based on climatic similarities of locations in France and Asia predicted an expansion to most parts of France and neighbouring European countries” (Ibáñez-Justicia & Loomans, 2011, Villemant *et al.*,

	2011a). The comparison between native and invaded areas shows that they differ in their level of precipitation during the driest month of the year, the invaded areas receiving more precipitation than the native area. It has been stated that: “Eight climatic suitability models have been used to predict the potential invasion risk of *V. v. nigrithorax* based on eight climatic data from WorldClim at 5 arc-minutes grid. We used occurrence data in the models from the invaded range as well as from the native range of this particular variety, gathering information from museum collections, published records and recent field sampling in its native range. The consensus map obtained from the models shows that *V. v. nigrithorax*could successfully invade many other parts of the world since the scenario of introductions through international trade - as it occurred in France - could well be repeated.” (Rome *et al.*, 2009) Map: Limoges (France) Match Climate Europe. Green triangles indicate locations of *V. velutina* nests until 2009 (INPN 2010), blue dots indicate stations where the Climate Matching Index (CMI) >0.7, and crosses indicate stations where CMI <0.7. (Ibáñez-Justicia & Loomans, 2011) Map from Rome et al. (2011). Predicted potential invasion risk of *V. v. nigrithorax* based on ensemble forecast models using eight climatic data from WorldClim. Verified data only. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? List them. As above. INPN (2010) Inventaire National du Patrimoine Naturel. http://inpn.mnhn.fr.
Outcome	Compliant

4. SUMMARY

The risk assessments for 56 species (Table 4.1) were considered through this project, 52 were agreed to be fully compliant with the minimum standards, four were not considered to be compliant because of major information gaps, and a further risk assessment (*Crassostrea gigas*, Pacific oyster) although compliant with the minimum standards, is excluded from the scope of the regulation (see art 2.e) because it is listed in annex IV of Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture.

As a result of the workshop discussion, and despite the efforts to fill in the relevant information gaps, the four risk assessments considered "not compliant" were *Elodea canadensis, Heracleum mantegazzianum, Mephitis mephitis, Nasua nasua.*

Heracleum mantegazzianum

The original risk assessment was carried out within the EPPO DSS protocol. According to the risk assessment, the impact was high, but according to the EPPO approach, the species is too widespread to be considered as a quarantine pest, thus did not qualify and was not screened through a full risk assessment by EPPO. A full risk assessment, with recommendations, has been voluntarily completed after the workshop by one of the report authors and workshop participants, Jan Pergl, and is attached to the report (see Annex 4). The updated risk assessment confirmed the species as having a high impact.

Elodea Canadensis

The provisional GB NNRA for this species was circulated before the workshop but there have been recent amendments that have not yet been approved. So strictly speaking an approved risk assessment is simply not available. Additionally, it is thought that this species has already colonised most of the sites it may potentially invade and that its abundance therein is decreasing. We recommend to wait for the amended version to be finalised, and then to be re-considered for discussion.

Mephitis mephitis and Nasua nasua

The relevant risk assessments made within the GB NNRA system are the only ones discussed in this report for which a low impact is indicated, and for that reason they were not already included in the list of the previous report (Roy *et al.*, 2014b). The information gaps determined before the workshop, relative to the lack of data on socio-economic benefits, environmental impact with respect to ecosystem services, status of species or habitat under threat, and possible effects of climate change in the foreseeable future, were only partially completed. More importantly, as the risk assessments for these species were focused on Great Britain only, it was stressed that the actual and potential impact on the species might well be underestimated when taking into account a wide-European approach, which in this case was clearly missing. In particular both the known adaptability of these species under a range of climatic conditions, and their well known impact in other areas of the world is likely to increase the risk outcome for these species. We therefore recommend the two species being fully re-assessed through a pan-European approach.

Table 4.1 Summary of the information compiled against the minimum standards for each risk assessment considered through the workshop including outcome and key recommendations (key recommendations are only included for species for which the outcome was “not compliant” or where changes to the impact scores or associated uncertainty should be considered)

Scientific name	Common name	Risk Assessment Method	Outcome	Key recommendations
Ambrosia artemisiifolia	Common ragweed	EPPO, GB NNRA	Compliant	
Azolla filiculoides	Water fern	GB NNRA	Compliant	Reduce risk from high (GB NNRA) to medium with medium uncertainty
Baccharis halimifolia	Eastern Baccharis	EPPO	Compliant	
Branta canadensis	Canada goose	GB NNRA	Compliant	
Callosciurus erythraeus	Pallas's squirrel	This project	Compliant	
Cabomba caroliniana	Fanwort	EPPO	Compliant	
Caprella mutica	Japanese Skeleton Shrimp	GB NNRA	Compliant	
Cervus nippon	Sika deer	GB NNRA	Compliant	
Corvus splendens	Indian house crow	GB NNRA	Compliant	
Crassostrea gigas	Pacific Oyster	GB NNRA	Compliant	Excluded from the scope of the regulation because it is listed in aanex IV of Council Regulation (EC) 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture

