Invasive alien species –

framework for the identification of invasive alien species of EU concern

ENV.B.2/ETU/2013/0026

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# Contents

# Executive summary

Invasive alien species (IAS) are considered to be one of the greatest threats to biodiversity, particularly through their interactions with other drivers of change (MEA 2005, GBO 2011). In recent years the European Commission (EC) has intensified their commitment to provide a comprehensive, problem-oriented, well-balanced and manageable solution to IAS in Europe. The text of a European Union (EU) Regulation is expected to be adopted soon. A core component of the Regulation is a list of "IAS of EU concern" that will be drawn up together with European Member States (MS), based on scientifically robust risk assessments as laid down in the Regulation.

Risk assessment is the technical and objective process of evaluating biological or other scientific and economic evidence to identify potentially invasive alien species and determine the level of invasion risk associated with a species or pathway and specifically whether an alien species will become invasive. An effective and robust risk assessment method is seen as an essential component of IAS management (Shine, Kettunen et al. 2010) and a fundamental element of an early warning and information system in Europe (Genovesi, Scalera et al. 2010).

The purpose of this project was to provide a review of available IAS risk analysis protocols and use this, coupled with expert opinion, to inform the development of minimum standards necessary to ensure effective risk assessment methods for the EU. Additionally we considered gaps in knowledge and scope of existing risk analysis methods. Thus, we provide recommendations for developing existing risk analysis methods within a framework of minimum standards. Methods compliant with the minimum standards will be of value for supporting the development of a draft list of "IAS of EU concern". Such a list should include species that are already established within the EU but also be extended to a scoping study to consider species that are not yet established but that may present a significant threat to Europe in the near future.

## Task 1: Literature review and critical assessment of existing risk assessment methodologies on IAS

The purpose of the review was to critically assess the scope, robustness and effectiveness of current risk assessment methods and to provide information for their further development in the context of the study particularly underpinning the derivation of minimum standards.

**More than 100 relevant publications were derived through a literature search. Only 70 publications provided original risk assessment protocols and their applications and of these 29 were selected through filtering to eliminate those which simply described the implementation of**

**an existing protocol to a given geographic region or specific taxonomic groups without modification of the assessment protocol.** These 29 protocols were examined further to derive key attributes of the risk assessment method to inform the development of minimum standards. Basic information for all 29 risk assessment methods was provided. Case studies for 14 of these protocols were included to provide further context for subsequent tasks. The 14 protocols included as case studies were selected on the basis of a number of criteria: relevance of the protocol to Europe, taxonomic breadth and/or geographic breadth, likely compliance with minimum standards and availability of experts with key involvement in the protocol to provide the case study.

**At both the international and regional-level as well as among countries, there is huge variation in how the risks posed by alien species are assessed.** Indeed risk assessment protocols vary widely in approach, objective, implementation and taxa covered, the majority are based on qualitative methods, even though the need to develop quantitative risk assessments has been recognised. Major hurdles preventing the use of quantitative risk assessment methods are the lack of data and challenges in interpretation and communication.

**Two critical gaps were identified through this task: consideration of ecosystem services and evaluation of user-friendliness and consistency of outcomes.** Very few risk assessment protocols reviewed specifically considered impacts on ecosystem services. Consistency in risk analysis has been recently discussed and assessed for pest risk analyses in the EU-funded project PRATIQUE and methods to improve consistency have been developed. PRATIQUE only considered the EPPO decision support scheme (EPPO DSS), however this work will be extended through consideration of additional risk assessments within the current EU-funded COST Action Alien Challenge.

## Task 2: Develop minimum standards for risk assessment methodologies

**The review of characteristics of risk assessments through task 1 resulted in a long-list of attributes.** The derived attributes ranged from broad consideration of general characteristics including description of the species through to criteria relevant to the invasion process including likelihood of arrival, establishment and spread. Impacts were classified broadly and included biodiversity and socio-economic impacts alongside perspectives influencing impacts such as climate change. Additional consideration was given to implementation of the protocol including quality assurance and alignment with agreed international standards and policies such as the World Trade Organisation (WTO) and relevant EU Directives including the EU Marine Strategy Framework Directive (MSFD) and EU Water Framework Directive (WFD).

**From the long-list the core project team developed and selected a draft short-list of attributes that were considered to be relevant for performing risk assessments of IAS.** The short-list of minimum standards was agreed by the project team and preliminarily reviewed through a pre-workshop survey in Task 3.

## Task 3: Risk assessment workshop

The overarching aim of the risk assessment workshop (27-28th March 2014) was to peer-review the derived short-list of minimum standards. The derived minimum standards are required to underpin evaluation of existing risk assessments and ensure they are fit for the purpose of supporting the development of a list of "IAS of EU concern".

**We aimed to distil the critical components of a risk assessment that, through expert opinion and consensus, are agreed necessary to achieve overarching, robust and rigorous assessment of the risk of an IAS, regardless of the specific approach taken.** Additionally consideration was given to recognized international guidelines and recommendations with relevance to the development of minimum standards for risk assessments.

**The workshop included participants from the project team (23 experts from nine organisations) and 12 additional invited experts.** The invited experts and those from within the team represented a breadth of expertise from a variety of perspectives including taxonomic (all taxa, including pathogens), environmental (freshwater, marine and terrestrial), impacts (environmental, socio-economic and health) and disciplines (ecologists, economist, conservation practitioners, scientists, policy-makers, risk assessors). Many of the experts had been actively involved in the development, testing and implementation of risk assessment protocols for IAS.

**The experts were invited to review and refine the list of attributes derived through Tasks 1 and 2 for inclusion as potential minimum standards.** The long list of attributes of risk assessments derived through Task 1 and 2 were circulated in the form of a pre-workshop survey (using Survey Monkey) in which the experts were asked to rank the importance of each as a potential minimum standard on a scale of 1 (low importance) to 5 (high importance). Experts were also asked to provide additional attributes that were not apparent from the long-list.

**The pre-workshop survey revealed a high level of consensus between all experts for most of the attributes.** However one-third of the experts stated that a totally new EU-wide risk assessment system tailored for the new IAS Regulation should be developed. Attributes aligning with socio-economic aspects also appeared to cause division in responses by the experts. Furthermore, questions relating to cost-benefit led to a high degree of uncertainty with more than a third of participants responding “unsure”. The disagreement or uncertainty expressed by respondents on these specific themes highlighted the need to ensure that socio-economic considerations were included as a substantial component of the workshop programme.

**Clarity is an overarching requirement of risk assessment protocols to ensure consistency.** It is of utmost importance that a protocol asks questions that are sufficiently clear and understandable for assessors. This is essential to ensure that responses (accompanied by an indication of level of uncertainty) deliver similar assessments for the same species in the same area, irrespective of the identity of the assessors – as long as these have the necessary expertise or are provided with the necessary information.

**Fourteen criteria were agreed, through consensus methods, to represent the minimum standards.** The minimum standards are:

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)
2. Includes the likelihood of entry, establishment, spread and magnitude of impact
3. Includes description of the actual and potential distribution, spread and magnitude of impact
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional
5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes
6. Can broadly assess environmental impact with respect to ecosystem services
7. Broadly assesses adverse socio-economic impact
8. Includes status (threatened or protected) of species or habitat under threat
9. Includes possible effects of climate change in the foreseeable future
10. Can be completed even when there is a lack of data or associated information
11. Documents information sources
12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary
13. Includes uncertainty
14. Includes quality assurance

## Task 4: Screening of existing risk assessment methodologies

**None of the analysed risk assessment protocols were fully compliant with the minimum standards.** However, there were a number of protocols that appeared to be compliant with a sufficient number of the minimum standards or with the potential to be modified in accordance with the minimum standards to be included within Task 4.

**The GB NNRA, EPPO DSS, Harmonia$^+$ and ENSARS were the risk assessment protocols that most closely met the minimum standards, they are further referred to as "substantially compliant risk assessments".** The risk assessments undertaken with the GB NNRA and EPPO DSS were accessible and included a range of species. Harmonia$^+$ has potential as a risk assessment protocol with broad taxonomic and geographic applicability. It is a comprehensive risk assessment protocol, however it has only recently been published and currently no species have been formally assessed using this method. ENSARS includes assessments for a number of species but these are not yet formally published.

**GB NNRA and Harmonia$^+$ both currently lack inclusion of description of socio-economic benefits**. However, experts representing these methods acknowledge a willingness to include this aspect as a priority in the future. The EPPO DSS and ENSARS already consider such benefits.

**Consideration of possible effects on climate change in the foreseeable future was lacking in most protocols.** However, the GB NNRA does include climate change considerations. ENSARS, Harmonia$^+$ and EPPO fail to include climate change considerations within their protocols but could easily include this aspect as a priority for updates in the future.

**Consideration of the effects of IAS on ecosystem services was almost consistently lacking in the risk assessment protocols.** This was identified through the literature review (Tasks 1 and 2) but was confirmed through Task 4. IAS impacts on biodiversity, ecosystem patterns and processes, ecosystem services and related socio-economic implications are clearly interlinked. Therefore, there are foreseen to be overlaps in how these different impacts are determined in practice: the identification of impacts on biodiversity and ecosystem characteristics clearly forms the basis for impacts on ecosystem services whereas identifying the impacts on ecosystem services form a key conceptual basis for assessing the foreseen socio-economic impacts of IAS invasion. These overlaps – or synergies - should be taken into consideration when developing these three minimum standards further in the future. It is foreseen that a dedicated guidance on how to assess the impact on ecosystem services, in the context of EU risk assessments for IAS, would need to be developed.

## Task 5: Screening of potential "IAS of EU Concern" and proposal of a list

Prioritisation of potential "IAS of EU concern" is essential to both target IAS interventions at the species constituting the highest risks and for allocating the limited resources available for invasion management based on feasibility of outcomes. The establishment of a risk analysis framework, in consultation with the EC, would ensure a coherent and coordinated response to risks of EU relevance which could be termed "IAS of EU concern".

**The main objective of the study was to analyse a set of species that have been risk assessed using protocols meeting the minimum standards to develop the list of "IAS of EU concern"**. As a result of the analysis in Task 4, it was apparent that none of the existing protocols screened, tested and discussed within Task 3 meet the full set of minimum standards.

**We proceeded with the analysis of the list of 80 species provided by the Commission against those protocols for risk assessment that were considered as "substantially compliant".** Due to the lack of risk assessment protocols compliant with the minimum standards, it was not possible to obtain a fully compliant list of proposed "IAS of EU concern" as initially foreseen. However, four risk assessment protocols, namely the EPPO DSS, ENSARS, GB NNRA and Harmonia$^{+}$, were selected as they meet "most" minimum standards and included a breadth of species in existing assessments. The lists generated from the four selected protocols were thus cross-tabulated against the list of 80 species provided by the EC. It is important to note that some of the existing assessments (most notably within GB NNRA, ENSARS and Harmonia$^{+}$) apply to a restricted area within Europe and so caution in extrapolating outcomes to a European-scale is required.

**In total 50 species are included within the draft list of proposed "IAS of EU concern" and these were identified through the "substantially compliant" risk assessments as posing a medium to high risk on biodiversity and/or human health and the economy. Of these 37 are from GB NNRA, 18 from EPPO and one from ENSARS. Seven of the species were assessed within more than one protocol.** The list includes 14 species in addition to those within the original list provided by the EC.

**The draft list of proposed "IAS of EU concern" includes 25 plants, 12 vertebrates, 13 invertebrates of which most are found in the terrestrial and freshwater environments (24 and 20 respectively whereas only six marine species are included).** The draft list is constrained by inclusion of only the IAS for which a "substantially compliant" risk assessment is available. Furthermore, there are inherent limitations of a list of proposed "IAS of EU concern" compiled on the basis of risk assessment protocols which do not fully comply with the agreed minimum standards. This is reflected in a number of shortcomings or inconsistencies resulting from the outcomes of the four protocols which were used to draft the list of proposed "IAS of EU concern".

## Concluding remarks and key recommendations

**Available risk assessment protocols that meet the minimum standards are an important step in developing a list of "IAS of EU concern".** Refinements to existing risk assessment protocols are required to ensure they include consideration of ecosystem services, climate change and adverse impacts on socio-economic benefits. As these criteria are encompassed it will be necessary to critically test and evaluate the performance of these modified protocols as it is necessary to improve consistency of outcomes.

**Support should be given to enable developments to modify risk assessment protocols within their mandate to comply with the new EU Regulation.** This should include the development of appropriate guidance on the interpretation and use of minimum standards where required. Additionally the importance of national impact assessment protocols should be recognised with consideration given to modifications of methods to provide a scientific basis for EU assessments. These assessments should serve as source to identify potential additional 'IAS of EU concern' and evaluation of the list.

**Impact assessments are not compliant with the minimum standards because of lack of consideration of mechanisms of introduction and establishment. However, impact assessments provide a detailed basis upon which to quantify the impacts of IAS and include aspects that could be considered for inclusion within full risk assessments.** The risk assessment methods based on the protocol devised by EPPO DSS, namely GB NNRA and ENSARS, provide a basis on which to begin developing a list of 'IAS of EU concern'. However, the breadth of species considered relevant is influenced by the original purposes of both protocols. Harmonia$^+$ is a new and promising risk assessment method. It will be essential to consider the relevance of this protocol as one of the key players going forward.

**A critical issue exists in the simplification of extrapolating national or regional assessments to the total area of the EU.** The EU is rich in biodiversity and is a highly heterogeneous and large territory and so risk assessments of IAS may differ substantially when different regions are considered. Consideration of European biogeographic regions as contex for existing national risk assessments protocols would be appropriate. It is essential to ensure that risk assessments undertaken for restricted regions within Europe (such as the GB NNRA, ENSARS and Harmonia$^+$) have relevance to the EU as outlined above. Review of the applicability of such assessments for EU relevance is unlikely to be trivial for many IAS. Re-assessment of risks identified through national risk assessment protocols at the EU level (with consideration of biogeographic regions) through scientific experts should be prioritised.

**Further development of the list of proposed "IAS of EU concern" is necessary and should involve scientific experts based on the framework provided by the new EU Regulation.** It will be essential to develop a process for consolidating the draft list of proposed "IAS of EU concern" through involvement of scientific experts. The list of proposed "IAS of EU concern" will need to be reviewed on a regular basis to ensure it remains current as the number of new arrivals escalates. Equally the knowledge underpinning our understanding of invasions and environmental change will improve and additional relevant concepts will emerge. Therefore, periodically it will be necessary not only to review the list of proposed "IAS of EU concern" but also the framework of minimum standards upon which it is based as, for example, understanding increases and evidence suggests the need to modify minimum standards or indeed include additional minimum standards.

**Consideration of the establishment of a formal procedure for evaluating the list of proposed "IAS of EU concern" after 2016 should be prioritised.** It will be essential to provide support for cooperation between scientific experts (responsible for the risk assessments) and the Member State and stakeholder experts (responsible for the risk management and communication). Indeed before the final list of "IAS of EU concern" is determined risk management factors should be taken into account, such as how widespread the species is within the EU, what benefits are associated with the species and the cost-benefit of adding the species to the list of "IAS of EU concern".

# Acronyms

IAS – Invasive Alien Species

BELSPO – Belgian Science Policy Office

BfN – German Agency for Nature Conservation

BINPAS – Bioinvasion impact (biopollution) assessment system

CBD – Convention on Biological Diversity

CEC – Commission for Environmental Cooperation

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

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

IAP – Invasive Alien Plants

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 – Invasive Species Specialist Group

IUCN – International Union for Conservation of Nature

MAES – Mapping and Assessment of Ecosystems and their Services

MEA – Millennium Ecosystem Assessment

MS – Member State

MSFD – Marine Strategy Framework Directive

NAAEC – North American Agreement on Environmental Cooperation

NAFTA – North American Free Trade Agreement

NIS – non-indigenous species

NNSS – GB non-native species secretariat

OIE – World Organisation for Animal Health

PRA – Pest Risk Analysis

PRATIQUE – Pest Risk Analysis TechnIQUES

RA – Risk assessment

SPS – Sanitary and Phytosanitary Measures

TEEB – The Economics of Ecosystems and Biodiversity

WFD – Water Framework Directive

WoRMS – World Register of Marine Species

WRA – Weed Risk Assessment

WTO – World Trade Organisation

# Glossary

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

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

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

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

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

**Risk analysis** is a broad term encompassing a complex process involving both risk assessment and risk management (Genovesi, Scalera et al. 2010). In the context of IAS, it involves the evaluation of the likelihood of entry, establishment or spread of an alien species in a given area, and of the associated potential biological and economic consequences, taking into account possible management options that could prevent spread or impacts.

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

**Risk management** of IAS involves the evaluation and selection of options to reduce or mitigate the risks of introduction and spread of an invasive alien species.

# Introduction

Invasive alien species (IAS) are considered to be one of the greatest threats to biodiversity, particularly through their interactions with other drivers of change (MEA 2005, GBO 2011). Several international agreements recognize the negative effects of IAS and reflect the growing concerns of policy, stakeholders and society. For example, European countries have obligations in relation to alien species and must “strictly control the introduction of non-indigenous species” (Bern Convention on the Conservation of European Wildlife & Natural Habitats) and “eradicate those alien species which threaten ecosystems, habitats or species” (UN Convention on Biological Diversity).

In recent years the European Commission (EC) has intensified its commitment to provide a comprehensive, problem-oriented, well-balanced and manageable solution to IAS introduced and established within Europe. It is recognized that the priorities are to protect native biodiversity and related ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these IAS can have. Recently, an agreement on the text of an European Union (EU) Regulation was found by the European Council and Parliament; formal adoption is expected to take place in autumn 2014. The Regulation should ensure harmonisation and prioritization at the EU-level recognizing the importance of prevention, early warning and rapid response. Risk analysis (encompassing risk assessment, risk management and risk communication) is a vital component of a sound IAS policy and the decision-making process. Indeed risk analysis is essential for underpinning many components of IAS policy, including prevention (informing legislation and justification of restrictions), early warning and rapid response (prioritizing action and guiding surveillance) and long-term control (prioritizing species for control). A core component of the Regulation is a list of ‘IAS of EU concern’ that will be drawn up together with European Member States, based on scientifically robust risk assessments as laid down in the Regulation.

