Invasive Alien Species - Prioritising prevention efforts through horizon scanning

ENV.B.2/ETU/2014/0016

Final report

Dr Helen E. Roy
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DISCLAIMER

ACRONYMS

IAS – Invasive Alien Species

CBD – Convention on Biological Diversity

CEFAS – Centre for Environment, Fisheries & Aquaculture Science

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

ENSARS – European Non-native Species in Aquaculture Risk Assessment Scheme

EPPO – European and Mediterranean Plant Protection Organisation

EPPO DSS – EPPO Decision Support Scheme

EPPO PP – EPPO Prioritization Process

EPPO PRA – EPPO Pest Risk Analysis

EC – European Commission

EC-ASR – Council Regulation No. 708/2007 of 11 June 2007 concerning use of alien and locally-absent species in aquaculture

EFSA PLH for PRA – European Food Safety Authority Panel on Plant Health for Pest Risk Analysis

EU – European Union

FI-ISK – Freshwater Invertebrate Invasiveness Screening Kit

FISK – Fish Invasiveness Screening Kit

GABLIS – German-Austrian Black List Information System

GB NNRA – Great Britain Non-Native Risk Assessment

GISD – Global Invasive Species Database

GISS – Generic Impact-Scoring System

IEEP – Institute for European Environmental Policy

INBO – Research Institute for Nature and Forest

INRA – French National Institute for Agricultural Research

IPPC – International Plant Protection Convention

ISEIA – Invasive Species Environmental Impact Assessment Protocol

ISPM – International Standards for Phytosanitary Measures

ISSG – IUCN SSC Invasive Species Specialist Group

IUCN – International Union for Conservation of Nature

JRC – Joint Research Centre of the European Commission

MAES – Mapping and Assessment of Ecosystems and their Services

MS – Member State

MSFD – Marine Strategy Framework Directive

OIE – World Organisation for Animal Health

PRA – Pest Risk Analysis

RA – Risk assessment

WFD – Water Framework Directive

WoRMS – World Register of Marine Species

WRA – Weed Risk Assessment

WTO – World Trade Organisation

AUTHORS

Helen E. Roy - Centre for Ecology & Hydrology, UK

Project leader and Principal Scientist, leads zoological research within the UK Biological Records Centre (part of the Centre for Ecology & Hydrology). 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 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 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) and "Scientific workshop to complete selected invasive alien species (IAS) risk assessments" (ARES (2014) 2425342 - 22/07/2014). Helen led this project and contributed expertise on terrestrial invertebrate species.

Tim Adriaens – Research Institute for Nature and Forest, Belgium

Conservation ecologist at INBO, a Flemish government research institute. IAS expert at the Department of Management and Sustainable Use, research group on wildlife management. Coordinates IAS activities throughout the scientific community and provides support in relation to implementation of European IAS regulation in Belgium. Provide expertise and support to the government and the Agency for Nature and Forest with regards to invasive species management and biodiversity. Current invasion biology topics include control of invasive amphibians and exotic geese populations, invasive weeds and shrubs, ruddy duck and Pallas squirrel eradication, aquatic invasive species, exotic insects used for biological control, invasive species recording through citizen science, surveillance and early warning systems for IAS, among others. Performs and reviews risk assessments for selected IAS and involved in the development of the Harmonia+ protocol. Very active in the European-funded projects Invexo (www.invexo.eu), RINSE (www.rinse-europe.eu) on IAS management, research and policy. Contributed expertise on terrestrial vertebrates.

David Aldridge – Department of Zoology, University of Cambridge, UK

Head of the Zoology Department's Aquatic Ecology Group, with broad research interests in applied aquatic ecology and conservation. Two areas of particular interest are the prediction, ecology and control of IAS and the restoration of polluted freshwaters. Work involves extensive collaboration with the water industry, government agencies and NGOs and currently includes projects in four continents. David has taken the lead on a number of national and international projects to horizon-scan, risk-assess and prioritise existing and future freshwater invaders. David co-led the group for freshwater species in the horizon-scanning exercise for IAS likely to have an impact on biodiversity in the UK . He is also currently leading a project funded by the UK government to review the evidence base for the management of high-risk freshwater invaders. In this project, David was the lead for the freshwater fish and invertebrate group of experts.

Sven Bacher – University of Fribourg, Switzerland

Sven is head of the Biological Invasions research group at the University of Fribourg. He received his PhD in 1996 at the ETH Zurich and since then was leading research groups on agro-ecology, pest control, and invasive species at the universities of Bern and Fribourg. Sven participated in several European research projects, among others ALARM, DAISIE, PRATIQUE, and advises the national and international authorities on issues of biological invasions. His research focuses on invasion biology and risk analysis including management of pest organisms. He was instrumental in developing impact assessment protocols, e.g. the GISS and the IUCN EICAT schemes. Sven serves on the editorial board of Oecologia, Neobiota, and Journal of Applied Entomology. In this project, he was co-leading the group on terrestrial vertebrates.

John Bishop – Marine Biological Association of the UK, UK

Marine biologist with more than 30 years' research experience, leader of marine invasive species research group at the MBA. Extensive experience of surveys for non-native species (NNS) in artificial habitats in the UK, continental Europe and North America. Work-package co-leader for NNS components of FP6 Marine Genomics Europe network of excellence and Interreg IVA Channel/Manche 'Marinexus' project. Member of MBA team responsible for species factsheets and register entries for the marine component the GB Non-native Species Information Portal. Involved in running training workshops for NNS identification and biosecurity planning at marina and harbour sites. A main contributor to successive editions of the UK *Identification guide for selected marine non-native species.* In this project, he was co-leading the group on marine species.

Tim M. Blackburn – University College London, UK

Tim is currently Professor of Invasion Biology in the Centre for Biodiversity & Environment Research at UCL. He has more than 25 years experience of research into questions concerning the distribution, abundance and diversity of animal species. For the last 15 years, his research has primarily addressed questions relating to human-mediated biological invasions, using birds as a model taxon (see e.g. Blackburn *et al.* 2009, *Avian Invasions. The ecology and evolution of exotic birds*. OUP). He has recently developed a method to evaluate, compare and predict the impacts of different alien species, that can be applied to impacts that occur at different levels of ecological complexity, at different spatial and temporal scales, and assessed using a range of metrics and techniques. In this project, he contributed to the work on vertebrate species.

Etienne Branquart – Invasive Species Unit, Service Public de Wallonie, BE

Etienne coordinates preventive and control actions against IAS for the Walloon Government. He is currently involved as a national expert within the EPPO panel on invasive plants. Etienne formerly worked for the Belgian Biodiversity Platform for which he established the Belgian Forum on IAS 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 alien 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. In this project, he contributed to the group on plant species but also expertise on biogeographic regions and impact assessment methods.

Juliet Brodie – Natural History Museum, London, UK

Juliet Brodie is a research phycologist at the Natural History Museum, London, specializing in genomic approaches to macroalgae and microbiomes, seaweeds in a time of rapid environmental change and taxonomy, phylogenetics and conservation of algae. She is a leading authority on the Bangiales, a cosmopolitan order of red seaweeds including nori and laver. Current research also addresses the impact of ocean acidification on calcified red algae and the effects of climate change on large brown habitat-forming seaweeds. In this project, she contributed to the group on marine species.

Carles Carboneras – Royal Society for the Protection of Birds, UK

RSPB Nature Policy Officer – Invasive Non-native Species and BirdLife Europe coordinator of the Invasive Alien Species Programme. Co-leader of the subgroup on terrestrial vertebrates. With a background in Ecology and Law, he has 15 years' experience in biodiversity conservation. Carles is an expert ornithologist and the author of over 40 publications, including several family and 300+ species accounts for the Handbook of the Birds of the World. He leads on a BirdLife project to develop a Priority List of Invasive Alien Species in Europe, with contributions from experts and representatives of conservation organisations. He is a member of the IUCN-SSC Invasive Species Specialist Group and coordinator of the IAS working group of the European Habitats Forum. In this project, he was co-leading the group on vertebrate species.

Gordon H. Copp – Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK

Gordon has over 25 years' experience in the environmental biology of freshwater fishes, encompassing invasion biology, early fish development, fish life-history traits, and otter-fish interactions. Following a post-doctoral fellowship with the Freshwater Biological Association and ten years as Reader in Ichthyology at the University of Hertfordshire, Gordon joined Cefas in 2002 to lead research and development of risk analysis protocols for the assessment of risks and impacts posed by non-native species, in particular freshwater fishes. As part of his R&D work on IAS and risk analysis, Gordon provides specialist advice to UK Defra well as other national and international organisations on various aspects of aquatic biological invasions (including the EC, CABI-International, ICES Working Group on Introductions and Transfers of Marine Organisms, UK-TAG Alien Species Group for Water Framework Directive implementation). In this project, he contributed to the group on freshwater fish and invertebrate species.

Elizabeth J. Cook – Scottish Association for Marine Science (SAMS), Scotland, UK

Senior Lecturer at SAMS, University of the Highlands and Islands, specializing in marine invasive species and Head of the SAMS-United Nations University Associate Institute. Elizabeth contributed to the marine species group in the UK horizon-scanning exercise for IAS likely to have an impact on biodiversity (published in Roy et al., 2014). She has over 14 years of research experience on the ecology of marine species, with particular interest drivers of invasive species introduction. She has published over 50 publications (> 45 in journals of the Science Citation Index), has led a number of research projects and activities (including Marine Aliens I & II), has supervised 6 completed Ph.D. theses, and is currently a handling editor for the journal Aquatic Invasions. Elizabeth is also an editor for AquaNIS, an on-line information system for brackish and marine non-indigenous environments in Europe. In this project, she was a member of the group on marine species.

Hannah Dean – Centre for Ecology & Hydrology, UK

Hannah is a data management and informatics specialist with over 10 years experience of both data and project management. Hannah works with a wide variety of complex biodiversity and ecological datasets with her main focus on improving the accuracy and efficiency of data capture and storage. Hannah also works with the Environmental Information Data Centre where she provides support and guidance to scientists who want to make their data publicly accessible. Combining her data and project management skills, Hannah supports a wide variety of project and was involved in the recently completed "Invasive alien species – framework for the identification of invasive alien species of EU concern" (ENV.B.2/ETU/2013/0026). In this project, she has provided project and data management support.

Jørgen Eilenberg – University of Copenhagen, Denmark

Professor in insect pathology and biological control, member of the sub-team on terrestrial invertebrates. He has more than 30 years of experience with insect pests and their diseases, as well as biological control of pests and he has published > 100 papers or book chapters. He is leading the research group 'Insect Pathology and Biological Control' and has been supervisor for > 40 PhD or MSc students. Jørgen has led several national and international programmes. He was 2012-2014 president for Society of Invertebrate Pathology. He is teaching at both BSc, MSc and PhD level subjects like biodiversity, biological control and human benefits from insects. At department he is PhD coordinator and he was 2010-2013 head of Section of Organismal Biology (SOBI). He is 2013-2015 expert member of a working group to advise the EU commission about 'low risk substances'. In this project, he contributed to the group on terrestrial invertebrate species.

Franz Essl – Environment Agency Austria, Austria

Ecologist, with a broad interest in botany, biogeography and (macro-)ecology at the Dept. of Biodiversity and Nature Conservation, EAA. Co-Task leader and co-leader of the sub-team on plants. Current work is focusing on non-native species, climate change, conservation biogeography, biodiversity indicators and monitoring. Currently working on a systematic review of the evidence of non-native species and their human health impacts. Co-developer of the German-Austrian Black List Information System (GABLIS). Providing support to the government in relation to the implementation of the EU IAS regulation. Half-time Assistant Professor position at the University of Vienna. More than 200 scientific papers or book chapters. In this project, he was co-leading the group on plant species.

Philip E. Hulme, Lincoln University, New Zealand

Professor of Plant Biosecurity, Bio-Protection Research Centre, Lincoln University New Zealand. Co-leader of the sub-team on plants. He has been recognised by Thomson-Reuters as a highly cited researcher and is a Fellow of the Royal Society of New Zealand. He has 25 years of research experience addressing biological invasions and biosecurity with a strong focus on understanding the ecology of invasions by introduced plant species, assessing the subsequent consequences for natural and managed ecosystems and developing tools to help prevention or management. He has led a number of high profile European programmes on biological invasions e.g. EPIDEMIE, DAISIE, ALARM. In New Zealand, he leads the biological invasion theme in the Bio-Protection National Centre of Research Excellence and the biological risk and threat programme of the Biological Heritage National Science Challenge. He has published over 150 ISI listed publications as well as a similar number of conference proceedings and book chapters. In this project, he contributed to the group on plant species.

Belinda Gallardo – Pyrenean Institute of Ecology (IPE-CSIC), Spain

Aquatic invasive species specialist with five years' experience on the use of ecological modelling to screen for new IAS, and risk assess their likelihood of arrival, spread, and impact, with particular regard to climate change-invasive species potential interactions. With over 15 peer review publications on invasive species, she has participated and leaded projects dealing with IAS for several European countries (Great Britain, France, Belgium, Netherlands and Spain), she is currently leading several projects on the interplay between climate change and invasive species, and actively participates in the COST Action Alien Challenge (TD1209). She has also contributed to the development of key EU documents to support the prevention and management of IAS including "Scientific workshop to complete selected invasive alien species (IAS) risk assessments" (ARES(2014)2425342 - 22/07/2014). She participated in the Freshwater Invertebrates sub-group of experts screening and evaluating new potential IAS in Europe. In this project, she contributed to the group on freshwater fish and invertebrate species.

Mariana Garcia - IUCN

Mariana Garcia is Biodiversity Conservation Assistant at IUCN European Regional Office, and is part of the Global Species Programme. She holds a BSc Environmental Science from the University of Extremadura, Spain and an MSc Biodiversity Conservation from Bournemouth University, UK. Mariana has experience in different environmental fields, having worked at an environment consultancy, as a researcher whilst at University, and as a Conservation Technician at the Spanish National Research Council (Royal Botanical Gardens, Madrid). She has also participated in several volunteering projects. Prior to her current position, she completed a six-month internship at the IUCN. Her work focuses on assessing species' extinction risk, as part of the IUCN Red List of Threatened Species, and other biodiversity conservation oriented projects. In this project, she co-led Task 4.

Emili García-Berthou - University of Girona, Spain

Professor of Ecology at the Institute of Aquatic Ecology, University of Girona. He has 25 years of research experience on the ecology of freshwater fish, with emphasis on understanding the drivers of decline of native species and the effects of invasive species. He has published over 150 publications (> 85 in journals of the *Science Citation Index*), has led a number of research projects and activities (including http://invasiber.org), has supervised 10 completed Ph.D. theses, and is currently member of the editorial boards of the journals *Biological Invasions*, *Ecosphere*, *Neobiota,* and *Neotropical Ichthyology.* In this project, he was co-leading the group on freshwater fish and invertebrate species.

Piero Genovesi - ISPRA, and Chair IUCN SSC Invasive Species Specialist Group, Italy

Senior Scientist and Head of Wildlife Service with ISPRA, chairs the IUCN SSC Invasive Species Specialist Group. Works in close collaboration with main international institutions, such as the Convention on Biological Diversity, the Bern Convention, the European Environment Agency, and the Convention on Migratory Species. Active member of the Liaison Group on Invasive Alien Species of the Convention on Biological Diversity. Founding member of the Steering Committee of the GIASIPartnership, launched by the Convention on Biological Diversity. Member of the Steering Committee of the Species Survival Commission of IUCN. Partner of the DAISIE program. Acted as Coordinator of the European Environmental Agency programme "Towards an early warning and information system for invasive alien species (IAS) threatening biodiversity in Europe". Collaborated to several projects on IAS funded by the European Commission. In this project, he was contributed expertise on terrestrial vertebrates.

Marc Kenis – CABI, Switzerland

Marc is a senior researcher with 27 years' experience in applied and environmental entomology. He leads the Risk Analysis and Invasion Ecology Section at the CABI Switzerland Centre, and is specialist in insect invasion, including risk analysis, impact assessment, biological control and integrated management. He is also leader of the COST Action ALIEN CHALLENGE Working Group 3 on impact assessment and is/was partner of many other international research projects and networks on insect invasions, including the EU-FP projects ALARM, PRATIQUE, BACCARA, ISEFOR and DROPSA and the Cost Action PERMIT. Marc is also coordinator of the IUFRO Working Party 7.03.13 "Biological Control of Forest Pests and Pathogens" and member of the Scientific Committee of the Swiss Biological Records Center. He is the author of more than 120 scientific publications and member of the editorial board of 2 journals, "Entomologia" and "Journal of Insects as Food and Feed". In this project, he contributed expertise on terrestrial invertebrate species.

Francis Kerckhof – Royal Belgian Institute of Natural Sciences (RBINS) - Operational Directorate Natural Environment, Belgium

Francis is senior Researcher at the RBINS. He is an expert in marine and coastal biodiversity with a long lasting expertise in introduced species that resulted in many publications. He is the Belgian representative of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) and the ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) and he actively contributed to several international projects such as the European funded Daisie project (Delivering Alien Invasive Species Inventories for Europe). He has a broad taxonomic invertebrate expertise and contributed to the Marine Group.

Marianne Kettunen – Institute for European Environmental Policy (IEEP) London / Brussels

Marianne 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 this project she provided guidance on ecosystem services.

Dan Minchin – Marine Organism Investigations, Killaloe, Ireland and Marine Science and Technology Centre, Klaipeda University, Lithuania.

Aquatic invasive species specialist with an interest in pathway processes with 200 published accounts over two millennia. Practical knowledge of ships' ballast water and hull fouling. Developed risk assessment and monitoring for current and expected non-indigenous species for Ireland under MSFD requirements. Currently studying the invasive dynamics of non-indigenous freshwater biota and undertaking rapid assessment surveys in brackish and marine ecosystems. A developer of the AquaNIS on-line information system for brackish and marine non-indigenous environments in Europe. A member of the IUCN Invasive Specialist Species Group and Horizon Scanning Marine Group. In this project, he contributed expertise on marine species.

Wolfgang Nentwig – University of Bern, Switzerland

Professor of Ecology at the Institute of Ecology and Evolution, University of Bern, Switzerland with broad interest in agricultural landscapes, ecology and non-target-effects of transgenic plants, ecology of spiders, and alien and invasive species. Member of the sub-team on terrestrial invertebrates. Involved in a variety of projects on the biological control of pests and weeds, contributions to the European projects Giant Alien, ALARM, and the establishment of the European database DAISIE, including risk and impact assessments as the Generic Impact Scoring System. Author or contributor to more than 20 books, 25 book chapters and 200 ISI journal publications. In this project, he contributed expertise on terrestrial invertebrate species.

Ana Nieto - IUCN

Ana Nieto is European Biodiversity Conservation Officer at IUCN European Regional Office. Ana has outstanding, demonstrated project management skills acquired during her twelve years of professional experience coordinating and managing complex international projects. At IUCN, she is part of the Global Species Programme and is responsible for the development, coordination, and implementation of biodiversity projects, including, the European Red Lists for Species, and Habitat Types and invasive alien species. She has significant experience in monitoring and assessing species status and trends and is a certified IUCN Red List Trainer, competent in the application of the IUCN Categories and Criteria at the global and regional levels. She is also responsible for the development and management of projects and programmes, and the identification of sources of funding. Ana stays abreast of relevant European policy in order to inform the development and direction of IUCN work, and likewise, to enable best use of IUCN science and knowledge in guiding European policy. Ana provides the Secretariat function to the European Habitats Forum and coordinates the IUCN engagement with the NGO community in Brussels, by promoting coordinated action and information exchange for the implementation and future development of EU biodiversity policy, and integration into sectoral policies. Before IUCN, Ana worked as Project Manager for ECNC-European Centre for Nature Conservation (the Netherlands) and did an internship at EUCC-the Coastal Union (the Netherlands). Ana holds a Master Degree in Environmental Science/Environmental Management. In this project she co-led Task 4.

Jan Pergl – Department of Invasion Ecology, Institute of Botany, The Czech Academy of Sciences, Czech Republic

His research focusses on the population biology of invasive plants, with interest in modelling techniques, application of GIS and analysis of large datasets. Currently he is a project coordinator of research project "Naturalization of garden plants as a result of interplay of species traits, propagule pressure and residence time" and participate on COST project - European Information System for Alien Species. In the past he worked as a post-doc at University of Bern, Switzerland on a project that updated and analysed DAISIE database (ALIEN; Analysing Large-scale Invasion patterns using European Inventories - Update and Analysis of European Database of Alien Species

2010-2011). He is employed at Department of Invasion Ecology at the Institute of Botany and participated in several EU projects (ALARM, PRATIQUE, DAISIE and GIANT ALIEN), where he was involved in data management and handling the Czech plant database, as well as in population biology studies (mainly on giant hogweed Heracleum mantegazzianum). He closely cooperate with the Ministry of the Environment of the Czech Republic in the field of biological invasions. In this project, he contributed expertise on plant species.

Oliver Pescott – Centre for Ecology & Hydrology, UK

Oliver is a research associate botanist at CEH Wallingford. He has experience in the areas of vascular plant and bryophyte monitoring, and has a strong interest in ecological statistics. He is currently the CEH lead for the National Plant Monitoring Scheme, a volunteer-based project collaborating with the biological recording sector to produce regularly updateable vascular plant trends for semi-natural habitats in the UK. Oliver also works on a range of projects in the general area of using biological records to gain insight into ecological change, including the creation of novel Bayesian methods that allow different types of information on species' abundances and distributions at different scales to be combined into a framework for predicting abundances across unsurveyed sites. He is also an active plant and bryophyte recorder with a particular interest in grasses alien to the UK. In this project, he contributed to botanical expertise.

Jodey Peyton – Centre for Ecology & Hydrology, UK

Botanist and scheme coordinator based in Wallingford. My current role requires expertise in ecological survey design and coordination of field work for a variety of projects. Works on projects with multiple government agencies as well as with private industry partners. Contributed to the GB Horizon Scanning (Roy et al., 2014). In this project, she contributed to organisation and facilitation of the workshop alongside data compilation.

Cristina Preda – Ovidius University of Constanta, Romania

Postdoctoral researcher with a keen interest in invasion biology and nature conservation, currently teaching at the Faculty of Natural and Agricultural Sciences (Ovidius University of Constanta). She conducted research on invertebrates in protected and urban areas and has expertise in monitoring and impact assessment of IAS. Cristina has contributed to several national projects related to invasive species in the south-eastern part of Europe, held a one-year postdoctoral grant at the University of Fribourg (Switzerland) and is currently involved in COST Actions focused on invasive species (ALIEN Challenge TD1209, SMARTER FA1203). Her current research interests involve predicting the impact of IAS on the environment and aspects related to IAS and human health. In this project, she contributed expertise on terrestrial invertebrate species.

Wolfgang Rabitsch – Environment Agency Austria, Austria

Entomologist, with a broad interest in zoology and ecology at the Dept. of Biodiversity and Nature Conservation, EAA. Co-Task leader and member of the sub-team on terrestrial invertebrates. Most of the current work is situated in the science-policy-interface, focusing on non-native species, climate change, conservation biogeography, biodiversity indicators and monitoring, national ("Biodiversity Strategy Austria 2020+"), EU and CBD nature conservation policies and reporting obligations. Currently working on a systematic review of the evidence of non-native species and their human health impacts. Co-developer of the German-Austrian Black List Information System (GABLIS). Providing support to the government in relation to the implementation of the EU IAS regulation. Particularly fond of true bugs (Heteroptera). Lecturer at the University of Vienna. President and Vice-President of the Austrian Society for Entomofaunistics and the Austrian Entomological Society, respectively. More than 200 scientific papers or book chapters. In this project, he contributed expertise on terrestrial invertebrate species but also led task 1 and contributed considerably to all tasks.

Alain Roques - Institut National de la Recherche Agronomique, France

Forest entomologist with 35 years of experience on the biology, ecology and behaviour of forest insects. During the last 10 years, his research activity turned towards biological invasions and the effect of global warming on the spatial expansion of terrestrial invertebrates. He participated in most of the recent EU-funded projects dealing with biological invasions, and coordinated the inventory of alien terrestrial invertebrates in Europe realized in the DAISIE project. He was the main editor of the book 'Alien terrestrial arthropods of Europe', published in 2010, which provided the first comprehensive review of the fauna of alien terrestrial arthropods having colonized the European continent and its associated islands. The book summarizes the present knowledge of the arthropod invasion process from temporal trends and biogeographic patterns to pathways and vectors, invaded habitats, and ecological and economic impacts. He published more than 150 peer-reviewed papers, 20 books and book chapters. In this project, he contributed expertise on terrestrial invertebrate species.

Steph Rorke – Centre for Ecology & Hydrology, UK

Steph is a database specialist with 10 years of experience in the public and private sectors, she has spent the last 7 years at CEH working as a Biodiversity Database Manager for the Biological Records Centre (part of the Centre for Ecology & Hydrology) whose database holds over 15 million records of more than 12000 species. Steph's work focuses on the dataflow management of datasets from volunteer schemes and societies and the servicing of data requests (data extraction, map production and data analysis) of colleagues to support research and the volunteer community. Steph also lead the dataflow management of the GB Non-Native Species Information Portal which provides information to underpin IAS strategy. In this project Steph led the management of information flow.

Riccardo Scalera - programme officer of the IUCN/SSC Invasive Species Specialist Group (ISSG), Italy

Zoologist with experience in the field of conservation biology, wildlife management and European policy and legislation on nature protection and relevant financial programmes. He has been working 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) and the national level (e.g. in Italy and Denmark). In relation to the IAS issue, he has been actively contributing to the development of key EU policy documents, among which the recently completed "Invasive alien species – framework for the identification of invasive alien species of EU concern" (ENV.B.2/ETU/2013/0026) and "Scientific workshop to complete selected invasive alien species (IAS) risk assessments" (ARES (2014) 2425342 - 22/07/2014). In this project, he was co-leader of Task 5 and co-leader of the group for vertebrates.

Stefan Schindler – Environment Agency Austria, Austria

Ecologist and senior expert at the Dept. of Biodiversity and Nature Conservation, EAA. Task leader Task 2. Most of the current work is situated at the science-policy-interface, focusing on non-native species; conservation biology; biodiversity indicators; landscape and biodiversity pattern; agro-, grassland and forest ecology and management; ecology, population biology and conservation of birds of prey; global change biology as well as national, EU and CBD nature conservation policy and reporting obligations. Currently leading a systematic review of the evidence of impacts of non-native species on human health. Lecturer and research associate at the University of Vienna. Author of more than 40 scientific papers or book chapters. In this project, he mainly contributed to Task 2 (Inventory and review of appropriate data sources).

Karsten Schönrogge – Centre for Ecology & Hydrology, UK

Principal Scientist, co-leader of Task 3 and member of the sub-team on terrestrial invertebrates with a particular interest in tree herbivore species and invasive social insects, particularly ants. He has led studies on the direct and indirect interactions of alien herbivores with related native species via shared natural enemies and worked in this areas for 25 years publishing >85 papers. Karsten is acting editor and associate editor of Insect Conservation and Diversity and Proceedings of the Royal Society B respectively. His current interest is in tree health including introduced pests and pathogens where he is co-PI on the UK funded project: Promoting resilience of UK tree species to novel pests and pathogens (BBSRC: BB/L012243/1). He is also supervising studies on the invasion of Europe by the chestnut gallwasp, *Dryocosmus kuriphilus*, and the biocontrol agent *Torymus sinensis*. In this project, he contributed expertise on terrestrial invertebrate species but also led task 3 and contributed considerably to other tasks.

Wojciech Solarz – Institute of Nature Conservation, Polish Academy of Sciences, Poland

His main research themes include theoretical aspects of biological invasions and practical solutions to mitigate their impacts. He was involved in a number of national and international scientific projects, including the Delivering Alien Invasive Species Inventories for Europe (DAISIE), Assessing LArge scale Risks for biodiversity with tested Methods (ALARM) and ParrotNet. He was also involved in development of national and international laws, strategies and codes of conduct on alien species and he is the manager of Alien Species in Poland portal. He is also a member of the State Council for Nature Conservation, responsible for biological invasion issues. As a delegate of the Ministry of Environment, he was also involved in the alien species-related work of the European Commission, Convention on Biological Diversity, Bern Convention and International Plant Protection Convention. In this project, he contributed expertise on vertebrate species.

Alan Stewart – University of Sussex, UK

Senior Lecturer in Ecology, specialising in invasive species, insect-plant interactions, insect community and restoration ecology, and insect conservation, with a specialist interest in the Auchenorrhyncha (Hemiptera). Co-leader of Task 3 (developing a horizon scanning method for IAS of EU concern) and co-leader of the sub-team for terrestrial invertebrates. Alan co-led the group for terrestrial invertebrates in the horizon scanning exercise for IAS likely to have an impact on biodiversity in the UK (published in Roy *et al*., 2014). He contributed to the recent project "Invasive alien species – framework for the identification of invasive alien species of EU concern"

(ENV.B.2/ETU/2013/0026), as well as a recent horizon scanning workshop for "enhancing understanding of invasive alien pathogens" within COST Action TD1209. Currently supervising a project on the impact of an invasive non-native insect (the planthopper *Prokelisia marginata*) on an invasive non-native plant (*Spartina* spp.) and its associated invertebrate community in Britain. Editor of *Insect Conservation & Diversity*; Honorary Fellow of the Royal Entomological Society.

Elena Tricarico - University of Florence, Italy

Post-doctoral zoologist in Florence, working on biological invasions, mainly in freshwater ecosystems, through different perspectives, from behavioural ecology to management aspects. She participated to several national and European projects (such as DAISIE, IMPASSE) on alien species, and she is involved in the COST Action TD1209 (Alien Challenge). She is currently working in LIFE projects (RARITY, SOS TUSCAN WETLANDS) for controlling alien crayfish. Particularly interested in distribution models (also in relation to climate change), in risk assessment protocols (she adapted the FISK protocol to invertebrates together with G. H. Copp), and in evaluating the multilevel impacts of invasive species, including the pathogens/diseases they transmit to native species and humans. More than 70 scientific papers/book chapters/book. In this project, she contributed expertise on freshwater invertebrate and fish species.

Sonia Vanderhoeven - Belgian Biodiversity Platform - SPW DEMNA, Belgium

Sonia Vanderhoeven is Science Officer at the Belgian Biodiversity Platform, Service Public de Wallonie – DEMNA. Plant biologist specialized in evolutionary ecology, Sonia is the coordinator of the Belgian Forum on Invasive Species. Sonia has been involved in research projects dedicated to assess the impacts of IAS on ecosystem properties and the evolutionary potential of exotic plant species. Working at the science-policy interface, she is now involved in the development and implementation of risk analysis protocols, reports and horizon scanning exercises. In the Belgian Biodiversity Platform, she has contributed to the development of the ISEIA and Harmonia+ protocols in order to assess the impacts of exotic species in the Belgian territory. She is the national manager of the Harmonia database that integrates scientific information on distribution, ecology and impacts of invasive alien species in Belgium. The consequent national species lists inspire the development of different policies related to IAS, including a code of conduct on ornamental plant species and different regulatory tools. Sonia is member of the management committee of the newly formed COST Action Alien Challenge (TD1209) which has been implemented to link and analyse information on IAS across Europe, and she is the Belgian representative in NOBANIS, the European network on Invasive Alien Species. In this project, she contributed expertise on plant species.

Gerard van der Velde – Institute for Water and Wetland Research (IWWR), The Netherlands

Associate Professor at Radboud University Nijmegen, Department of Animal Ecology & Ecophysiology (IWWR), Visiting professor Vrije Universiteit Brussel, and guest collaborator of Naturalis Biodiversity Center, Leiden. He is a member of the Netherlands Centre of Expertise for Exotic Species (NEC-E), Nijmegen. He worked since 1974 in the area of Aquatic Ecology publishing on invasive species since 1975. He was involved in the programme Ecological Rehabilitation of the River Rhine (Rhine Action Program). He was in the organization of the International Conference of Aquatic Invasive Species (ICAIS) for years and in the editorial boards of several journals on which Biological Invasions and Aquatic Invasions. He published more than 380 publications in English (244 in the Science Citation Index), edited some books such as

'The Zebra Mussel in Europe' and was (co)promoter of 30 PhD theses. His study field was macrophytes, macroinvertebrates and fish and their relations in freshwater, brackish water and marine systems worldwide. He is retired for three years but is still active as guest collaborator of above mentioned organizations. He participated as expert in the freshwater invertebrate and fish species group.

Montserrat Vilà - Estación Biológica de Doñana (EBD-CSIC), Spain

Deputy Director at EBD, co-leader for the plant sub-group of experts. Main areas of interest are the ecological factors influencing the success of non-native plant species, and their impacts on biodiversity and ecosystem services. She has participated in several European projects dealing with IAS (EPIDEMIE, DAISIE, ALARM, STEP). Author of more than 130 ISI papers and 30 book chapters, she has been in 2014 among the top 1% researchers for most cited documents in the Ecology/Environment field. She has also edited 4 books on conservation and written more than 30 papers for the general public. She is President of NEOBIOTA and member of the IUCN SSC Invasive Species Specialist Group. In this project, she co-led the plant species group.

Christine Wood – Marine Biological Association of the UK, UK

Marine ecologist, a member of a marine invasive species research group at the MBA, with a particular interest in sessile fauna. She has twelve years' experience in carrying out rapid assessment surveys for and collecting IAS in artificial habitats in the UK, France and South America. She is a contributor of species factsheets and register entries to the GB Non-Native Species Information Portal. She has published several papers and reports on IAS and is involved in training for IAS identification and biosecurity. She was a main contributor to the 2014 edition of the UK *Identification guide for selected marine non-native species.* She is currently studying the growth and reproduction of the invasive bryozoan *Schizoporella japonica,* and planning further IAS surveys. In this project, she contributed expertise on marine species.

Argyro Zenetos - Hellenic Centre for Marine Research (HCMR), Greece

Argyro is currently a Research Director at the Institute of Biological Resources and Inland Waters at 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. However, her main area of research is the Saronikos Gulf (which has been monitored for over 25 years) and the development of its benthic ecosystem. She is the co-ordinator of the Hellenic network on Aquatic Invasive Species (ELNAIS) http://elnais.hcmr.gr. She is 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 May 2014 under EEA contracts. Consultant to EEA and UNEP/MAP MEDPOL, UNEP/MAP on indicators for pollution under WFD and MSFD including Non Indigenous Species. Consultant to JRC for Quality Control of EASIN and to UNEP MAP RAC/SPA for development of MAMIAS (a Mediterranean database). In this project, she co-led the marine species group.

OTHER CONTRIBUTORS

Ana Cristina Cardoso - European Commission, Joint Research Centre

Science officer, Expertise: Freshwater (lakes) and marine ecological assessments, alien species, eutrophication, implementation of European policy for water (including marine), biodiversity and sectors (e.g. drinking water, nitrate, urban waste water)

#papers: 54, H-Index:13, #citations: 554, Member of the advisory board of REABIC (Regional Euro-Asian Biological Invasions Centre) Journals, member of several groups giving support to the European policy implementation (e.g. the Marine Strategy WG GES (Good environmental Status), the Biodiversity Strategy WG MAES (Mapping and Assessment of Ecosystem Services). Scientific project manager of SEACOAST (Monitoring, modelling and assessment of environmental status and biodiversity of marine and coastal waters) and EASIN (European Alien species Information Network). Contributes to several relevant European research projects, e.g. DEVOTES, MARS. Work Group leader and member of the management committee of the COST Action Alien Challenge (TD1209). Her scientific interests span from biological invasion, to aquatic ecosystems eutrophication, to development of ecological quality indicators and the role of alien species in altering aquatic ecosystems.

Eugenio Gervasini - European Commission, Joint Research Centre

Science officer, Expertise: Phytopathology, Entomology, Agronomy, Integrated Pest Management, surveillance plans on crop harmful organisms, contingency plans, biological control, alien species, implementation of European policy on plant health, food safety, and on invasive alien species.

Coordinator of the EASIN Editorial Board. His scientific interests include sustainable agriculture, reduction of the agricultural impact on the environment, forestry, and biological invasion.

ABSTRACT

The European Union Regulation (EU) 1143/2014 on invasive alien species (IAS) establishes an EU-wide framework for action to prevent, minimise and mitigate the adverse impacts of IAS on biodiversity and centres around the development of a list of IAS of EU Concern. The initial list of IAS of EU concern will be based on available risk assessments compliant with agreed minimum standards but horizon scanning is seen as critical to inform future updating of the list, in order to prioritise the most threatening new and emerging IAS.

A workshop was held with the overarching aim of reviewing and validating an approach to horizon scanning to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on biodiversity or related ecosystem services in the EU over the next decade.

The agreed horizon scanning approach involved two distinct phases:

i) Preliminary consultation between experts within five thematic groups to derive initial scores;

ii) Consensus-building across expert groups including extensive discussion on species rankings coupled with review and moderation of scores across groups.

The outcome of the horizon scanning was a list of 95 species, including all taxa (except microorganisms) within marine, terrestrial and freshwater environments, considered as very high or high priority for risk assessment.

RESUME

Le Règlement de l'Union Européenne (UE) 1143/2014 sur les espèces notices envahissantes (EEE) établit un cadre d'actions à l'échelle européenne pour prévenir, réduire au minimum et atténuer les impacts négatifs des EEE sur la biodiversité, et se concentre sur le développement d'une liste d'EEE de préoccupation européenne. La liste initiale d'EEE de préoccupation européenne est basée sur les analyses de risque disponibles conformes aux standards minimums reconnus. Mais l'horizon scanning est essentiel pour informer les mises à jour futures de la liste, dans le but de prioritiser les EEE nouvelles et émergentes les plus menaçantes.

Un workshop a été organisé avec pour but général d'évaluer et de valider une approche d'horizon scanning en vue de produire une liste ordonnée d'EEE susceptibles d'arriver, de s'établir, de se disperser et de présenter un impact sur la biodiversité et les services écosystémiques associés dans l'UE durant la prochaine décennie.

L'approche d'horizon scanning avalisée comprenait deux phases distinctes:

i) Une consultation préliminaire entre experts au sein de cinq groups thématiques pour produire des scores initiaux

ii) L'établissement de consensus au travers des groups d'experts incluant une discussion approfondie sur les classements des espèces, combinée à une évaluation et une modération des scores entre groupes.

Le résultat de l'horizon scanning consistait en une liste de 95 espèces, comprenant tous les types taxonomies (excepté des microorganismes) au sein des environnements marins, terrestres et d'eau douce, et considérées comme étant de priorité très élevée à élevée pour la réalisation d'analyses de risque.

EXECUTIVE SUMMARY

The recently published European Union Regulation (EU) 1143/2014 on invasive alien species (IAS) sets out rules to effectively tackle the problems linked to IAS, seeking to prevent the entry of IAS, to set up a system of early warning and rapid response, to ensure a prompt eradication of localized IAS and to more efficiently manage the IAS that have established and spread.

In order to guarantee harmonised and prioritised action at EU level, the Regulation focuses on a list of IAS of EU concern. Currently, work is on-going between the European Commission (EC) Directorate-General (DG) for the Environment and representatives from Member States on the IAS Committee to develop this list, which should be finalised by January 2016.

The initial list of IAS of EU concern will be based on available risk assessments compliant with the minimum standards but an approach is required to inform future updating of the list, in order to prioritise the most threatening new and emerging IAS. In this context, horizon-scanning is seen as essential in order to prioritise the threat posed by potentially new IAS which are not yet established within the EU.

For this purpose a workshop was held with the overarching aim of reviewing and validating an approach to horizon scanning to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on native biodiversity or associated ecosystem services in the EU over the next decade. Before the workshop a number of species were identified from across five thematic groups (namely Plants, Vertebrates, Terrestrial invertebrates, Marine species, and Freshwater invertebrates and fish).

The relevant lists were compiled into one spreadsheet to enable the participants to view the longlist of the 250 species considered. During the workshop between 20 and 30 species from each thematic group were shortlisted to produce a list of 127 species. The end result was a ranked list of IAS derived through discussion and broad consensus that were considered to represent a very high or high risk of arrival, establishment, spread and impact on biodiversity and ecosystem services and so should be prioritised for risk assessment. In particular 27 species were considered to be very high priority, 68 were considered to be high priority and a further 21 were considered to be medium priority for risk assessment. It should be noted that 4 further species were ranked as high priority but these already had risk assessments compliant with minimum standards. All the rest derived from the initial long list were considered as low risk.

The project involved 5 inter-linked tasks.

Task 1: Inventory and review of existing horizon scanning methodologies

A number of approaches have been used for horizon scanning of IAS, some of which have involved discrete taxonomic groups or distinct environments. Most of these approaches have not been consensual; they have relied on information from the literature coupled with expert opinion and have used risk assessment frameworks or modelling approaches. However, often knowledge gaps and high levels of uncertainty can limit the outcome of such approaches. Other methods, including consensus approaches, have been used to overcome such limitations. A consensus approach is a useful tool for prioritisation in conservation because informal expert opinion underpins most conservation decisions.

Consensus approaches involve a structured process whereby a systematic examination of potential threats is conducted through literature reviews and expert opinion, followed by discussions that aim to converge on consensus within the expert stakeholder group. It is particularly important to clearly define the scope of a horizon-scanning exercise. There are considerable strengths to this method, particularly when information is lacking, but it is important to acknowledge the weakness that opinion is not knowledge. Although based on scientific evidence, the outcome of horizon-scanning is not always predictable or repeatable. A different composition of experts may produce different results. Indicating the level of uncertainty of the assessments is therefore considered crucial in communicating the outcome of the exercise to a wider scientific or public audience. However, consensus approaches can reduce the levels of uncertainty that are inherent when dealing with data deficiency (insufficient information on species) through face-to-face collaborative discussions combining knowledge and opinions across experts.

Task 2: Inventory and review of appropriate data sources

Major sources of information on alien species are contained within databases developed at either the country or regional level by governments or other specialist organizations and networks who compile and manage alien species data and information with differing taxonomic, environmental and geographic focus. The most well-known and widely used in Europe are those developed within the EU funded project "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, www.europe-aliens.org) covering 12,000 species for the whole of Europe (79 countries/regions including islands and 57 coastal and marine areas) and the "European Network on Invasive Alien Species" (NOBANIS, http://www.nobanis.org/) covering 9,000 species for 20 countries in Northern and Central Europe. These two databases cover all taxonomic groups and all environments (i.e. terrestrial, freshwater, and marine environment), but other databases exist that are restricted to a particular taxonomic and/or environmental focus. The "European Alien Species Information Network" (EASIN, http://easin.jrc.ec.europa.eu/) is a recent initiative of the Joint Research Centre of the European Commission that aims to facilitate the access to data and information on alien species in Europe from 43 existing on-line databases.

In a recent synthesis of existing alien species databases at a global level, 238 databases were identified, ranging from sub-national (islands, federal states) to global geographical coverage (Essl et al. 2015). In total, 196 of these were live and accessible through the internet. While 16 of the 196 databases had a global coverage, 78 databases focused solely on North America, 75 on Europe and 15 on Australia (including Oceania). Almost half of the 196 databases, assessed pathways and 27% categorized pathways into intentional and unintentional introduction, but only 9% provided documentation to assist with interpretation of pathway information manual and 3% assessed trends in pathways (Essl et al. 2015). 160 databases covered plants, 93 covered invertebrates, 82 covered fish, 70 covered fungi, 68 covered microbes, and 61 covered algae.

For the purpose of the horizon scanning for IAS that have not yet arrived in the EU or have established in only a few small populations, we chose 43 of the 196 databases based on well-defined criteria (excellent overall coverage of the EU, coverage of areas outside the EU, number of species included in the database, amount and quality of information available per species, current status of updates and functionality of the database; complementarity among the databases regarding taxonomic coverage, geographic coverage and environmental coverage). The selected core set of 43 alien species databases proved to be an efficient instrument for assessing ecological traits and distribution trends for candidate species in the frame of a horizon scanning exercise. Databases covering non-EU countries can be used to investigate invasion behaviour of species not yet introduced into the EU, while databases covering EU countries can be used to assess whether the species has already arrived in the EU, whether it has arrived but is currently extinct or only established in a few small populations, as well as to assess actual information about the distribution, pathways, invasion history, impact in the EU and other management related information. A caveat when relying on the information within alien species databases is that their usefulness is strongly dependent on regular updates. However, such databases are only one source of information on alien species. Other highly relevant sources include original articles, particularly in scientific journals dedicated to invasion biology. Beyond this written evidence, the knowledge of experts is an excellent source of current information.

Task 3: Horizon scanning methodology for the EU, including the retrieval of data from the above data sources.

From a review of the horizon scanning methods and data sources identified in Task 1 and 2, we developed a horizon scanning method broadly based on the one employed by Roy et al. (2014) for Britain. It was apparent that the method had to be adapted for it to be applicable at the scale of the EU, given that in principle the species under consideration could invade from anywhere in the world.

The method developed for the present study focussed on four main criteria: i) the likelihood of arrival, ii) the likelihood of establishment, iii) the likelihood of spread post invasion and iv) the potential impact on biodiversity.

Additionally, five thematic groups of experts were established to ensure harmonisation of taxonomic and environmental coverage. In total 22 members of the project team participated in the process of deriving species lists, together with 14 additional experts invited to contribute with data, information and personal expertise (number of experts are indicated in parentheses):

Higher and lower plants (7 experts including 6 project team members and 1 invited expert; 4 attended the workshop)

Vertebrates (6 experts including 4 project team members and 2 invited expert; all attended the workshop)

Terrestrial invertebrates (9 experts including 6 project team members and 3 invited expert; all attended the workshop)

Marine species (6 experts including 4 project team members and 4 invited expert; 5 attended the workshop)

Freshwater invertebrates and fish (6 experts including 2 project team members and 4 invited expert; all attended the workshop)

Each group was asked to compile a preliminary list of species to be proposed for consideration as high priority. The groups were provided with detailed and explicit guidance on the criteria to use in developing the lists and specifically on species to exclude such as those already widely established within the EU or covered by other EU regulations. Beyond the four main criteria the groups were also asked to collate other useful and relevant information on taxonomic details, presence in the EU, key pathways, mechanisms of impact, and impacts on ecosystem services.

Lists of species were generated by individual experts and collated within thematic groups in advance of the workshop. Scores on a 1 (=low) to 5 (=high) scale for each of the criteria, coupled with information on the level of confidence of the relevant scores, were applied to each species and reviewed to allow collation into one consensus list for each thematic group. The workshop subsequently used consensus to derive a single agreed list of priority species across all thematic groups, whilst also reviewing the process that produced it (Task 4).