Scientific name	Common name	Risk Assessment Method	Outcome	Key recommendations
Crassula helmsii	Australian swamp stonecrop	EPPO, GB NNRA	Compliant	
Crepidula fornicata	Slipper Limpet	GB NNRA	Compliant	
Didemnum vexillum	Carpet Sea-squirt	GB NNRA	Compliant	
Eichhornia crassipes	Water hyacinth	EPPO	Compliant	
Elodea canadensis	**Canadian water/ pondweed**	**GB NNRA**	**Not compliant**	**Recent amendments to the GB NNRA should be considered when available**
Eriocheir sinensis	Chinese mittencrab	GB NNRA	Compliant	
Fallopia japonica	Japanese knotweed	GB NNRA	Compliant	High risk (also the hybrid *F. bohemica*)
Fallopia sachalinensis	Japanese knotweed	GB NNRA	Compliant	Low risk but consider all hybrids with *F. japonica* including backcrosses
Heracleum mantegazzianum	**Giant hogweed**	**EPPO**	**Not compliant**	**Review the updated risk assessment available in Annex 4**
Heracleum persicum	Persian hogweed	EPPO	Compliant	
Heracleum sosnowskyi	Sosnowski's hogweed	EPPO	Compliant	
Hydrocotyle ranunculoides	Floating pennywort	EPPO, GB NNRA	Compliant	
Lagarosiphon major	Curly waterweed	GB NNRA	Compliant	
Lithobates (Rana) catesbeianus	North American bullfrog	GB NNRA	Compliant	
Ludwigia grandiflora	Water-primrose	EPPO, GB NNRA	Compliant	
Ludwigia peploides	Floating primrose-willow	EPPO	Compliant	

Scientific name	Common name	Risk Assessment Method	Outcome	Key recommendations
Lysichiton americanus	American skunk cabbage	EPPO	Compliant	
Mephitis mephitis	**Skunk**	**GB NNRA**	**Not compliant**	**European-wide risk assessment required**
Muntiacus reevesii	Muntjac deer	GB NNRA	Compliant	
Myocastor coypus	Coypu	This project	Compliant	
Myiopsitta monachus	Monk parakeet	GB NNRA	Compliant	
Myriophyllum aquaticum	Parrot's feather	GB NNRA	Compliant	
Nasua nasua	**Coati**	**GB NNRA**	**Not compliant**	**European-wide risk assessment required**
Orconectes limosus	Spiny-cheek Crayfish	GB NNRA	Compliant	Consider increasing risk from medium to high impact
Orconectes virilis	Virile Crayfish	GB NNRA	Compliant	Medium risk as determined by GB NNRA but consider changing level of uncertainty from high to medium because of taxonomic issues
Oxyura jamaicensis	Ruddy duck	GB NNRA	Compliant	
Pacifastacus leniusculus	Signal Crayfish	GB NNRA	Compliant	
Parthenium hysterophorus	Whitetop Weed	EPPO	Compliant	
Persicaria perfoliata (Polygonum perfoliatum)	Asiatic tearthumb	EPPO	Compliant	
Potamopyrgus antipodarum	New Zealand Mudsnail	GB NNRA	Compliant	
Procambarus	Red Swamp	GB NNRA	Compliant	

Scientific name	Common name	Risk Assessment Method	Outcome	Key recommendations
clarkii	Crayfish			
Procambarus spp.	Marbled Crayfish	GB NNRA	Compliant	
Procyon lotor	Raccoon	GB NNRA	Compliant	
Pseudorasbora parva	Stone moroko	GB NNRA	Compliant	
Psittacula krameri	Rose-ringed parakeet	GB NNRA	Compliant	
Pueraria lobata	Kudzu Vine	EPPO	Compliant	
Rapana venosa	Rapa Whelk	GB NNRA	Compliant	
Sargassum muticum	Japweed, wireweed	GB NNRA	Compliant	
Sciurus carolinensis	American Grey Squirrel	This project	Compliant	
Senecio inaequidens	Narrow-leaved ragwort	EPPO	Compliant	
Sicyos angulatus	Star-cucumber	EPPO	Compliant	
Solanum elaeagnifolium	Silver-leaved Nightshade	EPPO	Compliant	
Solidago nemoralis		EPPO	Compliant	
Tamias sibiricus	Siberian chipmunk	GB NNRA	Compliant	
Threskiornis aethiopicus	Sacred ibis	GB NNRA	Compliant	
Vespa velutina	Asian hornet	GB NNRA	Compliant	

5. CONCLUDING REMARKS

For the majority of species considered the additional information compiled to achieve compliance of the risk assessment with the minimum standards did not alter the overall score of the original risk assessment. Thus, the risk assessments resulting in medium to high impact were mostly considered as compliant, and the original outcome was confirmed. However, although the GB NNRA, despite limited geographic scope, were agreed to comply with minimum standards, it was noted that the GB NNRA would benefit from additional information from other European countries. This would ensure the GB NNRA were more informative at a European-scale, but it is important to note that the overall result would not change in most cases. Indeed the information within the GB NNRA is often based on available data from other countries.