*Defining risk analysis, risk assessment and risk management*

Risk analysis is a broad term encompassing a complex process involving both risk assessment and risk management (Genovesi, Scalera et al. 2010). In the context of IAS it involves the evaluation of the likelihood of entry, establishment or spread of an alien species in a given area, and of the associated potential biological and economic consequences, taking into account possible management options that could prevent spread or impacts. Within this, risk assessment is the technical and objective process of evaluating biological or other scientific and economic evidence to identify potentially invasive species and determine the level of invasion risk associated with a species or pathway and specifically whether an alien species will become invasive (Genovesi, Scalera et al.

2010). Risk management of IAS involves the evaluation and selection of options to reduce or mitigate the risks of introduction and spread of an invasive alien species. An effective and robust risk assessment method is seen as an essential component of IAS management (Shine, Kettunen et al. 2010) and a fundamental element of an early warning and information system in Europe (Genovesi, Scalera et al. 2010). Indeed prevention and rapid response rely on identifying which alien species are most likely to cause a threat within the invaded area (Shine, Kettunen et al. 2010).

Risk assessment can involve very different levels of accuracy, depending on the objectives of the evaluation (Genovesi, Scalera et al. 2010). For example, when deciding how to respond to a new incursion, a quick screening of the risks associated with an introduced species is in general more than sufficient to identify the appropriate response. When prioritizing control actions on species already established or about to enter the assessed area, assessments focus largely on actual or potential impact in “impact assessment schemes”. However, when assessment is aimed at supporting regulations of trade, usually a full and comprehensive risk assessment is required for legal reasons. In line with the tender specifications we focused on the process of risk assessment but summarise other elements within risk analysis methods as appropriate.

Robust risk assessment methods are required to provide the foundation upon which to base measures that may affect imports into the EU and future agreements with trade partners without infringing the rules and disciplines of the World Trade Organisation (WTO) (Shine, Kettunen et al. 2010). There are a number of risk assessment methods available throughout Europe ranging from quick screening to impact assessment and full risk assessment and, depending on the assessment, covering a range of different groups of species / organism, but the lack of a common framework for assessing risks posed by IAS is seen as a key gap (Shine, Kettunen et al. 2010, Sandvik, Sæther et al. 2013). Indeed at both the international and regional level as well as among countries, there is huge variation in how the risks posed by alien species are assessed (WTO 1994, Pheloung, Williams et al. 1999, USDA 2000, CFIA 2001, FAO 2004, Baker, Hulme et al. 2005, Weber, Köhler et al. 2005, Gederaas, Salvesen et al. 2007, Bomford 2008, Invasive Species Ireland 2008, Branquart 2009, CEC 2009, Brunel, Branquart et al. 2010, Kumschick and Nentwig 2010, Essl, Nehring et al. 2011, PLH 2011). These assessment schemes vary widely in approach, objective, implementation and taxa covered (Verbrugge, Leuven et al. 2010), and the majority are based on qualitative methods, even though the need to develop quantitative risk assessments has been recognised (Genovesi, Scalera et al. 2010, Leung, Roura-Pascual et al. 2012). Major hurdles preventing the use of quantitative risk assessment methods are the lack of data (Kulhanek, Ricciardi et al. 2011) and challenges in interpretation and communication (Biosecurity New Zealand 2006).

Verbrugge et al. (2012) compared risk classifications for 25 aquatic alien species using different European risk identification protocols and found that for 72% of the species, the classifications were dissimilar between protocols/countries and concluded that differences resulted not only from differences in the protocols and data availability, but also from 'natural' biogeographic patterns. The authors call for a European standardization of risk assessment protocols and assessments tailored to the biogeographical rather than the country level (Verbrugge, van der Velde et al. 2012). Similarly, three risk assessment schemes were compared, with regard to their capacity to predict 180 alien woody plant species invasions in the Czech Republic, including invasive, naturalized but non-invasive, and casual species as well as species not yet reported to escape from cultivation (Pyšek, Danihelka et al. 2012). They found that the (Australian) Weed Risk Assessment model with additional analysis (Daehler, Denslow et al. 2004) performed best.

The purpose of this project was to provide a brief overview of available IAS risk assessment protocols and use this, coupled with expert opinion, to inform the development of minimum standards with which a risk assessment method should comply in order to constitute a suitably robust risk assessment to support the development of a list of proposed "IAS of EU concern". Additionally we considered gaps in knowledge and scope of existing risk analysis methods. Thus, we provide recommendations for developing existing risk analysis methods within a framework of minimum standards. The proposed minimum standards will be of value for development of an initial list of proposed "IAS of EU concern" including species that are already established within the EU but also extended to a scoping study to consider species that are not yet established but that may present a significant threat in future.

## General approach

The project was divided into five tasks and associated subtasks (Figure 1) in recognition of this aim:

Task 1: Literature review and critical assessment of existing risk assessment methodologies on IAS

Task 1.1: Critically review scope of current risk assessments

Task 1.2: Identify gaps and scope in risk assessment

Task 2: Develop minimum standards for risk assessment methodologies

Task 2.1: Produce a database of traits from risk assessment review in task 1 to inform recommendation of minimum standards

Task 2.2: Proposed minimum standards for review

Task 3: Risk Assessment workshop

Task 3.1: Identify and approve experts to attend the workshop

Task 3.2: Dissemination of project documents to approved experts

Task 3.3: The workshop

Task 3.4: Summarise the findings from the workshop

Task 4: Screening of existing risk assessment methodologies

Task 4.1: Compile and review table outlining results of screening of existing risk assessment methods

Task 4.2: Detailed overview of risk assessments that meet the minimum standards

Task 5: Screening of potential IAS of EU Concern and proposal of a list

Task 5.1: Compile the list of species for screening

Task 5.2: Assess the species against the minimum standards

Task 5.3: Propose list of "IAS of EU concern"

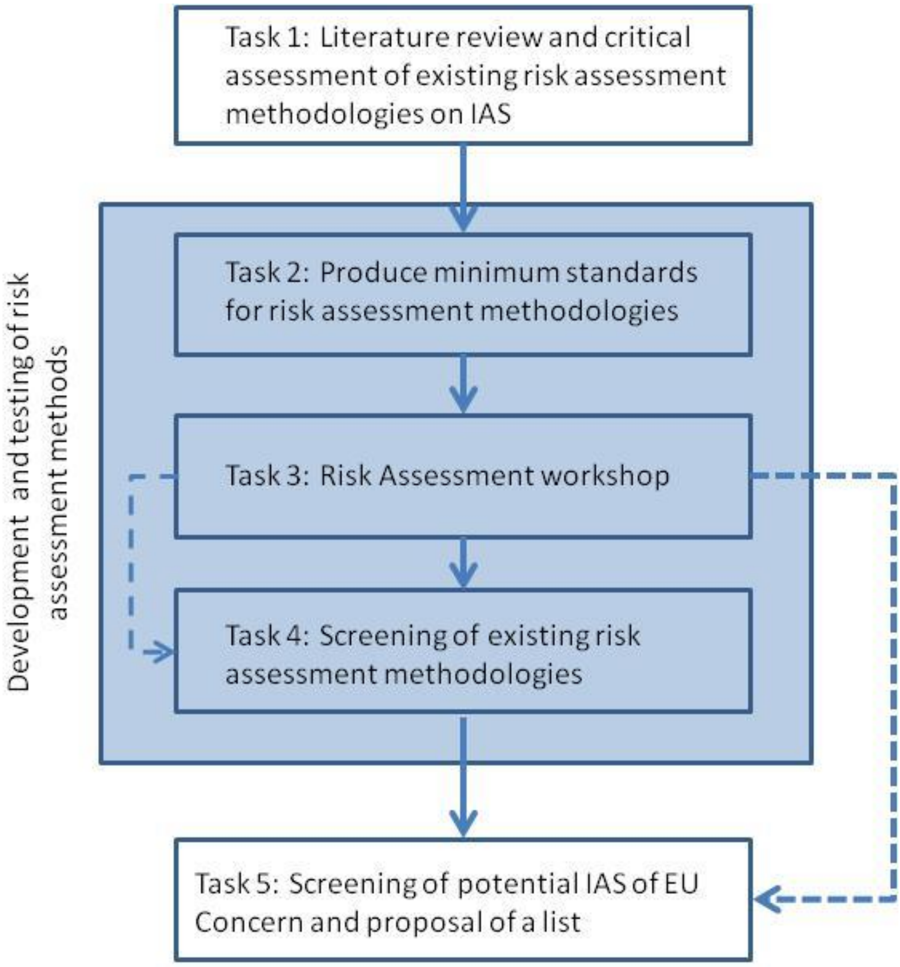



**Figure 1:** Flow diagram illustrating the links between tasks and iterative approach to the research

# Task 1: Literature review and assessment of existing risk assessment methodologies on IAS

## Task overview

The purpose of the review was to extract attributes from current risk assessment methods with relevance for the derivation of minimum standards. Through this task we compiled and reviewed the scientific and other literature (including policy-related publications) alongside online internet sources related to IAS risk assessment (drawing broadly on available risk analysis, risk assessment and risk management methods). The focus was on existing methods in Europe, but relevant risk assessment methods from all over the world were explored.

## Task 1.1: Review scope of current risk assessments for developing minimum standards

It is recognized that historically, the development of risk assessment tools in regions affected most by IAS is significantly ahead of Europe, e.g. for Australia, New Zealand, North America, and South Africa (Pheloung, Williams et al. 1999, Biosecurity Australia 2001, Robertson, Villet et al. 2003, Morse, Randall et al. 2004, Biosecurity New Zealand 2006). In recent years, risk analysis systems based on a specified set of criteria have become available for an increasing number of European countries (Baker, Hulme et al. 2005, Weber, Köhler et al. 2005, Baker, Black et al. 2008, Invasive Species Ireland 2008, Kenis and Bacher 2010, Essl, Nehring et al. 2011, Gederaas, Moen et al. 2013). However, there is considerable confusion with respect to the definitions and delimitations of the terms in use to describe risk analysis and associated processes. Such lack of clarity can complicate discussions and impede comparisons between different systems (Table 1.1).

**Table 1.1**: Selected definitions of key terms (risk analysis, risk assessment, risk management and risk communication) from international conventions and standards with reference to supporting documents from WHO, IPPC, OIE and CBD.

| Definitions of risk analysis | |
|---|---|
| Risk analysis is made up of three components: risk assessment, risk management, risk communication | http://www.who.int/foodsafety/micro/riskassessment/en/ |

| | |
|---|---|
| Risk analysis refers to (1) the assessment of the consequences of the introduction and of the likelihood of establishment of an alien species using science-based information (i.e., risk assessment), and (2) to the identification of measures that can be implemented to reduce or manage these risks (i.e. risk management), taking into account socio-economic and cultural considerations. | https://www.cbd.int/invasive/terms.shtm |
| Risk analysis is the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it | https://www.ippc.int/publications/glossary-phytosanitary-terms |
| Risk analysis is the process composed of hazard identification, risk assessment, risk management and risk communication. | http://www.oie.int/en/international-standard-setting/terrestrial-code/access-online/?htmfile=glossaire.htm |
| Definitions of risk assessment | |
| Risk assessment is the scientific evaluation of known or potential adverse health effects resulting from human exposure to food borne hazards. The process consists of the following steps: hazard identification, hazard characterization, exposure assessment, risk characterization. | http://www.who.int/foodsafety/micro/riskassessment/en/ |
| Risk assessment is the evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member State according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences; or the evaluation of the potential for adverse effects on human or animal health arising from the presence of additives, contaminants, toxins or disease-causing organisms in food, beverages or food. | http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm |
| Risk assessment is the evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences. | https://www.ippc.int/publications/glossary-phytosanitary-terms |
| Risk assessment refers to the evaluation of the likelihood and the biological and economic consequences of entry, establishment, or spread of a hazard within the territory of an importing country. | http://www.oie.int/en/international-standard-setting/terrestrial-code/access-online/?htmfile=glossaire.htm |
| Definitions of risk management | |

| | |
|---|---|
| Risk management is the process of weighing policy alternatives to accept, minimize or reduce assessed risks and to select and implement appropriate options. | http://www.who.int/foodsafety/micro/riskassessment/en/ |
| Risk management is the evaluation and selection of options to reduce the risk of introduction and spread of a pest. | https://www.ippc.int/publications/glossary-phytosanitary-terms |
| Risk management is the process of identifying, selecting and implementing measures that can be applied to reduce the level of risk. | http://www.oie.int/en/international-standard-setting/terrestrial-code/access-online/?htmfile=glossaire.htm |
| Definitions of risk communication | |
| Risk communication is an interactive process of exchange of information and opinion on risk among risk assessors, risk managers, and other interested parties. | http://www.who.int/foodsafety/micro/riskassessment/en/ |
| Risk communication is the interactive exchange of information on risk among risk assessors, risk managers and other interested parties. | http://www.oie.int/en/international-standard-setting/terrestrial-code/access-online/?htmfile=glossaire.htm |

*International definitions and requirements on risk assessment*

Risk assessment is defined by the WTO as 'the evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences'. The World Organisation for Animal Health (OIE) defines risk assessment as 'the evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country'. Within the International Plant Protection Convention, pest risk assessment is defined as 'the evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences'. The Convention on Biological Diversity (CBD) is an important convention for biodiversity related matters, including IAS. However, it is not a standard-setting organization that is recognized by the WTO, and for risk analysis, the CBD follows the WTO, International Plant protection Convention (IPPC) and OIE definitions.

The WTO, IPPC and OIE are organizations responsible for setting standards and all have similar definitions of risk assessment. The WTO also defines principles for risk analysis, which in general should be based on available scientific evidence and undertaken in an independent, objective and transparent manner. The main OIE Standards on risk assessment are Import risk analysis[1] and

[1] http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_1.2.1.htm

Guidelines for assessing the risk of non-native animals becoming invasive[2]. The main IPPC Standard is the ISPM[3] 11 Pest risk analysis for quarantine pests[4]. To be consistent with OIE and IPPC a risk assessment has to consider several elements that are summarized in Table 1.2.

**Table 1.2:** Comparison of criteria that a risk assessment has to consider to be consistent with OIE and IPPC requirements. Note that these criteria have been developed for quarantine pests.

| | OIE | IPPC |
|---|---|---|
| Criteria for inclusion of a species on an official list | Alien species + international spread + limited distribution + impacts or potential impacts on human or animal health + management possible | Alien species + absent or limited distributed + controlled + impacts to plants including the environment + establishment and spread potential |
| Qualitative/ Quantitative | Risk assessment may be qualitative or quantitative. | - |
| Distribution of the pest under study | At least one country has demonstrated freedom or impending freedom from the disease, infection or infestation. | Pest absent from all or a defined part of the PRA area. If the pest is present but not widely distributed, it should be under official control in the near future. |
| Information used | Should be well documented and supported with references to the scientific literature including other sources (including expert opinion). | Scientific publications as well as technical information such as data from surveys and interceptions may be relevant. Expert judgment may be used if appropriate. |
| Uncertainties | Should document the uncertainties and the assumptions made and the effects of these on the final risk estimate. | Degree of uncertainty should be documented. |
| Updating | Should be amenable to updating when additional information becomes available. | - |
| Entry | Entry assessment, including information on biological factors, country factor, commodity factors. | Pathways from the exporting country to the destination, and the frequency and quantity of pests associated with them. All relevant pathways should be considered. |
| Exposure/ establishment and spread | Exposure assessment / establishment and spread for invasive animals. | Probability of establishment and spread. |
| Consequence/ | Describes the potential consequences of | Assessment of potential economic |

[2]http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/OIEGuidelines_NonNativeAnimals_2012.pdf
[3]International Standard on Phytosanitary Measures
[4]https://www.ippc.int/sites/default/files/documents/1367503175_ISPM_11_2013_En_2013-05-02.pdf

| | | |
|---|---|---|
| Impact assessment | a given exposure and estimates the probability of them occurring / includes direct consequences and indirect consequences for invasive animals. | consequences including direct and indirect pest effects, commercial consequences, non-commercial and environmental consequences. |
| Overall risk | Produce overall measures of risk. | Conclusion of the pest risk assessment. |

It should be further noted that the scope of application for both the OIE and IPPC are clearly defined and the two systems are relevant for different organisms (Table 1.3). IPPC has a mandate for IAS that are plant pests, absent or limited in distribution and subject to official control. Such IAS should be considered as quarantine pests and are subject to IPPC provisions. However, a gap has been identified for animals that are IAS but are not pests of plants under the IPPC. OIE has a mandate for assessing the disease risks associated with the importation of animals, animal products, animal genetic material, feedstuffs, biological products and pathogenic material that affect human or animal health. The OIE has developed guidelines for assessing the risk of alien animals becoming invasive, but does not provide standards for animals that are not considered as IAS. In a recent review it was concluded that while some IAS (such as diseases of humans and livestock) are addressed by international agreements that coordinate efforts to reduce their impact, IAS that cause environmental impacts are almost exclusively managed at the national level (Perrings, Dehnen-Schmutz et al. 2005). More detailed criteria for the inclusion of diseases, infections and infestations on the OIE list include, for example, that spread of the agent via live animals or their products or vectors has been proven and severe/significant consequences to humans, domestic animals or wild animal populations has been shown (OIE 2011).

**Table 1.3:** Summary of the convention (IPCC or OIE) that should be followed for a risk assessment according to the type of organism concerned and the type of impacts considered.

| Type of impacts | Virus | Bacteria | Nematodes | Fungi | Terrestrial invertebrates | Plants | Mammals |
|---|---|---|---|---|---|---|---|
| Cultivated or wild plants (including agriculture), the environment, other social impacts | IPPC | IPPC | IPPC | IPPC | IPPC | IPPC (Annex 4) | - |
| Human or animal health, the environment and the economy | OIE | OIE | OIE? | OIE? | OIE? | -? | OIE (guideline on invasive animals) |

The objectives of the forthcoming EU Regulation will be achieved in accordance with the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). The International Office of Epizootics and the International Plant Protection Conventions are also relevant. It is, therefore, useful to consider the scope of international standards for informing the development of minimum standards.

## International standards: informing the development of minimum standards

*SPS Agreement*

The requirements on risk assessment in these international conventions primarily rely on the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement http://www.worldtradelaw.net/uragreements/spsagreement.pdf) of the World Trade Organization (WTO). It applies to all sanitary and phytosanitary measures which may, directly or indirectly, affect international trade. The SPS Agreement provides principles for its Member countries to take sanitary and phytosanitary measures necessary for the protection of human, animal or plant life or health.