Beyond developing the horizon scanning method, Task 3 also reviewed how information identified in Task 2 could be readily extracted for use in a horizon scanning exercise. It showed that the information contained in international IAS databases is very diverse both in their content and their presentation. Consequently, the information on the four main criteria used here is often available only indirectly, for instance the likelihood of arrival has to be deduced from information on potential invasion pathways, the current range of a species and its invasion history elsewhere. The need to integrate information and interpret matches in climate ranges and habitat types in current native and invaded ranges with potential ranges in the EU underlines the essential nature of the input from expert opinion.

Finally, consideration of the role of EASIN in horizon scanning for the EU has highlighted that its current remit does not fully cover the necessary information. We consider where EASIN could take a central role in information gathering for example: invasion pathways; analysis of information; inclusion of new spatial information for alien species already listed within the EASIN catalogue; and by incorporating the priority species identified through horizon scanning into the EASIN catalogue flagged as "horizon scanning species". Filters and widgets could be adjusted accordingly.

Task 4: Review and validate the methodology

A workshop was held on May 6-7 2015, in Brussels, with the overarching aim of reviewing and validating the proposed horizon scanning approach to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on native biodiversity or associated ecosystem services in the EU over the next decade. From the 29 members of the project team 22 attended the workshop and an additional 13 experts invited to review and validate the methodology also attended the workshop. These experts were selected from across the EU to ensure representation across taxonomic groups and environments. Ana-Cristina Cardoso (JRC) attended the workshop and represented EASIN. Myriam Dumortier and Spyridon Flevaris from the EC also attended and mainly observed the activities but also assisted with points of reference or clarification. In total, 38 people attended the workshop.

The draft reports from Task 1 and 2 were circulated to all participants two weeks in advance of the workshop. The participants were also divided into five thematic groups (as outlined in Task 3) representing taxonomic and environmental expertise. In advance of the workshop each thematic group compiled and circulated provisional lists of species considered to be relevant for prioritisation for risk assessment following relevant guidelines (outlined in Task 3).

The workshop began with a series of presentations outlining the project aims and outputs from Tasks 1, 2 and 3. The workshop participants and wider project team unanimously agreed that a consensus approach was the most effective method to derive a ranked list of IAS (for prioritisation for risk assessment) which are likely to arrive, establish, spread and have an impact on native biodiversity or associated ecosystem services in the EU over the next decade. The horizon scanning method adopted was validated both through initial discussions at the beginning of the workshop but also through implementation of the process during the workshop and through review at the end of the workshop. The horizon scanning approach involved two distinct phases:

i) Preliminary consultation between experts within five thematic groups to derive initial scores

ii) Consensus-building across expert groups including extensive discussion on species rankings coupled with review and moderation of scores across groups

A number of key issues were raised by the thematic groups during and following the workshop. Of particular note is the recognition that information on impacts is often very limited or non-existent, and relevant details of life-history characteristics for assessing the likelihood of arrival, establishment and spread may not be available. Even with participants who have broad relevant expertise there will be gaps in collective knowledge not least because horizon scanning for IAS demands vast breadth of taxonomic and ecological knowledge across a range of environmments on a large spatial scale. The importance of linking to information contained in regional databases, as well as in global databases, and the potential role of EASIN was highlighted. In the future, it is hoped that the outcomes of surveillance conducted at national and regional scales, and the results of the assessments of the most relevant pathways of introduction of IAS, will improve our capacity to identify the species most likely to arrive within the EU.

Task 5: Perform a horizon scanning

The outcome of the horizon scanning was a list of 102 species considered as very high or high priority for risk assessment. However, the final list had to be further reduced because three of the species (the buprestid beetles *Agrilus planipennis* (Coleoptera: Buprestidae) and *A. anxius* (Coleoptera: Buprestidae), and the silk moth *Dendrolimus sibiricus* (Lepidoptera: Lasiocampidae) are included within Annex II of the European Directive regarding plant health (2000/29/CE), are therefore beyond the scope of the EU IAS Regulation, and so were removed resulting in 99 species considered as very high or high priority for risk assessment. Additionally, four of the listed species (*Corvus splendens* (Passeriformes: Corvidae), *Callosciurus erythraeus* (Rodentia: Sciuridae), *Orconectes virilis* (Decapoda: Cambaridae), *Sciurus niger* (Rodentia: Sciuridae)) already have risk assessments compliant with the minimum standards agreed within previous studies so the final outcome was 95 species considered as very high or high priority for risk assessment. Of these 95 species, 46 were considered currently absent within the EU while 48 were considered to be present, but with a limited distribution of a few self-sustaining small populations, and thus they still qualified for horizon scanning as they might still represent a major threat for most EU countries. For one of the species the status, presence or absence, within the EU countries was uncertain.

The species identified through the horizon scanning represent a variety of taxonomic and functional groups, are native to a range of global regions, and in some cases have already invaded regions outside of the EU. All European bioregions will be recipients of IAS but it is notable that the Atlantic, Mediterranean, Continental and Macaronesia bioregions are considered most at risk under current climate conditions.

It is important to note the potentially huge numbers of species native to countries other than the EU that might qualify as invasive if introduced in the target region and, therefore, recognise the imperfect nature of horizon scanning lists (Roy et al. 2014a). There are many species that have not been considered through this horizon scanning approach that could arrive in the future: some will establish and become invasive while many others will not. Predicting which species will become problematic and which will not can be difficult. However, this will not necessarily represent a failure of the study. In fact, given the preventive scope of this exercise, it would be expected that the species currently prioritised for risk assessment will be subject to measures aimed at effectively preventing their invasion in the EU, and so the fact that they might never arrive should be considered a conservation success.

SOMMAIRE

Le Règlement de l’Union Européenne (UE) 1143/2014 récemment publié sur les espèces exotiques envahissantes (EEE) établit des règles pour s’attaquer aux problèmes liées aux espèces exotiques envahissantes, cherchant à prévenir l’entrée des EEE, à établir un système de détection précoce et de réponse rapide, à assurer une éradication rapide des EEE localisées et à gérer plus efficacement les EEE qui se sont établies et dispersées.

Afin de garantir une action harmonisée et prioritisée à l’échelle de l’UE, le Règlement se concentre sur une liste d’EEE préoccupantes pour l’UE. Un travail est actuellement en cours entre la Direction Générale (DG) pour l’Environnement de la Commission Européenne (CE) et les représentants des Etats Membres auprès du Comité EEE afin d’établir cette liste, laquelle devrait être finalisée en janvier 2016.

La liste initiale d’EEE préoccupantes pour l’UE se basera sur les analyses de risque disponibles qui sont conformes aux standards minimums, mais une approche est requise pour informer les mises à jour futures de la liste afin de prioritiser les EEE nouvelles et émergentes les plus menaçantes. Dans ce contexte, l’horizon scanning (‘prospective’) est considéré comme essentiel pour prioritiser la menace posée par des EEE potentiellement nouvelles qui ne sont pas encore établies au sein de l’UE.

A cette fin, un workshop s’est tenu avec pour objectif global d’examiner et de valider une approche d’horizon scanning pour en inférer un classement des EEE susceptible d’arriver, de s’établir, de se disperser et de présenter un impact sur la biodiversité native ou les services écosystémiques associés dans l’UE dans la décennie à venir. Avant le workshop, un certain nombre d’espèces ont été identifiées pour cinq groupes thématiques (à savoir les plantes; vertébrés; invertébrés terrestres; espèces marines; et invertébrés d’eau douce et poissons).

Les listes pertinentes ont été compilées en un tableau pour permettre aux participants de visualiser la longue liste de 250 espèces considérées. Durant le workshop, entre 20 et 30 espèces de chaque groupe thématique ont été sélectionnées pour produire une liste de 127 espèces. Le résultat final était un classement d’EEE obtenu sur base de discussions et d’un large consensus qui étaient considérées comme présentant un risque très élevé ou élevé d’arrivée, d’établissement, de dispersion et d’impact sur la biodiversité et les services écosystémiques et qui devraient ainsi être prioritaires pour les analyses de risque. En particulier, 27 espèces ont été considérées comme étant de très grande priorité, 68 de grande priorité et 21 supplémentaires de priorité modérée. Il est à noter que 4 autres espèces ont été classées comme très hautement prioritaires mais disposaient déjà d’analyses de risque conformes aux standards minimums. Toutes les autres espèces résultant de la longue liste ont été jugées de risque faible.

Tâche 1 : Inventaire et évaluation des méthodologies existantes d’horizon scanning.

Un certain nombre d’approches ont été utilisées pour l’horizon scanning des EEE, certaines d’entre elles concernant des groupes taxonomiques ou des environnements spécifiques. La plupart de ces approches n’étaient pas consensuelles; elles se basaient sur des informations de la littérature couplées à une opinion d’expert et utilisaient des structures d’analyses de risque ou des approches de modélisation. Les manques de connaissance et des niveaux d’incertitude élevés peuvent toutefois souvent limiter les résultats de telles approches. D’autres méthodes, incluant des approches consensuelles ont été utilisées pour surmonter ces limitations. Une approche consensuelle est un outil utile pour la prioritisation en matière de conservation car l’opinion informelle d’experts sous-tend la majorité des décisions liées à la conservation.

Les approches consensuelles consistent en un processus structuré par lequel on procède à un examen systématique des menaces potentielles au travers de revues de la littérature et d'opinion d'experts, suivi de discussions qui ont pour but de converger vers un consensus au sein du groupe d'experts intervenants. Il est particulièrement important de définir clairement la portée de l'exercice d'horizon scanning. Cette méthode présente des points forts considérables, particulièrement lorsque l'information est manquante, mais il est important de reconnaître comme point faible qu'une opinion ne vaut pas un savoir. Bien que basé sur l'évidence scientifique, le résultat de l'horizon scanning n'est pas toujours prévisible ou répétable. Une autre composition d'experts peut produire d'autres résultats. Communiquer le niveau d'incertitude de l'évaluation lors de la communication auprès d'un public plus large qu'il soit scientifique ou non est donc considéré comme crucial. Les approches consensuelles peuvent toutefois réduire le niveau d'incertitude inhérent au manque de données (informations insuffisantes sur les espèces) grâce aux discussions collaboratives en face à face qui combinent savoirs et opinions entre experts.

Tâche 2: Inventaire et évaluation des sources de données adéquates

Les principales sources d'information sur les espèces exotique sont présentes dans des bases de données développées soit au niveau de pays ou de régions par des gouvernements, soit par d'autres organisations ou réseaux spécialistes qui compilent et gèrent des données et de l'information sur les espèces exotiques suivant différents focus taxonomiques, environnementaux ou géographiques. Les mieux connues et plus utilisées en Europe sont celles développées au travers du projet financé par l'UE "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, www.europe-aliens.org), couvrant 12000 espèces pour toute l'Europe (79 pays/régions y-compris les îles et 57 zones côtières et marines), ainsi que le "European Network on Invasive Alien Species" (NOBANIS, http://www.nobanis.org/) couvrant 9000 espèces pour 20 pays d'Europe du Nord et centrale. Ces deux bases de données couvrent tous les groupes taxonomiques et les environnements (c.-à-d. les environnements terrestres, d'eau douce et marins), mais d'autres bases de données existent qui se limitent à un focus taxonomique et/ou environnemental particulier. Le "European Alien Species Information Network" (EASIN, http://easin.jrc.ec.europa.eu/) est une initiative récente du Joint Research Centre de la Commission Européenne qui a pour but de faciliter l'accès aux données et à l'information sur les espèces exotiques en Europe à partir de 43 bases de données en ligne existantes.

Dans une synthèse récente des bases de données d'espèces exotiques existant à l'échelle globale, 238 bases de données ont été identifiées, de couvertures géographiques sub-nationales (îles, états fédéraux) à globales (Essl et al. In press). Au total, 196 d'entre elles étaient actives et accessibles via internet. Alors que 16 de ces 196 montraient une couverture globale, 78 bases de données se concentraient seulement sur l'Amérique du Nord, 75 sur l'Europe et 15 sur l'Australie (y-compris l'Océanie). Quasi la moitié de ces 196 bases de données ont évalué les voies d'entrées et 27% les ont classées en introduction volontaires ou accidentelles, mais 9% seulement ont fourni de la documentation permettant l'interprétation du manuel d'information sur les voies d'entrée et 3% ont évalué les tendances au sein de ces voies d'entrées (Essl et al. In press). 160 bases de données couvraient les plantes, 93 les invertébrés, 82 les poissons, 70 les champignons, 68 les microbes et 61 les algues.

Pour les besoins de l'horizon scanning sur les EEE n'étant pas encore arrivées dans l'UE ou s'étant établies sous forme de quelques petites populations, nous avons choisi 43 de ces 196 bases de données sur base de critères bien définis (excellente couverture globale de l'UE, couverture de zones en dehors de l'UE, nombre d'espèces inclues dans la base de donnée, quantité et qualité de l'information disponible par espèce, statut actuel des mises à jour et fonctionnalité de la base de données, complémentarité des bases de données au regard des couvertures taxonomique, géographique, et environnementale). Le jeu sélectionné de 43 bases de données d'espèces exotiques s'est révélé être un instrument efficace pour évaluer les caractères écologiques et les tendances de distribution des espèces candidates dans le contexte d'un exercice d'horizon scanning. Les bases de données couvrant les pays non-EU peuvent être utilisées pour rechercher le comportement envahissant des espèces non encore introduites dans l'UE, alors que les bases de données couvrant les pays de l'UE peuvent être utilisées pour évaluer dans quelle mesure l'espèce est déjà arrivée mais serait actuellement éteinte ou établie en un petit nombre de populations seulement, ainsi que pour évaluer l'information disponible relative à la distribution, aux voies d'introduction, l'historique d'invasion, les impacts dans l'UE et d'autres informations relatives à la gestion. Il y a lieu de mettre en garde quant à l'utilité de ces bases de données sur les espèces exotiques, utilité qui est fortement dépendante de la régularité des mises à jour. Ces bases de données ne constituent qu'une seule source d'information sur les espèces exotiques. Les articles originaux constituent d'autres sources fortement pertinentes, particulièrement dans les journaux scientifiques dédiés aux invasions biologiques. Au-delà de cette évidence écrite, la connaissance d'experts est également une excellente source d'information actuelle.

Tâche 3: Méthodologie d'horizon scanning pour l'UE, y-compris la récupération de données à partir des bases de données sources précitées.

A partir de la revue des méthodes d'horizon scanning identifiées en Tâches 1 et 2, nous avons développé une méthode d'horizon scanning largement basée sur celle employée par Roy et al. (2014) pour la Grande Bretagne. Il était clair que la méthode devait être adaptée pour être applicable à l'échelle de l'UE, étant donné qu'en principe, les espèces considérées pouvaient provenir de n'importe quelle région du monde.

La méthode développée pour l'étude qui nous intéresse s'est concentrée sur quatre critères principaux : i) la probabilité d'arrivée, ii) la probabilité d'établissement, iii) la probabilité de dispersion au-delà de l'introduction, iv) l'impact potentiel sur la biodiversité.

De plus, cinq groupes thématiques d'experts ont été établis pour assurer l'harmonisation de la couverture taxonomique et environnementale. Au total, 22 membres de l'équipe du projet ont participé au processus d'établissement de listes d'espèces, ainsi que 14 experts supplémentaires invités à contribuer par leurs données, informations et expertise personnelle (le nombre d'experts est indiqué entre parenthèses) :

Plantes supérieures et inférieures (7 experts dont 6 membres de l'équipe du projet et 1 expert invité; 4 participants au workshop)

Vertébrés (4 experts dont 2 membres de l'équipe du projet et 1 expert invité; tous ont participé au workshop)

Invertébrés terrestres (9 experts dont 6 membres de l'équipe du projet et 3 experts invités; tous ont participé au workshop)

Espèces marines (6 experts dont 4 membres de l'équipe du projet et 4 expert invités; 5 participants au workshop)

Invertébrés d'eau douce et poissons (6 experts dont 2 membres de l'équipe du projet et 4 expert invités; tous ont participé au workshop).

Il a été demandé à chaque groupe de compiler une liste préliminaire d'espèces à considérer comme étant de haute priorité. On a fourni aux groupes une guidance détaillée et explicite sur les critères à utiliser pour développer les listes et spécifiquement sur les espèces à exclure comme celles déjà largement établies au sein de l'UE ou couvertes par d'autres régulations de l'UE. Au-delà des quatre critères principaux, on a également demandé aux groupes de collecter d'autres informations utiles et pertinentes sur des détails taxonomiques, la présence au sein de l'UE, les voies d'entrées clés, les mécanismes d'impact, et les impacts sur les services écosystémiques.

Les listes d'espèces étaient générées individuellement par les experts et collectées au sein des groupes thématiques préalablement au workshop. Des scores sur une échelle de 1 (= faible) à 5 (= élevé) couplés à de l'information relative au niveau de confiance des différent scores ont été attribués à chaque espèce et revus pour permettre l'attribution à une liste consensuelle pour chaque groupe. Par la suite, le workshop a utilisé le consensus pour en déduire une liste unique commune d'espèces prioritaires tous groupes taxonomiques confondus, tout en validant le processus permettant d'obtenir cette liste (Tâche 4).

En plus de développer la méthode d'horizon scanning, la Tâche 3 a aussi examiné comment l'information identifiée dans la Tâche 2 pouvait être facilement extraite pour être utilisée dans un exercice d'horizon scanning. L'information contenue dans les bases de données internationales est très diverse, tant en matière de contenu que de présentation. En conséquence, l'information sur les quatre critères principaux utilisés ici n'est souvent disponible qu'indirectement. Par exemple, la probabilité d'arrivée a dû être déduite à partir d'informations sur les voies d'introduction potentielles, la zone de distribution actuelle de l'espèce et son historique d'invasion par ailleurs. Le besoin d'intégrer de l'information et d'interpréter les adéquations entre zones climatiques et les zones potentielles de l'UE souligne la nature essentielle de l'apport que constitue l'opinion d'expert.

Finalement, la prise en compte du rôle d'EASIN dans l'horizon scanning pour l'UE a montré que ses attributs actuels ne couvraient pas totalement l'information nécessaire. Nous avons envisagé en quoi EASIN pourrait jouer un rôle central en collecte d'information par exemple : les voies d'introduction; l'analyse de l'information; l'inclusion de nouvelles informations spatiales pour des espèces exotiques déjà listées au sein du catalogue EASIN ; et l'incorporation d'espèces prioritaires identifiées par l'horizon scanning dans le catalogue EASIN sous un label spécifique 'espèce horizon scanning'. Les filtres et outils pourraient être ajustés en fonction.

Tâche 4: Evaluer et valider la méthodologie

Un workshop s'est tenu les 6 et 7 mai 2015 à Bruxelles, avec pour but général de produire une liste ordonnée d'EEE qui sont susceptibles d'arriver, de s'établir, se disperser et présenter un impact sur la biodiversité et les services écosystémiques en Europe dans la prochaine décennie. Parmi les 29 membres de l'équipe du projet, 22 ont assisté au workshop ainsi que 13 experts supplémentaires invités pour revoir et valider la méthodologie. Ces experts ont été sélectionnés en Europe pour assurer une bonne représentation des groupes taxonomiques et des environnements. Ana-Cristina Cardoso (JRC) a participé au workshop et représentait EASIN. Myriam Dumortier et Spyridon Flevaris de la Commission Européenne participaient également, observaient principalement les activités mais aidaient aussi par des points de clarification. Au total, 38 personnes ont donc assisté au workshop.

Les rapports provisoires des Tâches 1 et 2 ont circulé auprès des participants deux semaines avant le workshop. Les participants étaient divisés en cinq groupes thématiques (comme précisé en Tâche 3) représentant une expertise taxonomique et environnementale. Préalablement au workshop, chaque groupe thématique a compilé et fait circuler des listes provisoires d'espèces à considérer comme pertinentes pour la prioritisation par analyse de risque sur base de lignes directrices (comme précisé en Tâche 3).

Le workshop a débuté par une série de présentations mettant en lumière les buts du projet et les résultats des Tâches 1, 2 et 3. Les participants du workshop et plus largement l'équipe du projet a reconnu qu'une approche consensuelle était la méthode la plus efficace pour générer une liste ordonnée d'EEE (pour prioritisation par analyse de risque), lesquelles sont susceptibles d'arriver, de s'établir, de se disperser et d'avoir un impact sur la biodiversité native ou les services écosystémiques associés dans l'UE durant la prochaine décennie. La méthode d'horizon scanning adoptée a été validée tant au travers de discussions initiales au début du workshop que lors de la mise en œuvre du processus lui-même durant le workshop et par l'évaluation en fin de workshop. L'approche d'horizon scanning a consisté en deux phases distinctes :

i) Une consultation préliminaire entre experts au sein des cinq groups thématiques pour produire des scores initiaux

ii) L'établissement de consensus au travers des groups d'experts incluant une discussion approfondie sur les classements des espèces, combinée à une évaluation et une modération des scores entre groupes.

Un certain nombre de problématiques clés ont été soulevées par les groups thématiques pendant et suite au workshop. Il a été noté que l'information sur les impacts est souvent très limitée voire inexistante, et il se peut que les détails pertinents sur les traits d'histoire de vie permettant d'évaluer les probabilités d'arrivée, d'établissement et de distribution ne soient pas disponibles. Même avec des participants présentant une grande expertise pertinente, il y a des lacunes dans la collecte de la connaissance du fait que l'horizon scanning demande une large gamme de connaissances taxonomiques et écologiques au travers d'une grande variété d'environnements et à grande échelle spatiale. L'importance de relier l'information des bases de données régionales aussi bien que globales et le rôle de potentiel d'EASIN ont été mis en évidence. Dans le futur, il est à espérer que les résultats de la surveillance menée aux échelles nationales et régionales, et les résultats des évaluations des voies d'introduction les plus pertinentes d'EEE amélioreront notre capacité à identifier les espèces les plus susceptibles d'arriver au sein de l'UE.

Tâche 5: Réalisation de l'horizon scanning

L'horizon scanning a généré une liste de 102 espèces considérées comme étant de priorité très élevée à élevée pour les analyses de risque. Cependant, la liste finale a dû être réduite car trois de ces espèces (*Agrilus planipennis* (Coleoptera: Buprestidae) et *A. anxius* (Coleoptera: Buprestidae), et *Dendrolimus sibiricus* (Lepidoptera: Lasiocampidae) sont inclues dans l'Annexe II de la Directive Européenne relative à la santé phytosanitaire (2000/29/CE), ne sont de ce fait pas concernées par le Règlement de l'UE sur les EEE, et ont donc été retirées, résultant en 99 espèces considérées comme étant de priorité très élevée à élevée pour les analyses de risque. De plus, quatre espèces listées (*Corvus splendens* (Passeriformes: Corvidae), *Callosciurus erythraeus* (Rodentia: Sciuridae), *Orconectes virilis* (Decapoda: Cambaridae), *Sciurus niger* (Rodentia: Sciuridae)) présentaient déjà une analyse de risque conforme aux standards minimums reconnus par les études précédentes. Ainsi, le résultat final comporte 95 espèces considérées comme étant de priorité très élevée à élevée pour les analyses de risque. Sur ces 95 espèces, 46 sont considérées comme actuellement absentes de l'UE, alors que 48 sont considérées comme présentes mais avec une distribution limitée de quelques petites populations qui se maintiennent sans apport. Ces espèces sont donc toujours pertinentes pour l'horizon scanning puisqu'elles peuvent représenter une menace majeure pour la plupart des pays de l'UE. Pour une des espèces, le statut, présence ou absence, au sein de l'UE s'est avéré incertain.

Les espèces identifiées par l'horizon scanning représentent une variété de groupes taxonomiques et fonctionnels, sont natifs d'une diversité de régions à l'échelle globale et dans certains cas, ont déjà envahis des régions en dehors de l'UE. Toutes les biorégions européennes seront receveuses d'EEE, mais il est à noter que les biorégions Atlantique, Méditerranéenne, Continentale et Macaronésienne sont considérées comme plus à risque sous les conditions climatiques actuelles.

Il est important de noter le nombre potentiellement énorme d'espèces natives de pays autres que l'UE qui pourraient être qualifiées d'exotiques envahissantes si introduites dans la région cible et, de ce fait, il faut noter la nature imparfaite des listes d'horizon scanning (Roy et al. 2014a). De nombreuses espèces n'ont pas été considérées pour cette approche d'horizon scanning et pourraient toutefois arriver à l'avenir : certaines s'établiront et deviendront envahissantes alors que de nombreuses ne le deviendront pas. Prédire quelle espèce deviendra problématique et quelle espèce ne le deviendra pas peut s'avérer difficile. Cela ne représente toutefois pas un échec de l'étude. En fait, étant donné l'aspect préventif de cet exercice, on s'attendrait à ce que les espèces actuellement envisagées pour une analyse de risque soient sujettes à mesures ayant pour but de prévenir concrètement leur invasion dans l'UE, et ainsi, le fait qu'elles puissent ne jamais arriver doit être considéré comme un succès en matière de conservation.

PROJECT OVERVIEW

Horizon scanning is defined as a systematic examination of potential threats and opportunities within a given context. Horizon-scanning to prioritise the threat posed by potentially new invasive alien species (IAS) which are not yet established within a region is seen as an essential component of IAS management (Copp et al. 2007). There have been a number of horizon-scanning exercises for IAS but these have usually involved discrete taxonomic groups, such as plants (Andreu, Vilà 2010; Thomas 2011) or animals (Parrott et al. 2009), or distinct environments such as freshwater (Gallardo, Aldridge 2013). Recently a horizon scanning exercise for Great Britain was undertaken to create an ordered list of IAS (all plant and animal taxa, excluding microorganisms, across all environments) that are likely to arrive, establish and have an impact on native biodiversity within the next ten years (Roy et al. 2014a). Here we report on a project to develop a "Framework for the identification of invasive alien species of EU concern".

The specific objectives of the study documented within this report were to:

1. Provide an inventory and review of existing horizon scanning methodologies and exercises.

2. Provide an inventory and review of appropriate data sources on species and IAS.

3. Propose a horizon scanning methodology for the EU, including the retrieval of data from the above data sources, possibly through EASIN.

4. Review and validate the proposed approach with a workshop with relevant experts.

5. Perform a horizon scanning in order to propose a list of up to 80-100 potentially most threatening IAS to Europe, ranked in order of priority, and have the result peer reviewed.

The project involved inter-linked tasks (Figure 0.1). These tasks were detailed in associated subtasks:

Task 1: Inventory and review of existing horizon scanning methodologies

> *Task 1.1: Compile an inventory of existing methods including a description and assessment of each method*
>
> *Task 1.2: Compile an overview of horizon scanning methods*

Task 2: Inventory and review of appropriate data sources

Task 3: Horizon scanning methodology for the EU, based on the results of the inventory (Task 1) and including the retrieval of data from the above data sources (Task 2).

> *Task 3.1: Develop a methodology for horizon scanning for IAS likely to affect EU countries.*
>
> *Task 3.2: Develop a method for retrieving data from the sources identified in Task 2.*
>
> *Task 3.3: Consider the role of EASIN as input to future horizon scanning exercises.*

Task 4: Review and validate the methodology

Task 4.1: Identification and approval of experts to attend the workshop

Task 4.2: Workshop documentation

Task 4.3: The workshop

Task 4.4: Summary of the workshop

Task 5: Perform a horizon scanning

Task 5.1. Preliminary consultation between experts

Task 5.2. Consensus-building across expert groups

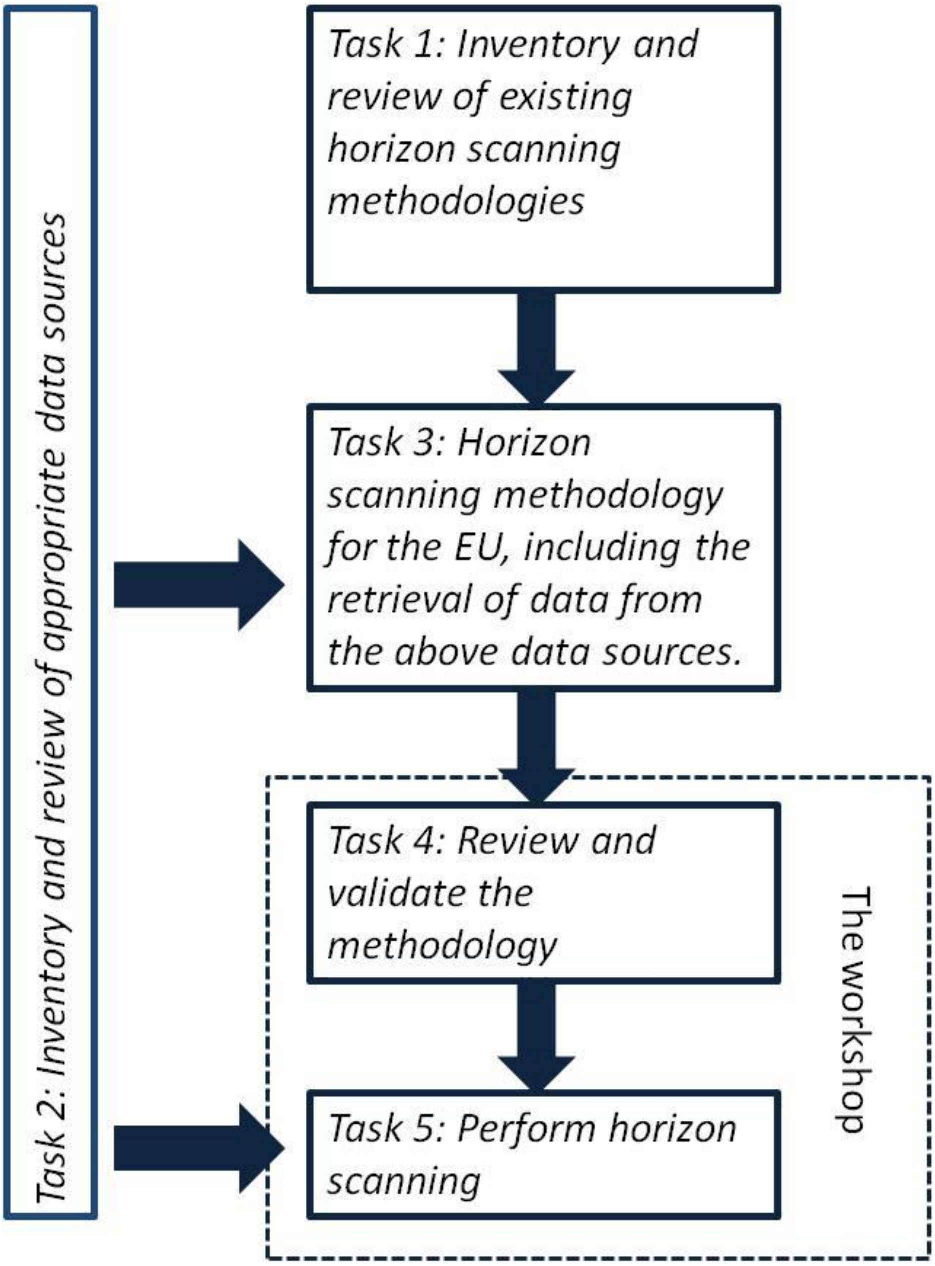

Figure 0.1: Flow diagram illustrating the links between tasks

TASK 1: INVENTORY AND REVIEW OF EXISTING HORIZON SCANNING METHODOLOGIES

Leading experts: Wolfgang Rabitsch (EAA), Helen Roy (CEH), Marianne Kettunen (IEEP)

Overview

Horizon-scanning can be defined as a systematic examination of potential threats and opportunities, within a given context, and likely future developments which are at the margin of current thinking and planning. Horizon scanning may explore novel and unexpected issues, as well as persistent problems and trends (Capdevila-Argüelles et al. 2006; CEC 2009). The aim of horizon scanning is to identify possible future trends and incidents by utilising early signs of events related to the subject. Horizon scanning usually follows a structured process of simplification from a larger set of data to carve out the most important and relevant details. Although not the main goal of horizon scanning, to this end a prioritization of the subject matter is often a useful extension and desired outcome of the process. A series of recent papers have provided convincing arguments that horizon scanning should play a more central role in environmental and conservation practice (Sutherland et al. 2012d; Sutherland et al. 2014b; Sutherland et al. 2013b; Sutherland et al. 2015; Sutherland, Woodroof 2009).

Horizon scanning is seen as an essential component of IAS management (Copp et al. 2007; Shine et al. 2010). It can help prioritisation of preventative measures, surveillance of possible entry pathways, and provide information on early response if prevention fails and the species actually appears in the area. Horizon scanning exercises, in the context of IAS, may include the pathways of introduction and the information may allow an analysis and evaluation of the priority pathways of possible future IAS, in compliance to article 13 of the EU Regulation on IAS.

Foresighted action can, therefore, increase the window of opportunity for taking action against the most threatening IAS. In this respect, horizon scanning is a useful addition to the manager’s tool-box for combating IAS. In essence, it could help shift policy responses and decision-making towards IAS from being purely reactive to proactive in the future. Finally, it should be noted that horizon scanning could also be employed to focus on other aspects related to biological invasions, for example, identification and prioritization of emerging and promising IAS management methods, technologies or control actions (Shine et al. 2010).

Approaches to horizon scanning

Horizon scanning has historically included extensive literature reviews, to ascertain species of concern, and generally (but not always) some form of risk assessment. However, the importance of risk assessment tools is increasingly recognised as a component of approaches to identify potential future IAS not already present within a region (Essl et al. 2011). Risk assessment tools based on a specified set of criteria have been developed for a number of countries. Many of these are used to prioritise alien species already present according to their impact (Randall et al. 2008) although their potential for identifying future IAS that are not already present is recognised (Roy et al. 2014a).

Strategic foresight is broadly defined as ‘the creative reorganization of information into future-oriented knowledge in the context of accelerated change and genuine uncertainty in high-velocity environments’ (Copp et al. 2005) or simply a structured process for exploring alternative future states (Copp et al. 2009). The different strategic foresight methods for conservation issues including (horizon) scanning, scenario planning and backcasting have been reviewed (Crosti et al. 2010) and each have advantages and disadvantages, depending on the purpose of the exercise, data availability and data (un)certainty, and involvement of experts from different scientific, governmental or public domains. A number of structured approaches have been used for horizon scanning across a range of environmental disciplines (Table 1.1). Sutherland and Woodroof (2009) recognised that horizon scanning can be divided into six stages: (i) scoping the issue; (ii) gathering information; (iii) spotting signals; (iv) watching trends; (v) making sense of the future; and (vi) agreeing the response. However, within the context of horizon scanning to derive a list of IAS for prioritisation for risk assessment, (i) scoping the issue and (ii) gathering information are specifically pertinent.

Scoping the issue and gathering information are critical to all horizon scanning; the scope or key question must be explicitly identified and clearly understood by all involved in the horizon scanning. Ensuring that all participants understand the scope can require several iterations (Sutherland, Woodroof 2009) and can be achieved through formal and structured interviews (Table 1.1). Gathering information can be achieved through a variety of approaches including open fora, questionnaires, literature review, modelling approaches, survey and experiment and expert workshops (Table 1.1) to supplement the prior knowledge of participants (Sutherland, Woodroof 2009). Expert workshops including consensus approaches (modification of the Delphi technique, inclusive, transparent, and structured communication process, developed for systematic forecasting) have been extensively employed as an approach to horizon scanning within environmental science (Sutherland et al. 2012c; Sutherland et al. 2014a; Sutherland et al. 2011a; Sutherland et al. 2013a).

Here we provide an inventory of on horizon scanning methods used to predict and prioritise action in relation to IAS[1].

[1] Prioritization exercises, such as the compilation of the "100 of the World's Worst IAS" (compiled by the Global Invasive Species Database, http://www.issg.org/database/species/search.asp?st=100ss) and "100 of the Worst" (DAISIE, Delivering Alien Species Inventories for Europe, http://www.europe-aliens.org/speciesTheWorst.do), had as purpose to raise awareness of the problem of IAS to a wider public audience rather than systematic horizon scanning. The methods used in these exercises (e.g. equal consideration of all environments, taxa, or pathways) were not prognostic and, therefore, will not be further considered here.

Table 1.1 Overview of broad approaches to horizon scanning including description, strengths and weaknesses. Examples relate to publications from the IAS-research area. Modified from Sutherland & Woodroof (2009).

Method	Detail	Strength	Weakness	IAS relevant examples
Interview	One-to-one questioning; structured without debate or open	Good at getting key individuals perspectives on the future	No interaction between participants; possible bias due to selection of experts	–
Open fora	Online platform (Wiki)	Wisdom of the crowd, broadest possible range of contributors	Unstructured without quality control	–
Questionnaire	Expert consultation through pre-defined questions	Provides an overview of opinion on a specific theme	No interaction; possible bias due to selection of experts and how questions are phrased	–
Literature review	Extensive review of existing literature	Broad approach underpinned by existing knowledge (if peer-reviewed)	Unavailability of published reports or expert opinion; delay between observation and publication	(Parrott et al. 2009; Thomas 2011)
Modelling approach	Quantitative approach to derive predictions	Available data used to construct models to derive predictions	Depends on detailed life-history datasets which for many species are lacking	(Gallardo, Aldridge 2013)
Survey and experiment	Surveys of the environment in some cases coupled with experimentation	Realistic data derived	Labour intensive and expensive	(Richardson, Pyšek 2006)

Inventory of existing horizon scanning methods

The Web of Science was used to derive horizon scanning methods relevant for assessment and critical review. A search for the keyword "horizon scanning" within the Web of Science revealed more than 1000 hits for the years 2000-2015 with some 200 publications from the Social Sciences and more than 900 from the "Science Technology" domain (including double-counting). A further refinement within the latter revealed 156 hits in the Research Area "Environmental Sciences Ecology" and 134 hits for "Agriculture", although these include publications not related to the method, but to other contexts (e.g. soil horizons). We further refined our analysis to the Research Area "Biodiversity Conservation", which delivered 27 hits, of which 20 were considered relevant after reading the abstracts of the papers (Table 1.2). The same search for the years 1990-1999 did not deliver a single relevant publication.

The scope of the horizon scanning examples listed in Table 1.2 was broad within the theme of biodiversity conservation and mainly in relation to identifying and prioritising issues rather than species. Only one of the examples is specific to IAS (Caffrey et al. 2014) but again this exercise involved a prioritization approach used to elucidate the top 20 IAS issues in Europe. Most of the examples involved workshops in which experts were invited to participate, in many cases using consensus methods (Sutherland et al. 2012a). We cross-checked the references cited in the 21 papers (Table 1.2) and consulted the expert network within the project team to add further publications relevant to IAS, including several reports specifically addressing horizon scanning of IAS (Table 1.3). Some of these were not revealed by the Web of Science search using the key phrase "horizon scanning" in part because some of the reports are not listed within Web of Science and others were not identified by the phrase "horizon scanning". However, the Web of Science search coupled with the exploration of citations within the identified publications and expert knowledge provides a comprehensive overview of relevant publcations. For these publications we identified and documented key attributes such as geographic, taxonomic and environmental scope alongside information on impacts considered e.g. biodiversity, ecosystem patterns and processes, ecosystem services and socio-economic impacts (Table 1.3).

Table 1.2 Publications on Horizon scanning derived from Web of Science within the Research Area "Biodiversity Conservation" (2000-2015).

Title	Scope	Method	Reference
Future novel threats and opportunities facing UK biodiversity identified by horizon scanning	Identify future developments of biodiversity in the UK up to 2050 that had not been important in the recent past	Consultation process with 452 people and consensus workshop with 35 representatives from environmental policy, academia and journalism	(Sutherland et al. 2008)
One hundred questions of importance to the conservation of global biological diversity	Identify scientific questions most relevant for conservation practice and policy	Consultation process with 761 people, e-mail voting to short-list questions and consensus workshop with 33 representatives from international organisations, members of the Society for Conservation Biology, and academia	(Sutherland et al. 2009)
The need for environmental horizon scanning	Calling for routine horizon scanning to decide on which issues researchers or practitioners should focus	Opinion paper	(Sutherland, Woodroof 2009)
A horizon scan of global conservation issues for 2010	Identify issues that could affect conservation of biological diversity	Consultation process of collecting, scoring and short-listing issues, followed by consensus workshop with subsequent e-mail discussion and re-scoring	(Sutherland et al. 2010)

Title	Scope	Method	Reference
Horizon scan of global conservation issues for 2011	Identify issues that could affect conservation of biological diversity	Consultation process with at least 158 people of collecting, scoring and short-listing issues, followed by consensus workshop with subsequent e-mail discussion and re-scoring	(Sutherland et al. 2011a)
Methods for collaboratively identifying research priorities and emerging issues in science and policy	Identify priority policy-relevant research questions in the UK, USA and CAN relating to global conservation	Review paper. Methods should be based on inclusivity, openness, democracy	(Sutherland et al. 2011b)
A horizon scan of global conservation issues for 2012	Identify issues that could affect conservation of biological diversity	Consultation process with at least 253 people of collecting, scoring and short-listing issues, followed by consensus workshop with 22 participants	(Sutherland et al. 2012c)
Making predictive ecology more relevant to policy makers and practitioners	Improve the capacity of testable predictions to aid policy makers and practitioners	Conceptual paper on different methods in predictive ecology	(Sutherland, Freckleton 2012)
Enhancing the value of horizon scanning through collaborative review	Develop a process to identify appropriate responses by policy makers and practitioners	12 environmental conservation organisations assessed collaboratively previously identified issues for their impact upon their organisations	(Sutherland et al. 2012a)
What's on the horizon for macroecology?	Identify future challenges for the scientific field ‘macroecology’ (the analysis of large-scale, multi-species ecological patterns and processes)	Case-studies and literature analysis by the authors	(Beck et al. 2012)

Title	Scope	Method	Reference
A horizon scanning assessment of current and potential future threats to migratory shorebirds	Examining future conservation issues of migratory shorebirds	E-Mail consultation process of scientists without scoring	(Sutherland et al. 2012b)
A horizon scan of global conservation issues for 2013	Identify issues that could affect conservation of biological diversity	Consultation process with at least 190 people of collecting, scoring and short-listing issues, followed by consensus workshop	(Sutherland et al. 2013a)
A horizon scan of global conservation issues for 2014	Identify issues that could affect conservation of biological diversity	Consultation process with at least 369 people of collecting, scoring and short-listing issues, followed by consensus workshop	(Sutherland et al. 2014a)
Horizon Scanning: a new method for environmental and biodiversity conservation	–	Opinion paper	(Jiang 2014)
Tackling invasive alien species in Europe: the top 20 issues.	A horizon scanning and issue prioritization approach used to elucidate the Top 20 IAS issues (as opposed to species) in Europe.	In excess of 100 expert delegates in a workshop setting	(Caffrey et al. 2014)
Strategic foresight: how planning for the unpredictable can improve environmental decision-making	Highlighting ways foresight could play in environmental decision making	Review paper	(Cook et al. 2014)
Evolutionary rescue in a changing world	Identify where the field of evolutionary rescue might develop	Case-studies and literature analysis by the authors	(Carlson et al. 2014)

Title	Scope	Method	Reference
A horizon scan for species conservation by zoos and aquariums	Identify the top ten emerging issues for species conservation for the world zoo and aquarium community	Consultation process with more than 100 experts from the conservation and the zoo and aquarium community, followed by a workshop to short-list the top ten priority issues with potential to impact upon threatened species by 2020	(Gusset et al. 2014)
Seventy-one important questions for the conservation of marine biodiversity	Identify important questions to conserve and manage marine resources	2 workshops with participants from academia, industry, government, and NGOs	(Parsons et al. 2014)
Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain	See below	See below	(Roy et al. 2014a)
A horizon scan of global conservation issues for 2015	Identify issues that could affect conservation of biological diversity	Consultation process with at least 270 people of collecting, scoring and short-listing issues, followed by consensus workshop	(Sutherland et al. 2015)

Table 1.3 Chronological list of publications on horizon scanning methods developed to determine the threat posed by potentially new IAS to Europe. The geographic, environmental and taxonomic scope is provided alongside the number of species identified, the data sources, the impact assessment method and the type of considered impacts, whether a consensus workshop was included and whether uncertainty was considered. # = includes species with high or medium risk; § = BIO – biodiversity, EPP - ecosystem patterns and processes, ES - ecosystem services, SOC - socio-economic impacts; ISEIA = Invasive Species Environmental Impact Assessment; WRA = Weed Risk Assessment; $ = pre-selected Ponto-Caspian species based on expert consultation of economic and ecological harm to Great Britain; * = Denmark, Estonia, Faroe Islands, Finland, Iceland, Latvia, Lithuania, Norway, Sweden.

	Geographic scope	Environmental scope	Taxonomic scope	Number of species#	Data sources	Impact Assessment Method	Impacts considered§	Prioriti-zation	Consensus Workshop	Uncertainty considered	References
1	England	All	All	84	databases, reference literature and expert opinion	Rapid screening process based on ISEIA	BIO, EPP	Yes	No	No	Parrott et al. (2009)
2	Great Britain	Freshwater, Terrestrial	Plants	92	databases, reference literature and expert opinion	Rapid Risk Assessment based on WRA	BIO	Yes	No	No	Thomas (2011)
3	Great Britain	Freshwater	Crustaceans, Fish	16	distribution data from GBIF and literature	Modelling	$	Yes	No	No	Gallardo & Aldridge (2013)
4	Ireland	All	All	147	databases, reference literature	Irish Risk Assessment	BIO, SOC	Yes	No	Yes	Kelly et al. (2013)
5	Great Britain, France, Belgium, Netherlands	All	Selected taxa (plants, molluscs, fish, anseriformes, mammalia)	72	databases, reference literature	Based on Molnar et al. (2008), Modelling	BIO, SOC	Yes	No	No	Gallardo et al. (2013)

	Geographic scope	Environmental scope	Taxonomic scope	Number of species[#]	Data sources	Impact Assessment Method	Impacts considered[§]	Prioriti-zation	Consensus Workshop	Uncertainty considered	References
6	Great Britain	All	All	93	reference and grey literature, and expert opinion	Rapid screening process based on ISEIA	BIO, EPP	Yes	Yes	Yes	Roy et al. (2014a)
7	Netherlands	All	All	90	Databases, reference literature and expert opinion	Different impact assessments from neighbouring countries	BIO, EPP	Yes	No	Yes	Matthews et al. (2014)
8	Northern Europe*	All	All	121	Nobanis-database, reference literature and expert opinion	Expert opinion	BIO, EPP, SOC	Yes	No	No	Nobanis (2015)

Comprehensive overview of identified IAS horizon scanning methods: description and assessment

Horizon scanning for new invasive non-native species in England (Parrott et al. 2009)

The scope of the horizon scanning approach to identify new IAS to England was determined as (i) species already present but not widely distributed or not yet invasive and (ii) species not yet present, based on data retrieved from non-native species databases, reference literature and expert opinion. The prioritization of environmental risk was evaluated using an adapted (simplified) version of the Belgian ISEIA (Invasive Species Environmental Impact Assessment) protocol using impact and invasion stage as criteria for the assessments. The outcome was the allocation of species into different lists: Black List (high risk and present: 12 species); Alert List (high risk and absent: 19 species); Watch List (medium risk and present or absent: 46 species); Climate List (high or medium risk and currently climatically constrained, but potentially supported by climate change: 7 species). The authors concluded that more detailed risk assessments are needed for the top-listed species and recommend linking results to further management actions.