The compliance of the GB NNRA is encouraging and suggestive that other risk assessments made by single MS could be considered for adoption at the European-level. However, it must be demonstrated that such risk assessments are compliant with the minimum standards and rapid review would be required to confirm that no major information gaps exists in relation to the limited geographic scope. During the workshop the participating experts briefly described risk assessments being developed at the national level by single MS, institutions or experts. For example, Spain has completed several risk assessments, to support the enforcement of the Royal Decree 1628 adopted in 2011, and then revised with Decree 630/2013. The risk assessments are so far available only in Spanish, and were thus not taken into account in the present report. Also Joint HELCOM/OSPAR Task Group on Ballast Water Management (HELCOM/OSPAR, 2014) has been developing harmonized criteria for defining target alien species. It was not possible to consider these through this project however, a dynamic process of information exchange between the EC (perhaps through EASIN) and others with respect to risk assessments is recommended. The COST Action ALIEN Challenge (TD1209) is currently undertaking a comparative review of impact and risk assessments methods.

Further risk assessments will be submitted to the EC for discussion and consideration in the (near) future. In order to assist the EC, and in the light of this project, it is advisable that the EC consider the constitution of a panel of independent experts to review risk assessments. Such an expert panel proved to be extremely effective for checking and verifying the compliance of risk assessments as well as the presence of bias and/or information gaps, by ensuring the mobilization of the required skills across countries, taxa and environments. Such a panel would ensure compliance and completeness of all risk assessments submitted, whether developed in relation to a national, regional or Europe-wide scale, and in this way could assist the foreseen Scientific Forum.

As a priority we suggest to consider the compliance of the new risk assessments for *Siganus* *luridus* (Annex 3). Finally, risk assessments should be conducted for the species not considered in the present report but listed in Annex B of the Council Regulation (EC) No 338/97 (further to Commission Implementing Regulation (EU) No 888/2014 of 14 August 2014 prohibiting the introduction into the Union of specimens of certain species of wild fauna and flora) and that are explicitly considered in preamble 14 of the EU Regulation as a priority, namely *Chrysemys picta, Trachemys scripta elegans, Sciurus niger*.

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ANNEX 1 TABLE OF INVASIVE ALIEN SPECIES CONSIDERED IN THE REPORT WITH LINK TO RELEVANT RISK ASSESSMENTS

Scientific name	Common name	Risk Assessment Method	Link
Ambrosia artemisiifolia	Common ragweed	EPPO, GB NNRA	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14124%20PRA-Ambrosia.doc https://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/99-7775%20repPRA%20Ambrosia%20spp.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=865
Azolla filiculoides	Water fern	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=235
Baccharis halimifolia	Eastern Baccharis	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/13-18359_PRA_record_Baccharis_halimifolia.pdf http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/13-18698_PRA_Report_Baccharis_halimifolia.pdf
Branta canadensis	Canada goose	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=236
Callosciurus erythraeus	Pallas's squirrel	This project	Annexed to the report
Cabomba caroliniana	Fanwort	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13385rev%20EPPO%20PRA%20CABCA%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13375rev%20EPPO%20PRA%20report%20CABCA%20rev.doc
Caprella mutica	Japanese Skeleton Shrimp	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=383
Cervus nippon	Sika deer	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=384

Scientific name	Common name	Risk Assessment Method	Link
Corvus splendens	Indian house crow	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=49
Crassostrea gigas	Pacific Oyster	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=647
Crassula helmsii	Australian swamp stonecrop	EPPO, GB NNRA	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12703_PRA_Crassula_helmsii_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12801%20PRA%20report%20CSBHE.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=237
Crepidula fornicata	Slipper Limpet	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=754
Didemnum vexillum	Carpet Sea-squirt	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=238
Eichhornia crassipes	Water hyacinth	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14407%20PRA%20record%20Eichhornia%20crassipes%20EICCR.pdf http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14408_PRAreport_Eichhornia.pdf
Elodea canadensis	Canadian water/pondweed	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=617
Eriocheir sinensis	Chinese mittencrab	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=51
Fallopia japonica	Japanese knotweed	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=239
Fallopia sachalinensis	Japanese knotweed	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=385

Scientific name	Common name	Risk Assessment Method	Link
Heracleum mantegazzianum	Giant hogweed	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14470%20PRA%20Heracelum%20mantegazzianum.doc
Heracleum persicum	Persian hogweed	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14472%20PRA%20Heracleum%20persicum.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15076%20PRA%20report%20Heracleumpersicum%20rev%20post%20WPPR.doc
Heracleum sosnowskyi	Sosnowski's hogweed	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/08-14471%20PRA%20Heracleum%20sosnowskyi.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15075%20PRA%20report%20Heracleumsosnowskyi%20post%20WPPR.doc
Hydrocotyle ranunculoides	Floating pennywort	EPPO, GB NNRA	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15108%20PRA%20Hydrocotyle%20ranunculoides%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15161%20PRA%20Report%20Hydrocotyle%20ranunculoides.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=240
Lagarosiphon major	Curly waterweed	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=241
Lithobates (Rana) catesbeianus	North American bullfrog	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=56
Ludwigia grandiflora	Water-primrose	EPPO, GB NNRA	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-16827%20PRA%20Ludwigia_grandiflora%20rev.doc