Principles for taking measures are as follows:

- Based on scientific principles
- Non discriminant

- Equivalence
- Adaptation to conditions (geography, ecosystems, etc.)
- Transparency

In addition, measures should be based on a risk assessment which:

- Shall take into account available scientific evidence
- Shall take into account relevant economic factors: the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease; the cost of control or eradication in the territory of the importing Member; the relative cost-effectiveness of alternative approaches to limiting risks
- Shall take into account the objective of minimizing negative trade effects

*Animal Health: International Office of Epizootics*

The risk analysis should be transparent, objective and defensible. The components are hazard identification, risk assessment, risk management and risk communication. The risk assessment may be qualitative or quantitative.

*Hazard identification*

It is necessary to identify whether each potential hazard is already present in the importing country, and whether it is a notifiable disease or is subject to control or eradication in that country and to ensure that import measures are not more trade restrictive than those applied within the country.

*Risk assessment (WTO 1994).*

Risk assessments should be well documented and supported with references to the scientific literature including peer-reviewed and other sources (expert opinion). It should document the uncertainties and the assumptions made and the effects of these on the final risk estimate. Risk assessment should be amenable to updating when additional information becomes available.

The following steps should be considered in risk assessment:

- Entry assessment - consists of describing the biological pathways necessary for an importation activity to introduce pathogenic agents into a particular environment, and estimating the probability of that complete process occurring, either qualitatively or quantitatively. It may include such information: biological factors (species and age of animals, vaccination, treatment, etc.), country factor (incidence of prevalence, control programmes), commodity factors (quantity of the commodity, ease of contamination, etc.).

- Exposure assessment - consists of describing the biological pathways necessary for exposure of animals and humans in the importing country to the hazards (in this case the pathogenic agent) from a given risk source, and estimating the probability of the exposure occurring, either qualitatively or quantitatively. The probability of exposure may include biological factors (properties of the agent), country factors (presence of the potential vector, human and animal demographic, etc.), commodity factors (quantity of commodity imported, intended use of the imported animals products, etc.).
- Consequence assessment - consists of describing the relationship between specified exposures to a biological agent and the consequences of those exposures, it describes the potential consequences of a given exposure and estimates the probability of them occurring.
- Risk estimation - consists of integrating the results from the entry assessment, exposure assessment and consequence assessment to produce overall measures of risk.

*Plant Health: International Plant Protection Convention*

In conducting a pest risk analysis (PRA), the obligations established in the IPPC should be taken into account (IPPC 2013). Those of particular relevance to the PRA process include: cooperation in the provision of information, minimal impact, non-discrimination, harmonization, transparency, avoidance of undue delay. Scientific publications as well as technical information such as data from surveys and interceptions may be relevant. Expert judgment may be used if appropriate. Degree of uncertainty should be documented.

Where the PRA is specifically aimed at determining if the pest should be regulated as a quarantine pest, ISPM 11 (IPPC 2013) is relevant for organisms that appear to meet the following criteria:

- not present in the PRA area or, if present, of limited distribution and subject to official control or being considered for official control
- having the potential to cause injury to plants or plant products in the PRA area
- having the potential to establish and spread in the PRA area

Pest introduction is comprised of both entry and establishment. Assessing the probability of introduction requires an analysis of each of the pathways with which a pest may be associated. This includes:

- Probability of entry - it depends on the pathways from the exporting country to the destination, and the frequency and quantity of pests associated with them. All relevant pathways should be considered. Aspects to be considered also include the probability of the pest to be associated with the pathways at origin, the probability of survival during transport or storage, the probability of the pest surviving existing pest management procedures as well as the probability of transfer to a suitable host.
- Probability of establishment - including availability of suitable hosts, alternate hosts and vectors, suitability of the environment, cultural practices and control measures.
- Probability of spread after establishment - including dispersal ability, availability of suitable hosts, alternate hosts and vectors, suitability of the environment, cultural practices and control measures.
- Assessment of potential economic consequences - including direct and indirect pest effects, commercial consequences, non-commercial and environmental consequences.

## Identification of relevant risk assessment protocols

There have been a number of recent reviews of risk assessment protocols and implementation (Baker, Battisti et al. 2009, Essl, Nehring et al. 2011). Therefore, we did not consider it necessary to repeat such a review process but instead collated risk and impact assessment protocols to derive attributes included within them. This was necessary to underpin all subsequent tasks. To identify the most relevant publications (and consequently protocols) we followed a step-wise process:

Step 1 - A literature search for IAS-risk assessment protocols and applications revealed more than 100 relevant publications and reports (Annex 1). The search was performed using the internet and scientific literature databases (Thomson Reuters Web of Science, Google Scholar) which were investigated through different combinations of relevant keywords (risk analysis, risk assessment, invasive alien species, non-native, biological invasions, black list, pathways, uncertainty, biosecurity).

Step 2 – The publications derived from step 1 were filtered by reading the abstracts and “material and methods” sections and 70 publications providing original risk assessment protocols and their applications were considered further (Annex 1). The search method was intended to collate risk and impact assessment protocols to derive criteria included within them for development of the minimum standards. It should thus not be considered as a systematic review to synthesize all available evidence on the topic and the resulting list (Annex 1) therefore has to be seen as a selection of the most relevant publications based on expert opinion.

Step 3 - The selection of risk assessment methods for detailed consideration was further refined by elimination of those methods (publications) which described the implementation of an existing protocol to a given geographic region (e.g. countries or other regions) or specific taxonomic groups without modification of the assessment protocol. According to the expert opinion of the task contributors from within the project team some protocols were excluded based on the high specificity of the geographic or taxonomic coverage. Consequently, 33 relevant publications were derived (Table 1.4) representing 29 protocols (noting that some of the protocols were described across multiple publications particularly where refinements have been published for example FISK and EPPO).

The diversity of risk assessment protocols is striking. The protocols vary in structure with some including only three questions (Bomford, Kraus et al. 2005) and the GB NNRA including 80 questions (Baker, Black et al. 2008). The mean number of questions for the 29 protocols we considered was 24 (standard deviation 19.5). The high standard deviation is perhaps surprising given the number of protocols that are developed from existing protocols. For example five of the protocols are based on the Fish Invasiveness Screening Kit (FISK). Similarly many are adaptations of the EPPO DSS including the GB NNRA.

Two-thirds of the protocols examined focused at the national-level or specified a couple of neighbouring countries. The European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS) is described as applicable at the European scale but most of the risk assessments that have been carried out with this protocol are only applied at a national scale (UK) or even to single river basins. The EPPO DSS has the greatest scope from a geographic perspective but is limited to assessment of plant pests as defined by the IPPC (including viruses, bacteria, nematodes, insects, etc. as well as plants). The GB NNRA has wide taxonomic scope but is limited to assessments at a national-scale.

**Table 1.4** Selected risk assessment publications to be considered for deriving attributes for development of minimum standards for risk assessment protocols (Task 2), including the name of the protocol, study type (original or further development of an existing protocol), geographic and taxonomic scope to which the protocol has been applied, total number of questions, types of question, output and associated reference. The 33 selected risk assessment publications represent 29 protocols (noting that some of the protocols were described across multiple publications particularly where refinements have been published for example EPPO and FISK).

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 1 | A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts | Original development | No application yet | No application yet | 10 | Five semi-quantitative scenarios describing impacts under each of ten mechanism to assign species to different levels of impact | Massive, major, moderate, minor, minimal; assignment corresponding to the highest level of deleterious impact associated with any of the mechanisms | Blackburn et al. (2014) |
| 2 | Australian freshwater fish model | Further development | Australia | Freshwater fish | 5 | Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics | Low, moderate, serious, extreme; determined from the various combinations of the three risk scores | Bomford & Glover (2004), Bomford (2006) |
| 3 | Australian reptile and amphibian model | Further development | Australia, UK, USA | Reptiles and amphibians | 3 | Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics | Low, moderate, serious, extreme; determined from the various combinations of the three risk scores | Bomford et al. (2005) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 4 | Australian bird and mammal risk assessment | Further development | Australia, New Zealand | Mammals and birds | 20 | Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics | Low, moderate, serious, extreme; determined from the various combinations of the three risk scores | Bomford (2008) |
| 5 | Invasive Species Environmental Impact Assessment Protocol (ISEIA) | Original development | Belgium | Selected species of several groups | 4 | Answers are scored on a 3-point scale | High, moderate and low environmental risk. (Black list, watch list, no list) | Branquart (2007) |
| 6 | A modular assessment tool for managing introduced fishes | Original development | England and Wales | Freshwater fish | 49+ (FISK-based) | Four modules for prioritization, assessment, management action and costs of action | Suggestion for management action for each population | Britton et al. (2011) |
| 7 | EPPO prioritization process for invasive alien plants | Original development | EPPO region | Plants | 11 | Five (Yes/No) and three (Low/Medium/High) | Phase 1: List of minor concern; Observation list; List of invasive alien plants; Phase 2: Small, Medium, Large priority for PRA; | Brunel et al. (2010) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 8 | Protocol to assess the environmental impact of pests in the EPPO decision-support scheme for pest risk analysis | Original development | EPPO-region | 2 versions: plants; plant pests (pathogens and invertebrates) | 8+6 (plant pests), 9+6 (plants) | Two main questions with sets of sub-questions: 9 sub-questions to assess the present impact in other invaded areas; if the answers cannot be applied to the assessment area, 6 additional questions on the potential impact in the assessment area. Uncertainty is scored for each question. | Sub-question and uncertainty scores are summarized into final scores by means of a 'rule-based matrix model. This is a module of the EPPO DSS scheme (EPPO, 2011), but can also be applied to assess present or potential impact of alien plants and plant pests. | Kenis et al. (2012) |
| 9 | EPPO computer-assisted pest risk assessment decision support scheme (EPPO DSS) | Development | EPPO-region | Plant pests including weeds | 48 | All answers are scored on a 5-point scale (3-point for impact). | No ranking | EPPO (2011) |
| 10 | Trinational Risk Assessment for Aquatic Alien Invasive Species (CEC) | Original development | North America (Canada, USA, Mexiko) | Aquatic species | 7 | Probability or impact estimates of seven elements that may be determined quantitatively or by subjective methods (Low/Medium/High) | Organism Risk Potential and Pathway Risk Potential | CEC (2009) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 11 | Fish Invasiveness Screening Kit (FISK) | Further development | UK | Fish | 49 | Central components (e.g. rank formation) of FISK are based on A-WRA | Accept, evaluate (=need further evaluation), reject taxon | Copp et al (2005) |
| 12 | FISK (with uncertainty and predictive power improvements) | Application | UK | Fish | 49 | Central components (e.g. rank formation) of FISK are based on A-WRA | Accept, evaluation (=need further evaluation), reject taxon | Copp et al (2009) |
| 13 | European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS) | Original development | EU (but most of the risk assessments are applied only to UK or even single river basins) | Species listed Annex IV of EU Regulation on the use of Aliens in Aquaculture | 49+ (FISK-based) | ENSARS consists of seven modules (Entry, Invasiveness, Organism, Facility, Pathway, Socio-economic Impact, Risk Summary & Risk Management) and a 5-point scale for the assessments | Assessments can be summarised by score summation and conditional probability leading to a high, medium or low risk assignment | Copp et al. (2008) |
| 14 | Harmonia+ and Pandora+: risk screening tools for potentially invasive organisms | Original development | Belgium | No application yet | 30 | The answers to the semi-quantitative questions can be used to calculate indices that reflect the risks posed by that organism | The Invasion score and the Impact score can be aggregated by taking the product yielding an ultimate score for the Invasion risk posed by the organism assessed | D'Hondt et al. (2014) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 15 | EFSA PLH Scheme for PRA | Original development | Europe | Plant pests | 6 main questions with several sub-questions | Magnitude of the impact is categorized in 5 classes. | Level of overall risk related to biodiversity is categorized as Minor, Moderate or Major, while risk related to ecosystem services is categorized as Minimal, Minor, Moderate, Major or Massive. | EFSA (2011) |
| 16 | GABLIS | Original development | Germany, Austria | Plants, vertebrates | 16 | Five impact criteria are scored on a 4-point scale (Yes/Assumed/No/Unknown) | Black List (with 3 sub-lists), Grey List (with 2 sub-lists), White List | Essl et al. (2011) |
| 17 | Full Risk Assessment Scheme for Non-native Species in Great Britain (GB NNRA) | Further development | Great Britain | All groups | 80 | Qu relate to screening (Y/N), entry, establishment, spread, and impact (semi-quantitative 5 point scale with confidence recorded on a 4 point scale) | Overall risk score is calculated based on all of the scores given in the assessment and presented in Risk summary sheets | Baker et al. (2008); http://napra.eppo.org/ |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 18 | Alien Species in Norway - with the Norwegian Black List 2012 | Further development | Norway | All groups | 9 | Nine semi-quantitative criteria on two axes, three determine species invasion potential and six the ecological impact | Five impact categories: severe, high, potentially high, low, no known impact. The two categories with the greatest impact (severe, high) form the 2012 Black List | Saether et al. (2010); Gederaas et al. (2012); Sandvik et al. (2013) |
| 19 | Risk analysis and prioritisation (Ireland and Northern Ireland) | Development | Ireland and Northern Ireland | All groups | 10 | Scoring system (maximum scores depend on question) | Sum of scores results in high, medium and low risk category | Kelly et al. (2013) |
| 20 | Environmental risk assessment for plant pests: A procedure to evaluate their impacts on ecosystem services | Further development | Not applicable | Plant pests (including plants) | - | scenarios that explicitly combine qualitative and quantitative information and estimates | Five ratings for the assessment of impacts: Massive, Major, Moderate, Minor, Minimal; overall impact and uncertainty are calculated according to EFSA (2011) | Gilioli et al. (2014) |
| 21 | Quantitative Risk Assessment for alien fishes | Development | North America (Great Lakes) | Fish | 25 | A quantitative model using species characteristics (Life-history, Habitat, Invasion history and Human use) | Probability model | Kolar & Lodge (2002) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 22 | A conceptual framework for prioritization of invasive alien species for management according to their impact | Development | Not applicable | All groups | 12 | Scoring system consisting of environmental and socio-economic criteria with 6 categories each | Final Impact Scores calculated by combining Change Assessment Score (considers ecological and socio-economic impact) and Weighted Impact Categories (considers stakeholder values) | Kumschick et al. (2012) |
| 23 | Generic Impact-Scoring System (GISS) | Development | Europe | Mammals and birds | 12 | Scoring system consisting of environmental and socio-economic criteria with 6 categories each | Continuous impact ranking | Nentwig et al. (2009), Kumschick & Nentwig (2010) |
| 24 | Biopollution Index | Development / Original ? | Baltic Sea | All groups | 5 | Impact questions scored on a 5-point scale, but abundance and distribution ranges on a 3- and 4-point scale, respectively | Biopollution Level on a scale 0 (weak) to 4 (massive). | Olenin et al. (2007), Zaiko et al. (2011) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 25 | Chinese WRA | Development | China | Plants | 19 | Questions structured hierarchically and scored into a continuous scale (from 0 to 100) based on the 'Analytic hierarchy process' (AHP) | Continuous impact ranking | Ou et al. (2008) |
| 26 | US Weed Ranking Model | Development | USA | Plants | 27 | Multiple-choice questions using different scales (ranging from 0-10 or 0-1 depending on the category) | Continuous impact ranking | Parker et al. (2007) |
| 27 | Australian WRA | Development | Australia | Plants | 49 | Qu to be answered with Yes/No; magnitudes not considered | Categories: accept, evaluation (i.e. needs further evaluation), reject | Pheloung et al. (1999) |
| 28 | Freshwater Invertebrates Scoring Kit (FI-ISK) | Application | Italy | Crayfish | 49 | Yes/No/Don't know questions, with level of certainty (spread over four rankings) | High, medium, low risk | Tricarico et al. (2010) |

| | Protocol | Study type | Geographic scope | Taxonomic scope | Total number of questions | Type of questions | Output | Reference |
|---|---|---|---|---|---|---|---|---|
| 29 | Expert System for screening potentially invasive alien plants in South African fynbos | Development | South Africa | Woody plants | 24 | Different types of predictor variables (continuous, categorical) related to species and environmental traits | Low or high risk | Tucker and Richardson (1995) |
| 30 | Invasive Ant Risk Assessment | Development | New Zealand | Ants | 32 | Answers scored on a 3-point scale | High, medium, low risk | Ward et al (2008) |
| 31 | Classification key for Neophytes | Development | Central Europe | Vascular plants | 12 | Multiple-choice questions with different scales, always ranging between 0 and 4 | High, intermediate, low risk | Weber & Gut (2004) |
| 32 | Climate-Match Score for Risk-Assessment Screening | Development | Florida (USA) | Amphibians, Reptiles | - | Distribution data | Bioclimatic modelling | van Wilgen et al. (2009) |
| 33 | Assessment of risk of establishment for alien amphibians and reptiles | Development | California and Florida (USA) | Amphibians, Reptiles | 9 | Nine variables used to assess establishment success | Probability model | van Wilgen & Richardson (2012) |

## Case studies of selected protocols

The diversity of methods for risk assessment is highlighted through the consideration of the 33 publications representing 29 protocols (Table 1.4). Case studies are provided for 14 of these protocols to provide an overview of the approaches to risk assessment and background to the development of the minimum standards. The 14 protocols were selected for case studies using the following criteria:

- Relevance of the protocol to Europe
- Taxonomic breadth and/or geographic breadth
- Likely compliance with minimum standards
- Experts with key involvement in the protocol available to provide case study

Experts with key involvement (responsible for the application or development of the protocol) in the protocol were invited to complete a case study template including a brief description of the protocol, assessment approach, outcome of the risk assessment, perspectives on perceived robustness (particularly in relation to quality assurance), applications and key reference.

Brief notes are provided for five other protocols after the case studies. These protocols included three non-European (Australian Weed Risk Assessment, Risk assessment models for vertebrate introductions to Australia and Trinational Risk Assessment for Aquatic Alien Invasive Species) and two European protocols (Managing Non-Native Fish in the Environment and FI-ISK). The two European protocols were not included as case studies becaue FI-ISK is derived from FISK (for which a case study is provided) and Managing Non-Native Fish in the Environment was developed for assessing risk management as opposed to risk assessment. However, all five provide useful reflections relevant to deriving attributes for the development of minimum standards.