The application of an existing impact assessment protocol (ISEIA) with available instructions that has been successfully employed in other circumstances is particularly helpful for delivering an unbiased assessment of the possible impacts of species. Although the geographic scope was limited, socio economic impacts and uncertainties were not considered, and no consensus was intended, this valuable approach resulted in a prioritized list of species that should be subjected to more detailed risk assessments. The method seems particularly promising if a large number of species needs to be addressed.

Horizon scanning for invasive non-native plants in Great Britain (Thomas 2011)

Thomas (2011) screened 599 non-native potentially invasive plant species in England employing a modified version of the Australian Weed Risk Assessment (WRA) protocol with 21 questions related to the potential damage on natural and semi-natural habitats. Economic considerations were not included and it was recommended to decouple these interests (economic costs and benefits) from invasive risk assessments. The list of aquatic plants was developed from a list of species known to be on sale in the UK, while the list of terrestrial plants was generated from the list of neophytes established in the wild in the UK and spreading fast. Out of the 599 assessed non-native plant species, 92 were recommended for a more detailed risk assessment as a matter of priority (33 aquatic and 59 terrestrial). Because of the inherent uncertainties of possible impacts, Thomas (2011) suggested to periodically review emerging evidence for all screened species.

The precautionary principle was applied to reduce the risk of false negatives (declaring a taxon to be low risk when it is not) as a more appropriate approach to influence policy-making and management decisions. Uncertainty was not considered and a worst-case scenario applied instead. However, it was suggested to consider scoring uncertainty in future modifications of the scheme. Consideration of worst-case scenarios could lead to an over-representation of species and may lack the discrimination required for prioritisation. Additionally providing an indication of certainty in relation to the worst case scenario could provide additional information for subsequent ranking of species with respect to levels of threat.

The application of an existing risk assessment protocol (WRA) with available guidelines is particularly helpful for delivering an unbiased assessment of the possible impacts of the species. The study was limited in geographical, environmental and taxonomic scope and the WRA might not be applicable to other environments and taxa without certain modifications (e.g. FISK could be used for fish or FI-ISK for freshwater invertebrates (Copp 2013; Tricarico et al. 2010). The incorporation of other types of impact would require additional modifications. The method, therefore, seems less applicable than others to the intended purpose of a European horizon scanning for all environments and taxa.

Socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland (Gallardo, Aldridge 2013)

In this study the ability of environmental and socio-economic factors to predict the risk of invasion by 12 potential aquatic invaders covering all major aquatic groups to Great Britain and Ireland was evaluated. It is stated that this is the first time socio-economic factors related to propagule pressure have been specifically integrated within a distribution modelling approach. Species distribution models were calibrated with a set of environmental factors (bioclimatic, geographical and geological) and integrated with socio-economic (human influence index, population density, closeness to ports) predictors. The geographic range under threat was identified.

The methods employed within this study are quantitative and include a range of environmental and socio-economic factors. However, the data required to calibrate the models is unlikely to be available for many species. This study considered only 12 species whereas comprehensive horizon scanning across taxonomic groups and environments involves assessments of hundreds of species. The modelling approaches employed in this study could be used to provide additional information on IAS identified through less data-intensive methods.

Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland (Kelly et al. 2013)

A list of 342 species, not yet present in Ireland, including potentially IAS from North Western European countries and Great Britain and Northern Ireland was derived from a risk assessment project considering IAS in Ireland (Kelly et al. 2013). The risk assessment protocol considered the likelihood of arrival, establishment (i.e. survival under Irish climate and habitats), spread and impact on conservation and economy, by taking into account control measures and societal factors that may limit or facilitate the spread of the species. A total of 147 species were scored as having a high (51 species) or medium (96 species) risk of impact, with the high-risk species spread across all environments (7 marine, 26 freshwater, 18 terrestrial). Pet and horticultural trade represent the priority pathways for these species.

This comprehensive approach considered all environments and taxa and used the Irish Risk Assessment protocol to assess both environmental and socio-economic impacts. It also accounted for uncertainty in both information available and the assessments by providing levels of confidence of the assessors' answers. Although geographically restricted, it is one of the most complete approaches and delivered a prioritized list of high impact species not yet present in the country. However, the time commitment reuired to complete such an exercise at the EU scale would possibly be prohibitive without considerable funding.

Targeting and Prioritisation for INS in the RINSE Project Area (Gallardo et al. 2013)

RINSE (Reducing the Impacts of Non-native Species in Europe) was an INTERREG-project co-funded by the EU, aiming to increase cooperation and share best-practice between key organisations involved in the management of IAS in the area that encompasses the coastal region of southern England, northern France, Belgium and the Netherlands (for details see http://www.rinse-europe.eu/).

Using 16 lists of IAS from national and international institutions, a meta-list of 340 'worst' species that are perceived to be having, or have the potential to have, the most negative impacts on biodiversity was developed and divided into two groups: an Alert List (species not yet present in any of the RINSE countries, 79 species) and a Black List (species already present in at least one of the RINSE countries, 261 species). Both lists were verified at a RINSE Experts Workshop by 22 invited experts. The Alert list was prioritized using a risk scoring system modified from (Molnar et al. 2008) which considers four risk categories: ecological impact, invasive potential, management difficulty and economic impact. The species were then ranked by their overall average score with the top 3 plants, terrestrial animals, aquatic inland animals and marine organisms chosen to generate a top 12 of Alert IAS. The Black List was prioritized using an online survey in which experts were asked to select 10 IAS that they regarded as the 'most concerning' in terms of their current and potential environmental impacts in the RINSE region. The results of this survey were used to produce a list of the top 12 Black List species.

This horizon scanning method covered a large geographical scope (several countries within a biogeographic region) and all environments. Although it considered only selected taxa the method might be applicable to other organisms as well. Ecological and economic impact but also management difficulties were assessed using a modified scoring system and an expert online survey. Potential species distributions were statistically modelled, which might not be applicable for a large number of species with often imprecise distributional data in the native range. In cases where data are available, of course, modelling approaches are useful additions to the assessments of the likelihood of establishment and secondary spread of IAS.

Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain (Roy et al. 2014a)

A horizon scanning exercise for Great Britain was undertaken to create an ordered list of IAS (all plant and animal taxa, excluding microorganisms, across all environments) that are likely to arrive, establish and have an impact on native biodiversity within the next ten years. This exercise coupled consensus methods (which have previously been used for collaboratively identifying priorities in other contexts) with rapid risk assessment (Branquart et al. 2010). Five hundred and ninety-one species not native to Great Britain were considered (Roy et al. 2014a). The evaluation of biodiversity impacts was evaluated using an adapted (simplified) version of the Belgian ISEIA protocol. Ninety-three of these species were agreed to constitute at least a medium risk (based on score and consensus) with respect to them arriving, establishing and posing a threat to native biodiversity (Roy et al. 2014a). Four of the top ten IAS highlighted through this approach have since been recorded within Great Britain. The method has been adopted in Scotland to construct a regional horizon scanning list. The information collated through this novel extension of the consensus method for horizon-scanning provides evidence for underpinning and prioritising management both for the species and, perhaps more importantly, their pathways of arrival.

The method included a consensus workshop which enabled experts with a range of knowledge to collaborate and share information to derive a ranked list of IAS. The consensus workshop allowed experts to transparently document knowledge gaps but also captured expert opinion to inform the process despite lack of information. The study was geographically limited to Great Britain but the methods adopted are applicable more widely. Assembling a group of experts (with sufficient expertise to cover all environments and taxa) for two days is costly but was an effective method for efficiently and rapidly capturing information on hundreds of IAS.

Horizon scanning for new invasive non-native species in the Netherlands (Matthews et al. 2014)

The horizon scanning in the Netherlands (Matthews et al. 2014) used information on the origin, vectors and pathways and the relative risk posed by each species to identify potential new invasive non-native species. It was carried out by compiling two separate lists. The first list was compiled using three criteria:

(i) alien species not yet present in the Netherlands, but introduction as a result of human mediated action is probable

(ii) alien species not yet present in the wild in the Netherlands, but kept by private owners or in zoos

(iii) alien species present in the wild in the Netherlands, but with limited occurrence, so that eradication is possible

The second list comprised species with available risk or impact assessments in countries with similar climates in Europe and North America. The risk scores were standardized for comparisons between methods and taxa, from 1 (low risk) to 3 (high risk). The standardized scores were then aggregated by calculating an average score for each species and ranked (prioritized). Uncertainty was expressed using the number of individual assessments (low uncertainty for medium and high risk species if 2 or more risk assessments were available; low uncertainty for low risk species if 4 or more risk assessments were available). Both lists were then combined and only species present on both lists were further considered. Species were grouped into all possible combinations of risk (high-medium-low) and uncertainty (high-low), which resulted in 6 different sub-lists.

The "high risk and high certainty" species were again checked for climate matching, and eventually removed if unlikely to survive in the Netherlands. Species were also removed if the national risk assessment has resulted in a low or medium risk score for the Netherlands. Potentially new "high risk" invasive non-native species for which no risk assessments were available, were added at this stage, based on expert opinion. Also, species were added if the national risk assessment has resulted in a high risk score for the Netherlands and if they satisfied the abovementioned criteria. The final list included 90 "high risk and high certainty" species. Further analysis of data confirmed previous knowledge that international trade (pets and aquarium, ornamentals) is the most important pathway, and Asia and North America are the most likely origins of new invaders.

This method used a unique approach by (i) drafting a list of IAS of concern kept by private owners or in zoos and (ii) using available impact assessments from neighbouring countries, translating these different assessments into a standardized scoring system and calculating averages for each species for prioritization. The method, therefore, cannot be easily used at the EU scale without modification. It considered all environments and taxa, and uncertainty (as the number of assessments), but not all types of impacts. It also dealt with species of limited distribution, defined as "amenable to eradication", with different taxa-specific thresholds provided by expert opinion.

Alien invasive species – Pathway analysis and horizon scanning for countries in Northern Europe (NOBANIS 2015)

The pathway and horizon scanning exercise for the Northern European countries investigated potential IAS ("door knockers") that have not yet arrived and established in the assessment area (Denmark, Estonia, Faroe Islands, Finland, Iceland, Latvia, Lithuania, Norway, Sweden) (NOBANIS 2015). It also included IAS already present but not established in the wild with a sustainable population (e.g. species currently restricted to greenhouses). From the Nobanis database a list of species was compiled with IAS being present in the other participating countries (Austria, Belarus, Belgium, Czech Republic, Germany, Greenland, Ireland, Netherlands, Poland, Slovakia, European part of Russia) but not occurring in the assessment area. Further species were added from available alert lists by Denmark, Norway, Germany and Ireland. 414 potentially IAS then were assessed for their likelihood of arrival, establishment and impact, with scores from 0 (not evaluated) to 3 (high risk), with impact assessed separately for biodiversity, human health and socio-economic concerns. Impact assessments were averaged and added to establishment scores (maximal score is 6) and held against the arrival scores in a cross-table with nine possible categorizations from overall low risk to medium and high risk. These assessments were made at three regional levels (Nordic region, Baltic region, Islands of the North Atlantic). For all regions combined 43 species were assessed as "high risk" and 78 as "medium risk". Almost 50% of the high risk species (20 species) were arthropods, followed next by pathogenic fungi (5 species). Approximately 37% of the medium risk species (29 species) were angiosperms, followed by arthropods (21 species). The most probable pathways in both cases are horticulture and secondary introduction, i.e. invasion from neighbouring countries.

This horizon scanning method covered a large geographical scope (several countries), all environments and taxa, and provided regional assessments at different geographical levels. The list of species (door knockers) was retrieved from the NOBANIS-database and supplemented by other sources, but as for the horizon scanning in the Netherlands, this approach might not work at an EU scale without modification. Environmental and socio-economic impacts were scored by expert opinion based on criteria and questions used in other assessment protocols, resulting in a prioritized list of high risk species, but without providing an estimate of uncertainty.

Prioritization within risk assessment protocols

Several existing risk assessment protocols have the capacity to assess species not yet present in the assessment area and so have horizon scanning elements although do not comprehenisively identify IAS. Often, the 'invasive elsewhere' criterion is applied to pre-select the relevant species in combination with climate matching and expert judgement. The process of impact assessment usually leads to a prioritized list of species that is termed 'Alert List' or 'Warning List' (e.g. EPPO PP (Brunel et al. 2010); ISEIA (Branquart et al. 2010); GABLIS (Essl et al. 2011); see also Harmonia+ (D'hondt et al. 2015). These exercises have an important role in the context of the development of a successful early warning and information systems (Genovesi et al. 2010) and provide useful information on the distribution, ecology and impact of IAS.

Since the pre-selection methods of species not yet present in the assessment area differ from comprehensive horizon scanning with defined scope, these efforts were not analysed in detail through this project (but see (Roy et al. 2014a) for an overview). However, in recognition of the importance and usefulness of these prioritization exercises we briefly provide information on such prioritization efforts for introduced species potentially arriving into hitherto uninvaded regions.

The Weed Risk Assessment (Pheloung et al. 1999)

The Weed Risk Assessment approach of Pheloung et al. (1999) is a series of questions based on the invasion history of the species elsewhere and its ecological traits. Scoring allows a comparison of the risk level for different sectors. It has been adapted for assessing IAS in several taxonomic groups and regions, e.g. the Fish Invasiveness Screening Kit (FISK) (Copp 2013), which is used as an IAS identification tool to complement full risk assessment schemes in the GB NNRA and the European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) and as a stand-alone screening tool applied so far to at least 16 countries across five continents.

Risk analysis of potential invasive plants in Spain (Andreu, Vilà 2010)

80 invasive alien plant species of neighbouring countries and Mediterranean regions were selected, which were not yet present in Spain and considered invasive in more than one country/region elsewhere, based on online databases and scientific references (including IUCN, DAISIE, EPPO). Environmental and socio-economic impacts were assessed using the Australian Weed Risk Assessment (Pheloung et al. 1999) and a suggested method for assessing the risk of invasive alien plant species in Central Europe (Weber, Gut 2004) and the species ranked according to their impact scores. Woody species (47%) dominated in life forms, Asian (31%) and South/Central American (28%) species prevailed in origins and 62% of the screened species were ornamentals. It was concluded that both assessment methods, which delivered similar results, reduce uncertainty and that high scoring species should be prohibited or kept out of trade related pathways.

The EPPO Prioritization Process (EPPO PP) for invasive alien plants (Brunel et al. 2010)

The EPPO Prioritization Process (EPPO PP) for invasive alien plants is a process for the prioritization of alien plants to produce risk-based lists of invasive alien plants and also to determine those plants that require a full pest risk analysis (PRA). If the species is not yet established (or present) in the region, the invasive behaviour in other countries/regions should be investigated, as well as the suitability of the ecoclimatic conditions in the area under consideration. The spread potential, the potential negative impacts on native species, habitats and ecosystems, as well as on agriculture, horticulture or forestry are considered.

Alien species in Norway: with the Norwegian Black List 2012 (Gederaas et al. 2013)

203 alien species not yet observed in Norwegian nature, but present in neighbouring countries or in artificial habitats considered likely to be able to become established during the next 50 years (‘door-knockers’), were selected by experts, based on available information (e.g. NOBANIS, DAISIE) and documented negative environmental impact with some methodological deviations between the different taxonomic groups. 134 species were then subjected to an impact assessment (based on the Norwegian Black List Protocol) with 7 species having a severe impact and 23 species having a high impact. Most ‘door-knockers’ originate from Europe, followed by North America and Asia.

Risk analysis of non-indigenous marine species, Ireland: including those expected in inland water (Minchin 2014)

This account examines the principal pathways through which alien species are spread, the likely invasive subcomponent and how and/or where they might be revealed on the island of Ireland. This reflects the ECs requirement for the monitoring of IAS under Descriptor 2 of the Marine Strategy Framework Directive (MSFD). There are 32 high impacting IAS and 32 of moderate impact that are expected or might arrive. A published classification system (Hayes, Sliwa 2003) was used for evaluating overall impact and risk was evaluated based on these criteria and what might be expected over the next decade. Hubs where species might arrive are indicated according to their physiology and where IAS have arrived in the past. Likely sites for monitoring are discussed using existing non-related surveys or facilities that could aid in monitoring and surveillance. ‘Waves’ of alien invasion in Northern Europe and Ireland are predicted: the further spread of Ponto-Caspian biota westwards, the arrival of north-western Pacific species via the Arctic route with shipping and gradual movement of southern species northwards.

The Harmonia⁺ protocol (D'hondt et al. 2015)

This new tools aims to quantify the invasion risk and prioritize various non-native organisms for the production of alert lists based on different individual modules, i.e. species introduction, establishment, spread and impacts (various kind of impacts may be considered). Harmonia$^+$ is intended to be the improved and more complete version of its predecessor, the Belgian ISEIA protocol which was used in the GB horizon scanning exercise (Roy et al. 2014a).

Harmonia$^+$ was designed as a robust risk analysis scheme including the following structural elements: (i) scientific experts from very different fields were contracted to provide input on components of the scheme, (ii) it strived to be maximally compliant with authoritative bodies (EPPO - plant health, OiE - animal health, WHO - human health), (iii) the invasion stages are based on a unified framework for biological invasions and (iv) scientific literature was used as the primary information source during the protocol development.

The scheme is essentially a questionnaire which has the following advantages:

- applicable to different taxa;
- not restricted to a given area or environment;
- the entire invasion process is covered from the introduction to impacts;
- when needed, different types of impacts may be considered (notably environmental, plant, animal and human health);
- considerable attention is paid to the role of pathogens in invasion within a parallel system Pandora$^+$clear guidelines are given to assess each different stage;
- many examples are included to support an assessment;
- the latest version of the protocol covers climate change and ecosystem services;
- an online version of the protocol allows different users to perform the assessment remotely, save its assessment in the system and export the results in excel;
- information can be compiled to facilitate a more complete, follow-on risk analysis.

Harmonia$^+$ was explicitly includes 30 questions, the first 5 of which define the context of the assessment. The 25 remaining questions are divided into modules that represent invasion stages and impact types: introduction (n=3), establishment (n=2), spread (n=2), environmental impacts (n=6), plant health impacts (n=5), animal health impacts (n=3), human health impacts (n=3) and impacts on Infrastructure (n=1). The number of alternative answers for these questions is five (where possible) or three. Harmonia+ allows for numerical output, by converting the (ordinal) answers into scores and then combining these scores for every module, using several operations. Ultimately, and if desired, it allows for a single risk score to be given to the species assessed ([0,1]-interval). Assessors are also asked to indicate a level of confidence with each answer provided ('low', 'medium' or 'high').

Harmonia$^+$ is a useful tool for horizon scanning because the numerical output together with the confidence level may be used to rank different species along a risk scale on the basis of standardized criteria. The time needed for the scoring exercise depends on the number of module considered (e.g. impact types) but is unlikely to exceed 0.5 to 1 hour per species, providing that assessor has a good species knowledge before completing the form. This timescale could be limiting when considering hundreds of species and relying on volunteer involvement for the assessment. However, Harmonia$^+$ is better suited for horizon scanning in comparison to ISEIA because introduction and establishment modules are included and these are considered as essential to produce alert lists and assess risks for species not yet introduced in a given territory.

Sentinel plants (Roques et al. 2015)

Sentinel plants represent a novel method that has recently been proposed for the detection of potential new plant pests in their region of origin prior to introduction to a new continent (Roques et al. 2015). Sentinel European trees, for example, have been planted in Asia (currently considered to be the native range of a high proportion of the insect IAS arriving within Europe) as a trial for an early warning tool to identify the potential for additional Asian insect pest species (Roques et al. 2015) and tree pathogens (Vettraino et al. 2015) with the potential to colonize European trees. The results are encouraging but further research is required.

Assessment of risks to animal, plant and public health (EFSA 2014)

Animal and plant health regulations have advanced reporting obligations regarding new arrivals, incursions or outbreaks of alien species or pathogens that affect animal, plant or human health directly (e.g. as agent of disease) or indirectly (e.g. via animal feed). In a recent report, EFSA (2014) described a structured approach for identification of drivers of emerging biological risks to animal, plant and public health. The three-step process included (i) a consultation of the Animal Health and Welfare (AHAW) and the Biological Hazards (BIOHAZ) Panels through a Delphi approach (MacMillan, Marshall 2006; Mukherjee et al. 2015) (an iterative and anonymous participatory method used for gathering and evaluating expert-based knowledge), (ii) a workshop to structure the data and (iii) a discussion with related Panels and by written consultation. These sectors are in the responsibilities of dedicated organisations (OIE, EPPO, EFSA) and directed towards specific interests and outside the scope of Regulation 1143(2014). The conclusions of EFSA (2014) confirm that the approach is applicable as a tool to achieve a proactive assessment of emerging risks.

CONCLUSIONS

A number of approaches have been used for horizon scanning across a range of disciplines. Extensive literature reviews have historically dominated horizon scanning across a range of sectors from criminology (Bateman et al. 2011) and public health (Biosecurity New Zealand 2006; Morgan et al. 2009) to ecological, specifically for the identification of potential IAS (Parrott et al. 2009; Thomas 2011), but also to examine for example forthcoming legislative issues of interest to ecologists and conservationists (Sutherland et al. 2014b). More recently step-wise approaches have been employed involving literature review coupled with extensive consultation followed by interactive workshops in which consensus approaches are used to meet the aims of horizon scanning (Roy et al. 2014a; Sutherland et al. 2015).

There have been a number of horizon scanning exercises for IAS (Table 1.1), some of which have involved discrete taxonomic groups, such as plants (Andreu, Vilà 2010; Thomas 2011) or animals (Parrott et al. 2009), or distinct environments such as freshwater (Gallardo, Aldridge 2013). Most of these approaches have have relied on information from the literature coupled with risk assessment frameworks (Parrott et al. 2009; Thomas 2011) or modelling approaches (Gallardo, Aldridge 2013).

Almost all IAS horizon scanning exercises begin with a list of species compiled from databases, scientific literature, and expert opinion. The delimitation of which species to include or exclude is often imprecise. Generally species not yet present in the assessment area are included, but most exercises also include species with local distributions or species that have not yet established in the region. There is often some degree of uncertainty with respect to whether the species is already present or not.

In the analysed regional assessments, species already present in neighbouring countries were often scored “high risk” because of the high likelihood of arrival in the assessment area. However, at least in terrestrial and freshwater environments, knowledge of IAS present in countries neighbouring the EU can be relatively poor. This is also the case with the marine environment although Lessepsian migration from the Red Sea to the Eastern Mediterranean is well studied and known to contribute alien species to EU states throughout the Mediterranean and beyond.

Almost all IAS horizon scanning exercises employed a scoring system for assessing the likelihood of arrival, establishment/spread and impact of the IAS. While some considered only environmental impact, others included also human health and socio-economic impacts. One method calculated the mean of impact scores (Nobanis 2015), while another method calculated the product of the scores of likelihood of arrival, establishment and impact (Roy et al. 2014a). However, it is important to note that often the scoring is used only as a guide to ranking species. All of the different methods documented above have merit for horizon scanning but we conclude that combining elements of them (such as literature review and impact assessment) and coupling with an expert workshop in which consensus can be achieved provides a robust method for horizon scanning. This is further explored through Task 3.

The role of consensus approaches for horizon scanning

Consensus approaches involve a structured process whereby a systematic examination of potential threats is conducted through literature reviews and expert opinion, followed by discussions which aim to converge on consensus within the expert stakeholder group. Parts of the process, particularly at the beginning, are often conducted as desk research without a physical meeting of the experts, e.g. via questionnaires, data mining of online databases and scientific literature, but the discussions to reach a consensus are most successful when experts meet through a workshop. However, to be efficient and successful, a horizon scanning activity needs to have clear scope and agreement on the key question that the project aims to answer and a clear understanding among participants of the scope of the IAS under investigation (Sutherland et al. 2011b).

Consensus approaches based on the Delphi technique (Mukherjee et al. 2015) facilitate a consensus among experts in the field of interest (Mukherjee et al. 2015; Sutherland et al. 2012a). There are considerable strengths to this method, particularly when information is lacking, but it is important to acknowledge the weakness that opinion is not knowledge (Sutherland et al. 2012a). Although based on scientific evidence, the outcome of horizon scanning is not predictable or repeatable. A different composition of experts may produce different results. To overcome disparate opinions within groups other tools are also available, such as voting systems (Copp 2013), structured expert judgements (Copp et al. 2008), web-based tools to elicit probability distributions about uncertain parameters from experts (Morris et al. 2014) or assessment of expert confidence using calibrated confidence scales (Keune et al. 2012). However, consensus approaches are recognised as being a useful tool for prioritisation in conservation because informal expert opinion underpins most conservation decisions (Sutherland, Freckleton 2012).

Reaching a consensus on the assessments during a joint workshop was included only within one exercise (Roy et al. 2014a), but provided an effective mechanism for sharing information and moderating rankings across taxonomic groups and environments. Indeed, discussions through consensus approaches, where not just scores are communicated, but the insights that led to them, can reduce levels of uncertainty that are inherent when dealing with data deficiency (insufficient information on species) because of the importance of expert knowledge and opinion. Indicating the level of uncertainty of the assessments is therefore considered crucial in communicating the outcome of the exercise to a wider scientific or public audience.

In conclusion the consensus approach provides an eloquent and effective method of reaching conclusions on prioritisation following extensive gathering of information (using various methods including literature review and synthesis of expert knowledge). As such the consensus approach can constitute one component of horizon scanning building on other formal and structured methods of compiling information. The details of the adopted method for the present horizon scanning at the EU level are detailed further below (Task 3).

TASK 2: INVENTORY AND REVIEW OF APPROPRIATE DATA SOURCES

Leading experts: Stefan Schindler, Wolfgang Rabitsch, Franz Essl (EAA)

One major source of information on alien species is alien species databases. Many countries, including most in Europe, and several specialist organizations and networks e.g. the European and Mediterranean Plant Protection Organization (EPPO) or the East and South European Network for Invasive Alien Species (ESENIAS) compile and manage alien species databases. So there are many databases but they vary in taxonomic, environmental and geographic focus. The most well-known and widely used alien species databases in Europe are the databases "Delivering Alien Invasive Species Inventories for Europe" (DAISIE, www.europe-aliens.org) covering 12,000 species for entire Europe (79 countries/regions including islands) and 57 coastal and marine areas and secondly the "European Network on Invasive Alien Species" (NOBANIS, http://www.nobanis.org/) covering 9,000 species for 20 countries in Northern and Central Europe. These two databases cover all taxonomic groups and all environments (i.e. terrestrial, freshwater, and marine environment), while others are restricted to a particular taxonomic and/or environmental focus. The "European Alien Species Information Network" (EASIN, http://easin.jrc.ec.europa.eu/) is a recent initiative of the Joint Research Centre of the European Commission that aims to provide easy access to data and information on alien species in Europe from 43 existing on-line databases (Katsanevakis et al. 2012).

In a recent synthesis effort to provide an overview of existing alien species databases at a global level, 238 alien species databases were detected, ranging from sub-national (e.g. islands, federal states) to global geographical coverage (Essl et al. 2015) . In total, 196 alien species databases were found at least partly functional and further analysed regarding the spatial scale of coverage (global to subnational), taxonomic, geographic and environmental coverage, and the available information on pathways (assessed versus not assessed; numbers of pathway categories used; availability of a pathway interpretation manual; assessment of temporal changes in pathways) (Essl et al. 2015) . Most of these databases (~150) contain species factsheets that are available online and summarize the available information on the species, including for instance ecological characteristics and the history of introduction in the area under concern.

While 16 of the 196 databases had a global coverage, most databases were dealing with North America (n = 78), Europe (n = 75), and Australia (incl. Oceania; n = 15). Out of the 196 databases, 45% assessed pathways, 27% categorized pathways into intentional and unintentional introduction, but only 9% provided a pathway interpretation manual and 3% assessed trends in pathways (Essl et al. 2015) . 160 databases covered plants, 93 covered invertebrates, 82 covered fish, 70 covered fungi, 68 covered microorganisms like bacteria, and 61 covered algae.

Selecting a core set of alien species databases

For the purpose of providing information for the horizon scanning on IAS that have not yet arrived in the EU or have established in only small populations, we chose a subset of the 196 databases in order to be more efficient for practical purposes. We chose the subset of databases by assessing the 196 databses (listed in Essl et al. 2015 – Supplementary Material 3[2]) against the following criteria:

[2] Currently available under "SUPPLEMENTARY MATERIAL" at: http://bioscience.oxfordjournals.org/content/early/2015/07/11/biosci.biv082.abstract

i) taxonomic, geographic and environmental coverage of the EU to allow for assessing the status of the species in the EU

ii) taxonomic, geographic and environmental coverage of areas outside the EU that might be the origin of IAS possibly becoming introduced into the EU

iii) number of species included in the database

iv) amount and quality of information available per species

v) functionality of the database including latest update

vi) complementarity among the databases regarding taxonomic, geographic, and environmental coverage

In line with the six criteria, the assessment was based on extracted information on geographic, taxonomic and environmental coverage, the number of species considered, the provisioning of species factsheets and pathway information, functionality and actuality, as well as references for further use.

Characteristics of the 43 selected alien species databases

This assessment of the 196 databases resulted in the selection of a set of43 databases, the remaining 153 databases were considered as less appropriate or redundant according to the six criteria. The 43 selected databases were further grouped into three categories (Table 2.1), applying the same six criteria as above. The first category, "most suitable", contains the 20 databases considered to be the most useful for the purpose of horizon scanning. They are well-known European databases of broad coverage (e.g. DAISIE, NOBANIS, EASIN, CABI Compendium, EPPO; cf. Table 2.1 for full names), most relevant databases of global coverage or from other continents (e.g. GISD, DIAS, IABIN-I3N, APASAD, WIP, NANIAD - Bugguide) and that have excellent coverage for a particular but still rather broad focus (e.g. AquaNIS, ESENIAS, ISEFOR, EUROPHYT, Q-bank). The second category, "suitable", contains eleven complementary databases that should provide useful information for many circumstances and increase geographic, taxonomic and environmental coverage (GCW, HEAR/PIER, IBIS, Invasive Invertebrate Threats, Invasive Species Encyclopedia, NEMESIS, NIMPIS, Pest Tracker, USDA APHIS Regulated Pest List, USDA-PLANTS, Weeds Australia database). The third category, "possibly suitable", includes twelve databases that were either large in terms of species numbers but lack specific focus on IAS (GBIF, Fishbase, Avibase, NatureServ) or small IAS databases with very particular focus and potentially weakly covered by most of the other databases (e.g. Artsdatabanken, Especies Introducidas en Canarias, GPDD, GRIN, NBIC). As the 196 databses and the information they contain have a strong bias towards Europe and North Amercia (Essl et al. 2015), we took care to adequately consider criterion (vi) on complementarity in order to avoid sets of databases with high overlap in coverage but collectively with information lacking on some particularthemes. For this reason some databases that might be relevant only in particular cases were considered as "most suitable" (e.g. WIP which is currently not entirely functional, but contains factsheets and can be considered as the most appropriate database with exclusively African focus; or ISEFOR which has no factsheets but a particular focus on forest pests), "suitable" (e.g. HIER/PEAR which is not actualized, but still a relevant portal for information on Hawaii and Pacific Islands) and "potentially suitable" (e.g. NIBIC as portal for ballast water issues or GRIN as portal for germplasm, i.e. living genetic resources such as seeds).

Assessing the coverage of the set of 43 databases we found that it contained eleven global, fourteen regional, and 18 (sub-) national ones. Additional to the coverage by the twelve global databases, North America is covered by a further 15 databases, Europe by twelve, Australia and Oceania by three, Africa by two, Asia by two, and South America by one (Table 2.1). 18 of the 43 databases cover all taxonomic groups, for two databases the taxonomic coverage is uncertain, while the remaining 23 databases cover one or more taxonomic groups, e.g. plants (covered by 15 further databases), invertebrates (n=10), fish (n=7), terrestrial vertebrates (n=5), fungi (n=4), and microbes (n=4) (Table 2.1). 19 of the 43 databases cover all environments (terrestrial, freshwater and marine); the remaining databases cover terrestrial and freshwater environments (n=9 databases), freshwater and marine environments (n=4), only terrestrial environments (n=7), and only marine environments (n=4) (Table 2.1). For 37 of the 43 databases the number of species could be evaluated. More than 10,000 species were covered by six databases, 5001-10,000 species by five databases, 1001-5000 species by eight databases, 501-1000 species by seven databases, while the remaining eleven databases covered between 60 and 500 species. It is important to note that different databases covering the same geographic area may portray different information (Gatto et al. 2013; Hulme, Weser 2011) and thus using multiple databases can introduce uncertainty into analyses. Experts provide an extremely important role in integrating and interpreting the disparate information.

CONCLUSIONS

The core set of 43 alien species databases, selected based on an assessment of 196 databases, is an efficient instrument for assessing ecological traits and distribution trends for candidate species in the frame of a horizon scanning exercise. Databases covering non-EU countries can be used to investigate invasion behaviour of species yet to be introduced into the EU, while databases covering EU countries can be used to assess whether the species has already arrived in the EU, whether it has arrived but is currently only established in small populations as well as to assess actual information about the distribution, pathways, invasion history, and impact in the EU. It must be clearly stated that alien species databases are only one kind of information source on alien species. Other highly relevant sources include original articles, particularly in scientific journals dedicated to invasion biology such as Diversity and Distributions, Biological Invasions, Neobiota, Aquatic Invasions, BioInvasions Records, and Management of Biological Invasions, but also other journals on ecology, conservation biology and environmental sciences. Beyond this written evidence, the knowledge of local/regional experts is an irreplaceable source of up to date information. A caveat when using the information of alien species databases is that their usefulness is strongly dependent on regular updates. The list of 43 databases presented here contains functional sources that seemed to be up to date according to their web appearance and any kind of limitations are indicated; however, regularity and frequency of updates could not always be definitively assessed.

Table 2.1 List of selected 43 alien species databases particularly suitable for the purpose of a European horizon scanning on alien species that have not yet arrived to the European Union (EU) (or have arrived but are only established in small populations). The attributes in this table relate to the six criteria used to select this core set of alien species databases: i. Taxonomic, geographic and environmental coverage of the EU to allow assessment of the status of species within the EU (Geographic, taxonomic, and environmental coverage), ii. Taxonomic, geographic and environmental coverage of areas outside the EU that might be the origin of IAS possibly becoming introduced into the EU (Geographic, taxonomic, and environmental coverage), iii. Number of species included in the database, iv. Amount and quality of information available per species (species fact sheets and pathway information), v. functionality of the database including latest update, vi. Complementarity among the databases regarding taxonomic, geographic, and environmental coverage (Geographic, taxonomic, and environmental coverage).

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
1	1 - most suitable	Asia	APASD	Asia-Pacific Alien Species Database	http://www.niaes.affrc.go.jp/techdoc/apasd/	317	regional	Asia-Pacific (Japan, Malaysia, Philippines, Taiwan, Thailand, Vietnam, mainland China)	All taxonomic groups (Plants, animals, viruses, bacteria, fungi)	freshwater, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2014	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
2	1 - most suitable	European seas	AquaNIS	Aquatic non-indigenous species	http://www.corpi.ku.lt/databases/index.php/aquanis/	1390	regional	European seas with capability of global coverage	All taxonomic groups (all multicellular and some single celled aquatic taxa)	marine (incl.brackish)	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Olenin, S., Narščius, A., Minchin, D., David, M., Galil, B., Gollasch, S., Marchini, A., Occhipinti-Ambrogi, A., Ojaveer, H., Zaiko, A. (2014). Making non-indigenous species information systems practical for management and useful for research: An aquatic perspective. Biological Conservation 173: 98-107.
3	1 - most suitable	Global	CABI Compendium	CABI Invasive Species Compendium	http://www.cabi.org/isc/	8957	Global	global	All taxonomic groups (incl. bacteria, fungi, protozoa, viruses)	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Pasiecznik, N. (2004). Pathways for plant introduction. CABI, Wallingford, UK,

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
4	1 - most suitable	Europe	DAISIE	Delivering Alien Invasive Species Inventories for Europe	www.europe-aliens.org	>15000	regional	wider European area (up to 94 countries/regionsincluding all EU-27 states and Norway)	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2012 (ongoing)	DAISIE (ed.) (2008). The Handbook of Alien Species in Europe, Springer-Verlag.
5	1 - most suitable	Global	DIAS	FAO Database on Introductions of Aquatic Species	http://www.fao.org/fishery/dias/en	5612	Global	global	Fish, crustaceans, molluscs	freshwater, marine	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Welcomme, R.L. (1988). International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, Food and Agriculture Organisation of the United Nations, Rome, 318 pp.
6	1 - most suitable	Europe	EASIN	European Alien Species Information Network	http://easin.jrc.ec.europa.eu/	16339	regional	Europe	All taxonomic groups (incl. bacteria, fungi, protozoa, viruses)	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Trombetti, M., Katsanevakis, S., Deriu, I. and A.C. Cardoso (2013). EASIN-Lit: a geo-database of published alien species records. Management of Biological Invasions 4(3): 261-264.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
7	1 - most suitable	Europe, Africa, Asia	EPPO	European and Mediterranean Plant Protection Organization	https://www.eppo.int/	91	regional	Europe, N-Africa, Central Asia	Plants	terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	EPPO Bulletin https://www.eppo.int/PUBLICATIONS/bulletin/bulletin.htm
8	1 - most suitable	Europe	ESENIAS	East and South European Network for Invasive Alien Species	http://www.esenias.org	n.a. (species lists and factsheets still under construction)	regional	South and Eastern Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Italy, Kosovo under UNSC Resolution 1244/99, FYR Macedonia, Montenegro, Serbia, Slovenia, Romania, Turkey)	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: currently not available Pathway information: currently not available	Under development Last update: 2015	Zenetos, A., Katsanevakis, S., Poursanidis, D., Crocetta, F., Damalas D., Apostolopoulos G., Gravili C., Vardala-Theodorou, E. and M. Malaquias (2011). Marine alien species in Greek Seas: Additions and amendments by 2010. Mediterranean Marine Science, 12, 1: 95-120.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
9	1 - most suitable	Europe	EUROPHYT	European Union Notification System for Plant Health Interceptions	http://ec.europa.eu/food/plant/plant_health_biosafety/europhyt/interceptions_en.htm	e.g. >500 in 2011	regional	Europe	Focus on plant pest but also notes host plants	terrestrial	Species fact sheets: NO Pathway information: YES	Fully functional Last update: 2015	Europhyt. (2011). European Union Notification System for Plant Health Interceptions. available from http://ec.europa.eu/food/plant/europhyt/index_en.htm
10	1 - most suitable	Global	GISD	Global Invasive Species Database	http://www.issg.org/database/welcome/	891	Global	global	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: n.a. (2015?)	Invasive Species Specialist Group ISSG (2015). The Global Invasive Species Database. Version 2015.1 <http://www.issg.org/database > Accessed at 26-May-2015

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
11	1 - most suitable	Global	Global Marine Invasive Species Assessment	Global Marine Invasive Species Assessment	https://www.conservationgateway.org/ConservationPractices/Marine/Pages/marineinvasives.aspx	330	Global	global seas and oceans	All taxonomic groups	marine	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015 (data until 2008)	Molnar, J.L., Gamboa, R.L., Revenga, C., and M.D. Spalding (2008). Assessing the global threat of invasive species to marine biodiversity. Frontiers in Ecology and the Environment 6(9), 485-492.
12	1 - most suitable	South America, Central America	IABIN-I3N	Inter American Biodiversity Information Network (IABIN) - Invasive Species Network (I3N)	http://www.institutohorus.org.br/iabin/i3n/index.html	436 (currently getting built up; for some countries functional – for others not yet)	regional	"Latin America" (Argentina, Bolivia, Brazil, Colombia, Chile, Costa Rica, Guatemala, Jamaica, Paraguay, Uruguay)	All taxonomic groups	freshwater, terrestrial	Species fact sheets: YES Pathway information: NO	For some countires functional; for most countires under development Last update: 2015	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
13	1 - most suitable	Europe	ISEFOR	Increasing Sustainability of European Forests	www.isefor.com	996	regional	Europe	Forest tree pests and pathogens (fungi, oomycetes and bacteria)	terrestrial	Species fact sheets: NO Pathway information: YES (focus on pathways, but no species specific pathway information readily available in a database or factsheets)	Fully functional (but no databases /factsheets) Last update: 2013	Vannini, M., Franceschini, S. and A.M. Vettraino (2012). Manufactured wood trade to Europe: a potential uninspected carrier of alien fungi. Biological Invasions 14: 1991-1997.
14	1 - most suitable	Central America	Malezas de Mexico	Weeds of Mexico / Malezas de Mexico	http://www.malezasdemexico.net/	appr. 1100	national	Mexico	Plants (focus on "weeds", but not all are alien)	terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: n.a.	n.a.
15	1 - most suitable	North America	NANIAD - Bugguide	Bugguide - List of non-native arthropods in North America	http://bugguide.net/node/view/32329	2273	regional	North America	Arthropods	freshwater, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2015	n.a.
16	1 - most suitable	North America	NAS Database	Nonindigenous Aquatic Species Database (USGS)	http://nas.er.usgs.gov/	1100	national	USA	Invertebrates and vertebrates	freshwater, marine	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Several original sources in each fact sheet

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
17	1 - most suitable	Europe	NOBANIS	North European and Baltic Network on Invasive Alien Species	http://www.nobanis.org/	8739	regional	20 countries in Northern and Central Europe: Austria, Belarus, Belgium, Czech Republic, Denmark, Estonia, Finland, Faroe Islands, Germany, Greenland, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, European part of Russia, Slovakia, Sweden	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Secretariat of NOBANIS (2012): Risk-mapping for 100 nonnative species in Europe. Copenhagen. http://www.nobanis.org/files/Riskmapping_report.pdf

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
18	1 - most suitable	Europe	Q-bank	Q-bank – Comprehensive Databases on Regulated Plant Pests	http://www.q-bank.eu/	appr. 2000	regional	Partners from 20 countries including The Netherlands, Belgium, United Kingdom, France, Denmark and Italy	Fungi, arthropods, plants, nematodes, viruses, phytoplasmas	terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Bonants, P., Edema, M. and V. Robert (2013). Q-bank, a database with information for identification of plant quarantine plant pest and diseases. EPPO Bulletin 43.2: 211-215
19	1 - most suitable	Africa	WIP	Weeds and Invasive Plants (South Africa)	http://www.agis.agric.za/wip/	appr. 600	national	South Africa	Plants	freshwater, terrestrial	Species fact sheets: YES Pathway information: NO	Partly not functional Last update: n.a. (probably not very often actualized)	Henderson, L. and C.J. Cilliers (2002). Invasive aquatic plants. Plant Protection Research Institute Handbook No. 16, Agricultural Research Council, Pretoria.
20	1 - most suitable	North America	www.invasive.org	The Bugwood Network (University of Georgia)	http://www.bugwood.org/ www.invasive.org	2908	national	USA	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2014	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
21	2 - suitable	Global	GCW	Global Compendium of Weeds	http://www.hear.org/gcw/scientificnames/scinameo.htm	>28000	global	global	Plants (Weeds)	freshwater, marine, terrestrial	Species fact sheets: YES (but poor) Pathway information: NO	Fully functional Last update: 2007	Randall, R.P. (2002). A global compendium of weeds. Second Edition, Publisher: Department of Agriculture and Food, Western Australia.
22	2 - suitable	Australia (and Oceania)	HEAR/PIER	Invasive species information for Hawaii and the Pacific	http://www.hear.org/	n.a.	regional	Pacific Islands	Plants	freshwater, marine, terrestrial	Species fact sheets: YES (but poor) Pathway information: NO	Limited functionality, may close soon Last update: 2012	US Forest Service, Pacific Island Ecosystems at Risk (PIER). Online resource at http://www.hear.org/pier/ accessed 26-May-2015
23	2 - suitable	Global	IBIS	Island Biodiversity and Invasive Species Database	http://ibis.fos.auckland.ac.nz	n.a.	global	global islands	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2015	Invasive Species Specialist Group –ISSG (2012). Island Biodiversity and Invasive Species Database -IBIS Version 2012.1 <http://ibis.fos.auckland.ac.nz/ >

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
24	2 - suitable	Australia (and Oceania)	Invasive Invertebrate Threats	Invasive Invertebrates in Natural Ecosystems (New Zealand)	http://www.landcareresearch.co.nz/research/biocons/invertebrates/	appr. 60	national	New Zealand	Invertebrates	freshwater, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	n.a.
25	2 - suitable	North America	Invasive Species Encyclopedia	Invasive Species in Canada (Wildlife Federation Canada)	http://cwf-fcf.org/en/discover-wildlife/resources/encyclopedias/invasive-species/	414	national	Canada	all taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	n.a.
26	2 - suitable	North America	NEMESIS	National Exotic Marine & Estuarine Species Information System (SERC)	http://invasions.si.edu/nemesis/databases.html	137	national	USA	Invertebrates	marine	Species fact sheets: YES Pathway information: YES	Currently geeting restricted, but seemingly fully functional Last update: n.a. (2015?)	Fofonoff, P.W., Ruiz, G.M., Steves, B. and J.T. Carlton (2014). National Exotic Marine and Estuarine Species Information System. http://invasions.si.edu/nemesis/. Access Date: 26-May-2015

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
27	2 - suitable	Australia (and Oceania)	NIMPIS	National Introduced Marine Pests Information System	http://data.daff.gov.au/marinepests/#srchByNameOrNumber	>100	national	Australia	all taxonomic groups	marine	Species fact sheets: YES Pathway information: YES	Fully functional Last update: n.a. (2015?)	NIMPIS (National Introduced Marine Pest Information System). (2009). Web publication <http://www.marinepests.gov.au/nimpis>. Date of access: 26-May-2015
28	2 - suitable	North America	Pest Tracker	PestTracker (NAPIS Purdue University; USDA-APHIS)	http://pest.ceris.purdue.edu/pests.php	617	national	USA	All taxonomic groups (plants, animals, fungi, bacteria, viruses)	terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2015	n.a.
29	2 - suitable	North America	USDA APHIS Regulated Pest List	USDA APHIS Regulated Pest List (www.invasive.org)	http://www.invasive.org/species/list.cfm?id=4	239	national	USA	All taxonomic groups (plants, animals, fungi, bacteria, viruses)	terrestrial	Species fact sheets: YES (but rather poor) Pathway information: NO	Fully functional Last update: 2009	n.a.
30	2 - suitable	North America	USDA-PLANTS	Federal and State Noxious Weeds (USDA-PLANTS)	http://plants.usda.gov/java/noxComposite	679	national	USA	Plants	freshwater, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: n.a. (2014?)	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
31	2 - suitable	Australia (and Oceania)	Weeds Australia database	Weeds Australia database	http://search.weeds.org.au/	481	national	Australia	Plants	freshwater, terrestrial	Species fact sheets: NO Pathway information: NO	Fully functional Last update: n.a.	Thorp, J.R., Wilson, M.W. (1998 onwards) Weeds Australia - www.weeds.org.au Date of access: 26-May-2015
32	3 - possibly suitable	North America	AKEPIC	Alaska Exotic Plant Mapping Project (Alaska)	http://aknhp.uaa.alaska.edu/botany/akepic/	160	(sub-)national	USA	Plants	freshwater, terrestrial	Species fact sheets: YES Pathway information: partly	Fully functional Last update: 2015	AKEPIC (Year). Alaska Exotic Plant Information Clearinghouse database (http://aknhp.uaa.alaska.edu/maps/akepic/). Alaska Natural Heritage Program, University of Alaska, Anchorage. Date of access: 26-May-2015

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
33	3 - possibly suitable	Europe	Artsdatabanken	Artsdatabanken	http://www.artsdatabanken.no/fremmedearter	2595	national	Norway	All taxonomic groups	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: n.a. (2015?)	Gederaas, L., Moen, T.L., Skjelseth, S. and L.-K. Larsen (eds.). Alien species in Norway– with the Norwegian Black List 2012. The Norwegian Biodiversity Information Centre, Norway.
34	3 - possibly suitable	Global	Avibase	Avibase – the world bird database	http://avibase.bsc-eoc.org/checklist.jsp?lang=EN	10000 (but most are not IAS!!)	global	global	birds	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2015	McKinney, M.L. (2006). Correlated non-native species richness of birds, mammals, herptiles and plants: scale effects of area, human population and native plants. Biological Invasions 8: 415-425.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
35	3 - possibly suitable	Europe	Especies introducidas en Canarias	Especies introducidas en Canarias	http://www.interreg-bionatura.com/especies/	appr. 1000	(sub-)national	Canary Islands (Spain)	animals, plants, fungi, algae	freshwater, marine, terrestrial	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2014	Arechavaleta, M., Rodríguez S., Zurita N. & A. García (Coord.) (2010). Lista de especies silvestres de Canarias (hongos, plantas y animales terrestres) 2009. Gobierno de Canarias. 579 pp.
36	3 - possibly suitable	Global	FishBase	FishBase – A Global Information System on Fishes	http://www.fishbase.org	32900 (but most are not IAS!!)	global	global	fish	freshwater, marine	Species fact sheets: YES Pathway information: NO	Fully functional Last update: 2015	Froese, R. and D. Pauly (eds.) (2014). FishBase. World Wide Web electronic publication. www.fishbase.org, version (05/2015).
37	3 - possibly suitable	Europe	Flora of Iceland	Flora of Iceland	http://www.floraislands.is/index.html	5610 (but most are not IAS!!)	national	Iceland	Plants (incl. mosses), Lichens, Fungi, Algae	freshwater, terrestrial	Species fact sheets: YES (only in Icelandic Pathway information: YES	Fully functional Last update: n.a.	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
38	3 – possibly suitable	Global	GBIF	Global Bio-diversity Informa-tion Facility	http://www.gbif.org/	appr. 1 600 000 (but most are not IAS!!)	global	global	All taxonomic groups (animalia, archaea, bacteria, chromista, fungi, incertae, plantae, protozoa and viruses)	Fresh-water, marine, terrest-rial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	Berendsohn, W.G., Vishwas C. and J. Macklin (2010). Summary of Recommendations of the GBIF Task Group on the Global Strategy and Action Plan for the Digitisation of Natural History Collections. Biodiversity Informatics 7.2.
39	3 – possibly suitable	Global	GPDD	Global Pest and Disease Database (USDA / PPQ) (restricted access)	https://www.gpdd.info/	3700	Global	Global	n.a.	freshwater, marine, terrestrial	Species fact sheets: n.a. Pathway information: n.a.	Restricted access Last update: n.a.	n.a.
40	3 – possibly suitable	North America	GRIN	Germplasm Resources Informa-tion Network (USDA)	http://www.ars-grin.gov/npgs/index.html	n.a.	National	USA	Plants, Animals, Microbes	freshwater, marine, terrestrial	Species fact sheets: NO Pathway information: NO	Fully functional Last update: 2010	n.a.