Scientific name	Common name	Risk Assessment Method	Link
			http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-17142%20PRA%20%20report%20Ludwigia%20grandiflora.doc https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=477
Ludwigia peploides	Floating primrose-willow	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-16828%20PRA%20Ludwigia_peploides%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/11-17143%20PRA%20%20report%20Ludwigia%20peploides.doc
Lysichiton americanus	American skunk cabbage	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15078%20PRA%20Lysichiton%20americanus%20final%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15077%20PRA%20report%20Lysichiton%20americanus.doc
Mephitis mephitis	Skunk	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=758
Muntiacus reevesii	Muntjac deer	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=386
Myocastor coypus	Coypu	This project	Annexed to the report
Myiopsitta monachus	Monk parakeet	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=52
Myriophyllum aquaticum	Parrot's feather	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=274
Nasua nasua	Coati	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=759

Scientific name	Common name	Risk Assessment Method	Link
Orconectes limosus	Spiny-cheek Crayfish	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=53
Orconectes virilis	Virile Crayfish	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=868
Oxyura jamaicensis	Ruddy duck	GB NNRA	Annexed to the report
Pacifastacus leniusculus	Signal Crayfish	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=54
Parthenium hysterophorus	Whitetop Weed	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/14-19987_PRA_Parthenium_hysterophorus.docx http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/14-19988_PRA_report_Parthenium_hysterophorus.docx
Persicaria perfoliata (Polygonum perfoliatum)	Asiatic tearthumb	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13387rev%20PRA%20POLPF%20rev.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13604_PRAreportPOLPF.dochttp://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13604_PRAreportPOLPF.doc
Potamopyrgus antipodarum	New Zealand Mudsnail	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=619
Procambarus clarkii	Red Swamp Crayfish	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=46
Procambarus spp.	Marbled Crayfish	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=620
Procyon lotor	Raccoon	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=621

Scientific name	Common name	Risk Assessment Method	Link
Pseudorasbora parva	Stone moroko	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=243
Psittacula krameri	Rose-ringed parakeet	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=55
Pueraria lobata	Kudzu Vine	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12701_PRA_Pueraria_lobata_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12802_PRA_report_PUELO.doc
Rapana venosa	Rapa Whelk	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=622
Sargassum muticum	Japweed, wireweed	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=57
Sciurus carolinensis	American Grey Squirrel	This project	Annexed to the report
Senecio inaequidens	Narrow-leaved ragwort	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12954_PRA_SENIQ.doc
Sicyos angulatus	Star-cucumber	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/09-15109rev_PRA_Sicyos_angulatus.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/10-16056_PRA_report_Sicyos_angulatus.doc
Solanum elaeagnifolium	Silver-leaved Nightshade	EPPO	http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/06-12702_PRA_Solanum_elaeagnifolium_final.doc http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/07-13607%20PRA%20report%20SOLEL.doc
Solidago nemoralis		EPPO	https://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_plants/04-11150%20PRAss_Report%20sol_nem3.doc
Tamias sibiricus	Siberian	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=58

Scientific name	Common name	Risk Assessment Method	Link
	chipmunk		
Threskiornis aethiopicus	Sacred ibis	GB NNRA	http://www.nonnativespecies.org/downloadDocument.cfm?id=59
Vespa velutina	Asian hornet	GB NNRA	https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=643

ANNEX 2 NEW RISK ASSESSMENTS: PALLAS SQUIRREL (*CALLOSCIURUS ERYTHRAEUS*), COYPU (*MYOCASTOR COYPUS*), AND GREY SQUIRREL (*SCIURUS CAROLINENSIS*) (NOTE: LINKS FOR THE RISK ASSESSMENTS FOR SKUNK (MEPHITIS MEPHITIS) AND COATI (NASUA NASUA) ARE PROVIDED IN ANNEX 1)

See file “Annex 2: New risk assessments”

ANNEX 3 OVERVIEW OF NEW RISK ASSESSMENT FOR *SIGANUS LURIDUS* (FOR RISK ASSESSMENT SEE SUPPLEMENTARY INFORMATION 2)

Scientific name	*Siganus luridus*
Common name	Rabbitfish, dusky spinefoot
Broad group	Vertebrate
Number of and countries wherein the species is currently established	5. CY, GR, MT, IT, HR (Cyprus, Greece, Malta, Italy, Croatia)
Risk Assessment Method	GISS by Stelios Katsanevakis

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)	The species has been recorded in the Mediterranean since 1931 and has become invasive in Greece, Cyprus and Malta. It continues to spread in the Adriatic Sea and has reached the French coasts (Daniel *et al.*, 2009). In the eastern Mediterranean it is commercially exploited. SY 1931 inv Gruvel., 1931 IS 1955 inv Ben Tuvia, 1964 LN 1962 inv George et al., 1964 CY 1964 inv Demetropoulos & Neocleous, 1969 GR 1964 inv Kavallakis, 1968 LB 1968 est Stirn, 1970 TN 1969 est Ktari-Chakroun & Bouhalal, 1971 EG 1972 inv George, 1972 TR 1973 inv Ben Tuvia, 1973 IT 2003 est Azzurro & Andaloro, 2004 FR 2008 cas Daniel et al., 2009 HR 2010 cas Poloniato et al., 2010 MT <2002 inv Azzurro et al., 2007
2. Includes the likelihood of entry, establishment, spread and magnitude of impact	It is likely to become invasive in the western Mediterranean
3. Includes description of the actual and potential distribution,	