### 1. European and Mediterranean Plant Protection Organisation (EPPO) Decision-support scheme (DSS) for quarantine pests (Text provided by S. Brunel)

**Description:** The EPPO Decision-support scheme for quarantine pests (EPPO DSS) is a comprehensive framework for Pest Risk Analysis (PRA) which has been developed by EPPO over the past 10 years through its international Panel on Pest Risk Analysis Development (EPPO 2011). The EPPO DSS has recently been updated with the outcomes of the FP7 European Research project PRATIQUE (https://secure.fera.defra.gov.uk/pratique/) in order to be consistent and complete in its questions and guidance (Pyšek, Schrader et al. 2012). The EPPO DSS is currently used by EPPO to perform PRAs at the EPPO scale. The scheme is used in EPPO countries and has also been adapted in the UK and in the Netherlands. PRAs produced with the EPPO DSS represent scientifically based justifications to the listing of species as quarantine pests, in line with the World Trade Organization requirements. The Pest Risk Management part is designed to identify preventive measures to the entry of the species assessed.

The EPPO DSS has been developed following rigorously the International Standard for Phytosanitary Measures n°11 of the International Plant Protection Convention (IPPC) (IPPC 2013). Pests as defined by the IPPC (including viruses, bacteria, nematodes, insects, etc. as well as plants) are the target of the EPPO DSS. The scheme asks questions on the probability of entry, establishment, spread and impacts on agriculture, the environment as well as on socio-economic interests. An environmental impact assessment module (Kenis, Bacher et al. 2012) included in the scheme can also be used on its own to assess the present and potential ecological impact of invasive plants and plant pests (Pyšek, Schrader et al. 2012).

**Assessment approach:** for each question, a rating is provided on a five-point scale basis, with a level of uncertainty (assessed as low, medium or high) and a referenced justification. Assessments are based on qualitative or semi-quantitative available evidence (scientific or expert opinion). At each stage (e.g. probability of entry, probability of establishment) a summary and a combination of all the answers is made. A specific section considers environmental impacts, including negative impacts on native biodiversity, alteration of ecosystem processes and patterns and conservation impacts.

**Outcome:** the outcome of the Pest Risk Assessment determines whether the species qualifies as a quarantine pest, and whether Pest Risk Management should be undertaken to identify adequate preventive measures. After an EPPO PRA is completed, reviewed and approved by the 50 EPPO Member Countries, the species assessed is recommended for regulation.

**Robustness:** The EPPO DSS provides a complete assessment of the following aspects: entry, establishment, spread, agricultural, economic, environmental and social impacts. Modules to summarize uncertainty and to visualize the different ratings provided for a section (e.g. for establishment) are available. For each question, guidance is provided as well as examples for the different ratings. Each PRA undergoes a comprehensive review process. After an Expert Working Group has elaborated a PRA, the document is sent for review to core members on PRA as well as to the dedicated EPPO Panel, and is then approved by the EPPO Working Party on Phytosanitary Regulations and by the EPPO Council. The full PRA and PRA report are then published on the EPPO website, with a datasheet on the species.

**Application:** Over 35 EPPO PRAs have been performed (see http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm), and 5 EPPO PRAs are undertaken each year in the framework of an EPPO Expert Working Group (see for instance https://www.eppo.int/MEETINGS/2013_meetings/EWG_PTNHY.htm). National risk assessments are also undertaken with this scheme. More than 4 training courses have been organized for EPPO countries (see for instance http://archives.eppo.int/MEETINGS/2008_conferences/PRA_training.htm and http://www.eppo.int/MEETINGS/2012_meetings/training_PRA.htm).

**Internet:** http://www.eppo.int

## 2. European and Mediterranean Plant Protection Organisation (EPPO) Prioritization Process for invasive alien plants (Text provided by S. Brunel)

**Description:** 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 pest risk analysis (PRA) (EPPO 2012). This process has been developed by the EPPO Panel on invasive alien plants over 5 years and has been tested on more than 50 species recorded in the EPPO framework (EPPO List of IAP, EPPO Observation list of IAP, EPPO Alert list). The EPPO PP is also being tested and used in countries such as Serbia.

The EPPO PP has been designed for plants. The process can be applied at any scale (a country or Europe) and the species may be present or absent from the area under assessment. Distribution, spread potential and 3 types of potential negative impact are considered: impacts on native species, habitats and ecosystems; impacts on agriculture, horticulture or forestry; and additional impacts (e.g. on animal and human health, infrastructures, recreational activities). If the species is considered invasive, the EPPO PP then assesses whether the species represents a priority for a PRA, in line with the International Standard for Phytosanitary Measures n°11 of the International Plant Protection Convention (IPPC) (IPPC 2013).

**Assessment approach:** The first part of the scheme is composed of eight questions on the distribution, spread potential and impacts. The second part assesses three questions whether the species represents a priority for PRA based on its pathway of entry and distribution in the area under assessment. For each question, a rating should be provided on a three-point scale basis (low, medium, high), with a level of uncertainty (assessed as low, medium or high) with a referenced justification. Assessments are based on qualitative or semi-quantitative available evidence (scientific or expert opinion).

**Outcome:** The outcome of the EPPO prioritization process determines whether the species qualifies as an invasive alien plant and whether pest risk analysis represents a priority for the species. After a prioritization assessment report is completed and reviewed, the species is placed within the EPPO List of IAP, the Observation list of IAP or is not a concern. If registered in the List of IAP, it is also determined whether the species represents a priority for an EPPO PRA.

**Robustness:** The EPPO PP provides a rapid assessment on the invasive behaviour of the species (by assessing spread and impacts of the species). For each question, guidance is provided as well as examples for the different ratings. Guidance is also provided to assess uncertainty. Each prioritization assessment undergoes a comprehensive review process. The prioritization report for a species is reviewed by the EPPO Panel on IAP, and the listing of the species is then approved by the EPPO Working Party on Phytosanitary Regulations and by the EPPO Council. The prioritization reports are then published on the EPPO website.

**Application:** Over 50 invasive alien plants have been assessed through the EPPO PP. Assessments are done through a consensus by confronting assessments at the EPPO scale and at countries' scales. A few species are assessed each year (see http://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm). National assessments are also undertaken with this scheme. Two training courses have so far been organized for EPPO countries.

**Internet:**

http://www.eppo.int

http://www.eppo.int/INVASIVE_PLANTS/ias_prioritization.htm

http://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm

### 3. Invasive Species Environmental Risk Assessment (ISEIA) (Text provided by E. Branquart)

**Description:** The development of the ISEIA risk assessment scheme has been conducted between 2007 and 2009 within the activities of the Belgian Biodiversity Platform, an initiative of the Belgian Science Policy Office (Branquart 2007, Branquart, Verreycken et al. 2010). It allows quick assessment, categorization and listing of non-native species according to their invasion stage in Belgium and to their impact on native species and ecosystem functions. It is one of the first national standardized risk assessment tools developed for non-native species in Europe and has been available online since 2007.

**Assessment approach:** The ISEIA scheme incorporates ten different questions related to four main criteria matching the last steps of the invasion process: (1) potential for spread, (2) colonisation of natural habitats and adverse ecological impacts on (3) native species and (4) ecosystems. As such, it is not a predictive tool as it is based on invasion histories documented from Belgium and neighboring areas characterized by similar eco-climatic conditions (entry and establishment capacity are not assessed). Consistent with other risk assessment standards, equal weight is assigned to each of the four criteria and a three-point scale is used for criteria scoring: low (or unlikely), medium (or likely) and high. The total ISEIA score is calculated as the sum of risk rating scores of the four criteria. To minimize linguistic uncertainty, ISEIA provides ample and precise guidance with every question and alternative answer. ISEIA can be used for any taxonomic group, geographic area and type of environment, but most of the guidance is based on Belgium and the terrestrial and freshwater environments.

**Outcome:** ISEIA allows for numerical output and allocation of non-native species to different list categories defined by the level of environmental risk (white, watch and black lists) combined with their invasion stage in the country.

**Robustness:** ISEIA allows a quick screening of all alien species already established in a reference area. It has been designed to minimize the use of subjective opinions and to make the process of assessing and listing invasive species transparent and repeatable.

**Applications:** Approximately 100 species have been assessed so far based on the ISEIA scheme in Belgium (vascular plants, vertebrates). It has also been widely used in neighboring countries, e.g. for a horizon scanning exercise in GB (Parrott, Roy et al. 2009), for risk scoring in Dutch non-native species risk analyses and for the development of a black list system in Luxembourg (Ries, Krippel et al. 2013).

**Internet:** http://ias.biodiversity.be

## 4. Harmonia$^+$ (Text provided by B. D'hondt and E. Branquart)

**Description:** The development of the *Harmonia*$^+$ risk analysis scheme was commissioned by the Belgian Science Policy Office (BELSPO, federal government), and lasted from Autumn 2012 until March 2014 (D'hondt, Vanderhoeven et al. 2014). It was developed by a consortium of eight Belgian scientific institutions, each of which provided input from their field of expertise on particular components of the scheme. *Harmonia*$^+$ is intended to be the improved and more complete version of its predecessor, the Belgian ISEIA protocol. It was constructed parallel to *Pandora*⁺, which is a risk analysis scheme for emerging pathogens and parasites.

**Assessment approach:** *Harmonia*⁺ essentially is a questionnaire, bringing together all questions deemed relevant for assessing the risk of potentially invasive organisms to a particular area. In a full assessment, an assessor answers a question by [1] selecting one of the pre-defined answers (type 'low', 'medium' or 'high') [2] by indicating a level of confidence with the answer provided ('low', 'medium' or 'high') and [3] by providing textual comments on top of that. To minimize linguistic uncertainty, *Harmonia*⁺ provides ample and precise guidance with every question and alternative answer. *Harmonia*⁺ can essentially be used for any taxonomic group, geographic area and type of environment, but most of the guidance is based on Belgium and the terrestrial environment.

**Criteria:** *Harmonia*⁺ was explicitly designed to be as complete as possible with regard to invasion stages and types of impacts covered. It 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 (3), Establishment (2), Spread (2), Environmental impacts (6), Plant health impacts (5), Animal health impacts (3), Human health impacts (3) and impacts on Infrastructure (1). The number of alternative answers for these questions is five (where possible) or three.

**Outcome:** *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). However, *Harmonia*⁺ may also be used to generate textual output, by emphasizing the answers provided, and the comments to answers, instead of its mathematical processing.

**Robustness:** *Harmonia*⁺ is considered to be a robust risk analysis scheme at least because of the following structural underpinnings : [1] scientific experts from very different fields were contracted to provide input on components of the scheme [2] it strived to be maximally compliant with authoritative bodies from these fields (cf. EPPO in plant health, OiE in animal health, WHO in human health) [3] the invasion stages are based on a unified framework for biological invasions [4] scientific literature was used as the primary information source during protocol development.

**Applications:** Given its recent date of finalization, *Harmonia*⁺ has so far only been used in a preliminarily way, by external experts for five species (*Lithobates catesbeiana, Ludwigia grandiflora*, *Nyctereutes procyonoides, Procambarus clarkii* and *Threskiornis aethiopicus*). The results accord well with those of the former ISEIA protocol. *Harmonia*⁺ is envisioned to be used in a multi-expert set-up to reach consensus scores for as many criteria as possible.

The scoring system of the Harmonia⁺ protocol will also be used in the coming months to quantify the level of risk linked to the establishment of 23 non-native species in Belgium for which separate reports were prepared on the basis of an extensive literature review. Impact on biodiversity, plant health, animal health, human health will be assessed separately. Altogether this information will form very detailed risk analysis reports for each of the 23 species.

**Internet:**

http://ias.biodiversity.be/harmoniaplus (risk analysis scheme and scoring system);

http://ias.biodiversity.be/species/risk (risk analysis reports for the 23 non-native species)

## 5. Pandora⁺ – a risk screening procedure for IAS-hosted pathogens and parasites (Text provided by B. D'hondt)

**Description:** The *Pandora*⁺ risk analysis scheme for emerging pathogens and parasites was developed parallel to the *Harmonia*⁺ scheme on invasive plants and animals (D'hondt, Vanderhoeven et al. 2014, D'hondt, Vanderhoeven et al. 2014). Both protocols are therefore much alike. It was commissioned by the Belgian Science Policy Office (BELSPO), developed by a consortium of eight Belgian scientific institutions, and finalized in March 2014.

*Pandora*⁺ assesses the risk of an emerging pathogen or parasite that may be carried by an invasive plant or animal host. Results of *Pandora*⁺ may feed in directly to a *Harmonia*⁺ assessment.

**Assessment approach:** *Pandora* includes 20 questions with regard to pathogen emergence and its consequences, divided by modules (Entry; Exposure; Environmental health, Plant health, Animal health, Human health, and other consequences).

**Outcome:** Analogous to *Harmonia*⁺.

**Robustness:** Analogous to *Harmonia*⁺.

**Applications:** Given its recent date of finalization, *Pandora*⁺ has so far only been preliminarily used, by external experts on ten pathogen cases.

**Internet:** http://ias.biodiversity.be

## 6. Great Britain Non-native Species Risk Assessment (GB NNRA) (Text provided by O. Booy)

**Description:** The GB Risk Analysis mechanism comprises risk assessment, risk management and risk communication; the risk assessment component (GB Non-native Risk Assessment scheme, or GB NNRA) is the most developed and described here. The GB NNRA was commissioned by the Department for Environment, Food and Rural Affairs (Defra), with support from the Scottish Government (SG). It was developed in 2005 by a consortium of risk analysis experts and based largely on the risk assessment tools used by the European Plant Protection Organization (Baker, Black et al. 2008). Since its inception the GB NNRA has been improved and refined, most notably following a review undertaken in 2006 during which the process was trialled and peer reviewed by risk analysis experts operating similar schemes in Australia and New Zealand (Booy, White et al. 2006). The output of the GB NNRA contributes to the evidence base used by policy makers in Great Britain and has been used to help underpin legislation as well as other regulatory requirements (e.g. Water Framework Directive and Aquaculture Regulation in the UK).

The GB NNRA can be used to assess non-native species from any taxonomic group or environment, either established in the territory or not. It comprises a series of detailed questions, based on those developed by EPPO, divided into four sections: entry, establishment, spread and impact. Economic, environmental and social impacts are assessed, with a particular focus on potential biodiversity and ecosystem impacts. Experts complete the assessments, providing response scores supported by evidence as well as confidence scores. Each assessment is peer reviewed by an additional independent expert and the process is overseen by a panel of risk analysis experts (known as the NNRAP) whose role is to ensure the quality and consistency of the assessments. Risk assessments are published and stakeholders are encouraged to comment on and refine evidence presented. In addition to the full detailed risk assessments, a shorter 'rapid' assessment can be used to illicit responses more quickly, but with less detail.

**Assessment approach:** There are 80 questions in total in the full risk assessment, divided by section: screening (21); entry (11); establishment (17); spread (9); impact (18); with additional questions on the potential impact of climate change (3) and research requirements (1). Apart from the screening section, which requires 'yes / no / text' responses, all responses are scored on a semi-quantitative 5 point scale (effectively from very low to very high) with confidence recorded on a 4 point scale (low, medium, high and very high). Summary scores are given for each section and an overall risk score is calculated based on all of the scores given in the assessment. All responses are supported by comments, including reference to published literature where available and expert judgment where not.

**Outcome:** Risk summary sheets are produced for each assessment, to inform policy / decision makers. These provide a summary of key points from the assessment, including the summary response and confidence scores for each section (entry, establishment, spread and impact) as well as the overall risk score and associated confidence. Risk scores are not directly translated into policy or legislation, but provide part of the evidence base upon which this is done. The GB Risk Management process is currently being developed in order to assist decision makers in prioritizing species not solely on the risk they pose, but also on the feasibility of responding to them.

**Robustness:** The GB NNRA scheme is a comprehensive risk assessment based on that used by EPPO, which is recognized in international law.

**Applications:** In total 125 assessments have been completed or are in progress: 60 assessments have been published (vascular plants, invertebrates, vertebrates; marine, freshwater and terrestrial) with 16 more complete and awaiting publication. Horizon scanning is used to prioritize new species to assess.

## 7. German-Austrian Black List Information System (GABLIS) (Text provided by W. Rabitsch)

**Description:** The development of GABLIS was commissioned by the German Agency for Nature Conservation (BfN). The method was recently updated (Version 1.2) with the aim to reduce some ambiguities and further improve the system (Essl, Nehring et al. 2011, Nehring, Essl et al. 2013). It is currently used in Germany, but not in Austria. It is not legally binding, but offers management recommendations on how to deal with invasive alien species (e.g. eradication, control, monitoring).

The system is a Black List approach, i.e. species are assessed and prioritized according to their negative impact on all elements of biodiversity (genes, species, and ecosystems). Socio-economic impacts (incl. human health) are intentionally excluded in the assessment, but have to be documented in the accompanying data sheet, including benefits that may be obtained from the use of the species. The system can be applied without modification to all taxonomic groups and environments and to all species if present or absent in the assessment region (Nehring, Kowarik et al. 2013).

**Assessment approach:** There are five basic impact criteria and six complementary ecological criteria that have to be answered "Yes/Assumed/Unknown/No". Assessments are based on qualitative or semi-quantitative available evidence (scientific or expert opinion).

**Outcome:** Based on the level of certainty of the impact, the species is listed either in a Black, Grey or White List (Nehring, Essl et al. 2010, Rabitsch, Gollasch et al. 2013). "Yes" means that there is scientifically sound evidence of the impact and leads to the Black List. "Assumed" means less confidence about the impact and species may be placed on the Grey List. The Black and Grey List are subdivided according to the distribution of the species and the availability of management techniques (BL-Warning List, BL-Action List, BL-Management List; GL-Observation List, GL-Operation List).

**Robustness:** GABLIS allows a quick screening of all alien species and includes consideration of uncertainty.

**Applications:** Approximately 200 species have been assessed so far (vascular plants, vertebrates) and additional animal groups will be assessed over the next years.

**References:** (Essl, Nehring et al. 2011)

## 8. Norwegian alien species impact assessment (Text provided by H. Sandvik)

**Description:** The development of the Norwegian set of criteria was commissioned by the Norwegian Biodiversity Information Centre (Artsdatabanken) (Sandvik, Sæther et al. 2013). It has been used to produce Norwegian lists of alien species in 2012 (Gederaas, Moen et al. 2013). It is not legally binding, but constitutes the basis of management decisions by the Norwegian Environment Agency (Miljødirektoratet).