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
41	3 – possibly suitable	North America	Nature Serve	Nature Serve Explorer	http://www.natureserve.org/conservation-tools/data-maps-tools/natureserve-explorer	70000 (but including ecosystems and native species!!)	Regional	USA & Canada	Plants, Animals, Fungi	freshwater, marine, terrestrial	Species fact sheets: n.a. Pathway information: NO	Much informa-tion but not fully functional. Most relevant tool (i.e. "Nature Serve Explorer") was not functional at last check (6.7.2015) Last update: 2015.	n.a.
42	3 – possibly suitable	North America	NBIC	National Ballast Water Informa-tion Clearing-house (SERC)	http://invasions.si.edu/nbic/	n.a.	national	USA	n.a.	marine	Species fact sheets: NO Pathway information: NO	Fully functional Last update: 2015	National Ballast Information Clearinghouse (2014). NBIC Online Database. Electronic publication, Smithsonian Environmental Research Center & United States Coast Guard. Available fromhttp://invasions.si.edu/nbic/search.html; searched 26-May-2015

ID	Horizon scan	Continent	Data-base name	Full name	Website	No of species in data-base	Geographic scale	Geographic coverage	Taxonomic coverage	Environ-mental coverage	Species fact sheets and pathway information	Function-ality and last update	References (Examples)
43	3 – possibly suitable	North America	NISIC	National Invasive Species Informa-tion Center (USDA)	http://www.invasivespeciesinfo.gov/about.shtml	150	national	USA	Plants, Animals, Microbes	Fresh-water, marine, terrest-rial	Species fact sheets: YES Pathway information: YES	Fully functional Last update: 2015	n.a.

TASK 3: HORIZON SCANNING METHODOLOGY FOR THE EU, BASED ON THE RESULTS OF THE INVENTORY (TASK 1) AND INCLUDING THE RETRIEVAL OF DATA FROM THE ABOVE DATA SOURCES (TASK 2).

Leading experts: Alan Stewart (University of Sussex), Karsten Schonrogge (CEH)

The aim of this task was to consider the merits of the various methodologies collated and summarised in Task 1 and then to develop an optimal and appropriate horizon scanning method for IAS that are likely to arrive, establish, spread and have an impact on EU member states. The primary objective was to develop a method for the rapid identification of future IAS so that subsequent risk assessments can be more effectively prioritised. An important consideration was to ensure that the recommended approach was compatible with the minimum standards agreed in our previous 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 methodology was then subjected to peer review and validation (Task 4) and used to perform horizon scanning (Task 5) through a 2-day workshop in Brussels (Task 4) that brought together 22 members of the project team and 13 selected invited experts.

Ultimately, the objective was to derive a horizon scanning methodology that could be used to produce a ranked list of potential IAS that identifies the species most likely to arrive, establish, spread and threaten biodiversity and related ecosystem services across the EU within the next ten years. This list would then be used to prioritise species for risk assessment. The important features of the horizon scanning methodology were considered to be:

i) standardised, to ensure a uniform approach across taxonomic/functional groups

ii) repeatable, at appropriate time intervals (e.g. annually or every three years)

iii) rapid, to ensure maximal responsiveness to changing circumstances (e.g. emergence of new threats)

iv) authoritative, drawing upon the most updated and reliable available information, coupled with experience, knowledge and opinion of experts in the field.

Outline of methodology adopted

After reviewing the range of existing methodologies in Task 1, it was agreed by the project team (subject to review and approval at the workshop in Task 4) that the best approach would employ a combination of (i) rapid assessment, based on literature review and expert opinion, and (ii) dynamic consensus building through face-to-face discussion. This approach had previously been adopted successfully in a horizon scanning exercise to identify IAS that are likely to arrive, establish, spread and have an impact on biodiversity in Britain (Roy et al. 2014a). Although the approach adopted here largely replicated the one developed for Britain (Roy et al. 2014a) the consideration of negative impacts was extended to consider ecosystem services alongside biodiversity. Furthermore the workshop (and associated pre-workshop preparation) enabled testing of the validity of scaling up of this approach for use at large geographic scales by conducting a horizon scanning exercise to identify potential IAS that could threaten biodiversity and associated ecosystem services at the EU level

(Task 5). As well as deriving a list of IAS for prioritisation for risk assessment, the objective of the horizon scanning was to examine the performance of the methodology in different contexts (taxonomic groups, environments, biogeographic regions), refine the details and expose any weaknesses which could then be addressed through discussion. The horizon scanning approach proceeded in a series of logical steps:

1. Establishment of thematic groups;
2. Compilation of lists of IAS considered to constitute the highest risk with respect to likelihood of arrival, establishment, spread and impact on biodiversity and ecosystem services;
3. Scoring of species to enable preliminary rankings to be determined (along with definition of relevant level of confidence).
4. Expert workshop to review and refine ranks leading to eventual consensus across all thematic groups

Step 1 Establishment of thematic groups

Given the comprehensive breadth of taxonomic groups and environments to be covered, it was decided that the most efficient approach would be to divide the workload between five broad thematic groups based on taxonomy and/or major environments (Table 3.1). The project team included 22 experts with representation across the thematic groups (Annex 1 and Table 3.1) but 14 additional experts with detailed knowledge of IAS were invited to join one of these sub-groups according to their specialist interests and expertise. Group sizes ranged between six and nine and contained two co-leaders (from within the project team) who agreed to coordinate and record activities and discussion between group members in advance of the workshop, during the workshop and in the post-workshop discussions.

Table 3.1 Thematic groups established for the horizon scanning approach. Each group was led by two experts (group leaders) and included a number of additional contributors. Invited experts are shown in italics. All other contributors were project team members. All group leaders attended the workshop. The contributors marked in bold contributed to the preliminary consultation and post workshop discussions but did not attend the workshop. Four additional project team members attended the workshop: Jodey Peyton and Steph Rorke from the Centre for Ecology & Hydrology assisted with facilitation and data management; Ana Nieto and Mariana Garcia from the IUCN led the organisation of the workshop alongside Helen Roy. Ana-Cristina Cardoso from the JRC attended as a contributory partner.

Thematic Group	Group leaders	Contributors
Plants	Etienne Branquart Montse Vilà	**Franz Essl** *Jan Pergl* **Oliver Pescott** **Philip Hulme** Sonia Vanderhoeven
Vertebrates	Riccardo Scalera Sven Bacher	Piero Genovesi Carles Carboneras *Tim Adriaens* *Wojciech Solarz*

Thematic Group	Group leaders	Contributors
Marine species	John Bishop Argyro Zenetos	*Juliet Brodie* Elizabeth Cook ***Marco Faasse*** *Francis Kerckhof* *Dan Minchin* **Christine Wood**
Terrestrial invertebrates	Wolfgang Nentwig Alan Stewart	*Jorgen Eilenberg* Marc Kenis *Cristina Preda* Wolfgang Rabitsch *Alain Roques* Karsten Schönrogge Helen Roy
Freshwater invertebrates and fishes	David Aldridge Emili García-Berthou	*Gordon Copp* *Belinda Gallardo* *Elena Tricarico* *Gerard van der Velde*

Step 2 Compilation of lists of IAS considered to constitute the highest risk with respect to likelihood of arrival, establishment, spread and impact on biodiversity and ecosystem services per thematic group

Each thematic group was asked to assemble lists of IAS that they considered to constitute the highest risk with respect to likelihood of arrival, establishment, spread and impact on biodiversity and ecosystem services, within the EU region over the next ten years. It was expected that they would derive these lists from a combination of literature searches (including academic journals, risk assessments, reports, authoritative websites and other 'grey' literature), querying of IAS databases (including the 43 identified in Task 2 but also databases not available on-line but accessible to the experts) and their own knowledge and expert opinion. The approaches adopted by each thematic group differed slightly with respect to data sources accessed as expected because of the diverse nature of the groups (Annex 2). The scope of the exercise was clearly stated alongside a number of exclusions:

a) Species that arrive by natural spread/dispersal without human intervention in response to changing ecological conditions and climate change

b) Species that are native somewhere in the EU

c) Pathogens that cause animal diseases (including to wildlife)

d) Harmful organisms listed in Annex I or Annex II to Directive 2000/29/EC

e) Species listed in Annex IV to Regulation (EC) No 708/2007 when used in aquaculture

f) Species or taxonomic groups that are regulated under other EU legislations

g) Micro-organisms

h) Genetically-modified organisms

i) Species having adverse impacts only on economic interests (such as agriculture, horticulture, timber production) or human health and wellbeing, unless these impacts are in addition to separate impacts on native biodiversity (in which case, these additional impacts were noted, but not used as primary selection criteria).

Species that have been included in other prioritization exercises, but do not appear on any dedicated EU Regulation, were eligible for selection (for example, species on the EPPO A1 and A2 lists, but see further below in "Group-specific approaches to species selection"). It was clearly stated that the lists should only include species alien to the EU acknowledging that the EU does not encompass all of Europe. Additionally consideration was only given to species that were currently absent or already present and/or established in the EU but with a limited distribution (not widely spread) (this proved to be problematic in terms of achieving consistency across thematic groups and is discussed further below in "Group-specific approaches to species selection"). The temporal scope of the horizon scanning exercise was stated such that only species likely to arrive in the next 10 years on EU territory should be included. This temporal limit has important consequences, because it limits the relevance of climate change considerations and the way in which changes in climatically matched areas are assessed.

For species likely to invade the EU, the geographic scope of the search needs to be worldwide. A potential, but not exhaustive, list of search criteria include species that: (i) are present in countries adjacent or physically connected to the EU; (ii) are present in areas of the world that are climatically matched to the EU; (iii) have documented histories of invasion and causing undesirable impacts in other areas; (iv) are found in trade to the EU or are present in areas that have strong trade and/or travel connections with the EU and where there is a recognised potential pathway for arrival.

Each of the five thematic groups took a slightly different approach to achieving this aim and this is documented below in Task 4 ("Group-specific approaches to species selection"). However, the general approach was that co-leaders of each of the thematic groups collated and harmonised the lists of IAS received from the experts within their group into a single list for their group.

The following core information for each species was then assembled in a spreadsheet arranged in a standard-format: accepted scientific name; any vernacular (English or common) name(s); taxonomic group; functional group (Table 3.2); native distribution (Table 3.3); whether or not the species is already present in the EU; and the most likely pathway through which the species could arrive in the EU (Table 3.4).

Table 3.2 Functional groups and associated codes used in the compilation of information on IAS for consideration within the horizon scanning

Functional group	Code
Detritivore	Det
Primary producer	PP
Filter feeder	Filter
Herbivore	Herb
Predator or parasite	Pred
Omnivore	Omni
Pollinator	Poll

Table 3.3 Native distributions (geographic region) for terrestrial and freshwater species and associated codes used in the compilation of information on IAS for consideration within the horizon scanning; for marine bioregions see Table 4.5

Geographic region	Code
Europe	Eur
Africa	Afr
Asia-temperate	As
Asia-tropical	At
Australasia	Aus
Pacific	Pac
N America	NAm
S America	SAm
Antarctica	Ant

Table 3.4 Potential pathways through which IAS could arrive were classified according to the scheme outlined by the CBD (CBD 2014). Multiple pathways are relevant for many species and these were documented as a list.

Category	Subcategory	Code
Release in nature	Biological Control	BC
	Erosion control / dune stabilisation (windbreaks/hedges)	EC
	Fishery in the wild	F
	Hunting	H
	Landscape/flora/fauna improvement in the wild	L
	Introduction for conservation purposes or wildlife management	Cons
	Release in nature for use (other than above)	R
	Other intentional release	Other
Escape from confinement	Agriculture	Ag
	Aquaculture	Aq
	Botanical garden/zoo/aquaria	BZA
	Pet/aquarium/terranium	Pet
	Farmed animals	Farm
	Forestry	For
	Fur Farm	FF
	Hortiulture	Hort
	Ornamental other than horticulture	Orn
	Research	Res
	Live food and live bait	Live
	Other escape from confinement	Other escape

Category	Subcategory	Code
Transport contaminant	Contaminant nursery material	CNM
	Contaminated bait	Bait
	Food contaminant	Food
	Contaminant on animals (except parasites)	Con Anim
	Parasites on animals	Par Anim
	Contaminant on plants (except parasites)	Con Plant
	Parasites on plants	Par Plant
	Seed contaminant	Seed
	Timber trade	TT
	Transportation of habitat material	THM
Transport-stowaway	Angling/fishing equipment	Ang
	Container/bulk	Container
	Hitchhikers on airplane	Air
	Hitchhikers on ship/boat	Ship
	Machinery/equipment	Mach
	People and luggage / equipment	Lug
	Organic packing material	Org
	Ship/boat ballast water	Ballast
	Ship/boat hull fouling	Hull
	Vehicles	Veh
	Other means of transport	Other transport
Corridor	Interconnected waterways – Water Tunnels and bridges	Tun
Unaided	Natural dispersal across border of IAS that have been introduced through pathways 1-5	Nat

Step 3 Score species to enable rankings to be determined

Experts were asked to score each species (on a scale of 1 =low to 5=high) for their separate likelihoods of: i) arrival, ii) establishment and iii) spread, and iv) to give a score for the potential negative impact on biodiversity within the EU.

The purpose of the scores was both to reduce the very long thematic group species lists and ensure they represented the IAS of highest priority for risk assessment but also as a first step of harmonisation between the different groups. Indeed the scores were intended to provide approximate guidance to inform discussion and the horizon scanning approach, but not to be considered as part of a full impact assessment.

Confidence level

Recognising that such a system is based on expert judgement but often also incomplete knowledge, experts were asked to attach a level of confidence to each of their scores (Table 3.5).

Table 3.5 Confidence scores accompanied by examples to provide context based on the proposed unified framework for environmental impacts (Blackburn et al. 2014) and the EPPO Pest Risk Assessment Decision Support Scheme (EPPO 2011).

Confidence Score	Examples
High	There is direct relevant evidence to support the assessment. The situation can easily be predicted. There are reliable/good quality data sources on impacts of the species. The interpretation of data/information is straightforward. Data/information are not controversial, contradictory.
Medium	There is some evidence to support the assessment. Some information is indirect, e.g. data from phylogenetically or functionally similar species have been used as supporting evidence. The interpretation of the data is to some extent ambiguous or contradictory.
Low	There is no direct evidence to support the assessment, e.g. only data from other species have been used as supporting evidence. Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous. The information sources are considered to be of low quality or contain information that is unreliable.

Scoring of arrival

Scores for the likelihood of arrival were based on a consideration of several relevant factors, including: previous history of invasion by the species in other regions; the existence of a realistic introduction pathway; volume and frequency of trade and/or travel between the existing range of the species and the EU. A score of 1 denoted that the species was extremely unlikely to arrive in the EU within the chosen timeframe. A score of 5 was used to denote certain, or near-certain, arrival. In the case of species with small self-sustaining populations already established in the EU, the likelihood of arrival and establishment was agreed to be the top category of 5.

Scoring of establishment

Having arrived, the probability of a species establishing a self-sustaining population will depend on the ecological properties of both the species itself and the community that it is invading. Scores therefore reflected life-history characteristics including reproductive rate and ecological features such as tolerance of a broad range of environmental conditions, availability of food supply and competitive ability.

Scoring of spread

Scores for likelihood of spread were primarily determined by the reproductive capacity of the species (to achieve a population size / density that would prompt dispersal), the dispersal ability and propensity of the species, and its history and speed of spread in other regions.

Scoring of impact

Experts were asked to score the magnitude of impact on ecosystem services, and the likelihood of colonisation of high-value habitats (as defined by the EU Habitats Directive). Furthermore, information was requested on the mechanisms through which each IAS could impact biodiversity and ecosystem function (details in Table 3.6).

Table 3.6 Impact categories, based on the likely mechanisms of impact (Blackburn et al. 2014), circulated to the thematic groups for consideration during the preliminary scoring phase of the horizon scanning. Experts were refered to the ecosystem services framework described in “Organisation and running of a scientific workshop to complete selected invasive alien species (IAS) risk assessment ARES(2014)2425342 - 22/07/2014 (Roy et al. 2015). The EU Habitats Directive was refered to for consideration of the colonisation of high conservation value habitats.

Impact category	Mechanisms
Adverse impact on native species	1. Competition 2. Predation 3. Hybridization 4. Disease transmission 5. Parasitism 6. Poisoning / toxicity 7. Bio-fouling 8. Grazing / herbivory / browsing 9. Interactions with other IAS
Adverse impact on, or alteration of, ecosystem function	a. Modification to nutrient cycling b. Physical modification of the habitat c. Modification of natural succession d. Disruption of food webs
Adverse impacts on ecosystem services	
Colonisation of high conservation value habitats	

The impact scoring system was modified from the ISEIA protocol (Branquart 2007; Branquart et al. 2010), the GB NNRA (Booy et al. 2006) and the proposed unified framework for environmental impacts (Blackburn et al. 2014). The 5-point scale (minimal concern, minor, moderate, major, and massive) was designed to achieve an appropriate balance between accuracy and resolution. Table 3.7 outlines the descriptors of the impact scoring system.

Table 3.7 Descriptors of the five point impact scoring system circulated to the thematic groups for implementation during the preliminary scoring phase of the horizon scanning (Minimal concern =1; Minor =2; Moderate = 3; Major = 4; Massive = 5)

Target of impact	Impact score	Definition
Impact on common species and habitats	Minimal concern	Localised and moderate (or regional and minor) losses, easy to reverse
	Minor	Regional and moderate losses, difficult to reverse
	Moderate	Regional and major (or widespread and moderate) losses, difficult to reverse
	Major	Widespread and major losses, irreversible
	Massive	Not achievable for common species and habitats
Impact on species and habitats of conservation importance	Minimal concern	Localised and minor losses, easy to reverse
	Minor	Localised and moderate (or regional minor) losses, difficult to reverse
	Moderate	Regional and moderate losses, difficult to reverse
	Major	Regional and major (or widespread moderate) losses, difficult to reverse
	Massive	Widespread and major losses, irreversible
Impact on ecosystem function	Minimal concern	Minimal change of function
	Minor	Minor change of function
	Moderate	Moderate change of function
	Major	Major change of function
	Massive	Massive change of all important ecosystem function

Further detail on the definitions of terms (Blackburn et al. 2014):

Minimal concern = small inconsequential changes; 0-10% of species population, habitat or function affected (or lesser impacts on multiple species, habitats or functions)

Minor = changes in size, quality or function of some consequence; 10-25% of species population, habitat or function affected (or lesser impacts on multiple species, habitats or functions)

Moderate = considerable, important changes in size, quality or function; 25-50% of species population, habitat or function affected (or lesser impacts on multiple species, habitats or functions)

Major = large, highly significant changes in size, quality or function; 50-75% of species population, habitat or function affected (or lesser impacts on multiple species, habitats or functions)

Massive = loss of all, or almost all, of a species, function or habitat; 75-100% of species population, habitat or function affected (or lesser impacts on multiple species, habitats or functions)

For each score a level of confidence was given (Table 3.5).

Deriving an overall score for guidance on ranking

While acknowledging that the scores were only for guidance on ranking and not to be used as absolute, an overall risk score for each species was calculated as the product of the individual scores for arrival, establishment, spread and impact as proposed in the Harmonia+ protocol (D’hondt et al. 2015). With a 5-point scoring system, this produces a maximum score of 625. The individual completed spreadsheets from each expert were then returned to group leaders for collation. It was suggested that group leaders produced collated scores for each species by calculating means across the experts’ scores, together with ranges and variances to indicate the level of agreement between experts. Collated spreadsheets and combined scores were then circulated back to individual experts to give them a chance to reconsider their scores in the light of comments from others and to generate discussion, especially where significant differences were apparent between experts. The objective was to reach broad consensus on the scores within each group in advance of the workshop. However, the specific approaches taken to achieve this aim varied between thematic groups and are documented in Task 4.

Methods for retrieving data from the sources identified in Task 2

The diversity of the information gathered in the information systems documented in task 2 and the way the information is presented is immense, which might not be surprising because they were designed to be used by different groups of stakeholders. However, here we describe how information can be extracted from disparate information sources to inform horizon scanning.

The evidence provided in the information systems in this context is often indirect and incomplete. Indirect evidence for the likelihood of establishment is often that current ranges and habitat use can be matched against the availability of the environmental conditions and habitat types in EU territory. It is a form of informal species distribution modelling that might be part of a subsequent risk assessment. Other areas where evidence is indirect if present are the likelihood of arrival, often a combination of information on range, and the frequency of previous invasions, and sometimes on pathways.

Information on biodiversity impacts and post-invasion spread is sometimes available and can be matched to potential EU scenarios but usually only qualitatively. Impacts on ecosystem services, however, are rarely described or considered specifically, although the narrative of impact descriptions often suggests such impacts are mainly on provisioning and aesthetic services and much less so on regulatory services.

Table 3.8 summarises which and how evidence is provided by the data systems identified in Task 2, Table 2.1. It is clear that an approach to employ experts to integrate the information available is highly appropriate. As a strategy it will require the experts to interrogate a series of these information systems and integrate the derived information with that from other sources of information, e.g. technical and grey literature; there is no single source that would provide all the information necessary within any of the thematic groups.

Table 3.8 Information contained in the listed information systems (Task 2, Table 2.1) and how it translates into the information categories used for the horizon scanning approach developed through Task 3 and adopted in Task 4 and 5.

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
1	APASD	No	No	by range & habitat & previous invasions	Y	No	previous invasions	ESS impacts only as part of a narrative not as a specific point
2	AquaNIS	has fields on tolerance to salinity, mobility and associations with vessels, which would contribute	Y	trait information for multiple life history stages contribute	No	Information on habitat modifying ability	Information on mobility at different life history stages	
3	CABI Compendium	via pathway & range	Y (partly: 1672 out of 8957)	Y (range)	Y	Y (partly)	Y	On CABI factsheets, which do not exist for all species in question; ESS impacts only as part of a narrative not as a specific point
4	DAISIE	via pathway & range	Y	Y (range)	Y	No	indirect, via features of reproducion	

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
5	DIAS	by number and location of previous invasions	Y as narrative	Y (past establishments)	Y	No	No	Has a field for Socioeconomic effects and their type, but not ESS; every introduction has a separate record by nation, which makes it hard to integrate the information
6	EASIN	No	Y	No	Y	No	No	EASIN collates information from a number of source databases. Rather than providing the relevant information it does provide links into those source systems.
7	EPPO	via pathway & range	Y (partly)	Y (range)	Y	No	Y	ESS impacts only as part of a narrative not as a specific point
8	ESENIAS	via invasiveness & pathway	Y	via habitat & range	Y	No	via invasiveness	Currently under development. Species information (factsheets, distribution maps, pathway information etc.) currently not available

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
9	EUROPHYT	Y (but see comments)	Y	No	No	No	No	Europhyte reports the number of interceptions at EU borders. While intuitively one expects a relationship with the likelihood of arrival studies in some areas suggest this not to be the case, i.e. terrestrial invertebrates (Kenis pers comm.). Also interecepted organisms are often not classified to species or genus.
10	GISD	via pathway & range	Y (partly)	Y (range)	Y	Y (partly)	Y	Revised GISD includes ESS impact and impact on Red Listed species but previously ESS impacts only as part of a narrative not as a specific point
11	Global Marine Invasive Species Assessment	via pathway & range	Y	Y (range)	Y	No	Y	
12	IABIN-I3N	via biogeography & history of invasions	Y (via trade)	Y via ecological features	Indirect, via ecological interactions	No	indirect, via features of reproducion	

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
13	ISEFOR	No	No	No	No	No	No	ISEFORE is not a data system, but a FP7 project site. It does, however, contain literature references with relevant information.
14	Malezas de Mexico	indirect, i.e. description of the biology	No	Y by habitat and range	No	No	indirect, i.e. description of the biology	
15	NANIAD - Bugguide	via pathway	Y (partly)	Y (range)	Y	No	Y (range by time)	Links to further information; ESS impacts only as part of a narrative not as a specific point
16	NAS Database	via pathway & range	Y	Y	Y	No	by range, time & pathway	ESS impacts only as part of a narrative not as a specific point
17	NOBANIS	No	Y	No	Y	No	No	Fact sheets not functional
18	Q-bank	No	No	No	No	No	No	Q-bank provides molecular barcodes and other information to ID species that are regulated plant pests. For invasion relevant information it links to EPPO

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
19	WIP	No	No	Y by habitat and range	No	No	No	
20	www.invasive.org	No	No	No	No	No	No	Acts more as a portal with extensive links to further information
21	GCW	previous invasions	No	Y (range)	No	No	No	many links to other resources
22	HEAR/PIER	No	No	Y by habitat and range	No	No	No	Records in PIER hold limited information, but where available they link to risk assessments that contain further relevant information. There are also external links that can yield relevant information. NOTE: PIER has not been updated since 2013
23	IBIS	No	No	No	No	No	No	

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
24	Invasive Invertebrate Threats	Y	No	Y (range)	Y (as narrative)	Y	Y	IIT information is based on narratives where sections on Biology and Pest Status does contain relevant information. Maps showing the ranges in New Zealand are also provided
25	Invasive Species Encyclopidea	Y (see comments)	Y	Y (range)	Y	No	Y	There are explicit fields on the invasive range, pathways, time of invasion and impacts. Where the information exists, that can provide indirect support for arrival and post-invasion spread. Information provided is basic.
26	NEMESIS	Y (via range & pathway)	Y, under vectors	Y by habitat and range	Y	Y	previous invasions	
27	NIMPIS	Y (via range & pathway)	Y, under vectors	Y	Y	No	Y	
28	Pest Tracker	No	No	Y (range)	No	No	range from previous invasions	

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
29	USDA APHIS Regulated Pest List	Y (partly via pathway and range)	Y (partly)	Y (range)	Y (partly)	Y (partly)	No	is part of the www.invasive.orgportal
30	USDA-PLANTS	No	No	Y by habitat and range	previous invasions	No	No	
31	Weeds Australia database	Y	No	Y	Y	Y	Y	WAD provides scored risk assessments. The database is very focussed on invasive weeds in agricutural settings.
32	AKEPIC	Y	Y	Y (climate matching)	Y	Y	Y	Records non-native plant species. For a limited number risk assessments are available that are scored, but also contain extensive narratives. ESS information is available where IAS impact on agriculture
33	Artsdatabanke	No	No	Y (range)	Y	No	No	Only available in Norwegian, i.e. the assessment here is limited by language

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
34	Avibase	No	No	No	No	No	No	Avibase provides very basic information on taxonomy and to some degree ranges. However, it provides links to multiple further sites that can hold relevant information.
35	Especies introducidas en Canarias	Y (but see comments)	Y	Y	Y	No	Y	Only available in Spanish i.e. the assessment here is limited by language. Exceptionally the species lists contain section for animal species not yet established and for plant for likely introductions, possibly an outcome of a horizon scanning exercise. There are risk assessments with extensive narratives with relevant information, however, only for very few species on the lists.

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
36	FishBase	Y	Y	Y (past establishments)	No	No	Y	There is little information on impact, but extensive information on past invasions/introductions with some on pathways. Where species have a longr history the information becomes relevant
37	Flora of Iceland	No	No	No	No	No	No	FoI is lostely in Icelandic with only sections in english. It was listed in table 2.1 as a potential sentinel location just outside the EU territory, but it is difficult to judge the detailed information.
38	GBIF	No	No	No	No	No	No	This is a classification system. GBIF does contain external links that might have relevant information

Reference to Table 2.1	Project / Database name	Data on the Likelihood of arrival	Information on pathways	Data on the Likelihood of establishment	Information on biodiversity impacts	Information on ESS impacts	Likelihood/extend of post-invasion spread	Comments
39	GPDD	-	-	-	-	-	-	While information in GPDD can be potentially useful for a horizon scanning exercise, access is restricted and could not be resolved in time for this exercise.
40	GRIN	No	No	No	No	No	No	GRIN is a Germplasm database
41	NatureServe	No	No	No	No	No	No	NatureServe is a conservation science information provider
42	NBIC	No	No	No	No	No	No	NBIC tracks ballast water treatment on individual vessels including their travel information. There is however, no species level information of the content.
43	NISIC	No	Y	Y (range)	Y	No	Y (US history)	While information in NISIC is scarce it also holds extensive external links

Step 4 Expert workshop to review and refine ranks leading to eventual consensus across all thematic groups

The expert workshop is described in detail in Task 4 but essentially all participants were then invited to review, consider and refine the rankings of all species through discussion both within and between thematic groups. Leaders of each thematic group were invited to justify to the other workshop participants the scores for their top-scoring species and to respond to queries or objections from members of other sub-groups. Changes to overall rankings for individual species were made only after hearing the evidence from appropriate experts, full discussion and, if needed, majority voting. The end result was a ranked list of IAS derived through discussion and broad consensus that were considered to represent a very high or high probability of arrival, establishment, spread and impact on biodiversity and ecosystem services and so should be prioritised for risk assessment.

A short step by step outline for a horizon scanning approach can be found at the end of the main report.

The role of EASIN as input to future horizon scanning exercises

Prepared by Ana Cristina Cardoso, Eugenio Gervasini and Konstantinos Tsiamis

EASIN in a nutshell

The European Alien Species Information Network (EASIN) was launched in 2012 by the European Commission to facilitate the exploration of existing alien species information and to assist the implementation of European policies on biological invasions.

EASIN has been conceived as a scientific tool aimed at providing scientific information in support to the EU policy on biodiversity and on IAS, gathering and harmonizing information on alien species from several sources worldwide.

At the core of EASIN, there is an inventory of all alien and cryptogenic species recorded in European databases (Katsanevakis et al., in press, available online at the following link http://www.reabic.net/journals/mbi/2015/2/MBI_2015_Katsanevakis_etal_correctedproof.pdf). The first version of the EASIN Catalogue was compiled by harmonizing and integrating information, such as taxonomic classification, pathways of introduction, year and country of first introduction, from 43 online databases (Katsanevakis et al. 2012). Subsequently, the initial compilation of the Catalogue was checked, revised, and updated by taxonomic experts.

The EASIN catalogue currently includes more than 14,000 species from 28 EU member states, 4 candidate countries (as listed in http://europa.eu/about-eu/countries/index_en.htm), and 17 other (non-EU) European countries, to have full coverage of the European marine area.

The EASIN catalogue includes the relevant information needed to efficiently link to existing online databases and (potentially) retrieve spatial information on alien species recorded in Europe. Although not yet validated and recognising the inherent difficulties of validation at the global scale, spatial records of species occurrence in Europe are stored in the EASIN geo-databases, integrating data from many data providers as well as from the scientific literature through the EASIN-lit (http://easin.jrc.ec.europa.eu/About/EASIN-Lit).

The Widget Framework (http://easin.jrc.ec.europa.eu/use-easin) provides tools and services through which harmonized information from the EASIN Catalogue, and species records from the 'Geo' database are exposed to the public. Any person or organisation might query for any species across Europe by searching for species names or by filtering elements of the EASIN catalogue, such as taxonomic classification, environment, impact, species status, and pathways. After defining such a query, the user may obtain a map showing the records of occurrence of the selected species across Europe, originating from the EASIN network of spatial data providers. However, comprehensive data are available yet for all species. The mapped results can be further tailored by excluding one or more of the data providers, excluding the native range of species that are partially native in Europe (i.e. for species that are native in some European regions but alien in others), and by selecting only records within a specified time range.

Since May 2014, an Editorial Board (EB) has been established and is responsible for all changes and updates to the EASIN Catalogue (with the notable exception of the maps and relevant spatial data), to guarantee the quality of the data (http://easin-eb.jrc.ec.europa.eu). The EB acts through an on-line platform, which permits access to any user for raising issues, participating in discussions and alerting to the presence of new alien arrivals in Europe (which will be validated by the relevant expert members of the EB). In the future the EB will also be asked to validate spatial records of IAS of EU concern before these are shared with the European Commission (EC) and the relevant Member State(s). JRC is currently increasing the number of members of the EB, ideally to cover all alien species and environments.

Since the enlargement of the data sources is a key issue to ensure a high quality of data JRC is also working towards increasing the number of providers by establishing collaboration agreements. An additional valuable input concerning species occurrence and spatial data will be offered by the collaboration and exchange of data with national databases, which will be fed by the results of the national surveys foreseen by the EU Regulation.

EASIN is also the supporting tool for the implementation of the EU Regulation 1143/2014 on IAS, in force since 1 January 2015. To this end, the system is undergoing further development with a creation of an Early Warning system (NOTSYS), through which EU Member States must notify the EC and the other MS about the detection of an IAS on the list of IAS of EU concern, and to report on the eradication measures applied and their efficacy.

EASIN role in Horizon Scanning

As indicated above, EASIN will play a central role in the implementation of the EU Regulation on IAS. However, the geographic coverage of EASIN data is currently limited to the IAS occurrences recorded in Europe and in close neighbouring countries (such as Russia).

In general terms, horizon scanning systems require:

1. approaches to identifying and gathering information

   EASIN could be a source of data and information for the future horizon scanning exercises for alien species already introduced in the EU, with limited distribution, and in neighbouring countries (outside the EU) (see above for EASIN geographic coverage). Furthermore, EASIN data can support assessments such as pathways (Katsanevakis et al. 2013) of alien species invasions and therefore inform the retrieval of data in future Horizon scanning procedures.

2. mechanisms for analysing information

   The EASIN catalogue is maintained and updated through the EASIN Editorial Board. This includes consideration for inclusion in the catalogue of new alien species within EASIN's geographic coverage. There are currently no mechanisms to include in EASIN species from outside Europe not yet detected in the continent. For species in the EASIN catalogue new spatial records will be available for mapping when existing in EASIN spatial data providers and in EASIN-Lit.

3. integration with strategic decision making

   The consolidated list of species derived through Task 5 could be included in the EASIN catalogue labelled as 'Horizon Scanning species'. Also, the widget framework could be adapted accordingly to allow filtering of these species. Inclusion in the EASIN catalogue would result in the inclusion of the species in the searches for spatial occurrences and early detection of the introduction in Europe.

CONCLUSIONS

A horizon scanning method is presented which uses a combination of rapid assessment, based on literature review and expert opinion, and dynamic consensus building through face-to-face discussion. This approach has been adopted successfully at a country-level geographical scale, but presents certain challenges when scaled up to the level of the EU.

A critical issue concerns how to define the scope of species to be considered: specifically, decisions are required on how to treat species that have already arrived in the EU but over only a small area and species covered by other legislative instruments. We suggest specific criteria for this.

The extent and quality of available information on potential IAS is very variable. In some taxa, lack of sufficient information severely constrains our ability to predict whether they will become invasive in the EU. We therefore adopt a simple scale (high, medium and low) to quantify the confidence attached to each of the likelihood scores. Although it does not affect the actual scores directly, it provides critical information into the discussion and consensus building process.

The information needed to predict the arrival, establishment, spread and impact of IAS in the EU is scattered across an extensive range of sources, mostly databases. There is no single simple mechanism for harvesting this information automatically. This emphasises the critical importance of input from specialists in IAS biology, using their up-to-date knowledge (which will often be ahead of information in databases) and expert opinion.

EASIN has a role to play both in gathering information for input into horizon scanning exercises and in holding and disseminating the results. It cannot be the sole source of information, however, given its current structure, remit and constraints. However, EASIN can provide tools to identify relevant and harmonised information on IAS for horizon scanning. Additionally the IAS identified as priorities for risk assessment through horizon scanning could be added to the EASIN catalogue.

TASK 4: REVIEW AND VALIDATE THE METHODOLOGY

Leading experts: Ana Nieto (IUCN), Mariana Garcia (IUCN), Helen Roy (CEH)

The overarching aim of this task was to review and validate the methodology outlined in Task 3 in consultation with experts within the project team and additional invited experts. The core of the task was conducted through a two-day workshop (6-7 May 2015) but considerable preparatory work was necessary to ensure all participants were duly informed and fully familiar with the process.

Identification and approval of experts to attend the workshop

The project team was selected to include experts with complementary taxonomic expertise and representing terrestrial, freshwater and marine environments. From the 29 members of the project team (Annex 1), 22 attended the workshop (Table 4.1). An additional 13 invited experts attended the workshop to review and validate the methodology. These experts were selected from across the EU to ensure representation across taxonomic groups and environments (Table 4.2). The invited experts were approved by the EC IAS team (Myriam Dumortier and Spyridon Flevaris). Ana Cristina Cardoso participated in the workshop representing EASIN. In total, 38 people attended the workshop including Myriam Dumortier and Spyridon Flevaris from the EC who mainly observed the activities but also assisted with points of reference or clarification.

Table 4.1 Experts (affiliated organisation and relevant expertise) from within the project team who attended the workshop (6-7 May 2015). Further information is available in the section "Author biographies" at the beginning of this report.

Project team experts	Affiliation	Relevant expertise
Ana Nieto	IUCN, Belgium	Task leader
Mariana Garcia	IUCN, Belgium	Task leader
Steph Rorke	Centre for Ecology & Hydrology, UK	Database management
Jodey Peyton	Centre for Ecology & Hydrology, UK	Ecologist and facilitator
Helen Roy	Centre for Ecology & Hydrology, UK	Project lead and terrestrial invertebrates
Alan Stewart	University of Sussex, UK	Terrestrial invertebrate thematic group leader
Wolfgang Nentwig	University of Bern, Switzerland	Terrestrial invertebrate thematic group leader
Marc Kenis	CABI, Switzerland	Terrestrial invertebrates
Wolfgang Rabitsch	EAA, Austria	Terrestrial invertebrates
Karsten Schönrogge	Centre for Ecology & Hydrology, UK	Terrestrial invertebrates
David Aldridge	University of Cambridge, UK	Freshwater invertebrate thematic group leader
Emili García-Berthou	University of Girona, Spain	Freshwater fish thematic group leader

Project team experts	Affiliation	Relevant expertise
John Bishop	Marine Biological Association, UK	Marine species thematic group leader
Argyro Zenetos	Hellenic Centre for Marine Research, Greece	Marine species thematic group leader
Elizabeth Cook	Scottish Association for Marine Science, UK	Marine species
Etienne Branquart	Invasive Species Unit, Service Public de Wallonie, Belgium	Plant thematic group leader
Montse Vilà	Estación Biológica de Doñana, Spain	Plant thematic group leader
Sonia Vanderhoeven	Belgian Biodiversity Platform, Belgium	Plants
Sven Bacher	University of Fribourg, Switzerland	Vertebrate (excluding freshwater) thematic group leader
Riccardo Scalera	IUCN/SSC Invasive Species Specialist Group (ISSG), Italy	Vertebrate (excluding freshwater) thematic group leader
Piero Genovesi	ISPRA, and Chair IUCN SSC Invasive Species Specialist Group, Italy	Vertebrates
Carles Carboneras	Royal Society for the Protection of Birds, UK	Vertebrates

Table 4.2 Invited experts (affiliated organisation and relevant expertise) who attended the workshop (6-7 May 2015). Further information is available in the section “Author biographies” at the beginning of this report.

Project team experts	Affiliation	Relevant expertise
Jørgen Eilenberg	University of Copenhagen, Denmark	Terrestrial invertebrates
Cristina Preda	Ovidius University of Constanta, Romania	Terrestrial invertebrates
Alain Roques	Institut National de la Recherche Agronomique, France	Terrestrial invertebrates
Gordon Copp	Centre for Environment, Fisheries and Aquaculture Science, UK	Freshwater fish
Belinda Gallardo	Pyrenean Institute of Ecology, Spain	Freshwater invertebrates
Gerard van der Velde	Institute for Water and Wetland Research (IWWR), The Netherlands	Freshwater invertebrates

Project team experts	Affiliation	Relevant expertise
Elena Tricarico	University of Florence,Italy	Freshwater fish and invertebrates
Juliet Brodie	Natural History Museum – London, UK	Marine species
Francis Kerckhof	Royal Belgian Institute of Natural Sciences, Belgium	Marine species
Dan Minchin	Marine Organism Investigations, Killaloe, Ireland	Marine species
Jan Pergl		Plants
Tim Adriaens	Research Institute for Nature and Forest, Belgium	Vertebrates
Wojciech Solarz	Institute of Nature Conservation, Polish Academy of Sciences, Poland	Vertebrates

Workshop documentation

The workshop agenda was compiled by the project team and approved by Myriam Dumortier and Spyridon Flevaris from the EC. The workshop agenda was circulated to all participants two weeks in advance of the meeting.

Figure 4.1 Workshop agenda circulated two weeks in advance. A few modifications were made during the workshop in response to the need for additional time for the thematic groups to refine and agree the methods to derive the species lists. Therefore, Day 2 commenced with continuation of "Compilation of list and initial feedback from subgroups on overall rankings" from Day 1. Discussions on EASIN commenced at 1130 on Day 2 rather than 0900 as planned.