spread and magnitude of impact	
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional	No , Lesseptiam immigrant
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes	Yes
6. Can broadly assess environmental impact with respect to ecosystem services	Some algal forests, such as *Cystoseira* spp. forests, are ecologically very important as nurseries for a number of littoral fish species. These *Cystoseira* forests are currently considered to be a threatened habitat in several regions of the Mediterranean (Otero *et al.*, 2013). Hence, ecosystem services provided by many sublittoral biotopes, especially communities of sublittoral algae on rocky bottoms, i.e. food, biotic materials, climate regulation, water purification, cognitive benefits, recreation, symbolic and aesthetic values, and life cycle maintenance (Salomidi *et al.*, 2012), are impacted. It reduces the recreational value (for snorekelling, SCUBA) of rocky shores but transforming algal forests to low-biodiversity rocky barrens.
7. Broadly assesses adverse socio-economic impact	Impact on fisheries primarily by causing the degradation of essential habitats for commercial fish and invertevrates, and secondary by outcompeting commercially important species (Katsanevakis *et al.*, 2014). The species is edible and is caught by trammel nets and gillnets; It is marketed in many Mediterranean countries. In 2008, *S. luridus* and *S. rivulatus* represented 4.6% in weight of the total catch of the artisanal fisheries in Cyprus (Katsanevakis *et al.*, 2009).

8. Includes status (threatened or protected) of species or habitat under threat	It has become dominant in many coastal areas (Bariche *et al.*, 2004, Katsanevakis, 2011, Sala *et al.*, 2011, Thessalou-Legaki *et al.*, 2012), outcompeting the main native herbivores, *Sparisoma cretense* (Linnaeus, 1758) and Sarpa salpa (Linnaeus, 1758) (Bariche *et al.*, 2004).
9. Includes possible effects of climate change in the foreseeable future	In a study in the Aegean Sea, areas of higher *S. luridus* abundance showed a significant overlap with areas of higher minimum winter SST. . A significant correlation between *S. luridus* abundance and SST was detected (r2 = 0.585, P < 0.05) (Giakoumi, 2014); The spatial variation of minimum sea surface temperature is possibly the reason for its distributional pattern.
10. Can be completed even when there is a lack of data or associated information	YES
11. Documents information sources	Acevedo P, Ward AI, Real R, Smith GC (2010) Assessing biogeographical relationships of ecologically related species using favourability functions: a case study on British deer. *Diversity and Distributions,* **16**, 515-528. Ackefors H (1998) The culture and capture crayfish fisheries in Europe. *World aquaculture,* **29**, 18-24. Adams SN, Engelhardt KaM (2009) Diversity declines in Microstegium vimineum (Japanese stiltgrass) patches. *Biological Conservation,* **142**, 1003-1010. Adkins S, Shabbir A (2014) Biology, ecology and management of the invasive Parthenium weed (*Parthenium hysterophorus* L.). . *Pest. Management Science,* **70**, 1023-1029. Adriaens T, Devisscher S, Louette G (2013) Risk analysis of American bullfrog *Lithobates catesbeianus* (Shaw). Risk analysis report of non-native organisms in Belgium. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.41). Instituut voor Natuur- en Bosonderzoek, Brussel. Ahern D, England J, Ellis A (2008) The virile crayfish, *Orconectes virilis* (Hagen, 1870)(Crustacea: Decapoda: Cambaridae), identified in the UK. *Aquatic Invasions,* **3**, 102-104. Ahmad A, Al-Othman AA (2014) Remediation rates and translocation of heavy metals from contaminated soil through *Parthenium hysterophorus*. *Chemistry and Ecology,* **30**, 317-327. Albertini G, Lanza B (1987) *Rana catesbeiana* Shaw, 1802 in Italy. *Alytes,* **6**, 117-129. Allan JR, Kirby JS, Feare CJ (1995) The biology of Canada geese *Branta canadensis* in relation to the management of feral populations. *Wildlife Biology,* **1**, 129-143. Alonso Á, Castro-Díez P (2012) The exotic aquatic mud snail *Potamopyrgus antipodarum* (Hydrobiidae, Mollusca):

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12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary	Although *S. luridus* is host of a number of parasites, there is no known impact on native species by transmission of diseases or parasites. Based on a caging experiment, it was concluded that *S. luridus* and *S. rivulatus* were able to create and maintain barrens (rocky areas almost devoid of erect algae) and contribute to the transformation of the ecosystem from one dominated by lush and diverse brown algal forests to another dominated by bare rock (Sala *et al.*, 2011). Some of these algal forests, such as *Cystoseira* spp. forests, are ecologically very important as nurseries for a number of littoral fish species. These *Cystoseira* forests are currently considered to be a threatened habitat in several regions of the Mediterranean (Otero *et al.*, 2013).
13. Includes uncertainty	High confidence level
14. Includes quality assurance	
Main experts	Stelios Katsanevakis Argyro Zenetos
Other contributing experts	
Conclusions and notes	Other countries where the species is present: Slovenia, France, Spain Impact on fisheries primarily by causing the degradation of essential habitats for commercial fish and invertevrates, and secondary by outcompeting commercially important species (Katsanevakis *et al.*, 2014).
Outcome	Compliant

ANNEX 4 UPDATED RISK ASSESSMENT - *HERACLEUM MANTEGAZZIANUM*

Information for *Heracleum mantegazzianum* (based on the EPPO scheme)		
2 Enter the name of the pest		*Heracleum mantegazzianum*
2A Indicate the type of the pest		Plantae
2B Indicate the taxonomic position		Apiaceae
3 Clearly define the PRA area		EPPO member countries
4 Does a relevant earlier PRA exist?		
5 Is the earlier PRA still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct pest, for another area with similar conditions)?		
Stage 2A: Pest Risk Assessment - Pest categorization		
6 Specify the host plant species (for pests directly affecting plants) or suitable habitats		Grasslands, open decidous forests, wetlands, riverbanks/canal sides, rail/roadsides, abandoned pastures, and urban areas.