The set of criteria assesses the negative ecological impact of alien species along two separate axes, viz. invasiveness and effect. Effects on all elements of biodiversity are considered (genes, populations, species, and habitat types). Socio-economic impacts (incl. human health) are intentionally excluded in the assessment, but are documented in the accompanying species description. The criteria are applicable to all taxonomic groups and environments and to all species, whether present or absent in the assessment region.

**Assessment approach:** There are three criteria to assess invasiveness (likelihood and extent/velocity of establishment and expansion) and six criteria to assess ecological effects. Based on documented evidence, each species is assigned to one out of four partial categories for each of the nine criteria, the thresholds between which are defined numerically (for invasiveness) or semi-quantitatively (for effects). A score is provided for invasiveness (roughly as the product of likelihood of establishment and velocity of expansion) and for effect (as the maximum score attained by the six criteria).

**Outcome:** Based on the invasiveness scores and effect scores, the species are assigned to one out of five impact categories: no known impact (NK), low impact (LO), potentially high impact (PH), high impact (HI), and severe impact (SE). The latter two categories constitute the Black List.

**Robustness:** The application of the Norwegian set of criteria in 2012 suggests that it allows a robust impact assessment of all alien species across taxa and habitats. No formal assessment of robustness (e.g. repeatability analysis) has been carried out.

**Applications:** In 2012, all 2320 multicellular alien species known to occur in Norway have been evaluated. Formal assessments using this set of criteria were carried out for the 1180 species known (or suspected to be able) to reproduce in the wild in Norway. In addition, 203 potential future alien species were assessed (so called "door knockers", horizon scanning).

## 9. Generic Impact Scoring System GISS (Text provided by W. Nentwig)

**Description:** The Generic Impact Scoring System (GISS) is a semi-quantitative scoring system which measures the impact of alien and invasive species as environmental and economic impact in 12 impact categories. As a generic system, it allows a direct comparison of species and it can be used for all taxonomic groups of animals and plants. GISS primarily allows ranking and prioritization of species according to their impact, but can also be used to establish black lists or warning lists at country level (Kumschick and Nentwig 2010, Nentwig, Kühnel et al. 2010, Kumschick, Alba et al. 2011).

GISS is characterized by (1) a systematic consideration of the total impact an alien and invasive species has and (2) by relying primarily on scientifically published information. Impact is measured in 12 categories, each with five intensity levels. By adding the impact scores of a given species, a total impact value is obtained. By default, all 12 impact categories are considered equally important, but it is possible to give different weights to selected impact categories.

**Assessment approach:** GISS asks for known impact in the environmental range (on plants or vegetation, on animals through predation or parasitism, on other species through competition, through transmission of diseases or parasites to native species, through hybridization, on ecosystems) and in the economic range (on agricultural production, on animal production, on forestry production, on human infrastructure and administration, on human health, on human social life), thus, including socio-economic aspects. The assessor has to attribute a given impact to five intensity levels and to three confidence levels.

**Outcome:** The primary outcome of a GISS application is the sum of total impact scores of a given alien species. This value can be used for ranking and prioritization of species, for black lists or warning lists, and for management recommendations. Depending on the area assessed, it is applicable on a large scale (e.g., Europe) or at country level.

**Robustness:** The application of GISS is performed with a questionnaire which includes detailed descriptions of all impact categories and intensity levels. This makes GISS a robust impact assessment that allows a quick screening of all alien species with known impact.

**Application:** About 350 species have been scored so far (terrestrial and aquatic species of invertebrate and vertebrate animals, as well as vascular plants) (Nentwig, Kühnel et al. 2010, Vaes-Petignat and Nentwig 2014).

## 10. The Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts (“IUCN Black List”) (Text provided by T. Blackburn)

**Description:** The classification scheme was the outcome of a working group entitled sImpact, formed to consider various aspects of alien species impacts, at sDiv, the Synthesis Centre within the German Centre for Integrative Biodiversity Research (iDiv) Halle- Jena-Leipzig. The idea was to produce a scheme that was functionally similar to the IUCN Red List of Threatened Species, which has a proven track record as a method robustly to classify species in terms of the consequences of a broad variety of impacts (Mace, Collar et al. 2008).

The classification scheme is a Black List approach, but one that identifies different levels of impact within the Black List. It is based on the mechanisms of impact used to code species in the IUCN Global Invasive Species Database, and the semi-quantitative scenarios describing impacts developed by Nentwig et al. (2010). There are thirteen different impact mechanisms for which impact can be assessed, and semi-quantitative scenarios describing five levels of impact under each mechanism; the levels are aligned and consistent across mechanisms. These scenarios under each mechanism are used to assign species to different levels of impact, where assignment corresponds to the highest level of deleterious impact associated with any of the mechanisms. Socio-economic impacts are intentionally excluded. The system can be applied without modification to all taxonomic groups and environments and to all species if present or absent in the assessment region, but currently requires that a species is alien somewhere to be assigned to an impact category.

**Assessment approach:** Species with alien populations can be assigned to five different categories describing increasing levels of impact – Minimal, Minor, Moderate, Major or Massive. The scheme also includes categories for species that are Not Evaluated, have No Alien Population, or are Data Deficient, and a method for assigning uncertainty to these classifications. Assessments are based on the fit of available evidence to the scenarios described, as determined by scientific or expert opinion.

**Outcome:** The classification system assigns species to one of the categories described under Criteria, depending on whether or not the species has been evaluated for impacts, whether or not an evaluated species has an alien population, whether or not a species with an alien population has sufficient data to evaluate its impact, and then if it does, at what level its environmental impacts sit. Note that this is a hierarchical process. Categorisation can be assigned high, medium or low confidence. Species may also be formally identified as cryptogenic if their alien status is unclear.

**Robustness:** The classification scheme allows a quick screening of all alien species and includes categories for species that are Not Evaluated, have No Alien Population, or are Data Deficient, and a method for assigning uncertainty to these classifications.

**Applications:** No species have yet been formally assessed using the full scheme (Blackburn, Essl et al. 2014), but the principal has been demonstrated using information collated to assess overall impacts across 6 of the 13 impact mechanisms of the GISD.

### 11. Environmental risk assessment for plant pests (Text provided by M. Kenis)

**Description**: The European Food Safety Authority (EFSA) asked the Panel on Plant Health to develop a guidance document on the environmental risk assessment of plant pests (EFSA on Plant Health 2011). This guidance includes and describes a methodology for assessing the environmental risks posed by non-endemic living organisms harmful to plants and/or plant products that are associated with the movement of plants and plant products, and that may enter into, establish and spread in the European Union. The range of the organisms of concern includes phytophagous invertebrates, plant pathogens, parasitic plants and invasive alien plant species. The document presents an original approach which considers the inclusion of both biodiversity and ecosystem services perspectives in a pest risk assessment scheme.  The ecosystem service assessment section is also described and tested (Gilioli, Schrader et al. 2014).

**Assessment approach:** The scheme is composed of 6 main questions and several sub-questions. The first set of sub-questions defines the background for the environmental risk assessment. The next two questions and series of sub-questions aim at assessing the effect on functional biodiversity in invaded areas and in the risk assessment area, respectively. The biodiversity at the different organisational levels, from infra-individual to landscape/ecosystem levels is considered, and the potential consequences on genetic, species and landscape diversity are assessed and scored separately. There is a consistent distinction between elements of structural biodiversity that are legally protected, and elements of native biodiversity, and the consequences for these are scored separately. The impact on ecosystem services in invaded areas and in the risk assessment area is assessed in the next two questions. The scheme evaluates the consequences for ecosystem services caused by the pest to determine how great the magnitude of reduction is in the provisioning, regulating and supporting services affected in the current area of invasion and in the risk assessment area. The scheme considers the list of the ecosystem originally proposed by the Millennium Ecosystem Assessment. The last question covers potential positive effects.

**Outcome:** The rating system is based on a probabilistic approach. It includes an evaluation of the degree of uncertainty. The rating system makes it possible to evaluate the level of risk and the associated uncertainty for every sub-question and then the overall risk and uncertainty for every question. At the end of the assessment process, the level of overall risk related to questions on biodiversity is categorized as either Minor, Moderate or Major, while for questions on ecosystem services, the categorisation is either Minimal, Minor, Moderate, Major or Massive. The degree of uncertainty is categorized as Low, Medium or High.

**Robustness:** The protocol is rather recent and has probably not been sufficiently applied to properly test its robustness. However, the probabilistic approach of the rating system ensures consistency and transparency of the assessment.

**Applications:** The EFSA protocol is new and has been used only a few times. Originally developed for plant pests, new unpublished versions are presently being developed and tested for other organisms.

## 12. The BINPAS impact assessment system of the AquaNIS database (Text provided by D. Minchin and S. Olenin)

**Description:** The BINPAS system is designed to compile data on IAS and their impacts into uniform biopollution measurement units (Olenin, Minchin et al. 2007, Olenin, Elliott et al. 2011, Narščius, Olenin et al. 2012, Olenin, Narščius et al. 2013). Biopollution is defined as the impacts of IAS at the level which disturbs ecological quality of aquatic and terrestrial ecosystems by effects on: an individual (internal biological pollution by parasites or pathogens), a population (by genetic change, i.e. hybridization), a community (by structural shift), a habitat (by modification of physical-chemical conditions), an ecosystem (by alteration of energy and organic material flow). The theoretical background of the system was designed during the ALARM and DAISIE FP6, its technical implementation was made during a FP7 project MEECE and it was merged as a block of the information system on aquatic non-indigenous and cryptogenic species AquaNIS (http://www.corpi.ku.lt/databases/aquanis) within a FP7 project VECTORS (Karosienė, Kasperovičienė et al. 2013).

A standardized description and evaluation of impacts is required and defined within a studied area for a specific time period, so enabling temporal comparison. The abundance and distribution range is then assessed. The biopollution impact is then be calculated based on impacts to communities, habitats or ecosystem function on a five-point scale ranging from weak impact (where it is not measurable) to massive impact (where there is extensive trophic re-arrangement). Evaluating the levels of these impacts will normally require historical information. BINPAS is a part of AquaNIS, which system stores and disseminates information on non-indigenous (NIS) introduction histories, recipient regions, taxonomy, biological traits, impacts, and other relevant documented data. Currently, the system contains data on NIS introduced to marine, brackish and coastal freshwater of Europe and neighboring regions (Zaiko, Lehtiniemi et al. 2011, Wittfoth and Zettler 2013), but can be extended to other world regions.

**Assessment approach:** The objective is to aid in the prioritization of management options and decisions, by aiding in the compilation of IAS target [‘black’], interregional comparison of IAS impacts and assessing status in relation to the management of the EU Water Framework Directive and the Marine Strategy Framework Directive legislative requirements. Managers require accurate knowledge on bioinvasion impact on native communities, habitats and ecosystem functioning which this system seeks to provide. References are supplied to qualify each dataset input. The advantage is that it is possible to make cross-taxon and interregional comparison of bioinvasion effects, facilitate development and application of the bioinvasion assessment method(s), and to provide a platform for constant update and quality control of data.

**Robustness:** The abundance and distribution range matrix is easily applied and must be undertaken before the biopollution assessment is undertaken. While there is a requirement for historical information to undertake the biopollution level there are indications, for some species, that the abundance and distribution range can act as a proxy for a biopollution level. There have been some difficulties in making a full biopollution assessment as the required historical information may not be available. BINPAS and AquaNIS seek to ensure the long-term maintenance and reliability of the database by continuous update and scientific validation of its data, making it useful for research and practical for management.

**Applications:** BINPAS which presently contains 571 assessments of 221 species from 255 areas. All entered data is compatible and linked to the taxonomy of the World Register of Marine Species (WoRMS) (Olenina, Wasmund et al. 2010, Minchin 2012, Minchin and White 2014). In the AquaNIS database there are several interrelated blocks under development, including specific lists for European ports. While BINPAS is available for entries at any time, the AquaNIS database is gradually being opened for free access according to Large Marine Ecosystem areas, seven of these are currently available for Northern European seas.

**Internet:** http://www.corpi.ku.lt/databases/binpas

## 13. Fish Invasiveness Screening Kit (FISK) (Text provided by G. Copp)

**Description:** FISK is a risk identification, decision-support tool for assessing the likelihood of a non-native freshwater fish becoming invasive in the selected risk assessment area (Copp, Vilizzi et al. 2009, Copp 2013). FISK was originally adapted from the Weed Risk Assessment (WRA) (Pheloung, Williams et al. 1999) during the development of a two-part risk analysis scheme for non-native freshwater fishes in the UK (Baker, Black et al. 2008). To broaden the geographical applicability of FISK to warm temperate and sub-tropical areas, FISK v1 was subjected to intensive review, both in terms of questions and guidance but also in the functionality of the user interface. The result was FISK v2 (Lawson, Vilizzi et al. 2012), which like the WRA and FISK v1 is provided in Excel® with a VisualBasic driven drop-down menu system for inputting responses to questions and confidence (certainty) rankings.

As with the WRA and its other four 'sister' tools, FISK consists of a series of 49 questions (responses: Yes/No/Don't Know) that are answered for the species under evaluation by assessors based on their expert evaluation of published literature. The literature used should be from peer-reviewed sources, though 'grey' literature and other available information may be used (with caution) when information on a species is lacking. With each response, the assessor is expected to provide a justification for the response as well as to indicate their level of confidence (certainty ranking) associated with the response.

**Assessment approach:** FISK questions examine the biogeography and history of the species, the presence of "undesirable traits" and species biology and ecology, and relies on the generally accepted premise that weeds in other parts of the world have an increased chance of being weedy (i.e. invasive) in other areas with similar environmental conditions (Pheloung 2001). Each question is scored, generally on a scale of -1 to +1, to produce a total numerical score that is positively correlated with 'weediness' (Pheloung, Williams et al. 1999). Each score is assigned to a category (agriculture, environmental, nuisance or combined), so that when the final score is calculated the sector most likely to be affected can be identified.

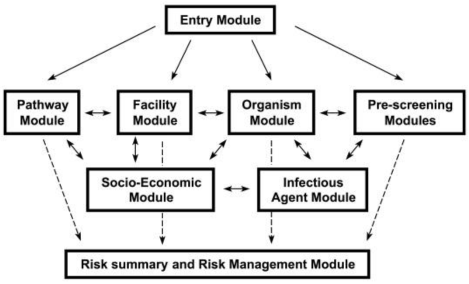
**Outcome:** The total score is then compared against a set of critical values that determine whether a species poses a high, low or uncertain risk of becoming invasive. Receiver Operator Characteristic (ROC) curve analysis is used to calibrate FISK scores for the risk assessment area to determine for that area the threshold between the species that pose a high risk of being invasive and those that pose a medium or low risk of being invasive. The overall level of certainty associated with each assessment is available to assist decision makers in evaluating the risks of the species being invasive in their area and any potential benefits the introduced species may provide.

**Robustness:** FISK has proved to be a useful means of identifying potentially invasive freshwater fishes in at least 16 countries across five continents (Copp 2013). Its 'sister' decision-support tool, FI-ISK (Freshwater Invertebrate Invasiveness Screening Kit) has been used widely  (Tricarico, Vilizzi et al. 2010, Papavlasopoulou, Perdikaris et al. 2014).

**Applications:** As one of fish screening tools for non-native aquatic species, FISK is used as an invasive species identification tool both to complement full risk assessment schemes, e.g. the GB NNRA (Baker, Black et al. 2008, Mumford, Booy et al. 2010) and the European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) (Copp, Russell et al. 2014) and as a stand-alone screening tool applied so far to at least 16 countries across five continents (Copp 2013).

## 14. European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) [text provided by G. Copp]

**Description:** The European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) was developed in response to European 'Council Regulation No. 708/2007 of 11 June 2007 concerning use of alien and locally-absent species in aquaculture' (EC-ASR) to provide protocols for identifying and evaluating potential risks of using alien species in aquaculture (Copp, Britton et al. 2008, Copp, Russell et al. 2014). Having been adapted from GB NNRA and the EPPO, ENSARS is modular in structure (see below) and provides a means for carrying out a full risk assessment of any aquatic plant or animal, though it is intended mainly for those being used in aquaculture.




ENSARS modular structure (from Copp et al. 2014a).

**Assessment approach:** Seven of the eight ENSARS modules contain protocols for evaluating the risks of escape, introduction to and establishment in open waters, of any non-native aquatic organism being used (or associated with those used) in aquaculture, i.e. transport pathways, rearing facilities, infectious agents, and the potential organism, ecosystem and socio-economic impacts (Copp, Russell et al. 2014). A concluding module is designed to summarise the risks and consider management options (Cowx, Angelopoulos et al. 2009). Each ENSARS module consists of several essential questions, which are accompanied by guidance, with each question requiring a response, a justification for the response and an indication (ranking) of the assessor's confidence in that response. Responses to questions involve an indication of likelihood (very unlikely to very likely), magnitude (very limited to very great) or similarity (e.g. not similar to very similar), with all scores ranging from 0 to 4 and confidence rankings being from 0 to 3 (low to very high). Each module may be used individually, and each requires a specific form of expertise, so a multi-disciplinary assessment team is required.

**Outcome:** Each ENSARS module provides an overall numerical score and confidence ranking, which are complemented by summary scores for each of the main sections of that module. Confidence rankings reflect the type and extend of evidence used to formulate responses to questions – those based on published (peer-reviewed) evidence attracting a higher confidence ranking and those based on circumstantial evidence or assessor opinion attracting a lower confidence ranking.

**Robustness:** The ENSARS score outputs are similar to those generated by the GB Non-native Risk Scheme, and in general terms to those produced by invasiveness screening tools, (e.g. FISK and its 'sister' tools, (Copp, Vilizzi et al. 2009)and therefore suitable for calibration using the same analytical approach as applied to FISK (Copp, Vilizzi et al. 2009) and to the EPPO DSS and GB NNRA (Holt, Leach et al. 2012).

**Applications:** ENSARS has been applied to 12 fish and three invertebrate species (Copp and Godard 2014), which are those species identified in Annex IV of the EC Alien Species Regulation as eligible for exemption from the Regulation if deemed appropriate by the Competent Authority of the Member State concerned.