Invasive alien species – horizon scanning workshop

DG Environment, Brussels, Belgium

6 – 7th May 2015

Day 1

Chair: Helen Roy

0900 Welcome (Myriam Dumortier and Spyridon Flevaris – EC)

0910 Aims of the workshop (Helen Roy)

0915 Task 1: Literature review on horizon scanning (Wolfgang Rabitsch)

0925 Discussion

0935 Task 2: Database review on horizon scanning (Wolfgang Rabitsch)

0945 Discussion

0955 Task 3: Consensus approach to horizon scanning (Karsten Schonrogge and Alan Stewart) 1010 Scope of the horizon scanning (Wolfgang Rabitsch) 1015 Task 4: Discussion on consensus approach and scope
1045 COFFEE
1100 Task 4: Discussion on consensus approach and validation of approach 1120 Overview of high ranking species - terrestrial invertebrates (Wolfgang Nentwig and Alan Stewart) 1135 Discussion 1140 Overview of high ranking species - freshwater invertebrates and fish (David Aldridge and Emili Garcia-Berthou) 1155 Discussion 1200 Overview of high ranking species - marine species (John Bishop and Argyro Zenetos) 1215 Discussion 1220 Overview of high ranking species – plants (Montse Vilà) 1235 Discussion 1240 Overview of high ranking species – vertebrates (Riccardo Scalera and Sven Bacher) 1255 Discusson
1300 LUNCH
1400 Subgroup discussions to consider rankings and missing species
1500 COFFEE
1530 Compilation of list and initial feedback from subgroups on overall rankings 1600 Task 5: Review of rankings and consolidation by consensus
1800 END OF DAY 1
Day 2 **Chair: Helen Roy** 0900 Task 4: Introduction to EASIN and role for horizon scanning (Ana Cristina Cardoso) 0920 Discussion of EASIN and horizon scanning
1015 COFFEE
1045 Subgroup discussions to consider mechanisms for horizon scanning
1300 LUNCH
1400 Plenary session – presentation of break-out sessions 1500 Proposed consolidated method 1600 End of workshop

Additional workshop documentation circulated in advance of the workshop:

- Draft reports for Tasks 1 and 2. All participants were invited to comment on these draft reports;
- Proposed methodology as outlined in Task 3 with accompanying documentation;
- Spreadsheet with links to IAS database as outlined in Task 2.

Further resources were shared between members of the thematic groups (coordinated by the thematic group leaders) to enable the preliminary species lists for each group to be derived in accordance with the instructions outlined in Task 3. Various approaches were developed by each thematic group to meet the demands of Task 3 acknowledging the individual needs of each thematic group. The group leaders were asked to document the processes adopted and the information sources used throughout the pre-workshop phase of the project. The group leaders were also asked to document all experts contributing to the task regardless of anticipated attendance at the workshop.

The workshop

The workshop was held on 6-7 May 2015 at DG Environment (Brussels, Belgium) and followed the agenda (Figure 4.1). The aims of the workshop were clearly outlined in an introductory talk (Helen Roy) and then a short session followed in which the scope of the horizon scanning was reiterated (presentations by the EC and Wolfgang Rabitsch) and the workshop participants were invited to discuss the proposed method. The participants had been provided with information on the proposed method and the inventory of other approaches (Task 1) in advance of the workshop and invited to comment by e-mail or telephone. No comments were received from the invited experts or the project team. Additionally all the workshop participants had been involved in the compilation of lists through association with the thematic groups and so had in part tested Step 2 (compilation of lists) and Step 3 (scoring of species) of the proposed method (Task 3). The participants unanimously agreed to the suggested consensus approach to horizon scanning (Task 3) and so the remainder of the morning of Day 1 was dedicated to talks providing an overview of the IAS selected by each thematic group during the preparatory phase in advance of the workshop. These thematic group presentations were particularly important because they informed the other groups of the range of species and their life-histories within each group. It was expected that these would enable the thematic groups to review and moderate the scores within the breakout sessions for each subgroup.

The first part of the afternoon of Day 1 was dedicated to the thematic group breakout sessions in which each thematic group met face-to-face to review their list of species (indicated in Annex 4 as a tick in the column "Preliminary") and associated scores. This was an important opportunity to add or remove species in the light of new evidence (either discovered just prior to the workshop or following reflection from the preceding workshop presentations and discussions), to justify and moderate scores through discussion and to consider levels of confidence/certainty attached to scores. The thematic groups were asked to restrict their lists to a total of 20 species (indicated in Annex 4 as a tick in the column "Day 1"), although a maximum of 30 was tolerated if the thematic group felt overly constrained, to limit the compiled list to a manageable size. The emphasis at this stage was to use the scores as guidance for informing the subsequent consensus-building component of the horizon scanning approach and deriving a ranked list rather than as a component of a full impact assessment.

All the species lists from across the thematic groups were compiled into one spreadsheet to enable the participants to view the entirety of the collated list. At this stage there were 250 species listed (Annex 4). This preliminary compiled list demonstrated a mismatch in the scoring of species between groups. Plant species appeared in one block ranked at the top of the list (primarily because many of the plant species are present in gardens and so likelihood of arrival was scored high) and many of the prioritised species from the marine and terrestrial invertebrate thematic groups were at the bottom of the list. While this could reflect the difference in threat between thematic groups, it was felt necessary, following discussions in which experts were invited to justify their scores in comparison to those of other groups, to have a further round of review and moderation of the lists through discussions within breakout groups to ensure an accurate reflection of the ranks of species. The thematic groups were given one hour at the beginning of Day 2 to achieve this aim. Additionally, the participants within each thematic group were invited to again highlight those species which were considered to constitute the highest risk with respect to likelihood of arrival, establishment, spread and impact on biodiversity and ecosystem services but also to highlight any species which they considered to be the lowest rank within their list of 20 (or up to 30) species. It was explained that these lowest ranking species were unlikely to be in the 80-100 species requested by the EC for prioritisation for risk assessment but that they are listed in Annex 4 for future consideration through horizon scanning or other exercises.

The lists of between 20 and 30 species (indicated in Annex 4 as a tick in the column "Day 2") from each thematic group were again combined to produce a list of 127 species. All participants were then invited to review, consider and refine the rankings of all species through discussion. Leaders of each thematic group were again asked to justify to the other workshop participants the scores for their top-scoring species and to respond to queries or objections from members of other sub-groups. Changes to overall rankings for individual species were made only after hearing the evidence from appropriate experts, full discussion and, if needed, majority voting. The end result was a ranked list of IAS derived through discussion and broad consensus that were considered to represent a very high or high probability of arrival, establishment, spread and impact on biodiversity and ecosystem services and so should be prioritised for risk assessment. The top 27 species (31 including four for which risk assessments compliant with the minimum standards are available) considered to be very high priority for risk assessment, the next 68 were considered to be high priority and a further 21 were considered to be medium priority. All the remaining species of the initial longlist were considered to be low priority for risk assessment. All workshop participants agreed that the list represented the outcome of the consensus approach. Three of the very high or high priority species originally listed were removed because they were already included within Annex II of the European Directive regarding plant health (2000/29/CE): *Agrilus planipennis*, *Agrilus anxius* and *Dendrolimus sibiricus*. The list is outlined in Task 5.

The horizon scanning method adopted was validated both through initial discussions at the beginning of the workshop but also through implementation of the process during the workshop and through review at the end of the workshop. Figure 4.2 provides a schematic outline of the approach.

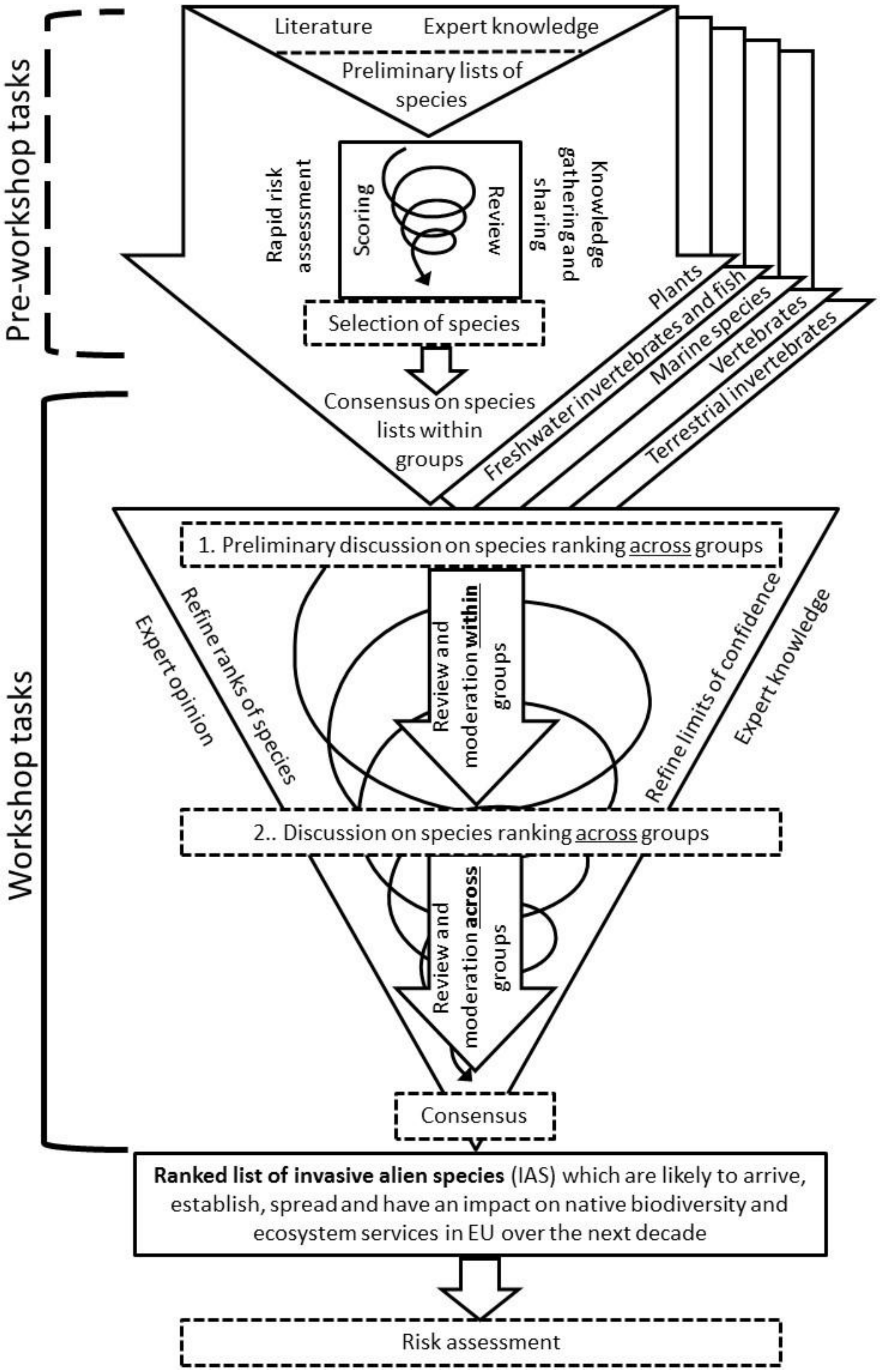

Figure 4.2 Horizon-scanning process, based on consensus method (Roy et al. 2014a), to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on native biodiversity or associated ecosystem services in the EU over the next decade. The process involved two distinct phases: preliminary consultation between experts within five thematic groups (upper arrows) and consensus-building across expert groups (lower triangle). It should be noted that the experts across the thematic groups needed two phases of discussion at the workshop:

1. Preliminary discussion on rankings across groups followed by within group discussions for review and moderation of preliminary scores within groups and,

2. Discussion on species rankings coupled with review and moderation of scores across groups leading to consensus.

Overview of comments from the thematic groups

Species selection

All groups adopted a species selection approach based on invasion history elsewhere and climatic comparability to Europe as the best predictors to identify potential IAS that are likely to arrive, establish, spread and impact on biodiversity within the next ten years. Here we present an overview across groups but specific details of the approaches adopted by each group are given in Annex 2.

The plant group focused mostly on horticulture as the major intentional pathway; however, potential species to be used as biofuel and macrophytes to be used as ornamental plants or that could be accidentally introduced were also explored. Ferns and mosses were included but not algae. Species were initially ranked by the number of regions or continents they had invaded outside Europe. Then, Species Distribution Models (SDMs) were constructed using GBIF and other data to evaluate whether they are likely to establish under current or future climates in Europe. The 70 species ranked as very high or high priority were then screened for documented impacts on biodiversity and ecosystem services based on available scientific publications and information systems. Search procedures differed slightly between geographic areas being screened, depending on availability of data and local circumstances (e.g. information on naturalization).

In the marine group, phytoplankton species were not considered because of lack of expertise within the group and persistent problems with ascertaining the status of species as alien or native. In some groups (e.g. vertebrates), further species not found through standard searches were added based on the expert opinion of members of the group (mostly species without invasion history, but present in known pathways, such as traded pets).

It was agreed across thematic groups that a number of species were excluded based on the following criteria:

a. Taxa that are members of unresolved species complexes or not considered reliably separable from their close relatives;

b. Species occurring in fewer than three member states, but judged too well established in the EU based on the criterion given during the workshop: ‘limited distribution in the EU of a few, small, isolated populations’;

c. Species already included in EU legislation (e.g. Plant Health regulation) were identified where possible and excluded but it was recognized that the experts were not familiar with all relevant lists.

Additional issues raised by thematic groups

A number of issues were raised by the thematic groups during and following the workshop:

a. Information on impacts is often very limited and relevant details of life-history characteristics for assessing the likelihood of arrival, establishment and spread may not be available.

b. In order for the list to be manageable with the limited resources and time available, it was decided to undertake preliminary assessment of only 50-100 species per thematic group. Consequently a number of important species could have been excluded. However, it is felt that this was not a major problem but certainly increased time and resources could have elucidated additional species of potential concern.

c. Environmental (especially climate) matching does not take into account the ability of some species to adapt to different (e.g. either warmer or cooler) conditions. Notable examples have been recorded amongst marine species. The degree of future plasticity in response to climatic differences is notoriously difficult to predict.

d. Some thematic groups (especially the marine and terrestrial invertebrate groups but also within the vertebrate group) felt that their groups were too taxonomically diverse (in the case of marine, across different phyla) to be considered by a single group of experts and should therefore be sub-divided. The marine species group had many phyla to consider and in future assessments it is recommended that the expertise in these groups should be enlarged, or the group split. For the marine group one potential split would be between photosynthetic organisms (macro-algae and potentially micro-algae, plus seagrasses) and animals.

e. There were gaps in taxonomic expertise. For example soil invertebrates were identified as an important group that was partly overlooked due to lack of suitable expertise and knowledge.

f. There was considerable variation between members of the same groups in the scores attributed to species. This was partly due to lack of expertise on some of the taxa within the broad thematic groups. However, it was agreed that the consensus method for horizon scanning relies on all members within a group scoring all species to get a true cross-section of expert opinion.

g. Species already established within the EU were given the score of 5 for likelihood of arrival and establishment. Therefore, the impact score was playing a comparatively minor role in the overall score for species that had already arrived and established on the continent. Another consequence was that species already established in the EU received on average higher scores and might be overrepresented in the current list which became obvious for plants already present in gardens. Alternative approaches to scoring or weighting of scores might help to overcome this problem, but within the workshop the consensus discussions moderated the ranking of some species.

h. It was difficult to know how to treat species that are already present but only in artificial conditions, such as glasshouses (e.g. the flatworm *Platydemus manokwari*) or gardens (plants), because it is unclear whether they will establish and spread under natural conditions.

The role of EASIN in horizon scanning

The remainder of the workshop was dedicated to consideration of the role of EASIN in horizon scanning. An overview of EASIN was presented by Ana Cristina Cardoso and a group discussion followed in which points requiring clarification were addressed. Following this session each thematic group was invited to consider the role of EASIN in horizon scanning but also to reflect on the horizon scanning approach employed through the workshop (Figure 4.2).

A conceptual framework (Figure 4.3) was derived and discussed. The flow chart illustrates a proposed horizon scanning framework for Europe as discussed in the experts' workshop held in Brussels.

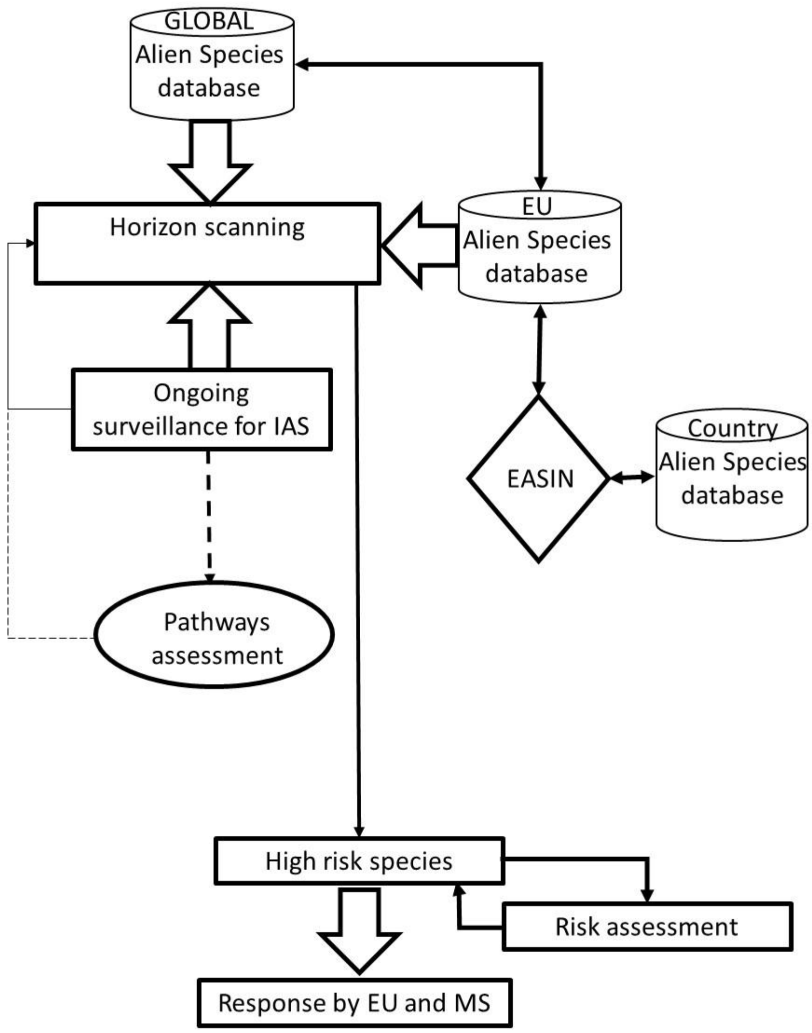

Figure 4.3 Proposed European horizon scanning framework illustrating possible routes of data flow for information to be used for the prioritisation of alien species for risk assessment.

The framework highlights the importance of linking to information contained in regional databases, as well as in global databases, and the role of EASIN. The outcomes of surveillance conducted at national scale, and the results of the assessments of the most relevant pathways of introduction of IAS, that enable the identification of species likely to arrive in the region, will also provide additional relevant information. For example, analyses of trade (Genovesi et al. 2010) can identify which species are at risk of being introduced into Europe, either directly as goods, or indirectly, as stowaways or contaminants on goods (Bacon et al. 2014). Similarly data on interception of alien species (Roques, Auger-Rozenberg 2006) identifies invertebrates accidentally introduced into the region which can then be considered in horizon scanning exercises (Bacon et al. 2012). However, perhaps counterintuitively, evidence suggests that the number of interceptions of a particular IAS is not a good predictor of invasion success and impact (Bacon et al. 2012; Eschen et al. 2015).

The outcomes of the horizon scanning will be the identification of high risk alien species that should be prioritised for risk assessment, or in some cases immediate response from the EU or national authorities.

Post workshop activities

The thematic groups were informed that the ranks of the species must not be changed and no further species were allowed to be added at this stage. This ensured the outcome of the consensus approach was unaltered. However, three listed species (*Agrilus planipennis, Agrilus anxius* and *Dendrolimus sibiricus*) were subsequently removed from the list because they are included in the EU plant health legislation (amendments to Council Directive 2000/29/EC as of 30.06.2014). It was further agreed by the group that additional information on the prioritised IAS would be advantageous and so the groups were instructed to provide the following additional information for each of the 95 (very high and high) ranked species: (i) EU biogeographic zones that are likely to be affected (see "Standardisation of information on the biogeographic zones" for standard approach); and (ii) known invaded range.

Standardisation of information on the biogeographic zones

Terrestrial and freshwater

A simplified framework was developed by Etienne Branquart and Philip Hulme following the workshop. It was decided to focus on five climatic zones based on the biogeographic regions of Europe defined by the European Environment Agency (EEA). A correspondence with Köppen-Geiger climate zones was provided to allow extrapolation of species establishment potential based on the species distribution in other continents (Table 4.3).

Table 4.3 Simplified bioregions for assigning the very high and high ranked alien species prioritised for risk assessment in relation to likely bioregions to be affected by the arrival, establishment, spread and impact of the alien species within the next ten years.

Simplified bioregion	EEA bioregions	Köppen-Geiger correspondence
MAC	Macaronesia (Canary Islands + Madeira + Azores)	Warm oceanic or subtropical climate (Cfa) + hot desert climate (Bwh)
MED	Mediterranean + Black Sea	Mediterranean climate with hot (Csa) and warm (Csb) summer + cold semi-arid climate (Bsk)
ATL	Atlantic	Cool (Cfb) + temperate (Cfc) oceanic climates
CON	Continental + Pannonian	Continental climate with warm summer (Dfb)
STE	Steppic	Continental climate with hot summer (Dfa)
BOR	Boreal + Arctic + Alpine	Subarctic (Dfc) and Arctic (ET) climates

Marine

The framework developed for the terrestrial and freshwater species was modified for the marine species. Within Europe the EEA regions were modified by adding the Baltic Sea and separating the Mediterranean and Black Seas (Table 4.4). Global marine bioregions were based on an existing classification (Spalding, Fox 2007) but modified to distinguish the east and west regions of the Atlantic and the Pacific (Table 4.5). The very high and high ranked species were checked against references, the Global Marine Invasive Species Assessment and NEMESIS databases to ascertain where a species was native or was already invasive. Then using sea temperature maps (http://www.seatemperature.org) the likely EU bioregions threatened were derived. Where a species might be relevant to the Baltic or Black Sea, the salinity tolerances were reviewed using references and relevant internet searches.

Table 4.4 Broad biogeographic groups modified from the EEA regions and applied to the marine species in relation to likely bioregions to be affected by the arrival, establishment, spread and impact of the alien species within the next ten years

Code	Bioregion	
MAC	Macaronesia	Canary Islands, Madeira, Azores
MED	Mediterranean	
BLK	Black Sea	
ATL	NE Atlantic	
BAL	Baltic	

Table 4.5 Global biogeographic regions applied to the marine species in relation to native range and invaded areas outside of Europe modified from Spalding (2007) http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/colorado/scienceandstrategy/marine-ecoregions-of-the-world.pdf

Code	Bioregion	
ARC	Arctic	Alaska, N Canada, N Russia
TeNWP	Temperate NW Pacific	Japan, Korea, N China, E Russia
TeNEP	Temperate NE Pacific	W Canada, W USA (California northwards), S Alaska
TeNWA	Temperate NW Atlantic	E USA, E Canada
TeNEA	Temperate NE Atlantic	Europe, NW Africa
EIP	Eastern Indo-Pacific	Hawaii, Guam
CIP	Central Indo-Pacific	Philippines, Malaysia, Taiwan, N Australia
WIP	Western Indo-Pacific	India, E Africa, Red Sea
TrEP	Tropical Eastern Pacific	Central America
TrEA	Tropical Eastern Atlantic	W Africa
TrWA	Tropical Western Atlantic	Caribbean, Brazil
TeSEP	Temperate SE Pacific	Chile, Peru
TeSWA	Temperate SW Atlantic	Argentina
TeSAf	Temperate Southern Africa	S Africa, Namibia
TeAu	Temperate Australasia	Australia, NZ
SOU	Southern Ocean	Antarctica

Summary of the workshop

The workshop enabled both the validation of the consensus approach to horizon scanning and the validated approach to be implemented. All participants agreed that the consensus approach (Figure 4.2) provided an appropriate method for horizon scanning. A number of key recommendations were agreed:

i) Recognising the dynamic nature of biological invasions, the horizon scanning exercise should be repeated on a three-year cycle and the previous list should be reviewed.

ii) The long lists (Annexes 3 and 4) produced in the pre-workshop phase should be reviewed after three years in light of changes in distribution to identify species of increasing threat or importance.

iii) The freshwater invertebrate and fish group adopted a Delphi approach for species selection in advance of the workshop (Figure 4.4) and this was thought to be a process that could be adopted more widely in the preliminary stages of species selection.

iv) Assessment of confidence in the scores was recorded on the spreadsheet, but these values were not used systematically in the subsequent ranking exercise; it does seem reasonable to moderate rankings based on the overall confidence in the component scores (Blackburn et al. 2014), particularly when considering very high-ranking species. This was done within groups, through discussions in which ranks were moderated on the basis of consideration of uncertainty, but not across groups.

v) Although the impact scoring method recommended in Task 3 and implemented through Tasks 4 and 5 was to guide the ranking process and provide a rapid broad assessment, it was agreed that improvements would be advantageous. An adapted version of Harmonia^{+} could be developed, however it would be essential that the method employed is sufficiently rapid to enable many potential species to be screened in a short time frame. GISS is a further prioritization method to assess impact in a very broad and comparative manner (Kumschick, Nentwig 2010).

vi) Horizon scanning should include consideration of future novel pathways for arrival of IAS in the EU. As an example, this is currently especially relevant to the marine environment where the enlargement of the Suez Canal will promote the arrival of Indo-Pacific species in the south-eastern Mediterranean. Also, the decline of Arctic ice cover is expected to increase shipping traffic and provide a new route for northern Pacific species to enter the North Atlantic, with impacts on northern European seas. Similarly, future changes in the pet trade will encourage the introduction of new vertebrate species.

vii) Future horizon scanning will be dependent upon the availability of taxonomic expertise across this large range of taxa, but such expertise is in decline; the success of such exercises, and indeed broad understanding of invasion biology from surveillance to management, in the future will require training of a new generation of experts in this discipline, with significant resource implications.

viii) It is not anticipated that horizon scanning could be automated in the near future; the involvement of experts is critical. Indeed, the interactions between experts in the pre-workshop phase of the project coupled with the face-to-face discussions at the workshop was seen to be essential. However, it should be noted that Delphi approaches can benefit from semi-automated procedures particularly in reducing bias.

ix) The focus of this horizon scanning approach was biodiversity and associated ecosystem services. While the latter will capture some relevant aspects in relation to socio-economic considerations it is important to note that some of the species will have additional impacts on socio-economic considerations or human health and wellbeing.

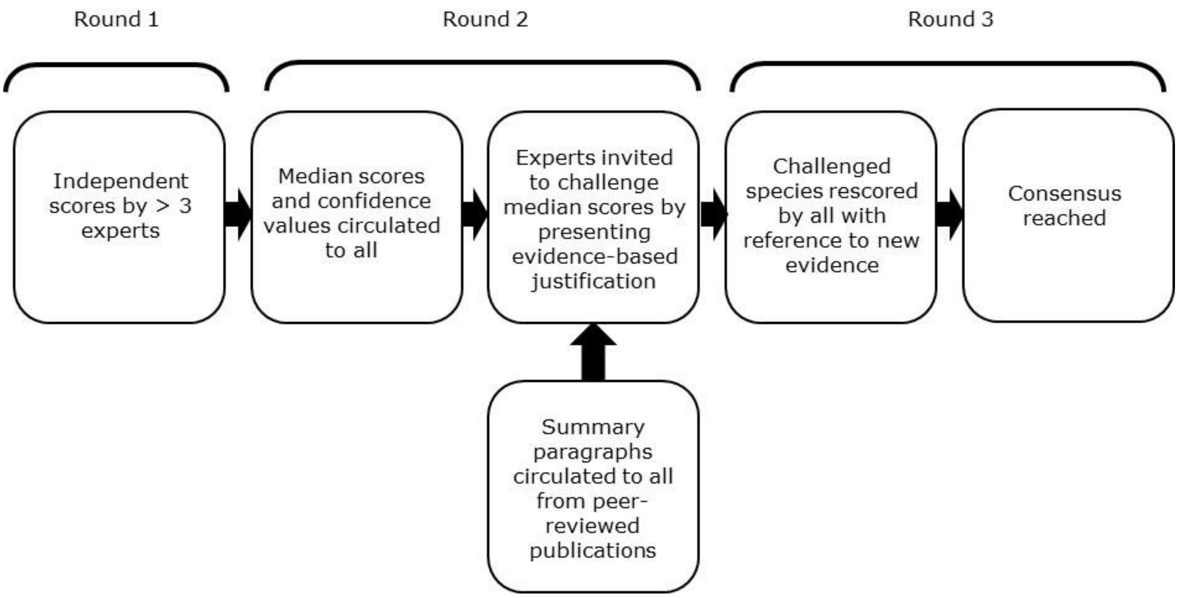

Figure 4.4 Delphi approach (MacMillan, Marshall 2006; Sutherland et al. 2011b) to deriving consensus <u>within</u> thematic groups on scores and prioritisation of species

CONCLUSIONS

The workshop was held with the overarching aim of reviewing and validating an approach to horizon scanning to derive a ranked list of IAS which are likely to arrive, establish, spread and have an impact on native biodiversity or associated ecosystem services in the EU over the next decade. The workshop participants and wider project team unanimously agreed that a consensus approach was an effective method. The horizon scanning approach developed through Task 3 and validated in Task 4 involved two distinct phases: preliminary consultation between experts within five thematic groups and consensus-building across expert groups. It is important to note that the experts across the thematic groups needed two phases of discussion at the workshop: 1. Preliminary discussion on rankings across groups followed by within group discussions for review and moderation of preliminary scores within groups and 2. Discussion on species rankings coupled with review and moderation of scores across groups leading to consensus.

A number of key issues were raised by the thematic groups during and following the workshop. Of particular note is recognition that information on impacts is often very limited and relevant details of life-history characteristics for assessing the likelihood of arrival, establishment and spread may not be available. Additionally even with a group of participants with broad taxonomic expertise there will be gaps in collective knowledge. The importance of linking to information contained in regional databases, as well as in global databases, and the role of EASIN was highlighted. However, the outcomes of surveillance conducted at national scales, and the results of the assessments of the most relevant pathways of introduction of IAS, that enable the identification of species likely to arrive in the region, will also provide additional relevant information.

TASK 5: PERFORM A HORIZON SCANNING

Preliminary consultation between experts

The preliminary consultation between experts was completed both through e-mail discussions in advance of the workshop and through the workshop breakout groups. Although overarching guidance was provided to each of the thematic groups (Task 3), the approaches adopted varied slightly between groups as described in Annex 2. Such differences in approaches in part reflect the availability of information sources for each thematic group. This flexibility was pivotal to allow thematic groups to achieve the desired outcome of horizon scanning. The preliminary consultations within thematic groups resulted in preliminary lists of species from each thematic group (the long list as described in Task 4) which could be considered through consensus-building.

Consensus-building across expert groups

The method of consensus building is described through Tasks 3 and 4. The context of the horizon scanning was to derive a short list of species for prioritisation for risk assessment based on the high probability of arrival, establishment, spread and threat to biodiversity and associated ecosystem services across the EU within the next ten years. The iterative and dynamic consensus approach led to varying numbers of species for each thematic group at various stages of the horizon scanning exercise (Figure 5.1). The outcome was a list of 120 species (Figures 5.1 and 5.2) and of these 102 were considered as very high or high priority for risk assessment. However, four of these species were removed because already have risk assessments compliant with the minimum standards (Roy et al. 2015; Roy et al. 2014b): Corvus splendens, Callosciurus erythraeus, Orconectes virilis, Sciurus niger. As discussed above a further three species (Agrilus planipennis, A. anxius, Dendrolimus sibiricus) were excuded because they are listed within Annex II of the European Directive regarding plant health (2000/29/CE). Of the 95 remaining species 46 were considered currently absent within Europe while 48 were considered to be present but with a limited distributed of a few small populations (Table 5.1). For one species the status with respect to absence or presence in the EU was uncertain. The following discussion is based on analysis of these 95 species.

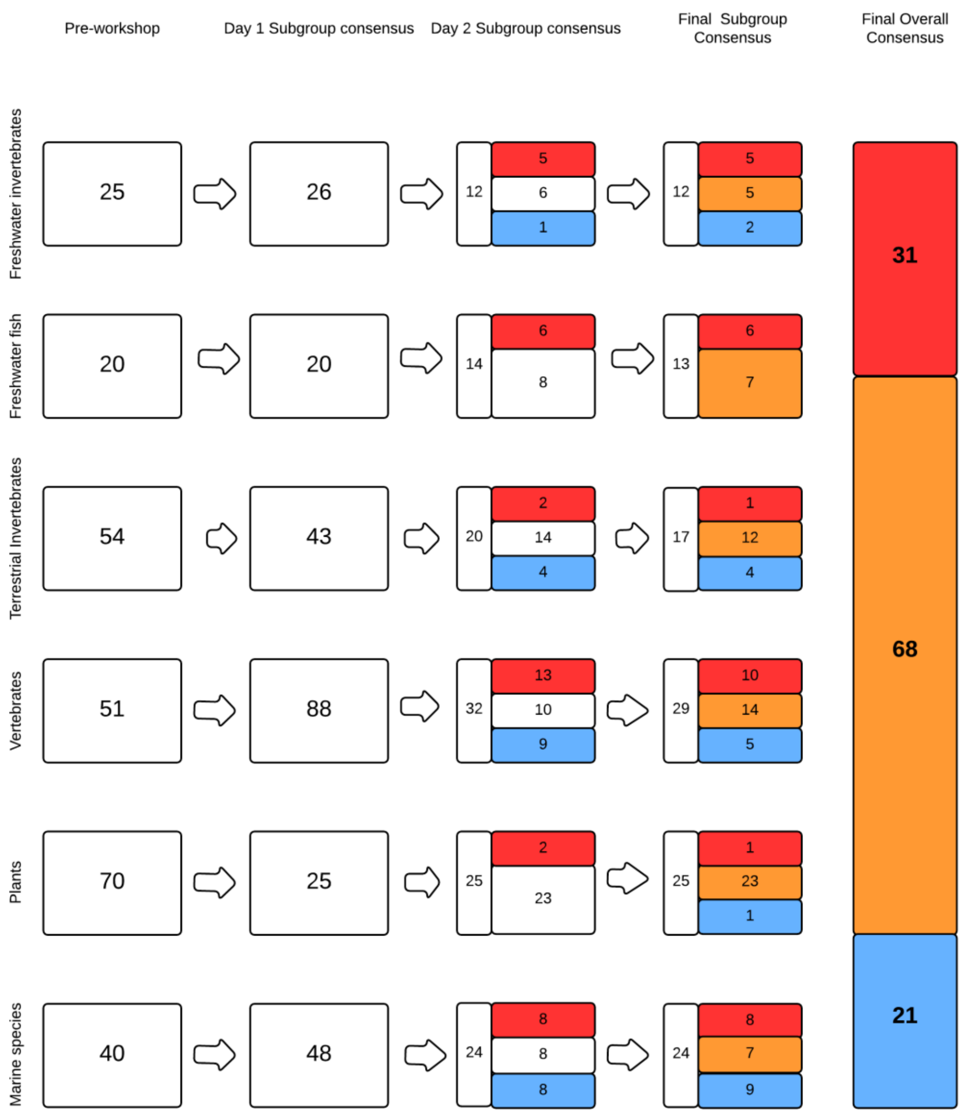

Figure 5.1 Number of species for each thematic subgroup at different stages of the horizon scanning process (long lists of species considered pre-workshop are provided within Annex 3 and Annex 4 provides species lists for the remaining within thematic subgroup stages). On day 2 the groups were first instructed to highlight high priority (red) and low priority (blue) species for prioritization for risk assessment within their thematic groups (Day 2 subgroup consensus) before arriving at a final within thematic group consensus (Final subgroup consensus) in which species were ranked as very high (red), high (orange) or medium (blue) priority for risk assessment. The final overall consensus was achieved across all thematic groups and resulted in 120 species again ranked as very high (red), high (orange) or medium (blue) priority for risk assessment.

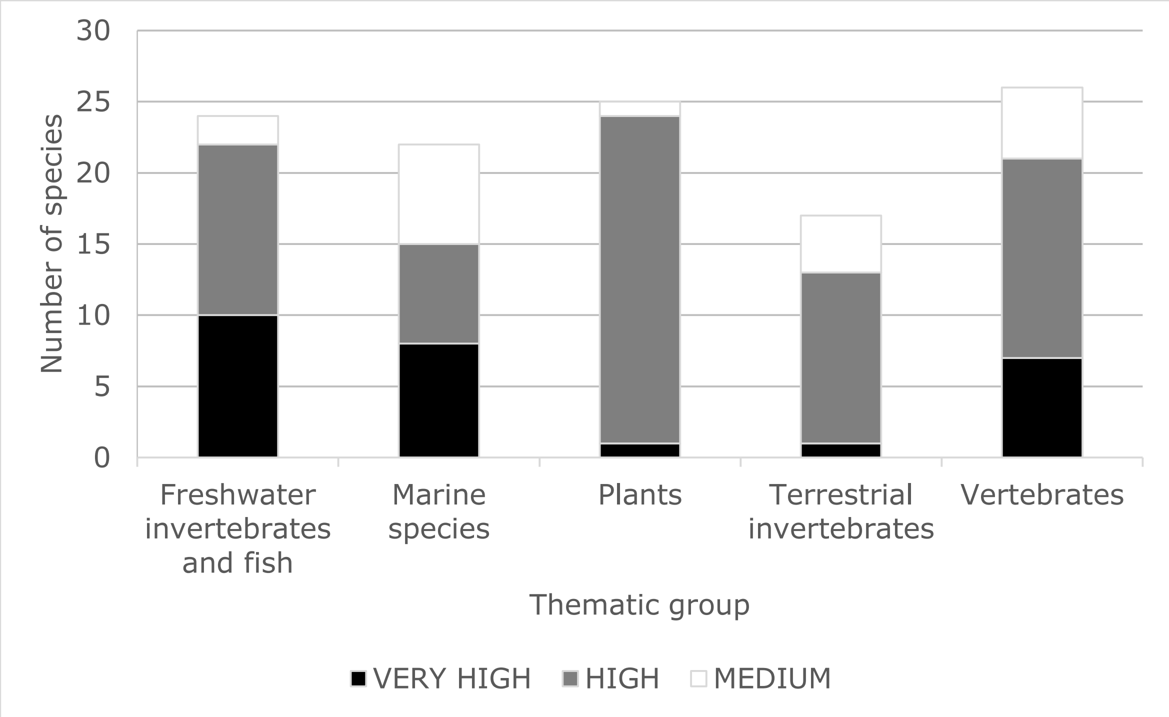

Figure 5.2 Number of species agreed by consensus for each thematic group (Freshwater invertebrates and fish, Marine species, Plants, Terrestrial invertebrates, Vertebrates) to represent very high, high or medium probability of arrival, establishment, spread and threat to biodiversity and associated ecosystem services across the EU within the next ten years.

A similar number of species, ranked as very high, high or medium priority for risk assessment, was included from each thematic group with the exception of the terrestrial invertebrate thematic group which listed fewer species than the other groups (Figure 5.2). For most terrestrial invertebrates, research on impacts is focused on commercial interests, such as forestry, or human health and well-being, rather than impacts on biodiversity (De Clercq et al. 2011; Roy et al. 2011). Therefore, it is perhaps not surprising that a number of the species highlighted by the terrestrial invertebrate thematic group were subsequently removed because of representation within Annex II of the European Directive regarding plant health (2000/29/CE). Knowledge gaps for terrestrial invertebrates have also been acknowledged (Kenis et al. 2009); it is notable that the list lacks insect parasitoid species even though their impact on biodiversity could be far-reaching (Henneman, Memmott 2001). However all thematic groups struggled with lack of information to some extent and this has been recognized through other studies (Vilà et al. 2010) and the main shortfall relating to understanding of impacts on ecosystem services (McLaughlan et al. 2014). Lack of information does not equate to absence of threat but a deliberately conservative approach was adopted whereby only those species with good supporting evidence of impacts on biodiversity were included in the list.