(for non parasitic plants) present in the PRA area.		
7. Specify the pest distribution		
8. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Yes	A close genetic relationship between the three invasive *Heracleum* species in Europe was found (Jahodová et al., 2007) and thus there have been confusions between *Heracleum mantegazzianum*, *H. sosnowskyi* and *H. persicum*. In recent genetical studies was found that there are three distinct tall Heracleum species invading Europe. Nevertheless identification problems may occur.
9. Even if the causal agent of particular symptoms has not yet been fully identified, has it been shown to produce consistent symptoms and to be transmissible?		
10. Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?	Yes	*H. mantegazzianum* is considered invasive in managed and unmanaged ecosystems, being a threat to biodiversity, eroding riverbanks, and posing a health risk - causing skin blistering on contact.
11. Does the organism have intrinsic attributes that indicate that it could cause significant harm to plants?	Yes	It was found that in communities dominated by *H. mantegazzianum* is less native species than in the non-invaded comparable communities (Hejda et al. 2009).
12 Does the pest occur in the PRA area?		

13. Is the pest widely distributed in the PRA area?	Yes	*H.mantegazzianum* is distributed in the whole Europe with exeption of southern countries.
14. Does at least one host-plant species (for pests directly affecting plants) or one suitable habitat (for non parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?	Yes	
15. If a vector is the only means by which the pest can spread, is a vector present in the PRA area? (if a vector is not needed or is not the only means by which the pest can spread go to 16)	/	A vector is not needed.
16. Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?	Yes	The species is native in Western Great Caucasus and grows also in high densities in lowlands.
17. With specific reference to the plant(s) or habitats which occur(s) in the PRA area, and the damage or loss caused by the pest in its area of current distribution, could the pest by itself, or acting as a vector, cause significant damage or loss to plants or other negative economic impacts (on the environment, on	Yes	Negative socio-economic impact is linked mainly with the health problems and decreasing accessibility of the invaded areas. Negative environmental impact is linked to decrease of species richness within invaded sites..

society, on export markets) through the effect on plant health in the PRA area?		
18. This pest could present a risk to the PRA area.	Yes	
19. The pest does not qualify as a quarantine pest for the PRA area and the assessment for this pest can stop.		There are some national regulations targeting *H. mantegazzianum*

Section 2B: Pest Risk Assessment - Probability of introduction/spread and of potential economic consequences

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		Note: If the most important pathway is intentional import, do not consider entry, but go directly to establishment. Spread from the intended habitat to the unintended habitat, which is an important judgement for intentionally imported organisms, is covered by questions 1.33 and 1.35.
1.1. Consider all relevant pathways and list them		Relevant pathways are the following: - unvoluntary introduction with soil/growing medium (with organic matters) as a commodity - unvoluntary introduction with soil as a contaminant on used machinery - unvoluntary introduction with soil as a contaminant on vehicles - unvoluntary introduction with soil as a contaminant on footwear - voluntary introduction of dried umbels for decoration. Dried umbels are reported to be used for decoration - introduction as an ornamental plant Closed pathway: - voluntary introduction as a fodder crop or as a meliferous plant, but because high public awareness this pathway is considered unlikely. Natural spread

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		- natural spread by wind and on the fur of animals (cattle): this is not considered in the entry pathways analysis as it mainly contributes to local spread.
1.8. How likely is the pest to survive during transport/storage?		Seeds may remain viable in the field this period is apparently much shorter – only 8.8% of seeds buried in the soil survived 1 year, 2.7% lasted 2 years and 1.2% remained viable and dormant after 3 years (Moravcová *et al*., 2007). Correspondingly, no viable seeds were found in a *Heracleum* site after 7 years of sheep grazing (Andersen & Calov, 1996).
1.9. How likely is the pest to multiply/increase in prevalence during transport /storage?		Seeds do not multiply.
1.12. In the case of a commodity pathway, do consignments arrive at a suitable time of year for pest establishment?		Whatever the time of arrival, seeds can remain viable for several months and wait untill suitable conditions to germinate.
1.13. How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?		There is a low probability that seeds will escape from soil during transportation. Seeds are only in the upper layer of soil, so when taking soil, these seeds will be covered by soil which occurred deeper.
1.14. In the case of a commodity pathway, how likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?		Whether soil is usually used for planting or other purposes (e.g. constructions) in unknown. When soil is used for planting, it will be used in gardens, road sides, nurseries, fields, natural or semi-natural areas, etc. which are suitable habitats for the plant.
1.4. How likely is the pest to be associated with the pathway at origin taking into		In infested areas, the soil of fields, gardens, road sides, pastures, waste lands, etc. can be infested with seeds. Seeds can therefore easily and widely be dispersed by soil as a