**References with URL links:**

http://cefas.defra.gov.uk/media/437410/impasse_44142_d3-2.pdf

## Brief notes on other European assessment protocols

### Freshwater Invertebrate Invasiveness Scoring Kit (FI-ISK)

Tricarico et al. (2010) proposed the Freshwater Invertebrate Invasiveness Scoring Kit (FI-ISK) as a screening tool for identifying potentially invasive freshwater invertebrates and tested it with alien crayfish species. FI-ISK was adapted from the Fish Invasiveness Scoring Kit (FISK). After calibration for score thresholds into low-, medium-, and high-risk categories, and 'receiver operating characteristic curves' FI-ISK was able to distinguish accurately between potentially invasive and non-invasive species of non-native crayfish (Tricarico, Vilizzi et al. 2010). FI-ISK originates from the UK but has been applied in Flanders and Belarus (Verbrugge, van der Velde et al. 2012).

### Managing non-native fish in the environment

Britton et al. (2011) developed a modular assessment scheme for assisting the risk management of introduced fishes in England but this risk management tool provides useful reflections relevant to risk assessment. Furthermore, the application of this protocol elsewhere (and even to other faunal groups) is considered possible and aims to enable more objective decision-making in management programmes and enhance conservation outcomes. The method proposed enables prioritisation of the introduced fishes in a risk assessment area according to their potential invasiveness and current distribution, then assesses populations in relation to the character of their receiving waters and the potential risks posed by their population in that circumstance (Britton, Copp et al. 2011). The output is a suggested management action for each population. The third module evaluates the suggested management action in relation to its potential impacts in the environment and how these impacts may be mitigated. The final module assesses the estimated cumulative cost of the selected management action relative to an alternative action. This method was not considered further because it is an invasion management tool as opposed to a risk assessment method.

## Brief notes on non-European risk assessment protocols

### Australian Weed Risk Assessment (WRA)

The Australian Weed Risk Assessment (WRA) process was adopted 1997 following consultation with government and stakeholders. Its outcomes are accepted in national legislation (*Environment Protection and Biodiversity Conservation Act 1999*) and it is compliant with WTO SPS Agreement and the IPPC. The WRA is a science-based quarantine risk analysis for determining the potential 'weediness' of potential new plant imports. The process consists of a 3-tiered system: status determination (is the species present in the risk assessment area or not), weed risk assessment (WRA) and post-entry evaluation. The WRA system is a question-based assessment of the weed potential of plants proposed for import. The assessment involves answering up to 49 questions (yes/no/unknown or numerical response) on specific characteristics of the species. The answers generate a numerical score relating to the weed potential of that plant and the score is then used to determine an outcome: accept the species for importation; reject the species for importation; or reject pending further evaluation of the species' weed potential.

The Australian WRA system is internationally recognized as one of the best systems to determine the potential of plant species to become weeds of agriculture and/or the environment. Modified versions of the WRA system have been tested, e.g. in Hawaii (Daehler, Denslow et al. 2004)(Daehler & Carino 2000), Florida (Gordon et al. 2008a), the Czech Republic (Kriválek & Pyšek 2006) and across varied geographies (Gordon et al. 2008b). Kriválek & Pyšek (2006) demonstrated the applicability of the Australian WRA to temperate Europe through their study on woody plant species but concluded the inclusion of additional analyses were necessary.

### Risk assessment models for vertebrate introductions to Australia

Bomford (2008) presented updated risk assessment models for the introduction of birds and mammals, of freshwater fish, and of reptiles and amphibians to Australia and new models to assess the risk that mammals and birds could establish in New Zealand. Using simple quantitative models considering propagule pressure, climate match, history of establishment elsewhere, and taxonomic group, the risk of establishment can be calculated, and a species ranked at four levels: low, moderate, serious or extreme. While the models may not estimate the probability of establishment success for every species to a high level of accuracy, the low cost of using such models allows large numbers of potential invaders to be screened.

**Trinational Risk Assessment for Aquatic Alien Invasive Species**

The Biodiversity Conservation Working Group within the Commission for Environmental Cooperation (CEC), which was established by the North American Agreement on Environmental Cooperation (NAAEC) as a side agreement to the North American Free Trade Agreement (NAFTA), developed the Trinational Risk Assessment for Aquatic Alien Invasive Species as Guidelines to North American resource managers who are evaluating whether or not to introduce a non-native species into a new ecosystem (CEC 2009). The two major components of the Risk Assessment Model (Probability of Establishment and Consequences of Establishment) are divided into seven basic elements (e.g. Estimate probability of the organism surviving in transit or Estimate environmental impact if established) that need to be answered as probability or impact estimates (Low/Medium/High) based on quantitative or subjective methods including estimates of uncertainty. High impact IAS within North America identified from this risk assessment could have relevance to Europe.

## Task 1.2 Identify gaps and scope in risk assessment

## Task overview

Here we provide a brief and preliminary discussion on two gaps of general concern that were identified through sub-task 1.1, namely consideration of ecosystem services and user-friendliness linking to consistency of outcomes. Further consideration of gaps and scope is given in Tasks 4 and 5. Indeed, task 4 provides a detailed evaluation of the compliance of risk assessment protocols with agreed minimum standards developed through Task 3. Therefore, gaps and scope in relation to the minimum standards are identified. Task 5 highlights additional constraints of existing risk assessment methods through the implementation of the minimum standards to support the development of a list of proposed “IAS of EU concern”.

*Ecosystem Services*

The forthcoming Regulation of the European Parliament and the Council on the prevention and management of the introduction and spread of IAS, specifically states that risk assessments defining IAS of Union concern should require a description of the adverse impact on biodiversity and the related ecosystem services. Among all European assessment protocols listed in Table 1.4, only one specifically considers impact assessments through effects on ecosystem services, the EFSA (2011) protocol on environmental risk assessments for plant pests. This EFSA protocol explicitly includes the concept of ecosystem services in the assessment by asking questions about ‘the consequences on structural (biodiversity) and functional (ecosystem services) aspects of the environment'(EFSA on Plant Health 2011). It should be noted that 'structure' and 'functionality' of ecosystems in an ecological context (and most environmental impact assessments) is understood in a different way (e.g. structural diversity or nutrient cycling of ecosystems). Furthermore, the current conceptual frameworks for ecosystem services, such as the ecosystem services cascade model by (Potschin and Haines-Young 2011) make a clear distinction between ecosystem structures, processes and functions, and related services and benefits provided. The purpose of this is to show that ecosystem services and benefits to people depend on functional ecosystems and that the ecosystem processes and ecosystem services are not necessarily one and the same (i.e. single ecosystem service can be the product of two or more processes or alternatively a single process can contribute to more than one service).

The risk assessment protocol devised by EFSA (EFSA Panel on Plant Health 2011) uses a rating system based on a probabilistic approach with an evaluation of the degree of uncertainty. For the list of the ecosystem services to be considered, EFSA adopted the MEA (Millennium Ecosystem Assessment 2005) classification, recognizing that methodological developments will emerge as experience accumulates. Specifically, the problem of double accounting due to partly overlapping MEA classifications needs attention. The issue of overlaps and double counting has been addressed in more recent ecosystem services classification systems such as TEEB (TEEB 2010) and CICES (http://cices.eu/). The section of the EFSA protocol focusing on ecosystem services was tested by evaluating the impacts of the citrus long-horn beetle *Anoplophora chinensis* (Gilioli, Schrader et al. 2014). They concluded that overall risk for provisioning services (on fibre and ornamental services) is high, and for regulating and supporting services (on erosion regulation and air quality) it is moderate.

*User-friendliness and consistency*

Most of the key characteristics of risk assessment protocols can be assessed simply by careful consideration of the protocol and guidance documents. In contrast, user-friendliness and consistency (or reproducibility) needs extensive testing with several assessors considering multiple species and comparing between protocols. Hence, it is of utmost importance that a protocol asks questions that can be answered with an acceptable level of uncertainty, and delivers similar assessments for the same species in the same area, irrespective of the identity of the assessors – as long as these have the necessary expertise or are provided with the necessary information. The two criteria are strongly linked so, for example, if the protocol contains questions that cannot be adequately answered, consistency between assessors will be adversely affected. Both the individual questions and the system summarizing risks should be consistent and unambiguous. Equally the rating guidance designed to help assessors select the most appropriate answer must be consistent and clearly described (Schrader, MacLeod et al. 2012). In systems where all questions contribute to the overall risk scores, a consistent response to each question is particularly critical (Schrader, MacLeod et al. 2012). Enhancing consistency does not only increase user-friendliness, it also gives results greater credibility and clarity when communicating with stakeholders (MacLeod 2010).

Consistency in risk analysis has been recently discussed and assessed for pest risk analyses in the EU-funded project PRATIQUE (Baker, Battisti et al. 2009, Schrader, MacLeod et al. 2012) and methods to improve it have been developed. However, PRATIQUE only considered one PRA protocol (EPPO 2011) whereas it should be applied to invasion risk assessments more generally (Kumschick and Richardson 2013). While it is assumed that developers of protocols carry out consistency tests with independent assessors, these are never published. User-friendliness has sometimes been compared between risk assessment protocols, using various criteria, including personal experience (Verbrugge, Leuven et al. 2010), but without repeating the assessments with different assessors. Standards and thresholds for user-friendliness and consistency are not easily defined and it is difficult to provide guidance on acceptability thresholds. Nevertheless, it would be unwise to propose the use of a protocol without having tested the user-friendliness and consistency by a panel of independent experts. The COST Action Alien Challenge (http://www.brc.ac.uk/alien-challenge/home) will test the consistency of a series of European risk and impact assessment protocols (all listed in Table 1.4 above). The plan is to focus primarily on the impact component (including spread) of the protocols, but the exercise could also be extended to the full risk assessment protocols.

## Summary: Task 1

More than 100 relevant publications were derived through a literature search. Of these only 70 publications provided original risk assessment protocols and their applications. The list of publications was filtered further to eliminate those which simply described the implementation of an existing protocol to a given geographic region or specific taxonomic groups without modification of the assessment protocol. Thus 33 publications (representing 29 protocols) were identified and examined further to derive key attributes of the risk assessment method to inform the development of minimum standards. Basic information for all 33 publications was provided after which 14 protocols were selected as case studies to provide further information as context to subsequent tasks. Two critical gaps were identified through this task: consideration of ecosystem services and evaluation of user-friendliness coupled with consistency of outcomes.

# Task 2: Develop minimum standards for risk assessment methodologies

## Task overview

The aim of this task was to develop a proposed list of minimum standards for risk assessment methods that provide assurance that any given species listed in any given European risk assessment system (compliant with the derived minimum standards) can be potentially considered for inclusion in a list of proposed "IAS of EU concern". Based on the information provided from Task 1, we compiled a list of attributes for critical evaluation (through Task 3) with respect to their usefulness, robustness and compliance to international standards (such as IPPC) to support a listing as an "IAS of EU concern".

## Task 2.1: Produce a database of criteria from the risk assessment review in Task 1 to inform recommendation of minimum standards

The review of characteristics (attributes) of risk assessments (Task 1) coupled with consideration of international standards was used to develop a long-list of attributes (Table 2.1) used to inform sub-task 2.2 and subsequently Task 3.

**Table 2.1:** Long-list of attributes derived from existing risk and impact assessment protocols (outlined in Task 1) with notes where appropriate.

| Attributes | Notes |
|---|---|
| 1) General | |
| Assessment area | |
| Environments covered | |
| Taxonomic scope | |
| Species descriptions | |
| 2) Protocol components-Invasion process | |
| Introduction/Entry | Is the likelihood of entry assessed? Subsequently refined as assessment approach (e.g. via pathway analysis, geographic proximity ("door-knockers")). |
| Establishment | Is the likelihood of (future) establishment assessed? Subsequently refined as assessment approach (e.g. climate matching, habitat matching). |

| Attributes | Notes |
|---|---|
| Spread | Is the likelihood of (future) spread assessed? Can/Should be separated into likelihood of dispersal (by the species capacity) and secondary translocation (by other forces) and/or a spatial and dynamic component. The spatial component is essential (what is the potential distribution of the assessed species in the target area) and should be among the minimum standard. The dynamic part (the speed of dispersal in the target area) is more complicated and maybe not essential. |
| Pathways considered | |
| 3) Protocol components-Impact | |
| a) Protocol for Ecology/Biodiversity risks | |
| Impact on biodiversity (genes, species, ecosystems) considered | Is the magnitude of negative impact on ecology/biodiversity assessed? This includes assessments of impacts of species already present and potential impacts of species not yet present. |
| Impact on specific elements of biodiversity considered (i.e. rare, keystone, red list, protected species) | |
| Impact thresholds considered | Is there any impact threshold defined? |
| Distribution range considered | Is the distribution range considered at the impact level and hence influencing the outcome of the assessment (compare below). |
| Environmental conditions considered | Are current conditions (e.g. temperatures) considered in the impact assessment? Can the species survive in the wild under current conditions or not. |
| Invasive elsewhere considered | Are impact data from outside the studied region considered? |
| Ecological directionality considered | Are positive and negative ecological effects considered? |
| b) Protocol for Socio-Economic risks | |
| Protocol considering economic sectors | Agriculture, Forestry, Fisheries/Aquaculture, Tourism, etc.; including animal and plant health aspects |
| Protocol considering human health | Impacts on Human Health include allergic reactions, intoxication, pathogen reservoir or vector, physical and mental wellbeing |

| Attributes | Notes |
|---|---|
| Protocol considering wellbeing and sustainable development | Possible risks related to IAS impacts on ecosystem services and, through those impacts, on aspects of human wellbeing and regional/local sustainable development. Including: food and water security, natural hazard mitigation, climate change mitigation and adaptation, recreation, support and/or diversification of sustainable regional development, employment, cultural and natural heritage, education, research and innovation |
| 4) Protocol components-Future | |
| Climate change considered | |
| Dispersal considered | dispersal models (e.g. including species traits, secondary spread, point release) may be calculated (without considering climate change) or simply: if a species disperses well (incl. e.g. if it is traded) the risk increases; |
| Future impacts on protected sites, endangered habitats or species, number of MS at risk, biogeographic areas considered | |
| Indirect facilitation | Are potential or known indirect effects (e.g. meltdown, mesopredator release) included in the assessment? |
| Other anthropogenic pressures considered | Are other pressures (land-use change, fragmentation, eutrophication, pollution, …) considered for future impact? |
| Socio-Economy considered | The socio-economic importance of ecosystem services and related benefits might change in the future, esp. in the context of climate change. |
| 5) Protocol components-Management | |
| Precautionary principle considered | |
| Distribution range considered | Is the distribution range considered at the management level and hence influencing the outcome of the assessment? |
| Eradication options considered | |
| Control options considered | |
| 6) Protocol method details | |
| Applicable to a broad range of taxa | |
| Applicable to all environments | |
| Comparability | Are the assessments (within the protocol) comparable between taxa and can be used for prioritization? |

| Attributes | Notes |
|---|---|
| Compliance with any other international/EU conservation system | Compliance with any other system, widely used in conservation (and conservation policies) would be a benefit (e.g. IUCN species and habitat red lists, GISD pathway terminology) |
| Decision rules | How is the final outcome of the assessment reached? |
| Equidistance/Weighting | Are ecological impact categories used equally relevant or is there any weighting? |
| Quantitative RA | |
| Repeatability/Quality control procedure | Is there any quality control mechanism included (e.g. peer-review or multi-assessor comparisons)? |
| Restrictions apply | Is the system aware of its gaps and/or explicitly mentions them? |
| Scoring RA | Is the protocol a scoring system, i.e. is impact translated into scores (e.g. from zero to five) or semi-quantified (e.g. classes of impact). |
| Stakeholder consultation | Are (concerned) stakeholders involved in the assessment procedure? This part of risk communication often is neglected and may jeopardize any intended management action on the ground. |
| Uncertainty considered | Different types of uncertainty occur in every component estimated underlying risk assessments. Here, it should be checked if and how the protocol handles linguistic uncertainty and stochasticity. |
| 7) Protocol data requirements | |
| Data gaps/lack of data considered | Unknown or missing data are frequently encountered during risk analysis (epistemic uncertainty) and the ability to deal with lack of data is a required feature. |
| Data transparency | Are all relevant parts of the assessment(s) cross-referenced? |
| 8) Protocol policy compliance | |
| Consideration of EU environment directives | |
| WTO compliance | |

## Task 2.2: Proposed and agreed minimum standards

Through a preliminary consultation involving a pre-workshop survey outlined in Task 3.2 a draft short-list of attributes were derived from the long-list that were seen essential for performing risk assessments of IAS. These were considered in detail and refined through Task 3.

**Table 2.2:** Short-list of attributes derived from the long-list extracted from the review of risk assessments through Tasks 1 and 2. Additional information and clarification on the agreed minimum standards are provided in Tables 3.4 and 3.5.

| Risk assessment attribute |
|---|
| Includes species description |
| Documents information sources |
| Can be used for a broad range of taxa |
| Includes the likelihood of entry, establishment, spread and magnitude of impact |
| Includes description of (1) the actual and potential distribution; (2) the likelihood of spread; (3) the magnitude of impact |
| Has the capacity to include multiple pathways of entry and spread, both intentional and unintentional |
| Has the capacity to include multiple pathways of secondary spread, both intentional and unintentional |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes |
| Broadly assesses environmental impact with respect to biodiversity and related ecosystem services |
| Includes status (endangered or protected) of species or habitat under threat |
| Has the capacity to consider future impacts due to environmental change |
| Broadly assesses socio-economic impact |
| Includes assessment of monetary cost of damage |
| Considers socio-economic benefits |
| Provides a summary of the different components of the assessment in a consistent and interpretable form |
| Includes measure of uncertainty |
| Can deal with lack of data |
| Unbiased and objectively assesses all species regardless of current status |
| Compliant with WTO standards |
| Includes quality assurance |

## Summary: Task 2

Risk assessment methods are diverse and include many attributes for consideration as potential minimum standards. A range of relevant attributes, including broad consideration of general characteristics through to attributes relevant to the invasion process such as likelihood of arrival, establishment and spread, were identified. Impacts were classified broadly and included biodiversity and socio-economic impacts alongside perspectives influencing impacts such as climate change. Agreed international standards and policies such as the World Trade Organisation (WTO) and relevant EU Directives including the EU Marine Strategy Framework Directive (MSFD) and EU Water Framework Directive (WFD) provide additional attributes for consideration within risk assessment methods. Through compilation of the attributes from the risk assessments, international standards and policies a draft short-list of attributes that were considered to be relevant for performing robust and rigorous risk assessments of IAS was derived.