Table 5.1 List of 95 species across thematic groups agreed by consensus to represent very high (bold text) or high risk (highlighted dark grey) of arrival, establishment, spread and threat to biodiversity and associated ecosystem services across the EU within the next ten years, listed according to their overall risk (Scores contributing to the overall risk are provided in Annex 5). An additional 21 species were agreed to represent a medium risk (Annex 4). Three of the very high or high risk species originally listed were removed because they are included within Annex II of the European Directive regarding plant health (2000/29/CE): *Agrilus planipennis*, *Dendrolimus sibiricus*, *Agrilus anxius*. Five further species highlighted through this horizon scanning have potential relevance to plant health; These are *Axis axis* (#50), *Tetropium gracilicorne* (#86), *Sirex ermak* (#88), *Saperda candida* (#91), *Aeolesthes sarta* (#94)

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
1	***Alternanthera philoxeroides***	Plants	Alligator-weed	Vascular plant	Primary prod	Hort, Orn	SAm	MAC, MED	Y	625	X									X	X	X	
2	***Pterois miles***	Marine	Devil firefish, Lion fish	Fish	Pred	Nat, Pet	WIP, TeSAf	MED, MAC, ATL	Y	563	X	X				X							
3	***Herpestes auropunctatus***	Vertebrates	Small Asian mongoose	Mammal	Pred	BC,Pet, Nat	Afr	MED, CON	Y	563	X	X							X				X
4	***Callosciurus finlaysonii***	Vertebrates	Finlayson's squirrel	Mammal	Herb	Nat, Pet, BZA	AT	ATL, MED, CON	Y	563	X	X		X				X	X		X		X
5	***Lampropeltis getula***	Vertebrates	Common Kingsnake	Reptile	Pred	Other, Pet, BZA	NAm	MAC, MED	Y	506	X	X											X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
6	***Limnoperna fortunei***	Freshwater	Golden mussel	Bivalve mollusc	Filter	Ballast, Ship, Ang, Container, Water, Nat	As	MED, ATL, CON, STE	N	500	X						X	X	X	X	X		X
7	***Orconectes rusticus***	Freshwater	Rusty crayfish	Crustacean	Omni	F, Aq, Pet, Res, Live, Ship, Ballast, Water, Nat	NAm	MED, ATL, CON, STE	N	500	X	X		X				X	X	X	X		X
8	***Penaeus aztecus***	Marine	Northern brown shrimp	Crustacean	Omni	Ballast, Hull	TeNWA	MED, MAC	Y	500	X	X						X	X				
9	***Gambusia affinis***	Freshwater	Western mosquitofish	Fish	Omni	BC, CNM	NAm	MAC, MED, ATL, CON, STE	Y	475	X	X											X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
10	***Plotosus lineatus***	Marine	Striped eel catfish	Fish	Pred	Nat	WIP, TeNWP, CIP, TeAu	MED, MAC	N	456	X	X				X							X
11	***Pycnonotus cafer***	Vertebrates	Red-vented Bulbul	Bird	Omni	Pet, Other	As	ATL, MED, CON	Y	450	X	X										X	X
12	***Acridotheres tristis***	Vertebrates	Common myna	Bird	Omni	Nat, Pet, BZA	As	ATL, MED, CON, MAC	Y	450	X	X						X	X				X
13	***Bufo mauritanicus***	Vertebrates	Berber toad	Amphibian	Pred	Pet, Other	Afr	MED, MAC	Y	450	X	X	?						X			X	X
14	***Nasua nasua***	Vertebrates	Coati	Mammal	Omni	BZA, Orn, Pet	SAm	ATL, MED, CON	Y	450	X	X		X					X				X
15	***Micropterus dolomieu***	Freshwater	Smallmouth bass	Fish	Pred	F, Aq	NAm	MAC, MED, ATL, CON, STE	Y	405		X											X
16	***Homarus americanus***	Marine	American Lobster	Crustacean	Pred	Other, Live	TeNWA	ATL, MED, MAC	Y	405	X	X	X	X					X				

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
17	***Codium parvulum***	Marine	a green alga	Alga	Primary Prod	Nat	WIP	MED, MAC	N	400	X						X		X	X	X		
18	***Channa argus***	Freshwater	Northern snakehead	Fish	Pred	R, Pet	AT	MAC, MED, ATL, CON, STE	N	383	X	X		X									X
19	***Oreochromis mossambicus***	Freshwater	Mossambique tilapia	Fish	Omni	R, Pet, Aq	Afr	MAC, MED	Y	363	X							X					X
20	***Botrylloides giganteum***	Marine	a tunicate	Tunicate	Filter	Hull, Ballast	TrEA	MED, MAC	Y	360	X						X			X	X		
21	***Oreochromis aureus***	Freshwater	Blue tilapia	Fish	Omni	R, Pet, Aq	Afr	MAC, MED	Y	322	X	X	X						X				X
22	***Arthurdendyus triangulatus***	Terrestrial Invertebrates	New Zealand flatworm	Platyhelminth	Pred	Org, THM	Aus	ATL, CON? BOR?	Y	300	X	X								X	X		X
23	***Oreochromis niloticus***	Freshwater	Nile tilapia	Fish	Omni	R, Pet, Aq	Afr	MAC, MED	Y	288	X	X						X					X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
24	***Pomacea canaliculata***	Freshwater	Golden apple snail	Gastropod mollusc	Herb	R, Aq, Pet, Bait, Con Plant, THM, Ang, Container, Ship, Hull, Water, Nat	SAm	MED, CON, STE	Y	240	X	X		X				X	X	X			X
25	***Pomacea maculata***	Freshwater	Giant apple snail	Gastropod mollusc	Herb	R, Ag, Aq, Pet, Live, Ang, Ship, Hull, Water	SAm	MED, CON, STE	Y	240	X	X		X				X	X	X			X
26	***Crepidula onyx***	Marine	Onyx slippersnail	Gastropod mollusc	Filter	Hull, Aq	TrEP	ATL, MED, MAC	N	240	X						X			X	X		

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
27	***Mytilopsis sallei***	Marine	Black striped mussel	Bivalve mollusc	Filter	Hull, Ballast	TrWA	MED, MAC, ATL, BAL, BLK	N	216	X						X			X	X	X	X
28	*Gymnocoronis spilanthoides*	Plants	Senegal tea	Vascular plant	Primary prod	Pet	As, SAm	MAC, MED	N	625	X									X	X	X	
29	*Lygodium japonicum*	Plants	Japanese Climbing Fern	Vascular plant	Primary prod	Hort, orn, BZA	AT	MAC, MED	N	625	X										X	X	
30	*Andropogon virginicus*	Plants	Broom-sedge	Vascular plant	Primary prod	Mach	NAm	ATL, CON, MAC, MED, STE	Y	500	X									X	X		
31	*Celastrus orbiculatus*	Plants	Oriental Bittersweet	Vascular plant	Primary prod	Hort	As	ATL, BOR, CON, MED	N	500													
32	*Cortaderia jubata*	Plants		Vascular plant	Primary prod	Hort	SAm	ATL, MAC, MED	N	500	X										X	X	
33	*Euonymus fortunei*	Plants	Winter Creeper	Vascular plant	Primary prod	Hort	As	ATL, CON, MAC, MED	Y	500	X									X	X		

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
34	*Euonymus japonicus*	Plants	Japanese spindle	Vascular plant	Primary prod	Hort	As	ATL, CON, MAC, MED	Y	500	X										X		
35	*Lespedeza juncea sericea (= L. cuneata)*	Plants		Vascular plant	Primary prod	Hort	As, Aus	ATL, CON, MAC, MED	N	500	X					X					X		
36	*Ligustrum sinense*	Plants	Chinese Privet	Vascular plant	Primary prod	Hort	As	ATL, MAC, MED	Y	500	X									X	X		
37	*Lonicera maackii*	Plants	Amur Honeysuckle	Vascular plant	Primary prod	Orn, EC, L	As	ATL, CON, MAC, MED	N	500	X										X		X
38	*Lonicera morrowii*	Plants	Morrow's Honeysuckle	Vascular plant	Primary prod	Orn, EC, L	As	ATL, CON, MAC, MED	N	500	X										X		X
39	*Microstegium vimineum*	Plants	Nepalese Browntop	Vascular plant	Primary prod	Seed, CNM	As	ATL, CON, MAC, MED	N	500	X									X	X		X
40	*Prosopis juliflora*	Plants	Prosopis	Vascular plant	Primary prod	For, Pr (biofuel)	SAm	ATL, MAC, MED	N?	500	X								X	X	X	X	

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
41	*Prunus campanulata*	Plants	Bell flower cherry	Vascular plant	Primary prod	Hort	As	ATL, MAC	N	500	X										X		
42	*Rubus rosifolius*	Plants	Roseleaf Bramble	Vascular plant	Primary prod	Hort	AT, Aus	MAC	N	500	X		X						X		X	X	X
43	*Triadica sebifera (Sapium sebiferum)*	Plants	Chinese Tallowtree	Vascular plant	Primary prod	Ag, hort	As	MAC, MED	N	500	X									X	X	X	X
44	*Acridotheres cristatellus*	Vertebrates	Crested Myna	Bird	Omni	Pet, Other	As	ATL, MED, CON, MAC	Y	405		X											
45	*Cinnamomum camphora*	Plants	Camphor Tree	Vascular plant	Primary prod	Hort	As,AT	MAC, ATL	N?	400	X					X					X		X
46	*Clematis terniflora*	Plants	Leather Leaf Clematis	Vascular plant	Primary prod	Hort	As, AT	MAC, ATL	?	400	x										x		
47	*Ehrharta calycina*	Plants	Perennial Veldtgrass	Vascular plant	Primary prod	L, EC, Ag	Afr	MAC, MED	Y	400	X									X	X		
48	*Wedelia trilobata (= Sphagneticola trilobata)*	Plants	Wedelia	Vascular plant	Primary prod	Hort, EC, L	SAm	MAC, MED	Y	400	X										X	X	
49	*Pycnonotus jocosus*	Vertebrates	Red-whiskered Bulbul	Bird	Omni	Pet, Other	As	ATL, MED, CON	Y	394	X	X							X			X	X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
50	*Axis axis*	Vertebrates	Indian spotted deer	Mammal	Herb	BZA, Nat, Pet, H, L, Orn	Afr	ATL, MED, CON	Y	394	X	X	X	X				X	X	X	X	X	
51	*Cynops pyrrhogaster*	Vertebrates	Japanese fire-bellied salamander	Amphibian	Omni	BZA, Pet	As	CON	N	354	X	X	?	X								X	X
52	*Chrysemys picta*	Vertebrates	Painted turtle	Reptile	Omni	Other, Pet, BZA	NAm	CON, MED	Y?	354	X	X		X									X
53	*Rhea americana*	Vertebrates	Greater rhea	Bird	Omni	BZA	SAm	CON, MED	Y	350	X	X						X					
54	*Psittacula eupatria*	Vertebrates	Alexandrine parakeet	Bird	Herb	Nat, Pet, BZA	AT	ATL, MED	Y	350	X			X				X	X				X
55	*Bison bison*	Vertebrates	European bison	Mammal	Herb	H, Cons	NAm	CON	N	338	X		X	X				X					
56	*Chromolaena odorata*	Plants		Vascular plant	Primary prod	Soil, timb, wood, pp	SAm	MAC, MED	N?	320	X			X							X	X	
57	*Cryptostegia grandiflora*	Plants		Vascular plant	Primary prod	Hort	SAm	MAC, ATL, MED	N?	320	X					X	X				X	X	

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
58	*Hemidactylus frenatus*	Vertebrates	House gecko	Reptile	Pred	Pet Container	Aus	ATL, MED, CON		320	X	X											
59	*Trichosurus vulpecula*	Vertebrates	Brushtail Possum	Mammal	Omni	Pet Orn	Aus	ATL, MED, CON, MAC		304	X	X		X				X					
60	*Albizia lebbeck*	Plants	Indian Siris	Vascular plant	Primary prod	Hort, For	AT	MAC, ATL, MED	N	300	X									X	X	X	
61	*Fundulus heteroclitus*	Freshwater	Mummichog	Fish	Omni	R, Pet	NAm	MAC, MED, ATL, CON, STE	Y	293	X												
62	*Eleutherodactylus planirostris*	Vertebrates	Greenhouse frog	Amphibian	Pred	Pet, Container	NAm	MED, MAC	N	288	X	X		X									
63	*Rhinella marina*	Vertebrates	Cane toad	Amphibian	Omni	Pet, Other, TT, THM, BC	SAm	MED, MAC	N	280	X	X				X			X	X			X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
64	*Boiga irregularis*	Vertebrates	Brown tree snake	Reptile	Pred	Pet, Other, BZA, Container, Ship, Air	Aus	MED, MAC	N	280	X	X				X			X				X
65	*Misgurnus anguillicaudatus*	Freshwater	Oriental weatherfish	Fish	Omni	R, Pet	AT	MAC, MED, ATL, CON, STE	Y	277	X	X						X					X
66	*Eleutherodactylus coqui*	Vertebrates	Common coquí	Amphibian	Pred	Pet, BZA, CNM, Ship	SAm	MED, MAC	N	252	X	X											
67	*Cyprinella lutrensis*	Freshwater	Red shiner	Fish	Omni	R, Pet	NAm	MAC, MED, ATL, CON, STE	Y	227	X	X	X	X									X
68	*Morone americana*	Freshwater	White perch	Fish	Pred	Aq	NAm	MAC, MED, ATL, CON, STE	N	221		X		X									X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
69	*Hypostomus plecostomus*	Freshwater	Suckermouth catfish	Fish	Herb	R, Pet	SAm	MAC, MED	Y	215	X							X		X	X		X
70	*Pseudonereis anomala*	Marine	a polychaete	Polychaete	Omni	Ballast, Hull, Nat	WIP, CIP	MED, MAC	Y	210	X	X					X	X	X		X		
71	*Cherax destructor*	Freshwater	Common yabby	Crustacean	Omni	F, Aq, Live, BZA, Pet	Aus	MED, ATL, CON, STE	Y	200	X	X		X				X	X	X	X		X
72	*Tilapia zillii*	Freshwater	Redbelly tilapia	Fish	Omni	R, Pet, Aq	Afr	MAC, MED	Y	195	X	X						X					X
73	*Acanthophora spicifera*	Marine	a red alga	Alga	Primary Prod	Hull,Ballast	TrWA	MED, MAC	N	192	X						X			X	X	X	
74	*Charybdis japonica*	Marine	Asian paddle crab	Decapod	Pred	Hull, Ballast	TeNWP, CIP	MED, MAC, ATL	Y	192	X	X		X				X					X
75	*Perna viridis*	Marine	Asian Green mussel	Bivalve mollusc	Filter	Hull, Ballast		MED, MAC, ATL	N	192	X					X	X		X	X	X		
76	*Symplegma reptans*	Marine	a tunicate	Tunicate	Filter	Hull		MED, MAC, ATL, BLK	N	192	X						X			X	X		

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
77	*Potamocorbula amurensis*	Marine	Asian basket clam	Bivalve mollusc	Filter	Ballast	TeNWP	MED, MAC, ATL, BLK, BAL	N	180	X	X						X	X	X	X	X	X
78	*Macrorhynchia philippina*	Marine	White stinger	Hydroid	Filter	Hull, Ballast	CIP, WIP	MED, MAC, ATL	Y	175	X					X							
79	*Pachycondyla chinensis*	Terrestrial Invertebrates	Asian Needle Ant	Insect	Omni	THM	As	MED, ATL, CON, STE, MAC	N	175	X	X							X	X	X	X	X
80	*Solenopsis invicta*	Terrestrial Invertebrates	Red Imported Fire Ant	Insect	Omni	THM	SAm	MAC, MED	N	160	X	X				X		X	X	X	X	X	X
81	*Solenopsis geminata*	Terrestrial Invertebrates	Tropical fire ant	Insect	Omni	THM	NAm/SAm	MAC, MED, ATL?, CON? STE	N	160	X	X				X			X	X	X	X	X
82	*Pheidole megacephala*	Terrestrial Invertebrates	Big-headed Ant	Insect	Omni	THM	Afr	MAC, MED	Y	158	X	X							X	X	X	X	X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
83	*Misgurnus mizolepis*	Freshwater	Chinese weather loach	Fish	Omni	R, Pet	AT	MAC, MED, ATL, CON, STE	Y	153	X	X	X							X			X
84	*Marissa cornuarietis*	Freshwater	South American giant ramshorn snail	Gastropod mollusc	Omni	BC, Aq, Pet, Con Plant, THM, Water, Nat, Pet, BZA	SAm	MAC, MED, CON, STE	Y	135	X	X						X	X	X		X	X
85	*Amynthas agrestis*	Terrestrial Invertebrates	Crazy snake worm	Annelid	Det	Org, THM	As?	ATL, CON	N	129	X								X	X	X	X	X
86	*Tetropium gracilicorne*	Terrestrial Invertebrates	Fine-horned spruce beetle	Insect	Herb	TT,THM ,CNM	As	ATL, CON, STE, BOR	N	128	X							X	X	X	X	X	X
87	*Solenopsis richteri*	Terrestrial Invertebrates	Black Imported Fire Ant	Insect	Omni	THM	SAm	MAC, MED, ATL?, CON? STE	N	128	X	X				X		X	X	X	X	X	X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
88	*Sirex ermak*	Terrestrial Invertebrates	Blue-black Horntail	Insect	Herb	TT, For	As	CON, STE, BOR	N	111	X			X				X		X	X	X	X
89	*Gammarus fasciatus*	Freshwater	Freshwater shrimp	Crustacean	Omni	Live, Bait, THM, Ang, Container, Ship, Water, Ballast	NAm	MED, ATL, CON, STE	N	108	X	X						X	X	X		X	X
90	*Cherax quadricarinatus*	Freshwater	Redclaw crayfish	Crustacean	Omni	Aq, Pet, Water	Aus	MED, ATL, CON, STE	Y	108	X	X		X				X	X	X	X	X	X
91	*Saperda candida*	Terrestrial Invertebrates	Round-headed Apple Tree Borer	Insect	Herb	TT, CNM	NAm	MAC? MED, ATL, CON, STE, BOR	Y	105	X							X	X	X	X	X	X

	Species	Subgroup	Common Name	Taxonomic Group	Functional Group	Pathway	Origin	Bioregions threatened	Already present in EU?	Overall Risk	Competition	Predation	Hybridization	Disease Transmission	Parasitism	Poisoning/Toxicity	Bio-fouling	Grazing/herbivory/browsing	Interactions with other IAS	Nutrient cycling	Physical modification of habitat	Natural succession	Disruption to food webs
92	*Bellamya chinensis*	Freshwater	Chinese mysterysnail	Gastropod mollusc	Filter	R, Aq, Con Plant, Live, Ang, Ship, Water, Pet	As	MED, ATL, CON, STE	Y	100	X			X			X	X	X	X			X
93	*Ashworthius sidemi*	Terrestrial Invertebrates		Nematode	Pred	Par Anim	As	CON, ATL?	Y	100				X	X								
94	*Aeolesthes sarta*	Terrestrial Invertebrates	City Longhorn Beetle, Qetta borer	Insect	Herb	Con Plant, TT, THM	As	MED, ATL, CON, STE, BOR	N	99	X							X	X	X	X	X	X
95	*Vespula pensylvanica*	Terrestrial Invertebrates	Western yellowjacket	Insect	Omni	TT	NAm	MAC? MED, ATL, CON, STE, BOR?	N	99	X	X				X			X	X			X

Native range

Asia, North America and South America are the native range of a high proportion of the species identified as high risk through the horizon scanning (Figure 53). The marine species are likely to originate from a range of geographic regions. It is important to note that for many species the introduction will not be from the native range but from an invaded region. Such secondary introductions can have implications on the invasion process for example some invasive populations might be a consequence of the bridgehead effect in which the IAS originates not from the native range, but from a previously successful invasive population, which serves as the source of invasion for new territories (Lombaert et al. 2010).

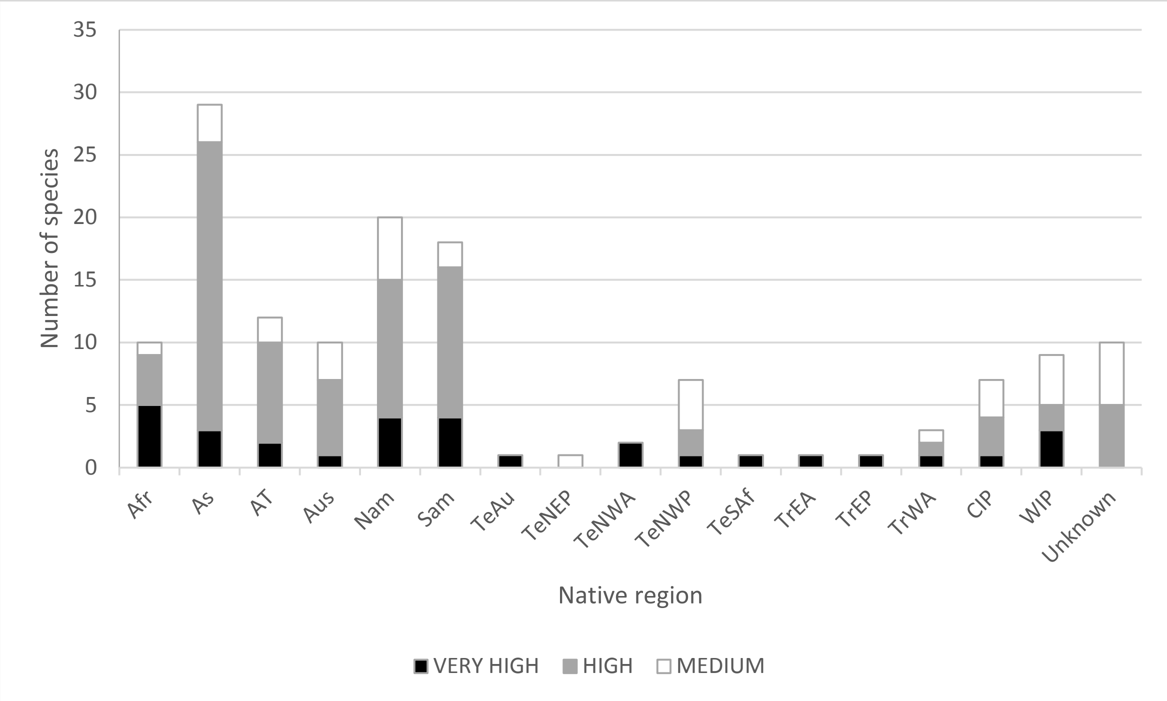

Figure 5.3 Native range of the species prioritised for risk assessment by each thematic group. Terrestrial and Freshwater: Afr = Africa; As = Asia Temperate; At = Asia Tropical; Aus = Australasia; NAm = North America; SAm = South America. Marine: TeAu = Temperate Australasia; TeNWA = Temperate NW Atlantic; TeNWP = Temperate NW Pacific; TeSAf = Temperate Southern Africa; TrEA = Tropical Eastern Atlantic; TrEP = Tropical Eastern Pacific; TrWA = Tropical Western Atlantic; CIP = Central Indo-Pacific; WIP = Western Indo-Pacific

Pathways of arrival

For each species the likely pathways of arrival were provided by the experts. Many of the species are anticipated to arrive along multiple pathways (Figure 5.4) but it is apparent that escape from confinement is particularly relevant to freshwater invertebrate and fish species, plants and vertebrates whereas marine species are most likely to arrive as stowaways and terrestrial invertebrates as contaminants (Figure 5.4a and b).

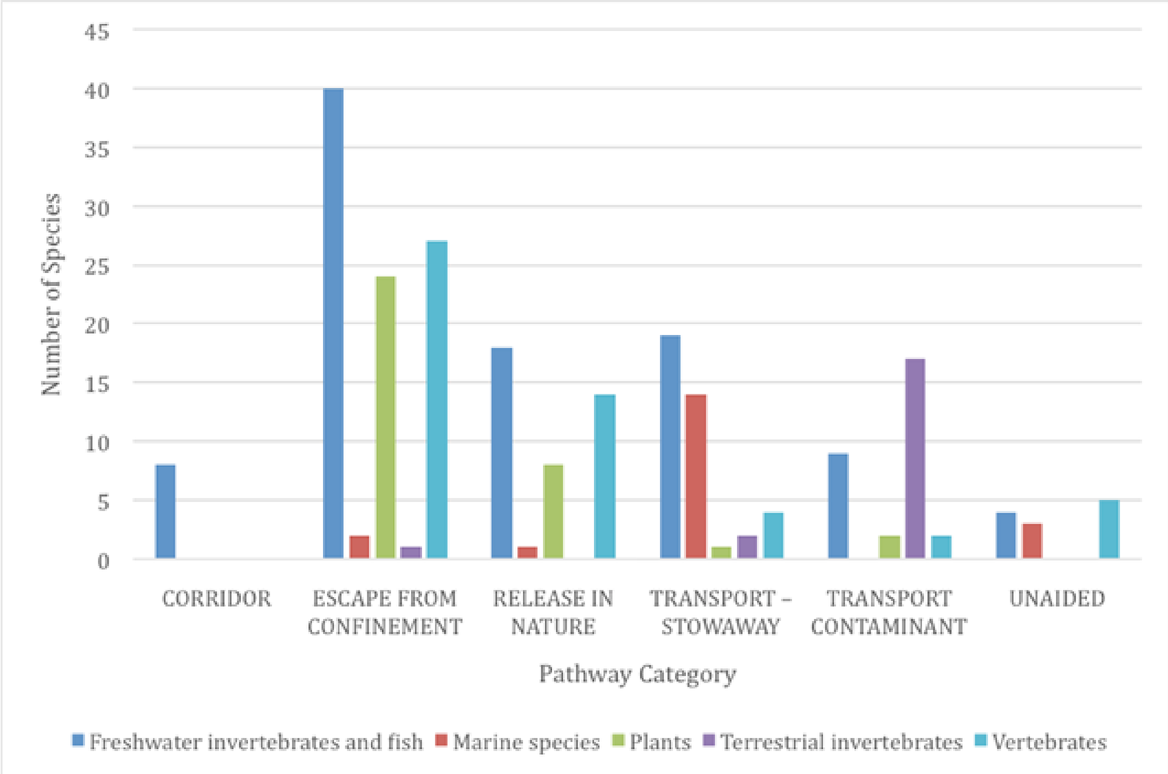

Figure 5.4a Number of pathways within broad categories (CBD 2014) by which the species prioritised for risk assessment by each thematic group and agreed by consensus are likely to arrive. Many species are predicted to arrive through multiple pathways.

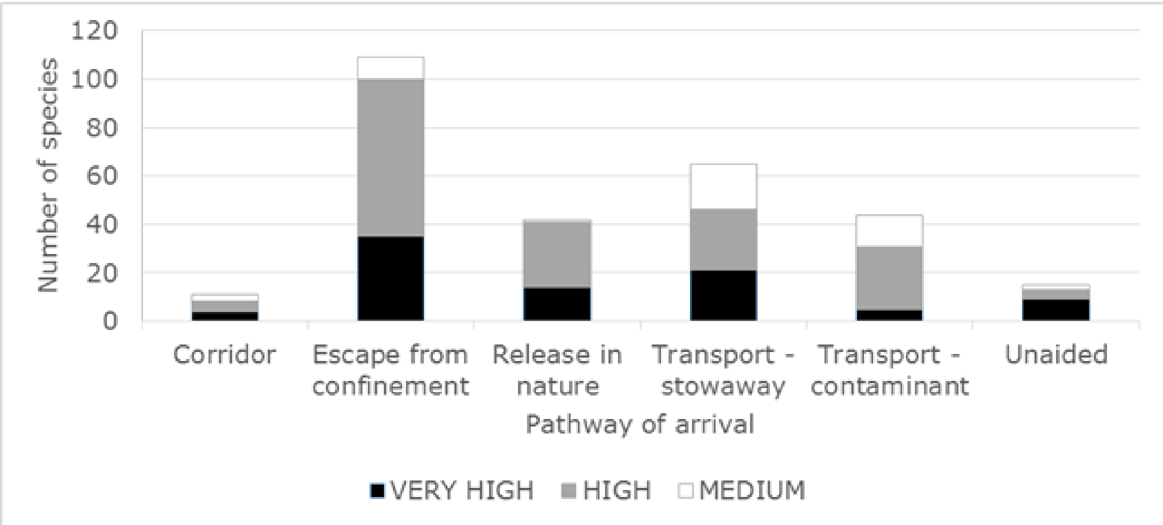

Figure 5.4a Number of pathways within broad categories (CBD 2014) by which the species prioritised as very high, high or medium for risk.

Functional groups

The species prioritised for risk assessment span a variety of functional groups (Figure 5.5). Omnivores and primary producers dominate the species listed as priority for risk assessment. A high proportion of the species considered to be very high priority for risk assessment are omnivores and predators. The prevalence of omnivores suggests the opportunistic nature of these species.

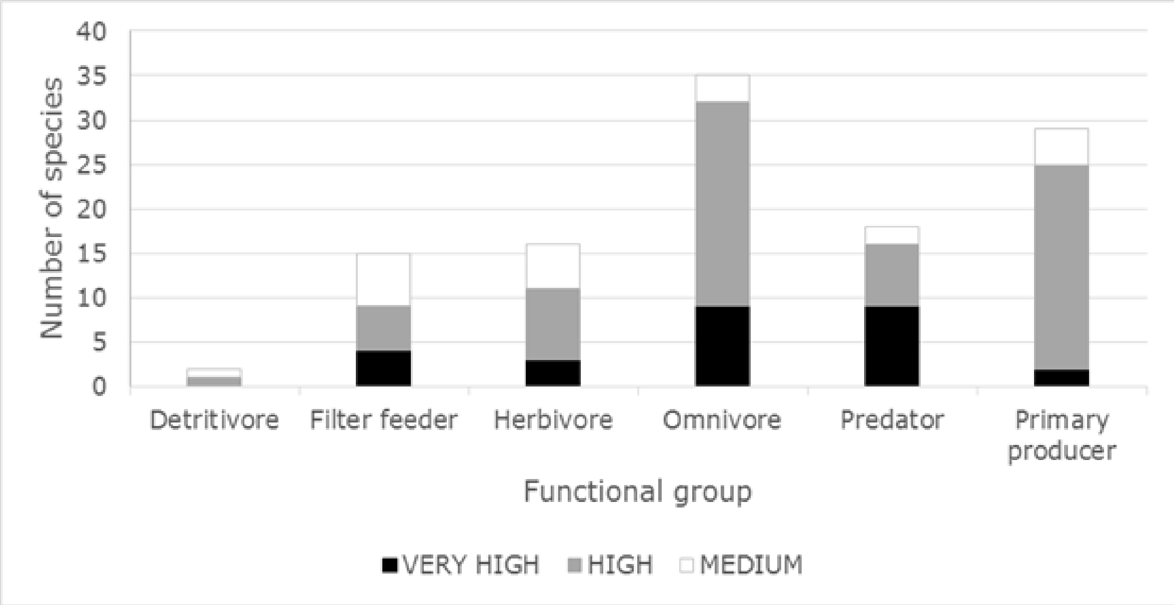

Figure 5.5 Functional groups of the species prioritised as very high, high or medium for risk assessment

Bioregions

The number of bioregions under threat from the species prioritised for risk assessment varied between thematic groups although the majority of the species were predicted to be of threat to two or more bioregions (Figure 5.6). A high number of the freshwater invertebrates and fish were anticipated to pose a threat to four or five bioregions. In contrast many of the marine species and vertebrates are likely to be restricted to two or three bioregions. The terrestrial invertebrates and plant species are more evenly spread with more than two bioregions predicted to be threatened in all cases. Two terrestrial invertebrates were considered to pose a threat to six bioregions, Round-headed Apple Tree Borer *Saperda candida*, and western yellow jacket *Vespula pensylvanica*, although there was some uncertainty with respect to at least one of the bioregions in each case.

The Mediterranean, Continental, Macaronesian and Atlantic bioregions are predicted to be the most threatened by the species prioritised for risk assessment across all thematic groups (Figure 5.6) whereas Baltic, Black Sea and Boreal bioregions appear to be least threatened. The terrestrial invertebrates, freshwater invertebrates and fish are likely to be of greatest threat to the Steppic bioregion. The Mediterranean and Macaronesian bioregions are most threatened because of the predicted arrival of marine western Indo-Pacific IAS as a consequence of proposed developments with the Suez Canal.

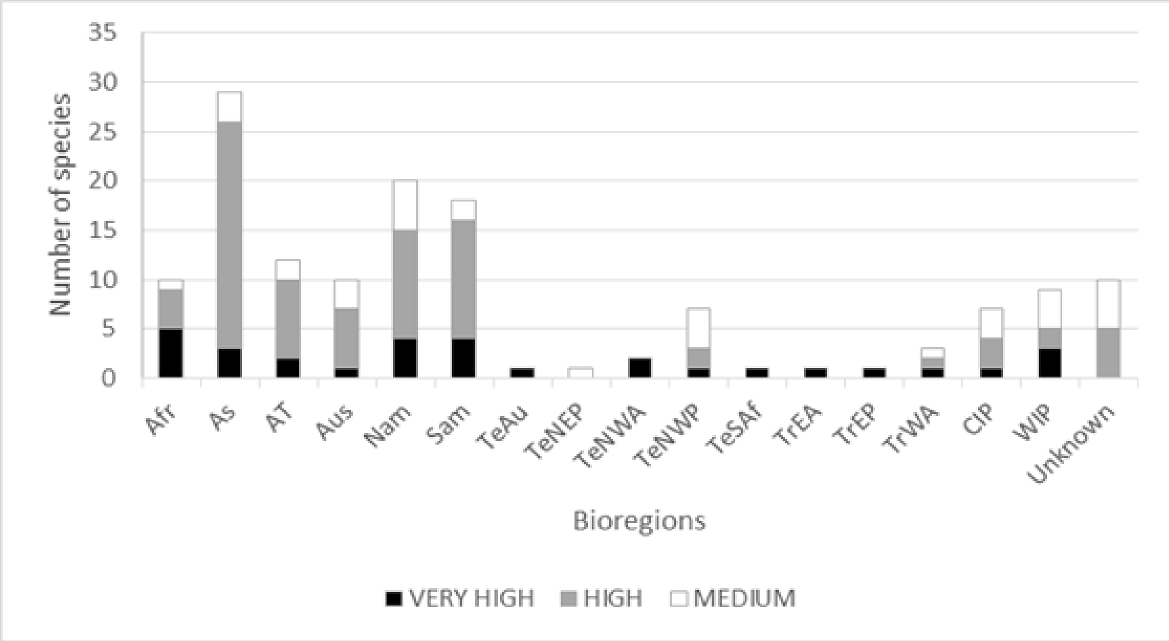

Figure 5.6 Threatened bioregions for the species prioritised as very high, high or medium for risk assessment

CONCLUSIONS

The species prioritised for risk assessment across the thematic groups originate from around the world and represent a range of functional groups which are likely to arrive in many different ways through multiple pathways. The breadth of bioregions that are considered under threat by these species is striking, but it is notable that the Mediterranean, Continental and Macaronesian bioregions are most at risk under current climate conditions. Climate warming is likely to play an important role in the future with respect to interactions with IAS (Bellard et al. 2013; Walther et al. 2009). Some of the species that are currently constrained to southern Europe will likely move northwards as the climate warms. It is essential that consideration is given to interactions between major drivers of change such as climate change but also habitat destruction and pollution. Indeed it is predicted that IAS will thrive in disturbed habitats for example the combined impacts of seawater warming and ocean acidification will adversely alter coastal ecosystems to the benefit of IAS (Brodie et al. 2014).

It is important to note the erratic nature of IAS introduction events and, therefore, recognise the imperfect nature of horizon scanning lists (Roy et al. 2014a). There are many species that have not been considered through this horizon scanning approach that could arrive in the future. However, horizon scanning can inform the three-stage hierarchical approach proposed by the CBD for managing the impacts of IAS. Communication and cross-boundary collaborations, ensuring knowledge on IAS is shared between countries, are essential to ensure successful implementation of IAS strategy.

KEY RECOMMENDATIONS

- Risk assessments to designate candidate species for the list of IAS of EU concern should be undertaken on all alien species identified as very high or high priority through horizon scanning. However, the alien species categorised as medium priority during the horizon scanning should also be reviewed, if possible through risk assessment. A sample of the low priority species could also be subject to risk assessment to validate the approach.
- The scope of the horizon scanning should be clearly defined in terms of taxonomic and environmental breadth but also with respect to status of species within a region. In this horizon scanning exercise we included alien species that were absent but also those present but not widespread. However, defining the scope explicitly in this regard would have been advantageous for the consensus process. Ideally only alien species known to be absent within the EU would be included and EASIN could be used for IAS present but with only a few, small populations documented.
- The databases identified through Task 2 provided one source of information for the thematic groups to build the lists of species but there was considerable reliance on other sources of information beyond the identified databases. This reflects the distributed nature of information on IAS despite considerable efforts to collate information in large databases. EASIN can provide a valuable role in gathering information from distributed databases and other sources such as peer-reviewed publications.
- The ranking of alien species identified during horizon scanning should be reviewed every three years. The review should include alien species not previously listed but that are subsequently considered as new potential threats for the EU. The review should propose updates for the list of IAS of EU concern.
- It was decided not to include taxa above the species level but it would have perhaps been useful to do so thus allowing the inclusion of species complexes which could not be completely resolved. However, risk assessments are designed for implementation at the species level and so risk assessment of a species complex could present challenges.
- The approach to scoring the species identified should be reviewed. Consideration of so many species requires a rapid method that enables effective but approximate ranking. The crude bracketing of species as very high, high and medium overcomes uncertainty or bias in the ranking. It is also important to remember that the scoring is to enable species to be prioritized for risk assessment and through such risk assessment scores underpinned by detailed evidence will be derived. The risk assessments will provide a further method of validation of the process.
- The focus of this horizon scanning exercise was primarily on the negative impacts of IAS on biodiversity and ecosystems, with some consideration on ecosystem service impacts. This scope was determined by the extent of existing information and expertise of the participants. Systematic consideration of ecosystem services and socio-economic impacts could form an integral part of a horizon scanning excersise, however for this to be the case dedicated frameworks for classification and scoring of such impacts would need to be developed and agreed. It is to be noted that the level of existing information might not allow for a very detailed and/or scientifically well-informed assessment of ecosystem service and/or socio-economic impacts, affecting the overall robustness of the scoring exercise. Therefore, biodiversity and ecosystem impacts are recommended to form be the core focus of a horizon scanning exersice with socio-economic factors included as secondary consideration.
- Given the scope of the horizon scanning exercise, which was partially focused on species not yet in Europe, the databases other than those with data limited to the

European region (such as EASIN) should be encouraged and sustained. For the purpose of the present study, a particularly relevant role has been played by the GISD. A need has been identified to invest sufficient resources in the future implementation of the GISD, given its relevance to the present study and links with European information systems should be improved. It is also important to explicitly identify knowledge gaps with respect to taxa, environments and geographic regions and increase investment specifically in these domains.

- Priority should be given to developing methods that enable semi-automation of the compilation of preliminary lists from databases alongside recognizing the importance of experts in validating and ranking such species. However, it is important to recognise the data limitations within databases. Indeed information on impacts and pathways is scarce and lack standardisation in the way they are documented. Such limitations would limit the interoperability of different databases through automated searches. Improvements to information gathering for horizon scanning need to be made including consistent use of terminology with respect to the categorisation of relevant data and information.

RECOMMENDED STEPWISE APPROACH TO HORIZON SCANNING BY CONSENSUS

The chronological sequence outlined here is to guide and implement Horizon Scanning exercises based on expert consensus. It describes the motivation behind the activities, which should assist in adapting the scheme for implementation at national scales. It is important to have a core team of people to manage the exercise: an overall chair (who will facilitate discussions throughout the process including the workshop), a database manager (who will collate information throughout the process including dynamically during the workshop) and ideally a facilitator (who will take notes throughout the workshop but also support the chair).

Step 1: Identify the scope of the exercise:

The scope of the exercise should be clearly defined particularly with respect to a number of key parameters. Different choices will lead to different priority lists:

1. Impact: biodiversity / ecosystem, societal or economic impacts could be the focus of the exercise. It would be challenging to give equal priority to all of these impacts within one horizon scanning exercise. Depending on the scope of horizon scanning exercise, there could be a hierarchy of importance so that, for example, biodiversity and ecosystem impacts form the main focus with socio-economic factors included as secondary consideration. Additionally it is essential to state whether or noth both negative and postive impacts are to be considered or just negative impacts. For most horizon scanning exercises focused on prioritising IAS for risk assessment then consideration of negative impacts only is justified, positive impacts can be considered at a later stage.

2. Species status within the region: the focus could be limited to species absent from the region or it could be expanded to also include those species with limited distributions within the region. It is critical to define the scope explicitly.

3. Taxonomic breadth or breadth of functional groups: This choice will clearly affect the selection of experts to be made and it will be important to acknowledge gaps in expertise or information available.

4. Geographic range: Of necessity, this will often be defined by political boundaries, although it should be recognized that these may not be well matched to biogeographically relevant regions. Defining the geographical scope for marine species should allow for the effects of major oceanic currents and periodic changes therein.

5. Temporal range: it is important to define the time-scale over which the horizon scanning is relevant. In this exercise we limited the temporal range to species likely to arrive within the next 10 years: a pragmatic balance between being short enough to maximize confidence in the predictions and not so long that major environmental changes, such as in the climate, need to be considered.

Step 2: Define the thematic groups to be considered and the expert teams for the assessment.

Distinct thematic groups should be established so that the taxonomic and environmental breadth of the horizon scanning exercise is covered adequately. The groups can be defined by a mixture of taxonomy, functional group and habitat. The aim should be to ensure that each thematic group has approximately the same number of species to consider. The number of experts in each group (typically 6-9 members) should reflect their inherent taxonomic complexities and the natural boundaries of expertise. As an example the five thematic groups could be marine organisms, terrestrial vertebrates, terrestrial invertebrates, plants, freshwater invertebrates and fishes but some of these groupings may need to be subdivided for particular horizon scanning exercises. Each team should have two expert leaders to coordinate the exercise. Criteria for the choice of experts should include:

1. In combination, the team should be expected to create a comprehensive list of candidate species for their group;

2. Every expert should be willing and able to assess all the species on the list they compile while being able to indicate the level of knowledge/uncertainty for each assessment.

Step 3: Define the criteria to select species.

Experts should agree on the criteria to be used when selecting species. Such species could have some or all of the following characteristics:

1. Present in an adjacent country, region or biogeographical area, connected to the focal area by a direct and feasible dispersal route

2. Present in a region with comparable climatic conditions to the focal area

3. A history of (recent) invasiveness and impact on the focal concern (e.g. biodiversity / ecosystems, ecosystem services, social and economic impacts)

4. Present in an area with strong trade or travel links with the focal area that provide a realistic potential invasion pathway.

Step 4: Identify parameters for the assessment of selected species.

These parameters will be common to all selected species. They should include those that can be scored for initial assessment and prioritization for subsequent risk assessments, and meta-data for instance on pathways, ecosystem services impacts, the means and types of impact. These will prove useful in subsequent discussions but should not be taken as absolute at this screening stage.

Useful parameters to score:

1. Likelihood of arrival. This will mainly reflect the results of Step 3 above.

2. Likelihood of establishment. This will reflect what is known about both the fundamental ecology of the IAS and the nature of the recipient habitats and environment.

3. Impact of IAS (likelihood and severity), with specific consideration of the following negative impacts

    a) Impact on biodiversity and ecosystems, e.g. impacts on species, habitats, ecosystems and ecosystem functioning

    b) Impact on ecosystem services, including provisioning, regulating and cultural services[2]

    c) Economic impact, including production losses, management costs and indirect losses to other activities and sectors (e.g. health sector)[3]

    d) Social impact, including individual and societal wellbeing and health, aesthetics, recreational and cultural values, food security, employment etc.

4. Likelihood of post-establishment spread. This will reflect what is known about the population ecology of the IAS, especially its reproductive potential and ability to disperse.

It is important to identify not just the parameters, but also definitions of the different score levels. Horizon scanning exercises commonly use scores from 1 (low) – 5 (high) and for instance definitions on impacts based on Blackburn, Essl et al. (2014)[3].

As regards scoring against the different parameteres, it is important to distinguish between (and score separately) impacts on species, habitats, ecosystem functions (e.g. nutrient cycling) and ecosystem services. Furthermore, it is to be noted that the level of existing information might not allow for a very detailed and/or scientifically well-informed assessment of ecosystem service and/or socio-economic impacts, affecting the overall robustness of the scoring exercise. Therefore, as highlighted under Step 1, biodiversity and ecosystem impacts are likely to form the core focus of a horizon scanning exercise with socio-economic factors included as secondary consideration.

Step 5: Compile lists of species to consider for prioritization within each group

Experts should be asked to compile lists of species for assessment by the wider thematic group using resources including available databases, but also primary and grey literature and in some cases their own knowledge. Basic factual information should be assembled for each species: taxonomy, functional role, native range, most likely invasion pathway, etc. Sources of information and brief justifications should be provided for each species proposed.

Step 6: Score, re-score and combine.

1. Each expert should receive the combined list from their team leader to score.

2. Scores from all experts should be circulated within the team, so that everyone has a chance to re-consider their own scores. The Delphi approach can be used during this phase as a structured method for group scoring (Figure 1).

3. Team leaders receive the revised scores from all team members and summarize them. Summary scores should reflect a central moment measure (mean, median, mode) and a measure of variation indicating level of agreement within the group.

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[3] Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, et al. 2014. A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts. *PLoS. Biol.* 12

2 http://biodiversity.europa.eu/maes/common-international-classification-of-ecosystem-services-cices-classification-version-4.3

3 http://www.nonnativespecies.org/downloadDocument.cfm?id=487

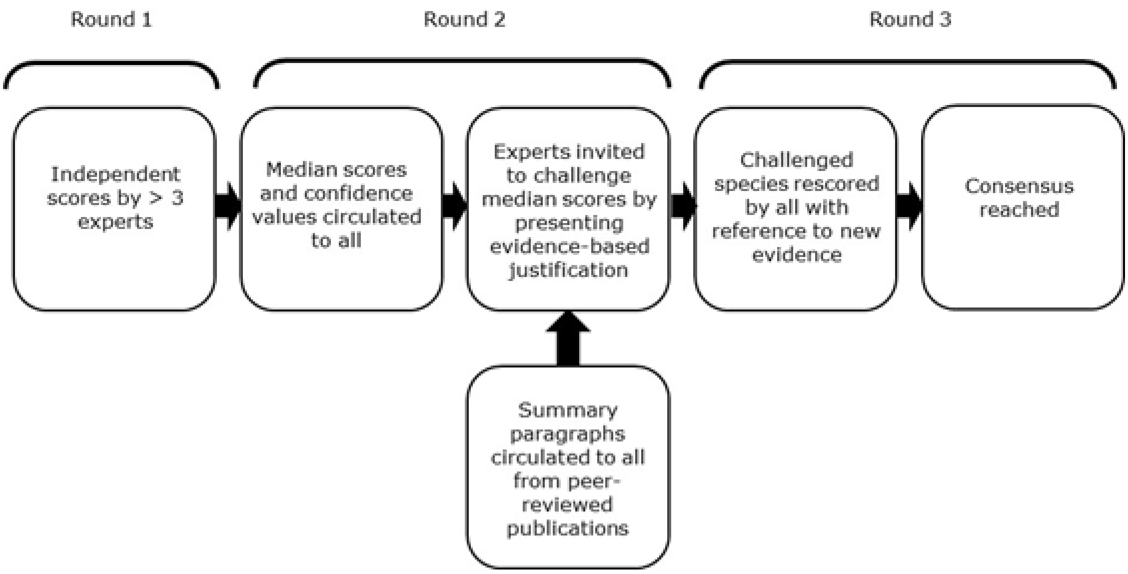

Figure 1 Delphi approach to deriving consensus within thematic groups on scores and prioritisation of species

We recognize the scoring system could be more complex, but suggest that the relatively high levels of uncertainty underlying horizon scanning argues against rigorous mathematical treatments, and also that the same uncertainties are accounted for in subsequent consensus discussions.

Step 7: A consensus workshop

Each team brings a consolidated and combined list for their group, ranked according to scores, to the workshop. At the workshop:

1. Team leaders introduces the species that their team has collated and the reasoning for the order/ranking given.

2. Teams discuss their scores in the context of score, and the reasoning for them, presented by other groups

3. Teams have the opportunity to revise scores according to the results of the above discussion.

4. Group lists are combined into an overall list according to scores.

5. The whole plenum is invited to challenge the rankings in the overall list and the responsible team is asked to defend the ranking of "their species" in the overall list. From this point onward, the rank positions of individual species are argued in relation to those of other species rather than on the basis of original or modified scores. These discussions should consider the confidence that proposing teams have in their rankings.

6. Rankings of individual species are adjusted following these discussions.

7. Consensus is reached amongst the workshop participants on a final ranked list of species.

One should recognize that it will not always be possibly to differentiate between priorities for individual species, but that groups (e.g. 11 – 20, 21 – 30) would still be useful to stakeholders.

Step 8: Collate the outcome of the workshop into a priority list for stakeholders including all the meta-data compiled through Steps 4 and 5.

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ANNEX 1. PROJECT TEAM, THEIR ROLE IN THE PROJECT AND MAIN AREAS OF RESPONSIBILITY ALONGSIDE A SUMMARY OF SKILLS

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
CORE TEAM											
CEH											
Helen Roy	Project management	Lead implementation of all tasks, supervision, quality control	✓	✓	✓	✓	✓	✓	✓	EN	✓
Oliver Pescott	Plant expert	Task 4, 5		✓	✓				✓	EN	✓
Karsten Schönrogge	Task leader and expertise in statistical uncertainty	Leading task 3 and contributing to tasks 4, 5	✓	✓	✓	✓			✓	DE, EN,	✓
Hannah Dean	Data and project management support	All tasks		✓			✓	✓	✓	EN	✓

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Jodey Peyton	Project support	All tasks		✓				✓	✓	EN	✓
Steph Rorke	Database manager	All tasks		✓	✓		✓	✓	✓	EN	✓
EAA											
Wolfgang Rabitsch	Co-Lead	Co-Lead implementation of all tasks, Contribution to implementation of all tasks	✓	✓	✓	✓	✓		✓	DE, EN	✓
Franz Essl	Task Leader	Leading task 2 and contributing to tasks 3, 4,5	✓	✓	✓	✓	✓		✓	DE, EN, FR, ES, RU	✓
IEEP											

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Marianne Kettunen	Task Leader and expert in socio-economic impacts	Leading task 1 and contributing to all	✓	✓	✓		✓	✓	✓	EN, FIN, ES, NL	✓
Belgian Biodiversity Network											
Etienne Branquart	Major contribution to tasks 1, 2	Contributing to all tasks		✓	✓	✓	✓	✓	✓	FR, EN	✓
Sonia Vanderhoeven	Major contribution to tasks 1, 2	Contributing to all tasks		✓	✓		✓	✓	✓	FR, EN	✓
Andre Heughebaert	IT expertise	Contributing to all tasks		✓				✓	✓	FR, EN	✓
University of Sussex											
Alan Stewart	Task Leader	Lead Task 3 and contributing to tasks 4, 5	✓	✓	✓		✓	✓	✓	EN	✓
ISSG											

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Riccardo Scalera	Task Leader	Lead Task 5 and contributing to tasks 2,3,4		✓	✓	✓	✓	✓	✓	IT, EN, FR, ES	✓
Piero Genovesi	Task Co-lead	Task 5 and contributing to tasks 3,4	✓	✓	✓	✓	✓	✓	✓	IT, EN, FR, ES	✓
IUCN											
Ana Nieto	Task Leader	Lead Task 4 and specically the workshop	✓	✓		✓		✓	✓	EN, ES	✓
Mariana Garcia	Task Co-lead	Support with organization of the workshop in task 4		✓				✓	✓	EN, ES	✓
SUB GROUP EXPERTS											

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Philip Hulme, Lincoln University	Subgroup Leader - Plants	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for alien plants		√	√	√	√	√	√	IT, EN, FR, ES	√
Tim Blackburn, University College London	Subgroup Leader - Vertebrates	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for vertebrates	√	√	√		√		√	EN	
Sven Bacher, Fribourg University	Subgroup Leader - Vertebrates	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for vertebrates	√	√	√	√	√	√	√	EN, FR, DE	√

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Carles Carboneras	Subgroup Leader - Vertebrates	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for vertebrates		✓		✓		✓	✓	ES, EN	✓
Emili García-Berthou, UdG	Subgroup Leader – Freshwater vertebrates	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for vertebrates	✓	✓	✓	✓	✓	✓	✓	ES, EN, FR	✓
David Aldridge, Cambridge University	Subgroup Leader – Freshwater invertebrates	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for freshwater invertebrates	✓	✓	✓	✓	✓	✓	✓	EN	✓

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Elizabeth Cook, SAMS	Subgroup Leader - Marine	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for marine species	✓	✓	✓	✓	✓	✓	✓	EN	✓
Jack Sewell, MBA	Subgroup Leader - Marine	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for marine species		✓	✓	✓	✓	✓	✓	EN	✓
John Bishop, MBA	Subgroup Leader - Marine	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for marine species	✓	✓	✓	✓	✓	✓	✓	EN	✓
Chris Wood, MBA	Task 3 contributor	Support on marine species						✓	✓	EN	✓

Expert	Role in the project	Main areas of responsibility	Summary of skills relevant to the project								
			10 years' experience in project management (teams of at least 5 people)	Scientific higher education degree and relevant professional experience	At least 5 years in the field of invasive alien species	At least 3 years on risk assessments and horizon scanning on invasive alien species	3 years on data management on invasive alien species	IT expertise in the field of database management	Excellent language skills in English	Language skills	Availability of international network to support language skills
Argyro Zenetos, HCMR	Subgroup Leader - Marine	Coordinate implementation of tasks 3,4,5 within subgroup. Horizon scanning for marine species	✓	✓	✓	✓	✓	✓	✓	GR, EN	✓
Wolfgang Nentwig, University of Bern	Subgroup Leader – Terrestrial invertebrates	Lead implementation of tasks within subgroup.	✓	✓	✓	✓	✓	✓	✓	DE, EN	✓
Marc Kenis, CABI	Subgroup Leader – Terrestrial invertebrates	Lead implementation of tasks within subgroup.	✓	✓	✓	✓	✓	✓	✓	FR, EN, NL, ES, DE	✓
Montserrat Vilà, EBD-CSIC	Subgroup Leader - Plants	Support on alien plants	✓	✓	✓	✓	✓	✓	✓	SP, EN, CAT, FR	✓

ANNEX 2. SPECIFIC APPROACHES ADOPTED BY EACH GROUP TO THE COMPILATION OF PRELIMINARY HORIZON SCANNING LISTS OF IAS

Marine Group

Group leaders: John Bishop and Argyro Zenetos

Contributors: John Bishop, Juliet Brodie, Elizabeth Cook, Marco Faasse, Francis Kerckhof, Dan Minchin, Christine Wood, Argyro Zenetos

A long list was created of alien species already introduced within European seas, but with limited distributions, detailing their occurrence in EU member states and adjacent non-EU countries in the Black Sea and eastern Mediterranean Sea. EASIN, DAISIE, AquaNIS and some recent literature sources were consulted.