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
account factors such as the occurrence of suitable life stages of the pest, the period of the year?		contaminant of soil on agricultural machinery and tools. Vehicles are usually mainly driven on road sides, and the probability of the pest to be on tires of vehicles is less likely than on machinery.
1.13. How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?		Vehicles could spread the plant on roadsides, fallowlands, etc. which are suitable habitats for the species.
1.16. Estimate the number of host plant species or suitable habitats in the PRA area (see question 6).		Grasslands, forests, wetlands, riverbanks/canal sides, rail/roadsides, woodland, grasslands, the edges of clearings, abandoned pastures, roadside verges, rubbish dumps and waste ground and urban areas are suitable habitats.
1.17. How widespread are the host plants or suitable habitats in the PRA area? (specify)		These habitats are very widely distributed in the EPPO region.
1.18. If an alternate host or another species is needed to complete the life cycle or for a critical stage of the life cycle such as transmission (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers), how likely is the pest to come in contact with such species?		No alternate host needed.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.19. How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the current area of distribution?		*H. mantegazzianum* is native in the mountainous areas of Caucasus (Jahodová *et al*., 2007). It is associated with areas with warm to hot wet summers and cool wet winters. It is not favoured by dried conditions. It is winter hardy down to –25°C. Seeds germinate in early spring (but not during summer) and require a period of cold stratification for breaking dormancy (less than 2 month). This makes the plant adapted to temperate climates, and not in the Mediterranean region.
1.20. How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the current area of distribution?		*H. mantegazzianum* grows at rich and slightly moist, neutral soils, in artificial and seminatural habitats
1.21. If protected cultivation is important in the PRA area, how often has the pest been recorded on crops in protected cultivation elsewhere?		
1.22. How likely is it that establishment will occur despite competition from existing species in the PRA area?		*H. mantegazzianum* is widely distributed in Europe. In amenity areas, established colonies compete strongly with, and rapidly replace most other plants except trees. Along riverbanks, it can almost totally replace the natural vegetation (Nielsen *et al*., 2005).
1.23. How likely is it that establishment will occur despite natural enemies already present in the PRA area?		*H. mantegazzianum* already established in the PRA area, and there is no record of natural enemies with any significant impact.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.24. To what extent is the managed environment in the PRA area favourable for establishment?		*H. mantegazzianum* is very often found in managed habitats, since it was planted as an ornamental plant.
1.25. How likely is it that existing pest management practice will fail to prevent establishment of the pest?		In managed habitats such as pastures and road sides, usual measure is cutting or regiular pasture managrment. This existing measure is usually insufficient since there is rapid re-growth from below ground, and it may encourgae the flowering of the plant (Holm, 2005) but largely can block the colonization of new sites.
1.26. Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the PRA area?		Seed longevity is expected to be 7 year (Andersen & Calov, 1996). Plant is sensitive to wide range of herbicides. Cutting and pasture is not sufficient to eradite the stands.
1.27. How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?		The flowers of *H. mantegazzianum* are insect-pollinated and self compatible. Reproduction is exclusively by seeds. The majority of seeds (98.2%) are distributed in the upper soil layer of 0-5 cm, with little in the deeper layers of 6-10 cm and 11-15 cm (Moravcová *et al*., 2007). Seeds may remain viable for up to 15 years when stored dry, but in the field this period is reduced to 7 years (Andersen & Calov, 1996).
1.28 How likely are relatively small populations to become established?		If the sites are managed correctly, than the establishment is relatively low. Regular management decreases probability of establisment of seedlings.
How adaptable is the pest?		No subspecies or pathotypes are reported, but the species appear in a wide range of habitats and climates. Hybrids with *H. sosnowskyi* and *H. persicum* are possible.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.30. How often has the pest been introduced into new areas outside its original area of distribution? (specify the instances, if possible)		It has been introduced several times from the native range. Within invaded range the first introductions were linked to botanical gardens and ornamental plant trade.
1.31. If establishment of the pest is very unlikely, how likely are transient populations to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) ?		The plant is established in the EPPO region.
Conclusion on the probability of establishment		The species is already established in the EPPO region, though it has been planted in these places. It is likely to enter new countries as a contaminant or ornamental plant trade, through seeds, which require cold temperatures for et least 2 months.
1.32. How likely is the pest to spread rapidly in the PRA area by natural means?		The plant does not reproduce vegetative , but seeds are dispersed locally near the mother plants and over long distances by watercourses and along roads and railroads
1.33. How likely is the pest to spread rapidly in the PRA area by human assistance?		Movement of the plant is linked to intentional spread and unintentional along roads and railroads. The seed can also be transported attached to clothes or animal fur (e.g. sheep and cattle) (Nielsen *et al*., 2005).
1.34. Based on biological characteristics, how likely is it that the pest will not be		Considering that the species only reproduce by seeds, and that seeds have a supposed longevity of 7 years (Andersen & Calov, 1996), it should be possible to contain the