# Task 3: Risk assessment workshop

## Task overview

In this task we critically examined and validated the minimum standards developed in Task 2 for evaluating risk assessment schemes. The overarching aim was to ensure that the minimum standards were peer-reviewed and robust to ensure that risk assessments are fit for purpose and undertaken using a scheme of appropriate quality to identify and assess potential "IAS of EU concern".

As outlined through Task 1 and 2 there is a diverse range of approaches to risk assessment. However, through Task 3 we aimed to distil the critical components that, through expert opinion and consensus, are agreed necessary to achieve overarching, robust and rigorous assessment of the risk of an IAS, regardless of the specific approach taken. The aim through instigating such a process was to develop a framework of minimum standards that will lead to the objective identification of proposed "IAS of EU concern".

The long-list of attributes derived from the review of risk assessment protocols in Tasks 1 and 2 provided the basis upon which to develop the minimum standards. Additionally, there are several relevant sections within the recently-adopted EU Regulation on IAS that provided further context for the minimum standards. Furthermore, risk assessment and invasion biology experts, invited to participate in the workshop to derive the minimum standards, provided additional attributes for consideration.

## Task 3.1: Identify and approve experts to attend the workshop

### Selection of experts

The project team included 23 experts from nine organisations and as such provided a strong basis to derive minimum standards for the identification of "IAS of EU concern". However, peer-review was seen as an essential part of the process of agreeing the minimum standards. Therefore, 16 of the experts from the project team (Table 3.1) and 12 additional invited experts (Table 3.2) were selected to contribute to the consensus process to elucidate the minimum standards in a transparent, collaborative and objective manner. The invited experts and those from within the team represented a breadth of expertise from a variety of perspectives including taxonomic (all taxa, including pathogens), environmental (freshwater, marine and terrestrial), impacts (environmental, socio-economic and health) and disciplines (ecologists, economist, conservation practitioners, scientists, policy-makers, risk assessors). Many of the experts had been actively involved in the development, testing and implementation of risk assessment protocols for IAS. The EC provided guidance throughout and approved the selection of experts and overall workshop programme.

**Table 3.1:** Contributors to the workshop from the project team.

| Name | Organisation | Relevant expertise |
|---|---|---|
| Helen Roy | CEH | Project lead and invasion biology |
| Hannah Dean | CEH | Database and information management |
| Karsten Schönrogge | CEH | Invasion biology |
| Jodey Peyton | CEH | Project support and ecology |
| Ana Nieto | IUCN | Task lead and Red lists |
| James Kemp | IUCN | Red lists |
| Riccardo Scalera | IUCN ISSG | Invasion biology and policy |
| Marc Kenis | CABI | Invasion biology and risk assessment development and implementation |
| Wolfgang Rabitsch | EAA | Invasion biology and risk assessment development and implementation |
| Marianne Kettunen | IEEP | Socio-economics |
| Sarah Brunel | EPPO | Pest risk assessment |
| Etienne Branquart | Belgian Biodiversity Platform | Invasion biology and risk assessment development and implementation |
| Sonia Vanderhoeven | Belgian Biodiversity Platform | Invasion biology and risk assessment development and implementation |
| Gordon H. Copp | CEFAS | Invasion biology and risk assessment development and implementation |
| Piero Genovesi | IUCN ISSG | Invasion biology and policy |
| Alan Stewart | University of Sussex | Horizon scanning and taxonomic expertise |

**Table 3.2**: Additional experts invited to contribute to the workshop.

| Name | Organisation | Expertise |
|---|---|---|
| Wolfgang Nentwig | University of Bern | Invertebrates, developing risk assessment methods, impacts on biodiversity and socio-economic issues |
| Niall Moore | Non-native Species Secretariat (UK) | Risk assessment, broad coverage of taxonomic groups, IAS strategy and coordination |
| Sven Bacher | University of Fribourg | Biodiversity, risk assessment, holistic approach, expertise on comparing schemes |

| Name | Organisation | Expertise |
|---|---|---|
| Frances Lucy | Environmental Services Ireland, Institute of Technology, Sligo | Marine, freshwater |
| Melanie Josefsson | Swedish Environmental Protection Agency | General knowledge on IAS, policy |
| Hanno Sandvik | Norwegian Biodiversity Information Centre | Norwegian IAS expert and risk assessment |
| Johan van Valkenburg | Dutch Plant Protection Organization | Aquatic and terrestrial plants |
| Tony Sainsbury | Institute of Zoology, London | Wildlife diseases, risk assessment methods |
| Aline De Koeijer | Central Veterinary Institute, NL | EFSA expert of human and animal pathogen prioritization, human health |
| Jean-Claude Grégoire | University of Brussels, BE | EFSA expert of assessing risks in pest insects |
| Alain Roques | INRA | Invasive insects and impacts on biodiversity, forest entomology |
| Hugo Verreycken | INBO | Non-native freshwater fishes and risk assessment |
| Tim Adriaens | INBO | Invasion biology and risk assessment |
| Bram D'hondt | Belgian Biodiversity Platform | Invasive alien species risk assessment development and review |

## Task 3.2: Dissemination of project documents to approved experts

### Preliminary consultation

The preliminary consultation phase involved providing relevant documentation to all contributing experts. Relevant documents (Table 3.3) were circulated two weeks in advance of the workshop. Additionally, experts were provided with an overview of the project and expectations of the role they would play. The long list of attributes of risk assessments derived through task 1 and 2 were circulated in the form of a survey (using Survey Monkey) in which the experts were asked to rank the importance of each as a minimum standard on a scale of 1 (low importance) to 5 (high importance). Experts were also asked to provide additional attributes that were not apparent from the long-list.

**Table 3.3:** Documents circulated to experts contributing to the workshop

| Document | Link or reference | Representative participant |
|---|---|---|

| | | |
|---|---|---|
| Workshop programme | Annex 3 | Ana Nieto (IUCN)<br>James Kemp (IUCN)<br>Helen Roy (CEH) |
| Regulation proposal | | Myriam Dumortier (EC)<br>Valentina Bastino (EC) |
| Survey results | Annex 2 | Helen Roy (CEH) |
| Introductory presentations | Annex 4 | Helen Roy (CEH)<br>Wolfgang Rabitsch (EAA)<br>Marc Kenis (CABI)<br>Marianne Kettunen (IEEP)<br>Etienne Branquart (Belgian Biodiversity Platform and EPPO)<br>Sarah Brunel (EPPO) |
| European and Mediterranean Plant Protection Organization<br>Guidelines on Pest Risk Analysis | Annex 5 | Sarah Brunel (EPPO) |
| GB Non-native species Rapid Risk Assessment (NRRA) | Annex 5 | Niall Moore (NNSS) |
| Harmonia+ (and Pandora+) | Annex 5 | Bram D'hondt (Belgian Biodiversity Platform) |
| Generic ecological impact assessments of alien species<br>in Norway | Annex 5 | Hanno Sandvik (Norwegian Biodiversity Information Centre) |
| German–Austrian Black List Information System | Annex 5 | Wolfgang Rabitsch (EAA) |
| Generic impact scoring system | Annex 5 | Wolfgang Nentwig (University of Bern) |

The survey revealed a high level of consensus between all experts for most of the attributes (Annex 2). The question as to whether or not the EU should develop a totally new EU-wide risk assessment system tailored for the forthcoming IAS Regulation provided a divided response with 8 experts stating "no", 9 stating "yes" and 8 stating "unsure". Equally, the question as to whether or not the EU should use one or several existing risk assessments resulted in lack of consensus with 13 experts stating "yes", 3 stating "no" and 9 were "unsure". In order to ensure a clear understanding of the context of the EU Regulation and the associated list of "IAS of EU concern", the workshop programme included provision at the beginning for a detailed overview of the remit of the project and also clarity from the EC with respect to the specific relevance of the project to the Regulation.

Attributes aligning with socio-economic aspects also appeared to cause division in responses by the experts. The importance of considering known uses and social and economic benefits deriving from those uses was not recognized by all the experts, indeed 10, 10 and 5 experts stating "no", "yes" and "unsure" respectively. Similarly the question "Should a risk assessment consider human well-being and sustainable development (e.g. food security, cultural and natural heritage and climate change mitigation)?" led to 7 experts stating they were "unsure" (and 17 experts stating "no"). Furthermore, three questions relating to cost-benefit analysis led to a high degree of uncertainty with more than a third of participants responding "unsure". Interestingly the majority of respondents were either unsure or agreed that a risk assessment should consider a broad assessment of cost-benefit analysis and consider potential costs of damage by IAS, but consideration of an assessment of monetary cost-benefit analysis was only supported by 5 out of 25 respondents. The high degree of disagreement or uncertainty expressed by respondents highlighted the need to ensure that socio-economic considerations were included as a substantial component of the workshop programme.

## Task 3.3: The workshop

The two-day workshop was held in Brussels on 27$^{th}$ and 28$^{th}$ March, with a programme (Annex 3) developed collaboratively within the project team and approved by the Commission. The programme was divided into four main sessions: project overview and introductory lectures, consensus approach to defining minimum standards, comparison of existing risk assessment protocols against minimum standards and introduction to developing the list of proposed "IAS of EU concern". The presentations are provided in Annex 4.

### Introductory lectures

During the morning of the first day, participants were provided with an overview of the project and perspectives from the Commission particularly in relation to the forthcoming Regulation. Additionally, the project team provided background information to risk assessments and specifically definitions of the terms to be used throughout the workshop. Socio-economic perspectives were introduced by Marianne Kettunen (IEEP) in recognition of the degree of divergence from respondents to the preliminary consultation survey.

## Consensus approach to defining minimum standards

The long-list of risk assessment attributes was circulated in advance of the workshop and participants were invited to add standards for consideration both during the preliminary consultation phase and during the workshop. The participants were divided into two groups and contributed to discussions on each attribute in relation to key themes of the risk assessment process: entry, establishment and spread, environmental impact and socio-economic impact. Rapporteurs were assigned to each group and they provided the entire workshop with a summary of the conclusions of their group's discussions. The outcomes from the discussions were rapidly compiled into a spreadsheet so that the entire workshop could again share opinions on each attribute and whether or not it should be included as a minimum standard for risk assessment methods from which the draft list of proposed "IAS of EU concern" will be constructed. The discussions were consolidated through a voting process in which people were asked to express agreement or disagreement with inclusion of the attribute as a minimum standard. In most cases the participants were in unanimous agreement but where there was substantial divergence in opinion then further discussion was invited to explore the basis of disagreement. In most cases, this led to re-wording of the minimum standard and subsequent consensus from the group. In this way the long list of attributes was modified substantially with many of the attributes deemed as inappropriate as a minimum standard (Annex 6). The final list included 14 minimum standards (Table 3.4).

There was extensive discussion as to the degree to which quantitative versus qualitative information should be presented. For some of the minimum standards quantitative information is either unavailable at this stage or inappropriate. Therefore, the minimum standards are phrased to broadly encompass themes within risk assessments rather than presenting prescriptive statements as to the mechanisms for implementing risk assessments. However, inclusion of a number of minimum standards provide overarching guidance on the approach to implementation for example: "documents information sources", "Provides a summary of the different components of the risk assessment and an overall summary, in a consistent and interpretable form", "Includes uncertainty" and "Quality assurance".

**Table 3.4:** Details of the minimum standards with summary of the comments derived from discussions during the workshop and the outcome of the vote (expert opinion). Further clarification of the minimum standards and reordering to provide a logical framework is provided in section "Post-workshop discussions: defining the minimum standards"

| | Minimum standard | Expert opinion |
|---|---|---|
| 1 | Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Unanimous |
| 2 | Includes the likelihood of entry, establishment, spread and magnitude of impact | Unanimous |
| 3 | Includes description of the actual and potential distribution, spread and magnitude of impact | Unanimous |
| 4 | Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | |
| 5 | Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Unanimous |
| 6 | Can broadly assess environmental impact with respect to ecosystem services | Not unanimous but large majority, providing the emphasis placed on qualitative and broad assessment. Considerable discussion over defining ecosystem services and the way in which such an approach could be interpreted differently within different risk assessments. Additional concern of duplication with ecosystem patterns and processes alongside socio-economic benefits. |
| 7 | Broadly assesses adverse socio-economic impact | Not unanimous but almost with only one abstaining over emphasis on "assesses" rather than "describes" |
| 8 | Includes status (threatened or protected) of species or habitat under threat | Not unanimous but large majority |
| 9 | Includes possible effects of climate change in the foreseeable future | Unanimous |

| | Minimum standard | Expert opinion |
|---|---|---|
| 10 | Can be completed even when there is a lack of data or associated information | Unanimous |
| 11 | Documents information sources | Unanimous |
| 12 | Provides a summary of the different components of the risk assessment and an overall summary, in a consistent and interpretable form | Unanimous |
| 13 | Includes uncertainty | Unanimous |
| 14 | Includes quality assurance | Unanimous |

**Comparison of existing risk assessment protocols against minimum standards**

A number of participants were invited to present the protocols for risk assessment or, in a few cases, for impact assessment for which they have a key role in the development and/or implementation (Table 3.5). Guidance was given to reflect on the agreed minimum standards and specifically consider the constraints in compliance with the minimum standards. Each risk or impact assessment protocol was discussed in detail with specific reference to the minimum standards.

<u>The conclusion of this session was that none of the risk or impact assessment methods met all of the minimum standards.</u>

The impact assessments were particularly lacking in this regard because they focus on impact and so do not consider likelihood of entry and establishment. However, impact assessments have a distinct role to play within invasion management, specifically at the national or regional scale. Furthermore, the diversity and flexibility of approaches was seen as essential to encompass adequately the taxonomic breadth of IAS, the stage of invasion, the context and aims of the assessment. It was agreed that impact assessments could provide additional valuable information for informing the list of proposed "IAS of EU concern".

Three of the risk assessments considered during the workshop appeared to be compliant with the majority of minimum standards: EPPO DSS, GB NRRA and Harmonia$^{+}$. An additional protocol, ENSARS, was not discussed in detail during the workshop but was agreed to be "substantially compliant" through evaluation in Task 4. The main areas of divergence from the minimum standards related to lack of consideration of two of the minimum standards (ecosystem services and climate change) and only partial compliance with one minimum standard (socio-economic benefits require inclusion within the general description). A thorough consideration of existing risk assessment methods and compliance with the minimum standards will be given in Task 4 "Screening of existing risk assessment methodologies". However, the discussions at the workshop were extremely useful for exploring the clarity and application of the minimum standards. It was agreed that they provide a robust and rigorous framework for critically examining risk assessment methods which could inform a list of proposed "IAS of EU concern".

**Table 3.5:** Risk or impact assessment methods presented by representative participants to the workshop. For links to risk assessment documentation refer to Annex 5.

| Risk or impact assessment | Acronym | Representative participant |
|---|---|---|
| European and Mediterranean Plant Protection Organization<br>Guidelines on Pest Risk Analysis | EPPO DSS | Sarah Brunel (EPPO) |
| GB Non-native species Risk Assessment (NRRA) | GB NNRA | Niall Moore (NNSS) |
| Harmonia+ (and Pandora+) | | Bram D'hondt (Belgian Biodiversity Platform) |
| Generic ecological impact assessments of alien species in Norway | | Hanno Sandvik (Norwegian Biodiversity Information Centre) |
| German–Austrian Black List Information System | GABLIS | Wolfgang Rabitsch (EAA) |
| Generic impact scoring system | GISS | Wolfgang Nentwig (University of Bern) |

## Introduction to developing the list of proposed "IAS of EU concern"

During the final stage of the workshop, the participants discussed the implementation of the minimum standards to construct the draft list of proposed "IAS of EU concern" (Task 5 "Screening of potential "IAS of EU concern" and proposal of a list"). The session began with a presentation by Karsten Schönrogge (CEH) outlining approaches to developing the list and was followed by an overview of a consensus approach to horizon scanning based on a method implemented in Britain (Roy, Peyton et al. 2014) from Alan Stewart (University of Sussex). The resulting discussions provided constructive recommendations for a transparent and objective approach, employing the minimum standards, to take forward Task 5.

## Task 3.4: Summarise the findings from the workshop

### Post-workshop discussions: defining the minimum standards

The phrasing of the minimum standards was discussed extensively during the workshop, and it is hoped that the meaning is reasonably intuitive. However, some aspects require clarification, and it is important that the explanatory text is explicit. Therefore, the minimum standards are outlined here in detail. It was also agreed that to comply with the EU Regulation on IAS, overarching guidelines, including recommendations from the WTO and OIE, should be respected and therefore cut across the minimum standards.

### Overarching guidelines

As discussed through Task 1.2 risk assessment protocols must ask questions that are sufficiently clear and understandable for assessors. The guidance designed to help assessors select the most appropriate answer must be consistent and clearly described (Baker, Black et al. 2008, Schrader, MacLeod et al. 2012). This is essential to ensure that responses (accompanied by an indication of level of uncertainty) deliver similar assessments for the same species in the same area, irrespective of the identity of the assessors.

### The minimum standards

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

There are difficulties in quantifying impacts of IAS on ecosystem services and so it is foreseen that the assessment of the impacts as a minimum standard would be at qualitative and descriptive level. The basic considerations that would play a role in the assessment include, for example, identifying and briefly describing the ecological basis for impact on an ecosystem service (e.g. possible impact on a predator species playing a key role in controlling the population of pests), time horizon for impacts (short to long-term horizon), and the estimated spatial scale of impact. Additional, more challenging and labour intensive, consideration could include assessing the impacted ecosystem service's resistance/resilience to an impact and determining the scale of impact in the light of different invasion "scenarios". Furthermore, given the lack of existing information on impacts of IAS on ecosystem services and the difficulties in quantifying the impacts, any quantitative ranking of impacts on ecosystem services should be carefully considered and not required as a minimum standard. However, it is encouraging to note that relevant ecosystem functions such as nutrient pools and fluxes, change of quality of water bodies, soil and sediment modification (including pH and C/N ratio, salinity, fertility, eutrophication), changes in disturbance regimes (by vegetation flammability, erosion or soil compacting) and changes in primary production, water regulation and carbon sequestration, as well as modifications of successional processes are included in the description of "Impact on ecosystems" (in the Generic Impact Scoring System GISS) and could easily be incorporated into other protocols (Nentwig, Kühnel et al. 2010) and eventually cross-referenced to ecosystem services.