In parallel with this, a second list was made of species considered invasive in other world seas with environmental conditions similar to Europe, using databases from Task 2 and consultation of primary literature.

Care was taken to include species representative of the most important taxonomic groups globally amongst alien species. However, phytoplankton species were not considered because of lack of expertise within the group and persistent problems with ascertaining the status of species as alien or native.

Candidate species that scored reasonably highly but were removed from the list included:

i) Taxa presenting problems of identification as members of unresolved species complexes, or at least not considered reliably separable from their close relatives: *Asterias amurensis, Streblospio gynobranchiata, Phallusia nigra, Lithophyllum yessoense* and *Kappaphycus alvarezii*.

ii) Species occurring in fewer than three member states, but judged too well established in the EU based on the criterion given during the workshop, “limited distribution in the EU of a few, small, isolated populations”: *Schizoporella japonica* (UK only, but several large populations), *Chama pacifica* (well established and spreading in Greece and Cyprus), *Chrysonephos lewisii* (Italy and France), *Celtodoryx ciocalyptoides* (large populations in the Netherlands and southern Brittany), *Oithona davisae* (pelagic, with populations in the southern North Sea, and invasive in the Black Sea), *Fenestrulina delicia* (a species present in the southern North Sea and English Channel, elsewhere off the UK, and abundant inshore off the Netherlands).

The following high-ranking species were included in the list on available information as being represented by either one or a small number of isolated small populations within a restricted region: Pterois miles (possibly established in Cyprus), Penaeus azteca (established in Greece) and Homarus americanus (possibly established locally in Sweden).

It is likely, given additional time to select and score marine species and to debate the scores, that the species ultimately selected, and their order in the list, would have changed somewhat. The scores on the preliminary list brought to the workshop were altered substantially during debate within the specialist group, which is appropriate, but the final scores represent a general classification and not a definitive statement.

While the principle of environmental matching was used in identifying species likely to become invasive in Europe, species native to sub-tropical and tropical regions may have the ability to adapt to and colonise cooler environments. Adaptation from cooler to much warmer environments is also documented, for instance the North Pacific starfish Asterias amurensis invasive in southern Australia. The ultimate ranges of such species cannot, therefore, always be predicted.

Deciding and maintaining the appropriate geographical and taxonomic balance of the species assessed is a challenge in exercises such as these, particularly in the European marine context given potential domination by the highly invaded Mediterranean biota and the marked biogeographical division between the Mediterranean Sea and Atlantic coasts.

Some pronounced changes in pathways and vectors bringing IAS to Europe are underway. The development of a second Suez Canal is expected to increase markedly the rate of arrival of Indo-Pacific species in the south-eastern Mediterranean. With the decline of Arctic ice cover, the expected increase in shipping traffic via northern routes between the Atlantic and Pacific is likely to result in many north-western Pacific species entering the North Atlantic, with impacts on northern European seas. The substantial present problems of European oyster culture caused by oyster herpesvirus infections may stimulate the importation of replacement stock from distant regions, with attendant hitch-hikers, potentially reproducing the influx of IAS associated with analogous crises in the French oyster industry in the 1970s. Continuing global warming and ocean acidification might also accelerate the rate of change of species' distributions. Conversely, the imminent adoption of the international convention on ballast water management could substantially suppress the ballast water vector.

Plant group

Group leaders: Etienne Branquart and Montse Vila

Contributors: Franz Essl, Jan Pergl, Oliver Pescott, Philip Hulme, Sonia Vanderhoeven

The plant group adopted an approach based on invasion history elsewhere and climate suitability in Europe as the best predictors to identify potential IAS. The focus was mostly on horticulture as the major intentional pathway; however, potential species to be used as biofuel and macrophytes to be used as ornamental plants or that could be accidentally introduced were also explored. Ferns and mosses were included but not algae.

The following databases were used:

Horticultural plants already introduced in Europe

For horticultural plants, by far the most important single pathway of alien plants, we selected candidate species from a subset of species which are included in the European Garden Flora (i.e. all plants cultivated in Europe and not native to Europe), which are not yet present as established aliens in Europe, but have already established in other continents. This list was compiled in an ongoing Biodiversa Project (coordinated by Mark van Kleunen).

For the Horizon Scanning Project, a standardized taxonomy to the Plant List was employed, and species were ranked by the number of regions / continents they currently invade outside Europe. This was done based on the recently completed global alien plant distribution database, the GloNAF database. This database is not open access and so was not included within Task 2, however GloNAF has been used in a number of recent publications (Essl et al. 2015; Seebens et al. 2015). In total 290 species were identified as naturalized in at least three continents outside Europe, but not in Europe.

In a second step, Species Distribution Models for these species were made based on GBIF data etc. to evaluate which of these species are likely to establish currently and under future climates in Europe. This may provide some guidance to identify future likely invaders. Species were ranked according to the number of grid cells under moderate climate change (RCP 2.6 climate change scenario), but the sequence of species would also be similar for current climate. We screened the top 102 species for Horizon Scanning for documented impacts on biodiversity and ecosystem services based on available scientific publications and information systems (CABI ISC, IUCN, etc).

Plant species selection from lists of IAS in USA and Japan

Species known to be environmental weeds in USA or in Japan (Invasive Plant Species in Japan Accessed 2015) were extracted from local databases, from which were excluded:

1. Species native to EU countries, based on information from the DAISIE database, the CABI Invasive Species Compendium and Flora Europaea;

2. Species established in more than 5 EU countries, based on the same information sources (hereafter considered as widespread).

In a second step, the list of species was further refined in selecting only species with a good climate match with EU conditions (exclusion of tropical species) and with strong documented impacts on biodiversity and ecosystem services (environmental weeds) in CABI ISC, IUCN GISD, EPPO or NatureServe databases.

For USA, 222 sp with a medium to high environmental impact (I-Rank) value were extracted from the NatureServe database (NatureServe Explorer Accessed 2015). They were afterwards shared between the following categories:

1. Species native to EU countries: n = 105

2. Widespread alien species in Europe (established in more than 5 countries): n = 24

3. Absent or emergent species in Europe: n = 93

For Japan, 143 species were extracted from the list of invasive alien plants. They were afterwards shared between the following categories:

1. Species native to EU countries: n = 4

2. Widespread alien species in Europe (established in more than 5 countries): n = 39

3. Absent or emergent species in Europe: n = 57

Plant species selection from lists of IAS in New Zealand

The selection was based on:

1. Identification of all naturalised species known to invade protected areas in NZ (as a measure of potential ecological impact).

2. Selection on those species not native to Europe nor already naturalised in Europe.

3. Focus on species that occur in at least two administrative regions in NZ, as a measure of potential spread.

4. Target the subset of these species that are recent introductions and naturalization e.g. from around 1950 onwards potentially highlighting shorter lag phases.

5. Cross reference with horticulture websites in Europe to see whether the species has already been introduced.

Plant species selection from lists of IAS in Australia

Screening of this database was partial, because the database of the introduced flora of Australia and its weed status (Randall 2007) includes information for > 25 000 spp, whether or not naturalized over there.

The list of 102 horticultural species was cross-checked with the invasiveness information of the introduced flora of Australia and its weed status. Weedy status is collected from Australia and also from other areas in the world. A focus was put on environmental weed status and invasive status in Randall's typology. About 20 species came out of the 102 horticultural taxa.

Plant species selection from lists of IAS in other Mediterranean Regions

The database come from an Horizon Scanning conducted for Spain (Andreu, Vilà 2010) that included more than 80 species known to be invasive in non-European Mediterranean regions, namely, N Africa, California, and Mediterranean-climate regions in Chile and Australia. For these species the Phelung WRA (Pheloung et al. 1999) and the Weber WRA (Weber, Gut 2004) for Central Europe had ranked them by their potential invasive status.

Vertebrate group

Group leaders: Riccardo Scalera and Sven Bacher

Contributors: Piero Genovesi, Carles Carboneras, Tim Adriaens, Wojciech Solarz

The selection of species was carried out in two successive stages. During the compilation of the preliminary list, species were selected with a limited range in Europe (but neither native to Europe, not cryptogenic) or not yet present, and with high risk of being invasive in the EU, mostly taken from DAISIE/EASIN, plus some additions from a few reports (see Arena et al. 2012, Parrott et al. 2009). The information was cross-checked on GISD.

In general the overall approach suggested by Roy et al, 2014, and Faulkner et al. 2014 was followed. We added a few species selected through expert opinion by Sven Bacher and Riccardo Scalera. In total 51 species were selected (one of which was later removed because it is native to the EU).

Once the preliminary list was completed, the compilation of an additional list of species through two methodologies similar to the previous one was initiated:

a. using the revised GISD to try define a few additional vertebrate species to consider in the HS. Species causing impacts on endangered species (IUCN Red List CR, EN, VU) in other regions of the world, and not present in Europe were selected then the information within GISD was used to compile the required information.

b. a literature search of the DAISIE and GB NNSIP databases and the works of the SEO/BirdLife Working Group on Exotic Species, including the List of introduced birds in Spain and Europe by Santos Clavell & Sol, 2007. Preference was given to the species that had been detected in the wild in Europe but were yet to establish self-sustaining populations. We added two species selected through expert opinion of Wojtek Solarz. In total 39 species were selected (two of which were later removed because they are native to the EU).

Terrestrial invertebrate group

Group leaders: Wolfgang Nentwig and Alan Stewart

Contributors: Karsten Schonrogge, Wolfgang Rabitsch, Marc Kenis, Cristina Preda, Helen Roy, Alain Roques, Jørgen Eilenberg

The members of the terrestrial invertebrate group had expertise across Insecta, Arachnida, Gastropoda, Annelida, Platyhelminthes & Nematoda. Each group member was asked to submit lists, using the databases identified in Task 2 but also other sources, of potential IAS of EU concern which resulted in a combined list of 54 species. 15 species already present in the EU were placed into a separate list, leaving 39 species not yet present in the EU. All species were scored by the group members according to the guidance provided. Some group members refrained from scoring all species, because of a lack of expertise in some specific groups (e.g. spiders). Queries about the guidance were discussed within the group and if necessary passed to the project leader for clarification so that information would be passed to other groups as well.

A group score for each species was calculated as the mean over the scores of individual group members. Each of the lists was divided into species with high, medium and low scores, with boundaries set at 80 and 40. Setting the cut-off score at 80 produced a top 18 species, the largest groups being wood-boring beetles (9 species) and ants (5 species). The unified list was circulated to group members for consideration and as a basis for discussion at the workshop.

At workshop:

1. All confidence / certainty scores were used in the discussions about individual species but were not used in any quantitative way.

2. Some species were reinstated to the main list because they are present only in a “few small isolated populations” e.g. *Arthurdendyus triangulatus* (NZ flatworm) only present in part of UK.

3. Species listed on EPPO lists (A1 & A2) were included in the main list because they are not yet part of any EU regulation (following guidance from EC).

4. Four alien species of scolytid beetles attacking conifers were considered in the pre-list but were removed from the final list of the Horizon Scanning exercise because we took into account that the Annex II of the European Directive regarding plant health (2000/29/CE) mentions the regulation of all non-European scolytids as “*harmful organisms whose introduction into and spread within all member states should be banned*”. More specifically, Annex II indicates that the subject of contamination is “*the plants of conifers, over 3 m in height, other than cones and seeds, wood of conifers with bark and isolated bark of conifers, originating in non-European countries*”. Note that these four

species associated with conifers pose a risk to the environment, not only to forestry. They consist of *Polygraphus proximus, the* Sakhalin-fir bark beetle, which has been introduced from the Far East into both Siberia and European Russia (Saint Petersburg, Moscow), and is a vector of pathogenic fungi killing fir trees. This insect is thus a threat to fir stands in Europe (Horizon scanning score 134). Three *Dendroctonus* species native to North America constitute also threats for native pine and spruce stands in Europe: namely *D. ponderosae*, the mountain pine beetle- score 95; *D. valens,* red turpentine bark beetle- score 93; and *D. rufipennis,* the spruce beetle, score 75.

5. Four species of ambrosia beetles were initially removed from the list, but this was later discovered to be due to an erroneous reading of Annex II of the Regulation which applies only to scolytids associated with conifers. Thus, these 4 species were re-instated to the terrestrial invertebrates list, but only AFTER the overall list had been finalised by consensus. One species, *Pityophthorus juglandis* (score = 133), a vector of pathogenic fungi killing walnut trees, would have been included in the top 100 of the overall list.

6. Three species were removed following the workshop because it was evident that these species were already included in the EU plant health legislation (amendments to Council Directive 2000/29/EC as of 30.06.2014): *Agrilus planipennis* (score 500 – very high), *Dendrolimus sibirus* (score 128 – medium), and *Agrilus anxius* (score 96 – medium).

7. *Culex quinquefasciatus* was deleted (score < 80 in the list) because the freshwater group included it within their list.

8. The small hive beetle, *Aethina tumida,* was considered in the pre-list but was removed from the final list of the Horizon Scanning exercise because we considered it is already regulated.

Preliminary list of freshwater invertebrates

Five primary databases and lists were scanned comprehensively to derive our long list:

NOBANIS full list	http://www.nobanis.org/
DAISIE 100 Worst	http://www.europe-aliens.org/speciesTheWorst.do
GISD 100 Worst	http://www.issg.org/database/welcome/
DIAS full list	http://www.fao.org/fishery/dias/en
ISE-CANADA full list	www.issg.org/database/

Species restricted to tropical climates (in both their native and invaded range) were removed from the list. While this deselection was questioned by some colleagues at the meeting in Brussels, we would stress that this selection was based on species with NO record in a bioclimatically suitable region, and as such would have no evidence base on which to consider them a threat in the next decade. Species that were associated solely with brackish waters were sent to the Marine Subgroup for screening. The team then identified additional species which do not appear on any lists but are considered to be an emergent threat.

A summary of our methodology is given in Figure 1.

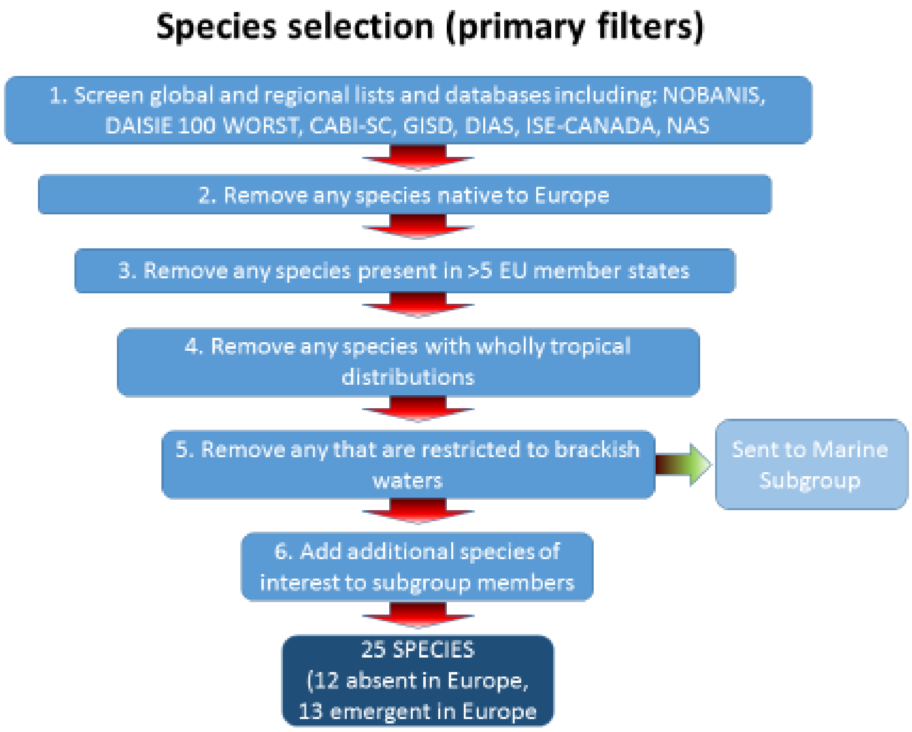

Figure 1. Summary of the process used to select species for scoring.

Scoring

Scoring used a three-round Delphi process as recommended by Sutherland (www.conservationevidence.com). Each species was scored blind by at least three experts from the subgroup (David Aldridge, Belinda Gallardo, Gerard van der Velde, Elena Tricarico). The project template was used and scorers were encouraged to provide an evidence base for their conclusions using the comments box and supporting references.

Median scores for risk and confidence were calculated and circulated to all assessors. Collective A*B*C*D scores were generated by multiplying the median scores for each category. Collective confidence was scored by taking medians from the assessors for each box in the spreadsheet.

There was broadly remarkable agreement in the scores given by each assessor. Where assessors disagreed with the collective median they were invited to challenge the score with a reasoned, evidence-based case. In each instance, the assessors were then asked to rescore that species.

A summary of the scoring methodology is given in Figure 2.

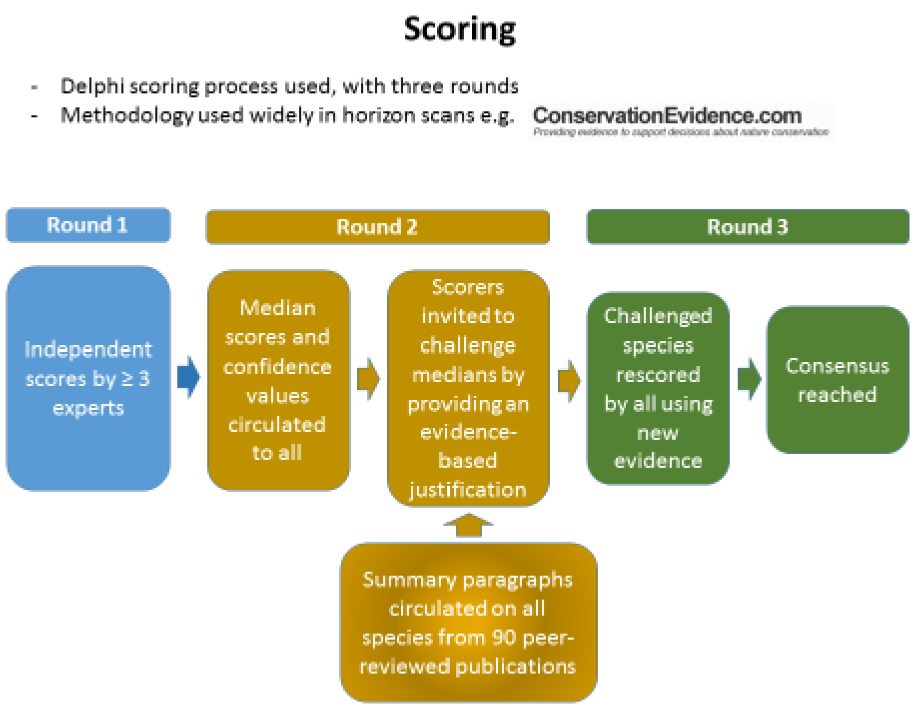

Figure 2. Summary of the three-round Delphi process used to reach consensus on species scoring and prioritisation.

Using this scoring the team identified our 12 most highly scoring species and these were entered into the collective ranking process.

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Preliminary list of freshwater fishes

Following the guidelines given, we only considered:

- spp. not native to Europe
- spp. not clearly widespread in EU
- spp. not listed in Annex IV to Regulation (EC) No 708/2007 when used in aquaculture. I.e., we EXCLUDED Siberian sturgeon *Acipenser baeri* (*); Russian sturgeon *A. gueldenstaeti* (*); Fringebarbel sturgeon *A. nudiventris* (*); sterlet *A. ruthenus* (*); Starry sturgeon *A. stellatus* (*); Atlantic sturgeon *A. sturio* (*); bighead carp *Aristichthys nobilis*; goldfish *Carassius auratus*; African catfish *Clarias gariepinus*; northern whitefish *Coregonus peled*; Pacific cupped oyster *Crassostrea gigas*; grass carp *Ctenopharyngodon idella*; common carp *Cyprinus carpio*; beluga sturgeon *Huso huso* (*); silver carp *Hypophthalmichthys molitrix*; channel catfish *Ictalurus punctatus*; largemouth bass *Micropterus salmoides*; rainbow trout *Oncorhynchus mykiss*; Japanese or Manila clam *Ruditapes philippinarum*; Arctic char *Salvelinus alpinus*; brook trout *S. fontinalis*; great lake trout *S. namaycush*; pikeperch *Sander lucioperca*; European catfish or sheatfish *Silurus glanis*.

For freshwater fish, we followed the following procedure:

1. We first compiled the species listed as having “Moderately High risk” or above on recent risk assessments of freshwater fish (with FISK) for the UK (Copp et al. 2009), Iberia (Almeida et al. 2013), and Finland (Puntila et al. 2013) and

removed the species that did not fulfil the abovementioned criteria. Also taken into consideration were FISK scores for risk assessment areas outside the EU (Japan, Florida USA, Turkey), noting that part of Turkey falls geographically into continental Europe.

2. We added to this list, a few other species that fulfilled the abovementioned criteria and were listed in other databases as invasive elsewhere and having "an impact on biodiversity and/or ecosystem services" or have been recorded as established in the wild in Europe recently. We considered as potential sources recently published peer-reviewed papers on introduced fish in Europe (see references below) and: Global Invasive Species Database (http://www.issg.org/database/welcome/), Natural England Commissioned Report NECR009, Roy et al. (2013), http://invasivespeciesireland.com/, http://nas.er.usgs.gov/,http://fishbase.org/search.php, and http://www.cabi.org/isc/.

3. This yielded a preliminary list of **32** species. From this list, we removed species that are established in **5** or more European countries and prioritized the **20** spp. that are more likely to establish (e.g. removed some tropical species that are unlikely to establish in most of Europe) and have an impact on biodiversity and/or ecosystem services.

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ANNEX 3: COMPILED LONG-LIST OF 250 SPECIES CONSIDERED AT THE WORKSHOP

Thematic group	Species name	Common name	Taxonomic group
Freshwater fish and invertebrates	Ameiurus catus	white catfish	Fish
Freshwater fish and invertebrates	Catostomus commersonii	white sucker	Fish
Freshwater fish and invertebrates	Channa argus	northern snakehead	Fish
Freshwater fish and invertebrates	Chrosomus eos (= Phoxinus eos)	redbelly dace	Fish
Freshwater fish and invertebrates	Cyprinella lutrensis	red shiner	Fish
Freshwater fish and invertebrates	Fundulus heteroclitus	mummichog	Fish
Freshwater fish and invertebrates	Gambusia affinis	western mosquitofish	Fish
Freshwater fish and invertebrates	Hypostomus plecostomus	suckermouth catfish	Fish
Freshwater fish and invertebrates	Micropterus dolomieui	smallmouth bass	Fish
Freshwater fish and invertebrates	Misgurnus anguillicaudatus	Oriental weatherfish	Fish
Freshwater fish and invertebrates	Misgurnus mizolepis	Chinese weather loach	Fish
Freshwater fish and invertebrates	Monopterus albus	swamp eel	Fish
Freshwater fish and invertebrates	Morone Americana	white perch	Fish
Freshwater fish and invertebrates	Oreochromis aureus	blue tilapia	Fish
Freshwater fish and invertebrates	Oreochromis mossambicus	Mossambique tilapia	Fish
Freshwater fish and invertebrates	Oreochromis niloticus	Nile tilapia	Fish
Freshwater fish and invertebrates	Pimephales promelas	fathead minnow	Fish
Freshwater fish and invertebrates	Tilapia mariae	spotted tilapia	Fish
Freshwater fish and invertebrates	Tilapia zillii	redbelly tilapia	Fish
Freshwater fish and invertebrates	Umbra pygmaea	eastern mudminnow	Fish
Freshwater fish and invertebrates	Anopheles quadrimaculatus	Malaria mosquito	Insect

Thematic group	Species name	Common name	Taxonomic group
Freshwater fish and invertebrates	Argulus japonicas	Japanese fishlouse	Crustacean
Freshwater fish and invertebrates	Bellamya chinensis	Chinese mysterysnail	Gastropod mollusc
Freshwater fish and invertebrates	Bellamya japonica	Japanese mysterysnail	Gastropod mollusc
Freshwater fish and invertebrates	Cherax destructor	Common yabby	Crustacean
Freshwater fish and invertebrates	Cherax quadricarinatus	Redclaw crayfish	Crustacean
Freshwater fish and invertebrates	Cherax tenuimanus	Hairy marron	Crustacean
Freshwater fish and invertebrates	Culex quinquefasciatus	Southern house mosquito	Insect
Freshwater fish and invertebrates	Cyrtobagous salviniae	Salvinia weevil	Insect
Freshwater fish and invertebrates	Daphnia lumholtzi	Water flea	Crustacean
Freshwater fish and invertebrates	Elimia virginica	Virginia river snail	Gastropod mollusc
Freshwater fish and invertebrates	Gammarus fasciatus	Freshwater shrimp	Crustacean
Freshwater fish and invertebrates	Gillia altilis	Buffalo pebblesnail	Gastropod mollusc
Freshwater fish and invertebrates	Lasmigonia subviridis	Green floater	Bivalve mollusc
Freshwater fish and invertebrates	Limnoperna fortunei	Golden mussel	Bivalve mollusc
Freshwater fish and invertebrates	Lophodella carteri	Bryozoan	Bryozoan
Freshwater fish and invertebrates	Marissa cornuarietis	South American giant ramshorn snail	Gastropod mollusc
Freshwater fish and invertebrates	Melanoides tuberculatus	Red-rim melania	Gastropod mollusc
Freshwater fish and invertebrates	Orconectes obscurus	Allegheny crayfish	Crustacean
Freshwater fish and invertebrates	Orconectes rusticus	Rusty crayfish	Crustacean
Freshwater fish and invertebrates	Orconectes virilis	Virile crayfish	Crustacean
Freshwater fish and invertebrates	Pomacea canaliculata	Golden apple snail	Gastropod mollusc
Freshwater fish and invertebrates	Pomacea maculata	Giant apple snail	Gastropod mollusc

Thematic group	Species name	Common name	Taxonomic group
Freshwater fish and invertebrates	Procambarus fallax forma virginalis	Marmokrebs	Crustacean
Freshwater fish and invertebrates	Skistodiaptomus pallidus	Copepod	Crustacean
Freshwater fish and invertebrates	Viviparus georgianus	Banded mysterysnail	Gastropod mollusc
Marine species	Acanthophora spicifera M.Vahl) Børgesen, 1910	a red alga	Alga
Marine species	Ascidia sydneiensis Stimpson, 1855	green tube tunicate	Tunicate
Marine species	Aulacomya atra (Molina, 1782)	bivalve	Mollusc
Marine species	Avrainvillea amadelpha (Montagne) A.Gepp & E.S.Gepp, 1908	a green alga	Alga
Marine species	Balanus glandula (Darwin 1854)	acorn Barnacle	Crustacean
Marine species	Batillaria attramentaria (G.B. Sowerby I, 1855)	Asian Horn Snail	Gastropod mollusc
Marine species	Botrylloides giganteum (Pérès, 1949)	tunicate	Tunicate
Marine species	Celleporaria brunnea (Hincks, 1884)	a bryozoan	Bryozoan
Marine species	Charybdis japonica (A. Milne-Edwards, 1861)	Asian paddle crab	Decopod
Marine species	Choromytilus chorus (Molina, 1782)	bivalve	Mollusc
Marine species	Ciona savignyi Herdman, 1882	tunicate	Tunicate
Marine species	Codium parvulum (Bory ex Audouin) P.C.Silva, 2003	a green alga	Alga
Marine species	Crepidula onyx G. B. Sowerby I, 1824	Onyx slippersnail	Gastropod mollusc
Marine species	Dictyosphaeria cavernosa (Forsskål) Børgesen, 1932	green bubble weed	Alga
Marine species	Didemnum perlucidum F. Monniot, 1983	tunicate	Tunicate
Marine species	Distaplia bermudensis Van Name, 1902	tunicate	Tunicate
Marine species	Dorvillea similis (Crossland, 1924)	a polychaete	Polychaete

Thematic group	Species name	Common name	Taxonomic group
Marine species	Gemma gemma (Totten, 1834)	gem clam	Mollusc
Marine species	Gracilaria salicornia (C.Agardh) E.Y.Dawson, 1954	a red alga	Alga
Marine species	Grandidierella japonica Stephensen, 1938	amphipod	Amphipod
Marine species	Haminoea japonica Pilsbry, 1895	Bubble shell	Mollusc
Marine species	Homarus americanus H. Milne Edwards, 1837	Am. Lobster	Decapod
Marine species	Ilyanassa obsoleta (Say, 1822)	black dog whelk	Mollusc
Marine species	Kappaphycus alvarezii (Doty) Doty ex P.C.Silva, 1996	red Alga	Alga
Marine species	Laonome calida Capa, 2007	a polychaete	Polychaete
Marine species	Megabalanus coccopoma (Darwin, 1854)	Titan barnacle	Crustacean
Marine species	Molgula ficus (Macdonald, 1859)	tunicate	Tunicate
Marine species	Mytilopsis sallei (Récluz, 1849)	black striped mussel	Mollusc
Marine species	Neomeris annulata Dickie, 1874	Fuzzy tip alga, finger alga	Alga
Marine species	Notomastus mossambicus (Thomassin, 1970)	a polychaete	Polychaete
Marine species	Nuttallia obscurata (Reeve, 1857)	purple varnish clam	Mollusc
Marine species	Paranthura japonica Richardson, 1909	isopod	Isopod
Marine species	Perna viridis (Linneaus, 1758)	Asian Green mussel	Mollusc
Marine species	Perophora multiclathrata (Sluiter, 1904)	tunicate	Tunicate
Marine species	Phallusia nigra Savigny, 1816	tunicate	Tunicate
Marine species	Plotosus lineatus (Thunberg, 1787)	striped eel catfish	Fish
Marine species	Polyopes lancifolius (Harvey) Kawaguchi &	a red alga	Alga

Thematic group	Species name	Common name	Taxonomic group
	Wang, 2002		
Marine species	Potamocorbula amurensis (Schrenck, 1861)	Asian basket clam	Mollusc
Marine species	Prionospio paucipinnulata Blake & Kudenov, 1978	a polychaete	Polychaete
Marine species	Pteria colymbus (Roding, 1798)	bivalve	Mollusc
Marine species	Pterois miles (Bennett, 1828)	devil firefish, lion fish	Fish
Marine species	Pyura praeputialis (Heller, 1878) /dopplelgangera	tunicate	Tunicate
Marine species	Rhodosoma turcicum (Savigny, 1816)	tunicate	Tunicate
Marine species	Sphaeroma quoianum Milne Edwards, 1840	Australasian isopod	Isopod
Marine species	Symplegma brakenhielmi (Michaelsen, 1904)	tunicate	Tunicate
Marine species	Symplegma reptans (Oka, 1927)	tunicate	Tunicate
Marine species	Tetrapygus niger (Molina, 1782)	Sea urchin	Echinoid
Marine species	Zostera japonica Ascherson & Graebner, 1907	dwarf eelgrass	Alga
Plants	Albizia lebbeck	Indian Siris	Vascular plant
Plants	Alternanthera philoxeroides	Alligator-weed	Vascular plant
Plants	Andropogon virginicius	Broom-sedge	Vascular plant
Plants	Celastrus orbiculata	Oriental Bittersweet	Vascular plant
Plants	Chromolaena odorata		Vascular plant
Plants	Cinnamomum camphora	Camphor Tree	Vascular plant
Plants	Clematis terniflora	Leather Leaf Clematis	Vascular plant
Plants	Cortaderia jubata		Vascular plant
Plants	Cryptostegia grandiflora		Vascular plant
Plants	Ehrharta calycina	Perennial Veldtgrass	Vascular plant
Plants	Euonymus fortunei	Winter Creeper	Vascular plant

Thematic group	Species name	Common name	Taxonomic group
Plants	Euonymus japonicus	Japanese spindle	Vascular plant
Plants	Gymnocoronis spilanthoides	Senegal tea	Vascular plant
Plants	Lespedeza juncea sericea		Vascular plant
Plants	Ligustrum sinense	Chinese Privet	Vascular plant
Plants	Lonicera maackii	Amur Honeysuckle	Vascular plant
Plants	Lonicera morrowii	Morrow's Honeysuckle	Vascular plant
Plants	Lygodium japonicum	Japanese Climbing Fern	Vascular plant
Plants	Microstegium vimineum	Nepalese Browntop	Vascular plant
Plants	Pinus patula	Mexican weeping pine	Vascular plant
Plants	Prosopis juliflora	Prosopis	Vascular plant
Plants	Prunus campanulata	Bell flower cherry	Vascular plant
Plants	Rubus rosifolius	Roseleaf Bramble	Vascular plant
Plants	Triadica sebifera (Sapium sebiferum)	Chinese Tallowtree	Vascular plant
Plants	Wedelia trilobata (= Sphagneticola trilobata)	Wedelia	Vascular plant
Terrestrial invertebrates	Achatina achatina	Giant Ghana snail	Gastropod mollusc
Terrestrial invertebrates	Adelges tsugae	hemlock woolly adelgid	Insect
Terrestrial invertebrates	Aeolesthes sarta	City Longhorn Beetle, Qetta borer	Insect
Terrestrial invertebrates	Agrilus anxius	Bronze Birch Borer	Insect
Terrestrial invertebrates	Agrilus auroguttatus	goldspotted oak borer	Insect
Terrestrial invertebrates	Agrilus planipennis	Emerald Ash Borer	Insect
Terrestrial invertebrates	Amynthas agrestis	crazy snake worm	Annelid
Terrestrial invertebrates	Archachatina marginata	Giant West African snail	Gastropod mollusc
Terrestrial	Arthurdendyus	New Zealand	Platyhelminth

Thematic group	Species name	Common name	Taxonomic group
invertebrates	triangulatus	flatworm	
Terrestrial invertebrates	Ashworthius sidemi		Nematode
Terrestrial invertebrates	Bradybaena similaris	Asian trampsnail	Gastropod mollusk
Terrestrial invertebrates	Coptotermes formosanus	Formosan subterranean termite	Insect
Terrestrial invertebrates	Crypticerya genistae		Insect
Terrestrial invertebrates	Culex quinquefasciatus	southern house mosquito	Insect
Terrestrial invertebrates	Dendroctonus ponderosae	Mountain Pine Beetle	Insect
Terrestrial invertebrates	Dendroctonus rufipennis	Spruce Beetle	Insect
Terrestrial invertebrates	Dendroctonus valens	Red Turpentine Bark Beetle	Insect
Terrestrial invertebrates	Dendrolimus sibiricus	Siberian Silk Moth	Insect
Terrestrial invertebrates	Dendrolimus superans	White-lined Silk Moth	Insect
Terrestrial invertebrates	Diaphorina citri	Asian Citrus Psyllid	Insect
Terrestrial invertebrates	Hylobitelus xiaoi	Chinese large pine weevil	Insect
Terrestrial invertebrates	Latrodectus geometricus	Black widow spider	Arachnid
Terrestrial invertebrates	Latrodectus hasselti	Black widow spider	Arachnid
Terrestrial invertebrates	Latrodectus mactans	Black widow spider	Arachnid
Terrestrial invertebrates	Limicolaria aurora	Nigerian land snail	Gastropod mollusc
Terrestrial invertebrates	Lissachatina fulica	Giant African snail	Gastropod mollusc
Terrestrial invertebrates	Malacosoma disstria	forest tent caterpillar	Insect
Terrestrial invertebrates	Pachycondyla chinensis	Asian Needle Ant	Insect
Terrestrial invertebrates	Pheidole megacephala	Big-headed Ant	Insect
Terrestrial invertebrates	Phoneutria fera	Brazilian wandering spider	Arachnid

Thematic group	Species name	Common name	Taxonomic group
Terrestrial invertebrates	Platypus quercivorus	oak ambrosia beetle	Insect
Terrestrial invertebrates	Polistes chinensis antennalis	Asian Paper Wasp	Insect
Terrestrial invertebrates	Polygraphus proximus	Sakhalin-fir bark beetle	Insect
Terrestrial invertebrates	Saperda candida	Round-headed Apple Tree Borer	Insect
Terrestrial invertebrates	Scolytus schevyrewi	banded elm bark beetle	Insect
Terrestrial invertebrates	Sirex ermak	Blue-black Horntail	Insect
Terrestrial invertebrates	Solenopsis geminata	Tropical fire ant	Insect
Terrestrial invertebrates	Solenopsis invicta	Red Imported Fire Ant	Insect
Terrestrial invertebrates	Solenopsis richteri	Black Imported Fire Ant	Insect
Terrestrial invertebrates	Tetropium gracilicorne	fine-horned spruce beetle	Insect
Terrestrial invertebrates	Vespula pensylvanica	western yellowjacket	Insect
Terrestrial invertebrates	Wasmannia auropunctata	Little Fire Ant	Insect
Terrestrial invertebrates	Xylosandrus mutilatus	Camphor Shoot Beetle	Insect
Vertebrates	Acridotheres cristatellus		Bird
Vertebrates	Acridotheres tristis		Bird
Vertebrates	Amadina fasciata		Bird
Vertebrates	Amandava amandava		Bird
Vertebrates	Amazona oratrix		Bird
Vertebrates	Ammotragus lervia		Mammal
Vertebrates	Anolis carolinensis		Reptile
Vertebrates	Anolis sagrei		Reptile
Vertebrates	Anser cygnoides		Bird
Vertebrates	Axis axis		Mammal
Vertebrates	Bison bison		Mammal
Vertebrates	Boa constrictor		Reptile
Vertebrates	Boa constrictor		Reptile
Vertebrates	Boiga irregularis		Reptile

Thematic group	Species name	Common name	Taxonomic group
Vertebrates	Bufo mauritanicus		Amphibian
Vertebrates	Callithrix geoffroyi		Mammal
Vertebrates	Callithrix jacchus		Mammal
Vertebrates	Callithrix penicillata		Mammal
Vertebrates	Callosciurus erythraeus		Mammal
Vertebrates	Callosciurus finlaysonii		Mammal
Vertebrates	Camelus dromedarius		Mammal
Vertebrates	Castor canadensis		Mammal
Vertebrates	Cercopithecus mona		Mammal
Vertebrates	Cervus Nippon		Mammal
Vertebrates	Chamaeleo jacksonii		Reptile
Vertebrates	Chelydra serpentina		Reptile
Vertebrates	Chloephaga picta		Bird
Vertebrates	Chrysemys picta		Reptile
Vertebrates	Corvus splendens		Bird
Vertebrates	Ctenosaura similis		Reptile
Vertebrates	Cynops pyrrhogaster		Amphibian
Vertebrates	Elaphe guttata		Reptile
Vertebrates	Eleutherodactylus coqui		Amphibian
Vertebrates	Eleutherodactylus planirostris		Amphibian
Vertebrates	Estrilda astrild		Bird
Vertebrates	Estrilda melpoda		Bird
Vertebrates	Estrilda troglodytes		Bird
Vertebrates	Euplectes afer		Bird
Vertebrates	Felis bengalensis		Mammal
Vertebrates	Gecko gecko		Reptile
Vertebrates	Graptemys geographica		Reptile
Vertebrates	Graptemys pseudogeographica		Reptile
Vertebrates	Gymnorhina tibicen		Bird
Vertebrates	Hemidactylus frenatus		Reptile
Vertebrates	Herpestes auropunctatus		Mammal
Vertebrates	Hydrochoerus hydrochoeris		Mammal

Thematic group	Species name	Common name	Taxonomic group
Vertebrates	Iguana iguana		Reptile
Vertebrates	Lampropeltis getula		Reptile
Vertebrates	Leiothrix lutea		Bird
Vertebrates	Lonchura malabarica		Bird
Vertebrates	Macrochelys temminckii		Reptile
Vertebrates	Muntiacus reevesi		Mammal
Vertebrates	Nandayus nenday		Bird
Vertebrates	Nasua nasua		Mammal
Vertebrates	Numida meleagris		Bird
Vertebrates	Nymphicus hollandicus		Bird
Vertebrates	Paradoxornis alphonsianus		Bird
Vertebrates	Paradoxornis webbianus		Bird
Vertebrates	Pelodiscus sinensis		Reptile
Vertebrates	Peromyscus fraterculus		Mammal
Vertebrates	Petrogale inornata		Mammal
Vertebrates	Phoenicopterus chilensis		Bird
Vertebrates	Pitangus sulphuratus		Bird
Vertebrates	Ploceus galbula		Bird
Vertebrates	Ploceus melanocephalus		Bird
Vertebrates	Poicephalus senegalus		Bird
Vertebrates	Pseudemys concinna		Reptile
Vertebrates	Psittacara acuticaudatus		Bird
Vertebrates	Psittacara erythrogenys		Bird
Vertebrates	Psittacara mitratus		Bird
Vertebrates	Psittacula eupatria		Bird
Vertebrates	Pycnonotus cafer		Bird
Vertebrates	Pycnonotus jocosus		Bird
Vertebrates	Python molurus		Reptile
Vertebrates	Quelea quelea		Bird
Vertebrates	Rhea Americana		Bird
Vertebrates	Rhinella marina		Amphibian
Vertebrates	Sciurus niger		Mammal

Thematic group	Species name	Common name	Taxonomic group
Vertebrates	Streptopelia roseogrisea		Bird
Vertebrates	Sylvilagus floridanus		Mammal
Vertebrates	Sylvilagus transitionalis		Mammal
Vertebrates	Tamiasciurus hudsonicus		Mammal
Vertebrates	Tenrec ecaudatus		Mammal
Vertebrates	Testudo horsfieldii		Reptile
Vertebrates	Trichosurus vulpecula		Mammal
Vertebrates	Vidua macroura		Bird
Vertebrates	Xenopus laevis		Amphibian
Vertebrates	Zosterops japonicus		Bird

ANNEX 4: SPECIES LIST FROM WORKSHOP DAY 1, DAY 2 AND FINAL WITHIN THEMATIC GROUP CONSENSUS

The scores (Initial Overall impact on biodiversity score) were provided by the experts within the five thematic groups at the first stage of consideration of the species. The scores were used for guidance only and should be viewed with caution, the discussions within and between thematic group experts provided the context of the scores and enabled the initial ranking (which were subsequently reviewed and moderated) of the species. These initial scores represent those provided in the preliminary assessment prior to the workshop (see ticks in Final List, Day 2, Day 1 and Preliminary columns for the point at which the species were included within the process) the scores listed below were the scores attributed at the first stage that the species was included for consideration. Following review through the consensus process the scores were altered, therefore the scores here and those in Table 5.1 are not the same. The scores in Table 5.1, while also for guidance only, were the final scores from the consensus following review and moderation through expert discussions. However, the final ranking of the species was determined by consensus through discussions across all thematic groups; the scores were not altered and so do not reflect the final rank. Some of the cells remain blank because many of the species were only included in preliminary stages and because of the number of species and time constraints the experts were unable to provide all this information for species that were subsequently removed from consideration.