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
contained within the PRA area?		species.
Conclusion on the probability of spread		Although the species could be contained if measures would be taken, the species has biological characteristics allowing both natural and human assisted spread, and has expanded its range in Europe.
2.1. How great a negative effect does the pest have on crop yield and/or quality to cultivated plants or on control costs within its current area of distribution?		There are no records of direct impact on crops. Significant costs are incurred by the measures taken to control the weed in amenities and other areas, as well as to turn the land back to agricultural area, particularly in Baltic countries (A. Garkaje, pers com., 2007). This management activity is also likely to increase soil erosion along stream banks where the plant occurs. In Latvia, the fungus *Sclerotinia sclerotiorum* has been observed on the plant. Farmers are making efforts to get ride of this fungus (A. Pence, pers com., 2006). Only in Latvia, the total cost of the 2006-2012 control program of this species is estimated 12 000 000 euros (Cabinet of Ministers Order No. 426), but it should be highlighted that the situation in this country is particular since the species has been planted over large areas in the past.
2.2. How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area without any control measures?		The plant has a negative impact in pastures due to its negative impact on human health. Cattles do not have problem with this plant.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.3. How easily can the pest be controlled in the PRA area without phytosanitary measures?		There are existing control measures (chemical and mechanical), though, they have to be applied with care, otherwise the species may re-grow. Another difficulty arises from the fact that the species grows in habitats which are not usually managed, such as fallow lands, natural and semi-natural habitats.
2.4. How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?		There are no records of direct impact on crops, but the plant is recorded to grow in pastures.
2.5. How great a reduction in consumer demand is the pest likely to cause in the PRA area?		Not relevant .
2.6. How important is environmental damage caused by the pest within its current area of distribution?		*Heracleum* mantegazzianum has a great negative impact on native vegetation (Hejda et al. 2009).
2.7. How important is the environmental damage likely to be in the PRA area (see note for question 2.6)?		In other countries than the ones where the species is already present, impact are expected to be the same as in areas already colonized.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.8. How important is social damage caused by the pest within its current area of distribution?		*H. mantegazzianum* contains photosensitizing furanocoumarins. In contact with the human skin and in combination with ultraviolet radiation, a phytotoxic reaction can occur 15 minutes after contact, with a sensitivity peak between 30 min and 2 hours causing burnings of the skin. After about 24 hours, flushing or reddening of the skin (erythema) and excessive accumulation of fluid in the skin (edema) appear, followed by an inflammatory reaction after three days. Approximately one week later a hyper-pigmentation (usually darkening the skin) occurs which can last for months. The affected skin may remain sensitive to ultraviolet for years. In addition, several furanocoumarins have been reported to cause cancer (carcinogenic) and to cause malformation in the growing embryo (teratogenic) (Nielsen *et al*., 2005). Moreover, dense infestations can seriously interfere with access to amenity areas, riverbanks, etc., and along roadsides, large stands can reduce visibility and result in road safety hazards.). Plantation schemes were eventually abandoned in the Baltic States, partly because the anise scented plants affected the flavour of meat and milk from the animals to which it was fed and partly because of the health risk to humans and cattle (Nielsen *et al*., 2005).
2.9. How important is the social damage likely to be in the PRA area?		In other countries than the ones where the species is already present, impact are expected to be the same as in areas already colonized.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.10. How likely is the presence of the pest in the PRA area to cause losses in export markets?		There are no interception records for this species.
As noted in the introduction to section 2, the evaluation of the following questions may not be necessary if the responses to question 2.2 is "major" or "massive" and the answer to 2.3 is "with much difficulty" or "impossible" or any of the responses to questions 2.4, 2.5, 2.7, 2.9 and 2.10 is “major" or "massive” or "very likely" or "certain". You may go directly to point 2.16 unless a detailed study of impacts is required or the answers given to these questions have a high level of uncertainty.		
Degree of uncertainty **Estimation of the probability of introduction of a pest and of its economic consequences involves many uncertainties. In particular, this estimation is an extrapolation from the situation where the pest occurs to the hypothetical situation in the PRA area. It is important to document**		

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
the areas of uncertainty (including identifying and prioritizing of additional data to be collected and research to be conducted) and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs. It should be noted that the assessment of the probability and consequences of environmental hazards of pests of uncultivated plants often involves greater uncertainty than for pests of cultivated plants. This is due to the lack of information, additional complexity associated with ecosystems, and variability associated with pests, hosts or habitats.		
Evaluate the probability of entry and indicate the elements which make entry most likely or those that make it least likely. Identify the pathways in order of risk and compare their importance in practice.		

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
Evaluate the probability of establishment, and indicate the elements which make establishment most likely or those that make it least likely. Specify which part of the PRA area presents the greatest risk of establishment.		
List the most important potential economic impacts, and estimate how likely they are to arise in the PRA area. Specify which part of the PRA area is economically most at risk.		The most important impact are on: - Human health - Erosion of river banks - Costs of management of the plant - Impact on biodiversity through competition with other species
The risk assessor should give an overall conclusion on the pest risk assessment and an opinion as to whether the pest or pathway assessed is an appropriate candidate for stage 3 of the PRA: the selection of risk management options, and an estimation of the associated pest risk.		The species represent a threat to human health, land and biodiversity is Baltic countries, where the plant has been largely planted. Voluntary introduction is unlikely, and the most likely entry pathways identified are not regulated (in the European Union). National management measures could be efficient measures as well.

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