Freshwater invertebrates

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Limnoperna fortunei	Golden mussel	Bivalve mollusc	Herb	As	No	625	H	✓	✓	✓	✓
Orconectes rusticus	Rusty crayfish	Crustacean	Omni	NAm	No	625	H	✓	✓	✓	✓
Orconectes virilis	Virile crayfish	Crustacean	Omni	NAm	Yes	500	H		✓	✓	✓
Procambarus fallax forma virginalis	Marmokrebs	Crustacean	Omni	NAm	Yes	250	H			✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Cherax destructor	Common yabby	Crustacean	Omni	Aus	Yes	200	H	✓	✓	✓	✓
Pomacea canaliculata	Golden apple snail	Gastropod mollusc	Herb	SAm	Yes	180	H	✓	✓	✓	✓
Pomacea maculata	Giant apple snail	Gastropod mollusc	Herb	SAm	Yes	180	H	✓	✓	✓	✓
Argulus japonicus	Japanese fishlouse	Crustacean	Pred	AT	Yes	150	M			✓	✓
Marissa cornuarietis	South American giant ramshorn snail	Gastropod mollusc	Omni	SAm	Yes	135	M	✓	✓	✓	✓
Cherax quadricarinatus	Redclaw crayfish	Crustacean	Omni	Aus	Yes	108	M	✓	✓	✓	
Gammarus fasciatus	Freshwater shrimp	Crustacean	Omni	NAm	No	108	M	✓	✓	✓	✓
Bellamya chinensis	Chinese mysterysnail	Gastropod mollusc	Herb	As	Yes	100	M	✓	✓	✓	✓
Daphnia lumholtzi	Water flea	Crustacean	Herb	As, AT, Aus	No	96	M		✓	✓	✓
Cherax tenuimanus	Hairy marron	Crustacean	Omni	Aus	Yes	90	L			✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Culex quinquefasciatus	Southern house mosquito	Insect	Omni	NAm	Yes	90	M		✓	✓	✓
Orconectes obscurus	Allegheny crayfish	Crustacean	Omni	NAm	No	60	M			✓	✓
Skistodiaptomus pallidus	Copepod	Crustacean	Herb	NAm	Yes	45	M			✓	✓
Melanoides tuberculatus	Red-rim melania	Gastropod mollusc	Herb	AT, Afr	Yes	40	M			✓	✓
Anopheles quadrimaculatus	Malaria mosquito	Insect	Omni	NAm	No	32	M			✓	✓
Viviparus georgianus	Banded mysterysnail	Gastropod mollusc	Omni	NAm	No	24	M			✓	✓
Lophodella carteri	Bryozoan	Bryozoan	Omni	As	Yes	20	L			✓	✓
Bellamya japonica	Japanese mysterysnail	Gastropod mollusc	Herb	As	No	18	L			✓	✓
Cyrtobagous salviniae	Salvinia weevil	Insect	Herb	SAm	No	8	M			✓	✓
Elimia virginica	Virginia river snail	Gastropod mollusc	Omni	NAm	No	4	L			✓	✓
Gillia altilis	Buffalo pebblesnail	Gastropod mollusc	Omni	NAm	No	2	M			✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Lasmigonia subviridis	Green floater	Bivalve mollusc	Omni	NAm	No	2	L			✓	✓

Freshwater fish

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Gambusia affinis	Western mosquitofish	Fish	Omni	NAm	Yes	475	M	✓	✓	✓	✓
Micropterus dolomieu	Smallmouth bass	Fish	Pred	NAm	Yes	405	H	✓	✓	✓	✓
Channa argus	Northern snakehead	Fish	Pred	AT	No	383	H	✓	✓	✓	✓
Oreochromis mossambicus	Mossambique tilapia	Fish	Omni	Afr	Yes	363	H	✓	✓	✓	✓
Oreochromis aureus	Blue tilapia	Fish	Omni	Afr	Yes	322	H	✓	✓	✓	✓
Fundulus heteroclitus	Mummichog	Fish	Omni	NAm	Yes	293	H	✓	✓	✓	✓
Oreochromis niloticus	Nile tilapia	Fish	Omni	Afr	Yes	288	M	✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Misgurnus anguillicaudatus	Oriental weatherfish	Fish	Omni	AT	Yes	277	H	✓	✓	✓	✓
Cyprinella lutrensis	Red shiner	Fish	Omni	NAm	Yes	227	M	✓	✓	✓	✓
Morone americana	White perch	Fish	Pred	NAm	No	221	M	✓	✓	✓	✓
Hypostomus plecostomus	Suckermouth catfish	Fish	Herb	SAm	Yes	215	M	✓	✓	✓	✓
Umbra pygmaea	Eastern mudminnow	Fish	Omni	NAm	Yes	208	H		✓	✓	✓
Tilapia zillii	Redbelly tilapia	Fish	Omni	Afr	Yes	195	H	✓	✓	✓	✓
Tilapia mariae	Spotted tilapia	Fish	Omni	Afr	No	162	M			✓	✓
Monopterus albus	Swamp eel	Fish	Omni	AT	No	148	M			✓	✓
Ameiurus catus	White catfish	Fish	Omni	NAm	Yes	138	M			✓	✓
Pimephales prom elas	Fathead minnow	Fish	Omni	NAm	Yes	135	M			✓	✓
Catostomus commersonii	White sucker	Fish	Omni	NAm	Yes	120	L			✓	✓
Misgurnus mizolepis	Chinese weather	Fish	Omni	AT	Yes	71	M	✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
	loach										
Chrosomus eos (= Phoxinus eos)	Redbelly dace	Fish	Omni	NAm	No	26	L			✓	✓

Terrestrial invertebrates

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Agrilus planipennis	Emerald ash borer	Coleoptera, Buprestidae	Xylo	As	No	457			✓	✓	✓
Aethina tumida	Small hive beetle	Coleoptera, Nitidulidae	Det	Afr	Yes	278					✓
Anoplophora glabripennis	Asian longhorned beetle	Coleoptera, Cerambyc-idae	Herb	As	Yes	273					✓
Arthurdendyus triangulatus	New Zealand flatworm	Platyhelmin-thes: Tricladida	Pred	Aus	Yes	243		✓	✓	✓	✓
Agrilus anxius	Bronze birch borer	Coleoptera, Buprestidae	Xylo	NAm	No	211			✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Solenopsis invicta	Red imported fire ant	Hymeno-ptera, Formicidae	Omni	SAm	No	209		✓	✓	✓	✓
Pachycondyla chinensis	Asian needle ant	Hymeno-ptera, Formicidae	Omni	As	No	181		✓	✓	✓	✓
Tetropium gracilicorne	Fine-horned spruce beetle	Coleoptera, Cerambyc-idae	Xylo	As	No	172		✓	✓	✓	✓
Pheidole megacephala	Big-headed ant	Hymeno-ptera, Formicidae	Omni	Afr	Yes	166	✓			✓	✓
Ashworthius sidemi		Nematoda, Trichostrongy lidae	Pred	As	Yes	165		✓	✓	✓	✓
Solenopsis geminata	Tropical fire ant	Hymeno-ptera, Formicidae	Omni	NAm/SAm	No	147		✓	✓	✓	✓
Amynthas agrestis	Crazy snake worm	Annelida: Oligochaeta		As?	No	142		✓	✓	✓	✓
Polygraphus proximus	Sakhalin-fir bark beetle	Coleoptera, Scolytidae	Xylo	As	No	134				✓	✓
Pityopthorus juglandis	Walnut twig beetle	Coleoptera, Curculion-idae	Herb	NAm	Yes	133					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Solenopsis richteri	Black imported fire ant	Hymeno-ptera, Formicidae	Omni	SAm	No	126		✓	✓	✓	✓
Popillia japonica	Japanese beetle	Coleoptera, Scolytidae	Herb	As	Yes	121					✓
Saperda candida	Round-headed apple tree borer	Coleoptera, Cerambyc-idae	Xylo	NAm	Yes	103		✓	✓	✓	✓
Xylosandrus crassiusculus	Granulate ambrosia beetle	Coleoptera, Curculion-idae	Herb	Afr, As	Yes	103					✓
Aeolesthes sarta	City longhorn beetle, Qetta borer	Coleoptera, Cerambyc-idae	Xylo	As	No	99		✓	✓	✓	✓
Vespula pensylvanica	Western yellowjacket	Hymeno-ptera, Vespidae	Omni	NAm	No	99		✓	✓	✓	✓
Dendroctonus ponderosae	Mountain pine beetle	Coleoptera, Curculion-idae	Xylo	NAm	No	95				✓	✓
Dendroctonus valens	Red turpentine bark beetle	Coleoptera, Curculion-idae	Xylo	NAm	No	93				✓	✓
Xylosandrus compactus	Shot-hole borer	Coleoptera, Curculion-	Herb	As, AT	Yes	91					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
		idae									
Dendrolimus sibiricus	Siberian silk moth	Lepidoptera, Lasiocamp-idae	Herb	As	No	87			✓	✓	✓
Platypus quercivorus	Oak ambrosia beetle	Coleoptera, Platypodidae	Xylo	As	No	87			✓	✓	✓
Wasmannia auropunctata	Little fire ant	Hymeno-ptera, Formicidae	Omni	SAm	No	84				✓	✓
Megaplatypus mutatas	Grand forest borer	Coleoptera, Platypodidae	Herb	SAm	Yes	83			✓		✓
Sirex ermak	Blue-black horntail	Hymeno-ptera, Siricidae	Herb	As	No	82		✓	✓	✓	✓
Agrilus auroguttatus	Goldspotted oak borer	Coleoptera, Buprestidae	Xylo	NAm	No	81			✓	✓	✓
Dendrolimus superans	White-lined silk moth	Lepidoptera, Lasiocamp-idae	Herb	As	No	78			✓	✓	✓
Malacosoma disstria	Forest tent caterpillar	Lepidoptera, Lasiocamp-idae		Nam	No	76				✓	✓
Dendroctonus rufipennis	Spruce beetle	Coleoptera, Curculion-	Xylo	NAm	No	75				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
		idae									
Polistes chinensis antennalis	Asian paper wasp	Hymeno-ptera, Vespidae	Pred	As	No	72				✓	✓
Culex quinquefasciatus	Southern house mosquito	Diptera	Pred	NAm	No	67				✓	✓
Platydemus manokwari	New Guinea flatworm	Platyhelmin-thes, Tricladida		Aus	Yes	64					✓
Scolytus schevyrewi	Banded elm bark beetle	Coleoptera, Scolytidae	Herb	As	No	62				✓	✓
Adelges tsugae	Hemlock woolly adelgid	Hemiptera, Adelgidae		As	No	60				✓	✓
Xylosandrus mutilatus	Camphor shoot beetle	Coleoptera, Curculion-idae	Xylo	As, AT	No	59				✓	✓
Polygyra cereolus	Southern flatcoil	Gastropoda, Polygyridae	Herb	SAm	Yes	53					✓
Lissachatina fulica	Giant African snail	Gastropoda, Achatinidae	Herb	Afr	No	42				✓	✓
Bradybaena similaris	Asian trampsnail	Gastropoda, Bradybaen-idae	Herb	tropical	No	36				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Hylobitelus xiaoi	Chinese large pine weevil	Coleoptera, Curculion-idae	Xylo	As	No	34				✓	✓
Latrodectus geometricus	Black widow spider	Araneae, Theridiidae	Pred	SAm	No	32				✓	✓
Latrodectus hasselti	Black widow spider	Araneae, Theridiidae	Pred	Aus	No	30				✓	✓
Diaphorina citri	Asian citrus psyllid	Hemiptera, Liviidae	Herb	AT?	No	27				✓	✓
Crypticerya genistae		Hemiptera, Monophleb-idae	Herb	SAm	No	23				✓	✓
Latrodectus mactans	Black widow spider	Araneae, Theridiidae	Pred	NAm	No	23				✓	✓
Coptotermes formosanus	Formosan subterran-ean termite	Isoptera, Rhinotermi-tidae	Omni/xylo	As	No	19				✓	✓
Achatina achatina	Giant Ghana snail	Gastropoda, Achatinidae	Herb	Afr	No	18				✓	✓
Archachatina marginata	Giant West African snail	Gastropoda, Achatinidae	Herb	Afr	No	18				✓	✓
Limicolaria aurora	Nigerian land snail	Gastropoda, Achatinidae	Herb	Afr	No	18				✓	✓
Heteropoda	Huntsmen	Araneae,	Pred		Yes	17					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
venatoria	spider	Sparassidae									
Phoneutria fera	Brazilian wandering spider	Araneae, Ctenidae	Pred	SAm	No	10				✓	✓
Loxosceles sp.	Brown recluse spider	Araneae, Sicariidae	Pred	SAm	No	5					✓

Vertebrates

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Axis axis	Axis deer	Mammals	Herb	As	Yes	625		✓	✓	✓	✓
Castor canadensis	American beaver	Mammals	Herb	NAm	Yes	625				✓	✓
Cervus nippon	Sika deer	Mammals	Herb	As	Yes	625				✓	✓
Corvus splendens	House Crow	Birds	Omni	As	Yes	625			✓	✓	
Herpestes	Egyptian	Mammals	Pred	Afr	No	625					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
ichneumon	mongoose										
Xenopus laevis	African clawed frog	Amphibians	Pred	Afr	Yes	563			✓	✓	
Pycnonotus cafer	Red-vented bulbul	Birds	Omni	As	Yes	506		✓	✓	✓	
Pycnonotus jocosus	Red-whiskered bulbul	Birds	Omni	As	Yes	506		✓	✓	✓	
Acridotheres tristis	Common myna	Birds	Omni	As	Yes	500		✓	✓	✓	✓
Callosciurus erythraeus	Pallas's squirrel	Mammals	Herb	AT	Yes	500			✓	✓	✓
Callosciurus finlaysonii	Finlayson's squirrel	Mammals	Herb	AT	Yes	500		✓	✓	✓	✓
Acridotheres cristatellus	Crested myna	Birds	Omni	As	Yes	450		✓	✓	✓	✓
Lampropeltis getula	Common kingsnake	Reptiles	Pred	NAm	Yes	400		✓	✓	✓	✓
Muntiacus reevesi	Reeve's muntjac	Mammals	Herb	As	Yes	400				✓	✓
Herpestes auropunctatus	Small Indian mongoose	Mammals	Pred	AT	Yes	375		✓	✓	✓	✓
Nasua nasua	Coati	Mammals	Omni	SAm	Yes	375		✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Rhea americana	Greater rhea	Birds	Omni		Yes	350		✓	✓	✓	
Bison bison	American bison	Mammals	Herb	NAm	No	338		✓	✓	✓	
Hemidactylus frenatus	House gecko	Reptiles	Pred	Aus	No	320		✓	✓	✓	
Trichosurus vulpecula	Brushtail possum	Mammals	Omni	Aus	No	304		✓	✓	✓	
Eleutherodactylus planirostris	Greenhouse frog	Amphibians	Pred	NAm	No	288		✓	✓	✓	
Euplectes afer	Yellow-crowned bishop	Birds	Herb	Afr	Yes	270				✓	
Anolis carolinensis	Carolina anole	Reptiles	Omni	NAm	No	256				✓	✓
Anolis sagrei	Brown anole	Reptiles	Pred	NAm	No	256				✓	✓
Eleutherodactylus coqui	Common coqui	Amphibians			No	252		✓	✓	✓	
Quelea quelea	Red-billed quelea	Birds	Omni	Afr	Yes	252			✓	✓	
Streptopelia roseogrisea	African collared-dove	Birds	Herb	Afr	Yes	252				✓	
Bufo mauritanicus	Berber toad	Amphibians	Pred	Afr	Yes	240		✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Gymnorhina tibicen	Australian magpie	Birds	Omni	Aus	No	225			✓	✓	
Sylvilagus floridanus	Eastern cottontail	Mammals	Herb	NAm	Yes	225				✓	✓
Amandava amandava	Red avadavat	Birds	Herb	AT	Yes	200				✓	✓
Chrysemys picta	Painted turtle	Reptiles	Omni	NAm	No	200		✓	✓	✓	✓
Estrilda astrild	Common waxbill	Birds	Omni	Afr	Yes	200				✓	✓
Estrilda troglodytes	Black-rumped waxbill	Birds	Omni	Afr	Yes	200				✓	✓
Pelodiscus sinensis	Chinese softshell turtle	Reptiles	Omni	As	No	200				✓	✓
Zosterops japonicus	Japanese white-eye	Birds	Omni	AT	No	196				✓	
Sciurus niger	Fox squirrel	Mammals	Herb	NAm	No	192			✓	✓	✓
Graptemys geographica	Northern map turtle	Reptiles	Omni	NAm	No	180				✓	✓
Vidua macroura	Pin-tailed wydah	Birds	Omni	Afr	Yes	180				✓	

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Amadina fasciata	Cut-throat	Birds	Omni	Afr	Yes	160				✓	✓
Graptemys pseudogeographica	False map turtle	Reptiles	Omni	NAm	No	160				✓	✓
Pseudemys concinna	River cooter	Reptiles	Omni	NAm	No	160				✓	✓
Rhinella marina	Cane toad	Amphibians	Omni	SAm	No	160		✓	✓	✓	✓
Poicephalus senegalus	Senegal parrot	Birds	Herb	Afr	Yes	158				✓	
Ammotragus lervia	Aoudad	Mammals	Herb	Afr	Yes	150			✓	✓	
Estrilda melpoda	Orange-cheeked waxbill	Birds	Omni	Afr	Yes	150				✓	✓
Leiothrix lutea	Red-billed leiothrix	Birds	Omni	As	Yes	150			✓	✓	✓
Lonchura malabarica	White-throated munia	Birds	Omni	AT	Yes	150				✓	✓
Paradoxornis alphonsianus	Ashy-throated parrotbill	Birds	Herb	As	Yes	150				✓	✓
Paradoxornis webbianus	Vinous-throated	Birds	Herb	As	Yes	150				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
	parrotbill										
Ploceus galbula	Rüppell's weaver	Birds	Herb	Afr	Yes	150				✓	✓
Ploceus melanocephalus	Black-headed weaver	Birds	Omni	Afr	Yes	150					✓
Psittacara acuticaudatus	Blue-crowned parakeet	Birds	Herb	SAm	Yes	150				✓	
Tamiasciurus hudsonicus	N American red squirrel	Mammals	Herb	NAm	No	144			✓	✓	✓
Chamaeleo jacksonii	Jackson's chameleon	Reptiles	Pred	Afr	No	138				✓	
Elaphe guttata	Corn snake	Reptiles	Pred	NAm	No	135				✓	✓
Psittacara erythrogenys	Red-masked parakeet	Birds	Herb	SAm	Yes	131				✓	
Psittacara mitratus	Mitred parakeet	Birds	Herb	SAm	Yes	131				✓	
Pitangus sulphuratus	Great kiskadee	Birds	Omni	SAm	No	123				✓	
Ctenosaura similis	Black iguana	Reptiles	Omni	SAm	No	122				✓	
Chelydra serpentina	Common snapping turtle	Reptiles	Pred	NAm	No	120				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Macrochelys temminckii	Aligator snapping turtle	Reptiles	Pred	NAm	No	120				✓	✓
Nandayus nenday	Nanday parakeet	Birds	Herb	SAm	Yes	120				✓	✓
Amazona oratrix	Yellow-headed amazon	Birds	Herb	SAm	Yes	118				✓	
Felis bengalensis	Leopard cat	Mammals	Pred	As	No	113				✓	✓
Phoenicopterus chilensis	Chilean flamingo	Birds	Pred	SAm	Yes	113				✓	
Peromyscus fraterculus	Northern Baja deermouse	Mammals	Omni	NAm	No	108				✓	
Psittacula eupatria	Alexandrine parakeet	Birds	Herb	AT	Yes	100		✓	✓	✓	✓
Python molurus		Reptiles	Pred		No	96			✓	✓	✓
Camelus dromedarius	Dromedary	Mammals	Herb	Afr	No	95				✓	
Boiga irregularis	Brown tree snake	Reptiles	Pred	Aus	No	90		✓	✓	✓	✓
Callithrix geoffroyi	White-headed marmoset	Mammals	Omni	SAm	No	90				✓	

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Callithrix jacchus	Common marmoset	Mammals	Omni	SAm	No	90				✓	
Callithrix penicillata	Black-tufted marmoset	Mammals	Omni	SAm	No	90				✓	
Iguana iguana	Green iguana	Reptiles	Herb	SAm	Yes	90				✓	✓
Tenrec ecaudatus	Common tenrec	Mammals	Pred	Afr	No	79				✓	
Nymphicus hollandicus	Cockatiel	Birds	Herb	Aus	Yes	78				✓	
Cynops pyrrhogaster	Japanese fire belly newt	Amphibians	Omni	As	No	72		✓	✓	✓	✓
Testudo horsfieldii	Russian tortoise	Reptiles	Herb	As	Yes	72				✓	✓
Cercopithecus mona	Mona monkey	Mammals	Omni	Afr	Yes	68				✓	
Chloephaga picta	Upland goose	Birds	Herb	SAm	No	56				✓	
Sylvilagus transitionalis	N England cottontail	Mammals	Herb	NAm	No	54				✓	✓
Numida meleagris	Helmeted guineafowl	Birds	Omni	Afr	No	50				✓	
Gecko gecko	Tokay gecko	Reptiles	Pred	AT	No	48				✓	✓
Anser cygnoides	Swan goose	Birds	Herb	As	No	45				✓	

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Boa constrictor	Boa constrictor	Reptiles	Pred	SAm	No	36			✓	✓	✓
Hydrochoerus hydrochoeris	Capybara	Mammals	Herb	SAm	No	36				✓	✓
Petrogale inornata	Unadorned rock-wallaby	Mammals	Herb	Aus	Yes	32				✓	
Pelophylax kurtmuelleri	Balkan water frog	Amphibians			Yes						✓

Plants species

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Albizia lebbeck	Indian siris	Fabaceae	Plant	AT	No	625	M	✓	✓	✓	✓
Casuarina equisetifolia	Horsetail casuarina	Casuarin-aceae	Plant	Aus	Yes	625	M				✓
Celastrus orbiculata	Oriental bittersweet	Vascular plant	Plant	As	No	625	H	✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Chromolaena odorata		Vascular plant	Plant	Am	No?	625	M	✓	✓	✓	✓
Cortaderia jubata		Poaceae	Plant	SAm	No	625	M	✓	✓	✓	✓
Elaeagnus umbellata	Autumn-olive	Vascular plant	Plant	As	Yes	625	M				✓
Euonymus fortunei	Winter creeper	Vascular plant	Plant	As	Yes	625	M	✓	✓	✓	✓
Euonymus japonicus	Japanese spindle	Celastraceae	Plant	As	No	625	H	✓	✓	✓	✓
Gymnocoronis spilanthoides	Senegal tea	Asteraceae	Plant	SAm	No	625	M	✓	✓	✓	✓
Hydrilla verticillata	Hydrilla	Vascular plant	Plant	Aus?	Yes	625	M				✓
Ligustrum lucidum	Chinese privet	Oleaceae	Plant	As	Yes	625	M				✓
Ligustrum sinense	Chinese Privet	Oleaceae	Plant	As	Yes	625	M	✓	✓	✓	✓
Lilium formosanum	Formosa lily	Liliaceae	Plant	As	No	625	M				✓
Lonicera maackii	Amur	Loniceraceae	Plant	As	No	625	M	✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
	honeysuckle										
Pennisetum setaceum	Crimson fountaingrass	Poaceae	Plant	Afr, As	Yes	625	M				✓
Pinus patula	Mexican weeping pine	Pinaceae	Plant	NAm	No	625	M		✓	✓	✓
Pistia stratiotes	Water lettuce	Vascular plant	Plant	SAm	Yes	625	M				✓
Pueraria montana		Vascular plant	Plant	As	No	625	M				✓
Rubus rosifolius	Roseleaf bramble	Rosacae	Plant	As	No	625	M	✓	✓	✓	✓
Savlinia molesta	Kariba weed	Vascular plant	Plant	SAm	Yes	625	M				✓
Spiraea japonica	Japanese spiraea	Rosaceae	Plant	As	Yes	625	M				✓
Tamarix ramosissima	Salt-cedar	Tamaricaceae	Plant	As	Yes	625	M				✓
Tillandsia usneoides		Bromeliaceae	Plant	Am	No	625	M				✓
Tradescantia	Wandering	Tradescant-	Plant	SAm	Yes	625	M				✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
fluminensis	jew	iaceae									
Alternanthera philoxeroides	Alligator-weed	Vascular plant	Plant	SAm	Yes	500	M	✓	✓	✓	✓
Andropogon virginicius	Broom-sedge	Poaceae	Plant	NAm	Yes	500	M	✓	✓	✓	✓
Bartlettina sordida	Blue mist flower	Asteraceae	Plant	NAm	No	500	M				✓
Brachychiton acerifolius		Vascular plant	Plant	Aus	No	500	M				✓
Calotropis procera		Vascular plant	Plant	Afr	Yes	500	M				✓
Canavalia cathartica		Vascular plant	Plant		No	500	M				✓
Carpobrotus chilensis	Baby sun-rose	Aizoaceae	Plant	SAf	Yes	500	M				✓
Cinnamomum camphora	Camphor tree	Lauraceae	Plant	As	No?	500	M	✓	✓	✓	✓
Clematis terniflora	Leather leaf clematis	Ranunculacea e	Plant	As	?	500	M	✓	✓	✓	✓
Coreopsis		Asteraceae	Plant	NAm	Yes	500	M				✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
lanceolata											
Cryptostegia grandiflora		Vascular plant	Plant	Afr	No?	500	M	✓	✓	✓	✓
Ehrharta calycina	Perennial veldtgrass	Poaceae	Plant	SAf	Yes	500	M	✓	✓	✓	✓
Embothrium coccineum	Chilean fire bush	Proteaceae	Plant	SAm	No	500	M				✓
Homalanthus populifolius	Queensland poplar	Euphorb-iaceae	Plant	Aus	No	500	M				✓
Lespedeza juncea sericea		Vascular plant	Plant	As	No	500	M	✓	✓	✓	✓
Leucaena leucocephala	Leucaena	Vascular plant	Plant	SAm	Yes	500	M				✓
Lonicera morrowii	Morrow's honeysuckle	Loniceraceae	Plant	As	No	500	M	✓	✓	✓	✓
Lycoris radiata		Vascular plant	Plant	As	No	500	M				✓
Lygodium japonicum	Japanese climbing fern	Vascular plant	Plant	As	No	500	M	✓	✓	✓	✓
Microstegium	Nepalese	Vascular	Plant	As	No	500	M	✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
vimineum	browntop	plant									
Osmanthus heterophyllus		Vascular plant	Plant	As	No	500	M				✓
Plectranthus ciliatus	Blue spur flower	Lamiaceae	Plant	Afr	No	500	M				✓
Prosopis juliflora	Prosopis	Fabaceae	Plant	NAm, SAm	No?	500	M	✓	✓	✓	✓
Prunus campanulata	Bell flower cherry	Rosaceae	Plant	As	No	500	M	✓	✓	✓	✓
Spartina alterniflora	Saltwater cordgrass	Poaceae	Plant	NAm	Yes	500	M				✓
Trachycarpus fortunei	Helm palm	Araceae	Plant	As	Yes	500	M				✓
Triadica sebifera (Sapium sebiferum)	Chinese tallowtree	Vascular plant	Plant	As	No	500	M		✓	✓	✓
Wedelia trilobata (= Sphagneticola trilobata)	Wedelia	Vascular plant	Plant	SAm	Yes	500	M	✓	✓	✓	✓
Berberis glaucocarpa	Great barberry	Berberid-aceae	Plant	As, AT	Yes	400	M				✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Cestrum aurantiacum	Orange cestrum	Solanaceae	Plant	NAm, SAm	No	400	M				✓
Cynanchum rossicum	European swallow-wort	Vascular plant	Plant	As	Yes	400	M				✓
Mesembryanthemum crystallinum	Common iceplant	Aizoaceae	Plant	SAf	Yes	400	M				✓
Opuntia humifusa	Indian fig	Cactaceae	Plant	NAm	Yes	400	M				✓
Passiflora tarminiana	Northern banana passion vine	Passiflor-aceae	Plant	SAm	No	400	M				✓
Passiflora tripartita	Banana passion vine	Passiflor-aceae	Plant	SAm	No	400	M				✓
Pinus oocarpa	Ocote	Pinaceae	Plant	NAm	No	400	M				✓
Sagittaria montevidensis	California arrowhead	Alismataceae	Plant	Nam, SAm	No	400	M				✓
Cestrum nocturnum	Night-blooming jasmine	Solanaceae	Plant	SAm	No	320	M				✓
Pyracantha koidzumii	Formosa firethorn	Rosacae	Plant	As	No	320	M				✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Ehrharta villosa	Pyp grass	Poaceae	Plant	Afr	?	300	M				✓
Ugni molinae	Chilean guava	Myrtaceae	Plant	SAm	Yes	300	M				✓
Plectranthus ecklonii	Large blue spurrbush	Lamiaceae	Plant	Afr	No	225	M				✓
Dichrostachys cinerea		Vascular plant	Plant	Am	?	200	M				✓
Jatropha curcas		Vascular plant	Plant	Am	?	200	M				✓
Panicum virgatum		Poaceae	Plant	Am	Yes	200	M				✓
Casuarina glauca	Swamp oak	Casuarin-aceae	Plant	Aus	No	144	M				✓

Marine

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Gracilaria vermiculophylla	Alga	Gracilariales, Gracilariacea	PP		Yes	500					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
		e									
Penaeus aztecus	Northern brown schrimp	Decapoda, Penaeidae	Omni	Nam	Yes	500		✓	✓	✓	✓
Schizoporella japonica	Orange ripple bryozoan	Cheilostomatidae, Schizoporellidae	Susp	AS	Yes	404					✓
Pseudodiaptomus marinus	a benthic copepod	Calanoida, Pseudodiaptomidae	Omni	AT	Yes	400					✓
Codium parvulum	a green alga	Bryopsidales, Codiaceae	PP	AT	No	394		✓	✓	✓	✓
Didemnum vexillum	Compound sea squirt	Aplousobranchia, Didemnidae	Susp		Yes	375					✓
Homarus americanus	Am. Lobster	Decapoda, Nephropidae	Pred		Yes	375		✓	✓	✓	✓
Undaria pinnatifida	Wakame	Laminariales, Alariaceae	PP		Yes	375					✓
Balanus glandula	Acorn barnacle	Sessilia, Balanidae	Susp		No	367			✓	✓	✓
Pterois miles	Devil firefish, Lion fish	Scorpaeniformes, Scorpaenidae	Pred	AT	Yes	360		✓	✓	✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Xenostrobus securis	Brown mussel	Mytiloida, Mytilidae	Susp	Aus	Yes	350					✓
Mytilopsis sallei	Black striped mussel	Veneroidea, Dreissenidae	Susp		No	315		✓	✓	✓	✓
Acanthophora spicifera	a red alga	Ceramiales , Rhodomelaceae	PP	Car, Florida	No	300		✓	✓	✓	✓
Corella eumyota	a tunicate	Phlebobranchia, Corellidae	Susp		Yes	300					✓
Dorvillea similis	a polychaete	Eunicida, Dorvilleidae	Det		No	300			✓	✓	
Styela clava	Rough sea squirt	Stolidobranchia, Styelidae	Susp		Yes	300					✓
Charybdis japonica	Asian paddle crab	Decapoda, Portunidae	Pred		Yes	288		✓	✓	✓	✓
Chama pacifica	Jewel box oyster	Veneroida, Chamidae	Susp	AT	Yes	270					✓
Neogobius melanostomus	Round Goby	Perciformes, Gobiidae	Pred		Yes	250					✓
Stephanolepis diaspros	a teleost				Yes	250					✓
Chrysonephos lewisii		Sarcinochrysidales, Sarcinochrysi	PP	NAm	Yes	240					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
		daceae									
Symplegma reptans	a tunicate	Stolidobranchia, Styelidae	Susp		No	240		✓	✓	✓	✓
Phallusia nigra	a tunicate	Phlebobranchia, Ascidiidae	Susp		Yes	225				✓	✓
Kappaphycus alvarezii	a red Alga	Gigartinales, Solieriaceae	PP	AT	No	214				✓	✓
Pseudoneris anomal						210			✓		
Watersipora arcuata	A bryozoan	Cheilostomatida, Watersiporidae	Susp		No	210					✓
Polysiphonia subtillissima	a red algae				Yes	203					✓
Botrylloides giganteum	a tunicate	Stolidibranchia, Styelidae	Susp	Afr	Yes	200		✓	✓	✓	✓
Celtodoryx ciocalyptoides	Cauliflower sponge	Poecilosclerida, Coelosphaeridae	Susp		Yes	192					✓
Crepidula fornicata	Slipper limpet	Littorinimorpha, Calyptraeidae	Susp		Yes	192					✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Perna viridis	Asian green mussel	Mytiloida, Mytilidae	Susp		No	184		✓	✓	✓	✓
Potamocorbula amurensis	Asian basket clam	Myoida, Corbulidae	Susp		No	184		✓	✓	✓	✓
Polyopes lancifolius	a red alga	Halymeniales, Halymeniaceae	PP		Yes	180			✓	✓	✓
Asterias amurensis	Japanese sea star	Forcipulatida, Asteriidae	Pred		?	167					✓
Zostera japonica	Dwarf eelgrass	Alismatales, Zosteraceae	PP	NW Pacific	No	160			✓	✓	✓
Ascidia sydneiensis	Green tube tunicate	Phlebobranchia, Ascidiidae	Susp	As	No	150			✓	✓	✓
Choromytilus chorus	a bivalve	Mytiloida, Mytilidae	Susp		Yes	135				✓	✓
Haminoea japonica	Bubble shell	Cephalaspidea, Haminoeidae	Herb	As	Yes	135				✓	
Ocenebra inornata	a gastropod	Neogastropoda, Muricidae	Pred		Yes	135					✓
Paranthura japonica	an isopod	Isopoda, Paranthuridae	Pred	As	Yes	135				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Celleporaria brunnea	a bryozoan	Cheilostomatida, Lepralielloidea	Susp	Pac	Yes	128				✓	
Didemnum perlucidum F.	a tunicate	Aplousobranchia,Didemnidae	Susp	SAm, NAm, Aus, AT	No	123			✓	✓	✓
Aulacomya atra	a bivalve	Mytiloida, Mytilidae	Susp		Yes	120				✓	✓
Ciona savignyi	a tunicate	Phlebobranchia,Cionidae	Susp	As	No	120			✓	✓	✓
Macrorhynchia philippina		Leptothecata, Aglaopheniidae	Susp		Yes	120			✓		✓
Nuttallia obscurata	Purple varnish clam	Veneroida, Psammobiidae	Susp	As	No	120				✓	✓
Batillaria attramentaria	Asian Horn Snail	Caenogastropoda, Batillariidae	Herb		No	118				✓	✓
Gracilaria salicornia	a red alga	Gracilariales, Gracilariaceae	PP		No	108				✓	✓
Ilyanassa obsoleta	Black dog whelk	Neogastrapoda,	Pred	NAm (Pac)	No	108				✓	✓

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
		Nassariidae									
Notomastus mossambicus	a polychaete	Scolecida, Capitellidae	Det	Indian	Yes	108				✓	
Rangia cuneata	Wedge clam	Veneroida, Mactridae	Susp		Yes	100 (A not scored)					✓
Ascidia cannelata	a tunicate	Phlebobranchia, Ascidiidae	Susp	AT	No	96					✓
Gemma gemma	Gem clam	Veneroida, Veneridae	Susp	W Atlantic	No	96				✓	✓
Prionospio paucipinnulata	a polychaete	Spionida, Spionidae	Det	Aus	No	96				✓	
Plotosus lineatus	Striped eel catfish	Siluriformes, Plotosidae	Pred	Afr	No	90		✓	✓	✓	✓
Pyura praeputialis	a tunicate	Stolidobranchia, Pyuridae	Susp	Aus	No	90				✓	✓
Rhodosoma turcicum	a tunicate	Phlebobranchia, Corellidae	Susp		No	90			✓	✓	
Grandidierella japonica	an amphipod	Amphipoda, Aoridae	Det	Pac	Yes	81				✓	✓
Megabalanus coccopoma	Titan barnacle	Sessilia, Balanidae	Susp	Pac	Yes	80				✓	
Symplegma brakenhielmi	a tunicate	Stolidobranchia, Styelidae	Susp	AT	No	80				✓	

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Distaplia bermudensis	a tunicate	Aplousobranchia, Holozoidae	Susp		Yes	75				✓	✓
Lithophyllum yessoense			PP		Yes	75 (D not scored)					✓
Avrainvillea amadelpha	a green alga	Bryopsidales, Dichotomosiphonaceae	PP	Afr, Asia	No	72				✓	✓
Crepidula onyx	Onyx slippersnail	Littorinimorpha,Calyptraeidae	Susp	NAm	No	72		✓	✓	✓	✓
Laonome calida	a polychaete	Sabellida, Sabellidae	Susp	Aus	Yes	72				✓	
Sphaeroma quoianum	Australasian isopod	Isopoda, Sphaeromatidae	Susp	Aus	No	72				✓	✓
Tetrapygus niger	Sea urchin	Echinoidea, Arbacioida	Herb		No	63				✓	✓
Molgula ficus	a tunicate	Stolidobranchia, Molgulidae	Susp	AT	No	48				✓	✓
Neomeris annulata	Fuzzy tip alga, finger alga	Dasycladales, Dasycladaceae	PP	Atlantic/IP	No	48				✓	

Species	Common name	Taxonomic group	Functional group	Native distribution	Already present in EU?	Initial Overall impact on biodiversity score (A*B*C*D)	Confidence in Overall score (H,M,L)	Final List	Day 2	Day 1	Preliminary
Perophora multiclathrata	a tunicate	Phlebobranchia, Perophoridae	Susp	AT	Yes	45				✓	✓
Pteria colymbus	a bivalve	Pterioida, Pteriidae	Susp		No	40				✓	✓
Dictyosphaeria cavernosa	Green bubble weed	Siphonocladales, Siphonocladaceae	PP		No	36 (D not scored)			✓	✓	✓

ANNEX 5: SCORES (ON A SCALE OF 1 =LOW TO 5=HIGH) ATTRIBUTED BY EXPERTS FOR LIKELIHOODS OF: I) ARRIVAL, II) ESTABLISHMENT AND III) SPREAD, AND IV) POTENTIAL NEGATIVE IMPACT ON BIODIVERSITY WITHIN THE EU.

The purpose of the scores was both to reduce the very long thematic group species lists and ensure they represented the IAS of highest priority for risk assessment but also as a first step of harmonisation between the different groups. Indeed the scores were intended to provide approximate guidance to inform discussion and the horizon scanning approach, but not to be considered as part of a full impact assessment. The overall scores listed below are the final scores from the consensus following review and moderation through expert discussion. However, the final ranking of the species was determined by consensus through discussions across all thematic groups; the scores were not altered and so do not reflect the final rank.

*The overall scores of the freshwater fish (marked with an asterisk) in the table below are the means of the overall scores attributed by individual experts, these are the overall scores that were presented during the workshop. The overall score for the species marked with an asterisk is not the factor of the component scores for A, B, C and D displayed in the table below. The component scores for A, B, C and D for these species are an average of the scores assigned for each component by the individual experts.

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Alternanthera philoxeroides	Alligator-weed	5.0	5.0	5.0	5.0	625
Pterois miles	Devil firefish, Lion fish	5.0	5.0	4.5	5.0	563
Herpestes auropunctatus	Small Asian mongoose	5.0	5.0	5.0	4.5	563
Callosciurus finlaysonii	Finlayson's squirrel	5.0	5.0	4.5	5.0	563
Lampropeltis getula	Common kingsnake	5.0	5.0	4.5	4.5	506
Limnoperna fortunei	Golden mussel	4.0	5.0	5.0	5.0	500
Orconectes rusticus	Rusty crayfish	4.0	5.0	5.0	5.0	500
Penaeus aztecus	Northern brown shrimp	5.0	5.0	4.0	5.0	500
*Gambusia affinis**	Western mosquitofish	5.0	5.0	4.0	4.7	475
Plotosus lineatus	Striped eel catfish	4.5	4.5	4.5	5.0	456
Pycnonotus cafer	Red-vented bulbul	5.0	5.0	4.0	4.5	450

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Acridotheres tristis	Common myna	5.0	4.5	5.0	4.0	450
Bufo mauritanicus	Berber toad	5.0	5.0	4.5	4.0	450
Nasua nasua	Coati	5.0	5.0	4.5	4.0	450
*Micropterus dolomieu**	Smallmouth bass	5.0	4.0	4.3	4.0	405
Homarus americanus	Am. lobster	5.0	4.0	4.5	4.5	405
Codium parvulum	a green alga	5.0	4.0	4.0	5.0	400
*Channa argus**	Northern snakehead	4.0	4.3	4.3	5.0	383
*Oreochromis mossambicus**	Mossambique tilapia	5.0	3.3	4.3	4.3	363
Botrylloides giganteum	A tunicate	5.0	4.5	4.0	4.0	360
*Oreochromis aureus**	Blue tilapia	5.0	3.3	4.3	4.0	322
Arthurdendyus triangulatus	New Zealand flatworm	4.5	4.0	3.7	3.0	300
*Oreochromis niloticus**	Nile tilapia	5.0	3.0	4.3	4.0	288
Pomacea canaliculata	Golden apple snail	5.0	4.0	4.0	3.0	240
Pomacea maculata	Giant apple snail	5.0	4.0	4.0	3.0	240
Crepidula onyx	Onyx slippersnail	3.0	5.0	4.0	4.0	240
Mytilopsis sallei	Black striped mussel	4.0	3.0	4.5	4.0	216
Gymnocoronis spilanthoides	Senegal tea	5.0	5.0	5.0	5.0	625
Lygodium japonicum	Japanese climbing fern	5.0	5.0	5.0	5.0	625
Andropogon virginicus	Broom-sedge	4.0	5.0	5.0	5.0	500
Celastrus orbiculatus	Oriental bittersweet	5.0	5.0	4.0	5.0	500
Cortaderia jubata		5.0	5.0	5.0	4.0	500

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Euonymus fortunei	Winter creeper	5.0	5.0	4.0	5.0	500
Euonymus japonicus	Japanese spindle	5.0	5.0	4.0	5.0	500
Lespedeza juncea sericea (= L. cuneata)		5.0	5.0	4.0	5.0	500
Ligustrum sinense	Chinese privet	5.0	5.0	4.0	5.0	500
Lonicera maackii	Amur honeysuckle	5.0	5.0	4.0	5.0	500
Lonicera morrowii	Morrow's honeysuckle	5.0	5.0	4.0	5.0	500
Microstegium vimineum	Nepalese browntop	4.0	5.0	5.0	5.0	500
Prosopis juliflora	Prosopis	5.0	4.0	5.0	5.0	500
Prunus campanulata	Bell flower cherry	5.0	5.0	4.0	5.0	500
Rubus rosifolius	Roseleaf bramble	5.0	5.0	4.0	5.0	500
Triadica sebifera (Sapium sebiferum)	Chinese tallowtree	4.0	5.0	5.0	5.0	500
Acridotheres cristatellus	Crested myna	5.0	4.5	4.5	4.0	405
Cinnamomum camphora	Camphor tree	5.0	4.0	4.0	5.0	400
Clematis terniflora	Leather leaf clematis	5.0	4.0	4.0	5.0	400
Ehrharta calycina	Perennial veldtgrass	4.0	5.0	4.0	5.0	400
Wedelia trilobata (= Sphagneticola trilobata)	Wedelia	5.0	5.0	4.0	4.0	400
Pycnonotus jocosus	Red-whiskered bulbul	5.0	5.0	3.5	4.5	394
Axis axis	Indian spotted deer	5.0	5.0	4.5	3.5	394
Cynops pyrrhogaster	Japanese fire-bellied salamander	5.0	4.5	4.5	3.5	354

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Chrysemys picta	Painted turtle	4.5	5.0	4.5	3.5	354
Rhea americana	Greater rhea	5.0	5.0	3.5	4.0	350
Psittacula eupatria	Alexandrine parakeet	5.0	5.0	3.5	4.0	350
Bison bison	European bison	5.0	4.5	5.0	3.0	338
Chromolaena odorata		4.0	4.0	5.0	4.0	320
Cryptostegia grandiflora		4.0	4.0	4.0	5.0	320
Hemidactylus frenatus	House gecko	5.0	4.0	4.0	4.0	320
Trichosurus vulpecula	Brushtail Possum	3.0	5.0	4.5	4.5	304
Albizia lebbeck	Indian Siris	5.0	4.0	3.0	5.0	300
*Fundulus heteroclitus**	Mummichog	4.3	4.7	4.3	3.3	293
Eleutherodactylus planirostris	Greenhouse frog	4.5	4.0	4.0	4.0	288
Rhinella marina	Cane toad	3.5	4.0	5.0	4.0	280
Boiga irregularis	Brown tree snake	4.0	3.5	5.0	4.0	280
*Misgurnus anguillicaudatus**	Oriental weatherfish	5.0	4.7	2.7	4.0	277
Eleutherodactylus coqui	Common coquí	4.0	4.0	4.5	3.5	252
*Cyprinella lutrensis**	Red shiner	4.3	3.7	3.7	3.7	227
*Morone americana**	White perch	3.3	4.0	3.7	4.3	221
*Hypostomus plecostomus**	Suckermouth catfish	5.0	2.3	3.7	4.0	215
Pseudonereis anomala	a polychaete	5.0	4.0	3.5	3.0	210
Cherax destructor	Common yabby	5.0	5.0	4.0	2.0	200
*Tilapia zillii**	Redbelly tilapia	4.3	3.0	3.7	4.0	195

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Acanthophora spicifera	a red alga	3.0	4.0	4.0	4.0	192
Charybdis japonica	Asian paddle crab	4.0	3.0	4.0	4.0	192
Perna viridis	Asian green mussel	4.0	3.0	4.0	4.0	192
Symplegma reptans	a tunicate	3.0	4.0	4.0	4.0	192
Potamocorbula amurensis	Asian basket clam	3.0	3.0	5.0	4.0	180
Macrorhynchia philippina	White stinger	5.0	5.0	2.0	3.5	175
Pachycondyla chinensis	Asian needle ant	2.8	3.6	4.3	3.8	175
Solenopsis invicta	Red imported fire ant	3.0	3.6	4.8	4.0	160
Solenopsis geminata	Tropical fire ant	3.3	2.9	4.6	3.4	160
Pheidole megacephala	Big-headed ant	3.6	3.1	4.1	3.4	158
*Misgurnus mizolepis**	Chinese weather loach	4.3	3.3	2.0	2.7	153
Marissa cornuarietis	South American giant ramshorn snail	5.0	3.0	3.0	3.0	135
Amynthas agrestis	Crazy snake worm	3.2	3.8	3.5	3.3	129
Tetropium gracilicorne	Fine-horned spruce beetle	3.4	3.9	3.6	3.6	128
Solenopsis richteri	Black imported fire ant	3.1	2.9	4.1	3.4	128
Sirex ermak	Blue-black horntail	3.0	3.9	2.6	3.6	111
Gammarus fasciatus	Freshwater shrimp	3.0	4.0	3.0	3.0	108
Cherax quadricarinatus	Redclaw crayfish	4.0	3.0	3.0	3.0	108
Saperda candida	Round-headed apple tree borer	4.0	4.1	2.5	2.5	105
Bellamya chinensis	Chinese mysterysnail	5.0	5.0	2.0	2.0	100
Ashworthius sidemi		4.5	3.7	3.3	3.0	100

Species	Common name	Arrival: A	Establishment: B	Impact: C	Spread: D	Overall score (A*B*C*D)
Aeolesthes sarta	City longhorn beetle, Qetta borer	2.6	3.6	3.6	2.9	99
Vespula pensylvanica	Western yellowjacket	2.5	3.6	3.1	3.5	99

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