Assessing possible impacts of IAS on ecosystem services requires a common list and/or classification of ecosystem services. The list/classification used in this context would need to be further discussed and determined. This classification could build on a number of most commonly accepted classifications, including classifications by Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB) and EEA Common International Classification of Ecosystem Services (CICES) (http://cices.eu/). In general, these classifications are rather compatible with the main difference being that they are designed to be used for different purposes. For example, the MA classification was primarily focused on communication and awareness whereas the TEEB classification was focused on underpinning economic valuation. In general, CICES – while still a work on progress – is currently commonly endorsed as the preferred ecosystem services classification in the EU context. It has been adopted to be used in a number of initiatives by the European Commissions, such as the Mapping and Assessment of Ecosystems and their Services (MAES) initiative (http://biodiversity.europa.eu/maes).

It is foreseen that the classification of ecosystem services in the context of IAS RAs should be feasible to be used by people who are not experts on ecosystem services (e.g. self-explanatory and not overly complicated). It should be primarily suitable for qualitative valuation purposes, while at the same time also being amenable for quantitative assessment in the future, with clear links to the classification used for the closely related IAS socio-economic impacts (outlined below), and with a view to clarify interlinkages between ecosystem services and related benefits (including possible issues related to double counting). Finally, the classification should be compatible with the most commonly used international and EU ecosystem service classifications while also taking into consideration and/or accommodating existing ways of addressing ecosystem services in IAS RAs (e.g. the European Food Safety Authority - EFSA protocol for plant pests). In general, CICES is considered to a flexible framework that could perhaps provide a good starting point for the classification.

Finally, IAS impacts on biodiversity, ecosystem patterns and processes, ecosystem services and related socio-economic implications are clearly interlinked. Therefore, there are foreseen to be overlaps in how these different impacts are determined in practice: the identification of impacts on biodiversity and ecosystem characteristics clearly forms the basis for impacts on ecosystem services whereas identifying the impacts on ecosystem services form a key conceptual basis for assessing the foreseen socio-economic impacts of IAS invasion. These overlaps – or synergies - should be taken into consideration when developing these three minimum standards further in the future. It is foreseen that a dedicated guidance on how to assess the impact on ecosystem services in the context of EU IAS RAs would need to be developed.

*7. Broadly assesses adverse socio-economic impact*

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

Given the difficulties in quantifying and monetizing socio-economic impacts, it is foreseen that the assessment of the impacts as a minimum standard would be qualitative (not quantitative or at the monetary-level). However, for the purposes of making robust arguments providing quantitative and monetary evidence, where available, could be encouraged. The basic considerations that would play a role in the assessment include, for example, identifying and briefly describing mode of impact (e.g. initial impact on ecosystem service and related socio-economic consequence), time horizon for impacts (short to long-term horizon), estimated spatial scale of impact and affected stakeholders and sectors. Additional, although challenging and labour intensive, consideration could include determining foreseen socio-economic impacts in the light of different invasion “scenarios”. As with ecosystem services, given the lack of existing information on socio-economic impacts of IAS and the difficulties in quantifying the impacts, any quantitative ranking of impacts should be carefully considered and perhaps not required as a minimum standard.

A systematic assessment of the IAS socio-economic impacts would require a common list and/or classification of possible impacts. The list/classification used in the context of EU risk assessments would need to be further discussed and determined, however a preliminary idea is provided (Table 3.6). This classification builds on the currently commonly identified socio-economic consequences of the loss of biodiversity and degradation of ecosystems and related services (e.g. in the context of EU guidance documents and assessments). Importantly, the classification of socio-economic impacts would need to be clearly linked with the classification of ecosystem service used in the context of risk assessments. This is because impacts of IAS on ecosystem services are often the “route” through which socio-economic impacts occur. The review of the existing risk assessment protocols under Task 4 clearly indicates that these interlinkages have not yet been fully considered and/or established.

As with the impacts on ecosystem services, it is foreseen that dedicated guidance on how to assess the socio-economic impact in the context of risk assessments would need to be developed.

Furthermore, guidance on how to classify, quantify and/or monetize the socio-economic impacts, as per biodiversity economics, is foreseen to be a useful development.

**Table 3.6:** A possible suggested classification of possible negative socio-economic impacts of IAS. Note: this preliminary classification does not yet make systematic links to the affected ecosystem services and further work is required to expand and refine this classification.

| Socio-economic impact | Description |
|---|---|
| Negative impacts on economic sectors | Negative impacts on agriculture sector |
| | Negative impacts on forestry sector |
| | Negative impacts on animal production (including fisheries and aquaculture) |
| | Negative impacts on tourism |
| Negative impact on human infrastructure | Damage to buildings (including dams, traffic and energy infrastructure) |
| Negative impact on human health | Injuries (including bites, stings, scratches, rashes), transmission of diseases and parasites to humans, bioaccumulation of noxious substances, health hazard due to contamination with pathogens or parasites, as well as secondary plant compounds, toxins or allergen substances such as pollen. |
| Negative impact on well-being and sustainable development | Noise disturbance (e.g. by parakeets), pollution of recreational areas (water bodies, rural parks, golf courses or city parks), fouling, eutrophication, damage by trampling and overgrazing, restrictions in accessibility (e.g. by thorns, other injuring structures, successional processes, or recent pesticide application) to habitats or landscapes of recreational value. Restrictions or loss of recreational activities, aesthetic attraction or touristic value. Restrictions concerning aesthetic values and natural or cultural heritage. |
| | Hindering local and regional sustainable development with respect to water security, food security, natural hazard mitigation, climate change mitigation and adaptation, employment. |
| | Hindering diversification of sustainable of regional development |
| | Hindering opportunities for education, research and innovation |

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

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

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

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

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

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

*11. Documents information sources*

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

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

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

*13. Includes uncertainty*

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

The Intergovernmental Panel on Climate Change (Mastrandrea, Heller et al. 2010) provides a framework for a consistent approach to treatment of uncertainties. In summary, confidence is considered as a function of evidence and agreement. Evidence relates to the type, amount, quality and consistency of evidence. Agreement relates to the degree of concurrence between the different evidence sources. These two functions can be plotted in two dimensions to derive a confidence score (D'hondt, Vanderhoeven et al. 2014). An alternative approach has been taken in the development of two graphical tools, which assist in summarizing the responses and uncertainties that results from a large number of question ratings and uncertainty scores: an uncertainty 'Visualizer' and the Rule-based matrix model (Holt, Leach et al. 2012). The Visualizer presents a case summary graph on a single page in such a way that the risk assessors and peer reviewers can see rating scores and uncertainties in a pictorial manner The Rule-based matrix model integrates all of responses to the individual assessment questions through a hierarchy of rules that attempt to mimic the logic used by the assessors. These are arranged in the form of a flow chart to give an overall rating with an accompanying expression of uncertainty.

*14. Includes quality assurance*

It is essential that the risk assessment is robust and rigorous reflecting the current state of knowledge. As such, it is important that the quality of the risk assessment is assured. There are many possible approaches to quality assurance from peer-review after the risk assessment has been conducted through to the involvement of a panel of experts invited to undertake the assessment in a collaborative manner. The GB Non-Native Species Risk Assessment protocol (GB NNRA) employs a variety of approaches to assure quality (Baker, Black et al. 2008). The GB NNRA for a species is:

- commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- drafted by an independent expert in the species and peer reviewed by a different expert.
- approved by the NNRAP (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- approved by the GB Programme Board for Non-native Species.
- placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- finalised by the risk assessor to the satisfaction of the NNRAP and GB Programme Board if necessary.

## Summary: Task 3

The overarching aim of Task 3 was to ensure that the derived short-list of minimum standards were peer-reviewed and robust to ensure that risk assessments selected to inform the development of a list of proposed “IAS of EU concern” are appropriately robust”. Expert opinion and consensus approaches were used to derive minimum standards for risk assessments. In total 35 experts (23 from the project team and an additional 12 invited experts) contributed to the consensus workshop to elucidate the minimum standards in a transparent, collaborative and objective manner. There was a high level of consensus between all experts for most of the attributes.

Fourteen attributes were agreed, through consensus methods, to represent the minimum standards. The minimum standards are:

1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)
2. Includes the likelihood of entry, establishment, spread and magnitude of impact
3. Includes description of the actual and potential distribution, spread and magnitude of impact
4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional

5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes
6. Can broadly assess environmental impact with respect to ecosystem services
7. Broadly assesses adverse socio-economic impact
8. Includes status (threatened or protected) of species or habitat under threat
9. Includes possible effects of climate change in the foreseeable future
10. Can be completed even when there is a lack of data or associated information
11. Documents information sources
12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary
13. Includes uncertainty
14. Includes quality assurance

# Task 4: Screening of existing risk assessment methodologies

## Task Overview

The minimum standards developed in Task 2 and agreed by consensus through the workshop in Task 3 were used as a framework against which to assess existing risk assessment methods.

## Task 4.1: Compile and review table outlining results of screening of existing risk assessment methods

The 29 selected protocols, identified through task 1, were mapped against the proposed minimum standards developed through tasks 2 and 3 (Table 3.4).

**Table 4.1:** Compilation of screening selected risk assessment protocols against the proposed minimum standards: 1. Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits); 2. Includes the likelihood of entry, establishment, spread and magnitude of impact; 3. Includes description of the actual and potential distribution, spread and magnitude of impact; 4. Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional; 5. Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes; 6. Can broadly assess environmental impact with respect to ecosystem services; 7. Broadly assesses adverse socio-economic impact; 8. Includes status (threatened or protected) of species or habitat under threat; 9. Includes possible effects of climate change in the foreseeable future; 10. Can be completed even when there is a lack of data or associated information; 11. Documents information sources; 12. Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary; 13. Includes uncertainty; 14. Includes quality assurance. The risk assessment protocols have been numbered to correspond with the numbering in Table 1.4

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts | No | No | Partly | No | ✓ | No | No | ✓ | No | Partly | No | ✓ | ✓ | Partly | 4 | (Blackburn, Essl et al. 2014) |
| 2 | Australian freshwater fish model | Partly | Partly | Partly | Partly | ✓ | No | Partly | No | No | Partly | No | ✓ | ✓ | Partly | 3 | (Bomford and Glover 2004, Bomford 2006) |
| 3 | Australian reptile and amphibian model | Partly | Partly | Partly | Partly | ✓ | No | Partly | No | No | Partly | No | ✓ | ✓ | Partly | 3 | (Bomford, Kraus et al. 2005) |

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Australian and New Zealand Bird and Mammal risk assessment | Partly | Partly | Partly | Partly | ✓ | No | Partly | No | No | Partly | No | ✓ | ✓ | Partly | 3 | (Bomford 2008) |
| 5 | Invasive Species Environmental Impact Assessment Protocol (ISEIA) | No | No | ✓ | No | ✓ | No | No | ✓ | No | ✓ | ✓ | ✓ | No | ✓ | 7 | (Branquart 2007) |
| 7 | EPPO prioritization process for invasive alien plants | Partly | Partly | Partly | Partly | ✓ | No | ✓ | No | No | ✓ | ✓ | ✓ | ✓ | ✓ | 7 | (EPPO 2012) |
| 8 | EPPO Decision-support scheme for quarantine pests | ✓ | ✓ | ✓ | ✓ | ✓ | No | ✓ | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | 12 | (EPPO, 2011) |
| 10 | Trinational Risk Assessment for Aquatic Alien Invasive Species (CEC) | ✓ | Partly | Partly | ✓ | ✓ | ✓ | ✓ | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | 11 | (CEC 2009) |
| 11 | Fish Invasiveness Screening KIT (FISK) (with uncertainty and predictive power improvements) | Partly | Partly | Partly | No | Partly | No | No | No | No | ✓ | ✓ | Partly | ✓ | ✓ | 4 | (Copp, Garthwaite et al. 2005, Copp, Vilizzi et al. 2009) |

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | 13 | (Copp, Britton et al. 2008) |
| 14 | Harmonia$^+$ and Pandora$^+$: risk screening tools for potentially invasive organisms | Partly | ✓ | ✓ | ✓ | ✓ | No | ✓ | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | 11 | (D'hondt, Vanderhoeven et al. 2014) |
| 15 | EFSA PLH scheme for PRA | Partly | ✓ | ✓ | ✓ | ✓ | ✓ | No | Partly | Partly | ✓ | ✓ | ✓ | ✓ | ✓ | 10 | (EFSA Panel on Plant Health 2011) |
| 16 | GABLIS | ✓ | No | Partly | ✓ | ✓ | No | No | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Partly | 9 | (Essl, Nehring et al. 2011) |
| 17 | Full Risk Assessment Scheme for Non-native Species in Great Britain (GB NNRA) | Partly | ✓ | ✓ | ✓ | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 12 | (Baker, Black et al. 2008) |

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Alien Species in Norway - with the Norwegian Black List 2012 | Partly | No | ✓ | ✓ | ✓ | No | No | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 10 | (Sæther, Holmern et al. 2010, Gederaas, Moen et al. 2013, Sandvik, Sæther et al. 2013) |
| 19 | Risk analysis and prioritisation (Ireland and Northern Ireland) | Partly | Partly | Partly | Partly | ✓ | No | ✓ | No | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8 | (Kelly, O'Flynn et al. 2013) |
| 21 | Quantitative Risk Assessment for alien fishes | Partly | Partly | Partly | ✓ | ✓ | No | Partly | No | No | ✓ | No | ✓ | No | ✓ | 5 | (Kolar and Lodge 2002) |
| 22 | A conceptual framework for prioritization of invasive alien species for management according to their impact | ✓ | No | Partly | No | ✓ | Partly | ✓ | ✓ | No | Partly | ✓ | ✓ | ✓ | ✓ | 8 | (Kumschick, Bacher et al. 2012) |

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Generic Impact-Scoring System (GISS) | Partly | No | Partly | No | ✓ | No | ✓ | ✓ | No | Partly | ✓ | ✓ | ✓ | ✓ | 7 | (Kumschick and Nentwig 2010, Nentwig, Kühnel et al. 2010) |
| 24 | Biopollution Index | No | No | Partly | No | ✓ | No | No | No | No | Partly | ✓ | ✓ | No | No | 3 | (Olenin, Minchin et al. 2007) |
| 25 | Chinese WRA | Partly | ✓ | ✓ | ✓ | ✓ | Partly | Partly | No | No | ✓ | ✓ | ✓ | No | ✓ | 8 | (Ou, Lu et al. 2008) |
| 26 | US Weed Ranking Model | Partly | No | Partly | No | ✓ | No | Partly | No | ✓ | ✓ | No | Partly | No | No | 3 | (Parker, Caton et al. 2007) |
| 27 | Australian WRA | Partly | No | Partly | Partly | ✓ | No | ✓ | No | No | ✓ | No | ✓ | Partly | ✓ | 5 | (Pheloung, Williams et al. 1999) |
| 28 | Freshwater Invertebrates Scoring Kit (FI-ISK) | Partly | Partly | Partly | No | Partly | No | No | No | No | ✓ | ✓ | Partly | ✓ | ✓ | 4 | (Tricarico, Vilizzi et al. 2010) |
| 29 | Expert System for screening potentially invasive alien plants in South African fynbos | Partly | Partly | No | No | Partly | No | No | No | No | ✓ | No | Partly | ✓ | No | 2 | (Tucker and Richardson 1995) |

| | Name | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Number of minimum standard compliances | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Invasive Ant Risk Assessment | Partly | Partly | Partly | ✓ | ✓ | No | ✓ | No | No | ✓ | No | No | ✓ | No | 5 | (Ward, Stanley et al. 2008) |
| 31 | Classification key for Neophytes | Partly | Partly | No | No | ✓ | No | No | No | No | No | No | No | No | No | 1 | (Weber and Gut 2004) |
| 32 | Climate-Match Score for Risk-Assessment Screening | No | Partly | Partly | No | No | No | No | No | No | No | ✓ | No | Partly | No | 1 | (van Wilgen, Roura-Pascual et al. 2009) |
| 33 | Assessment of risk of establishment for alien amphibians and reptiles | No | Partly | Partly | No | No | No | No | No | No | No | ✓ | No | Partly | No | 1 | (van Wilgen and Richardson 2012) |

## Task 4.2: Detailed overview of risk assessments that meet the minimum standards

It was proposed that all risk assessments which meet the minimum standards were documented in detail using a factsheet format to convey the major features of the method. However, none of the risk assessment protocols were fully compliant with the minimum standards. Therefore, we selected a number of protocols including those that complied with a high number (ten or more) of the minimum standards, but also others were selected based on their attributes that could inform the recommendation of refinement of risk assessment methods.

This broad selection process enabled representative experts for each of the protocols to contribute information and so provided the project team with information and perspectives beyond that available in published sources. Ten protocols were selected. Seven complied with ten or more minimum standards (Table 4.1). Six of these seven protocols also had European relevance and taxonomic breadth (the trinational risk assessment being North-American and so was excluded for detailed consideration at this stage). Therefore, it was considered appropriate to provide detailed consideration to assess the potential for the six European protocols to be modified in accordance with the minimum standards. Although risk assessment protocols meeting less than ten of the minimum standards were excluded from further consideration, a further three protocols which were focused on impact assessment were retained, because they provide more detailed assessment of impacts than risk assessment protocols and so have the potentially to inform the refinement of exisiting risk assessment protocols. Finally FISK, a horizon scanning tool, was included, because it has underpinned a number of other methods (Verbrugge, van der Velde et al. 2012) and, therefore, provided additional background information.

**Table 4.2:** Overview of the ten protocols (including protocol name, acronym, type and the expert representing the protocol within this project) that complied with ten or more minimum standards or impact assessments/horizon scanning tool with the potential to inform the development of risk assessment protocols in accordance with the minimum standards to be considered in detail through Task 4. The risk assessment protocols have been numbered to correspond with the numbering in Table 1.4.

| | Protocol | Acronym | Type | Expert |
|---|---|---|---|---|
| 5 | Invasive Species Environmental Impact Assessment | ISEIA | Impact assessment | Bram D'hondt (Belgian Biodiversity Platform) |
| 8 | European and Mediterranean Plant Protection Organization<br>Guidelines on Pest Risk Analysis | EPPO DSS | Risk assessment | Sarah Brunel (EPPO) |
| 11 | Fish Invasiveness Screening Kit | FISK | Horizon scanning | Gordon Copp (CEFAS) |
| 13 | European Non-native Species in Aquaculture Risk Assessment Scheme | ENSARS | Impact assessment | Gordon Copp (CEFAS) |
| 14 | Harmonia+ | Harmonia$^+$ | Risk assessment | Bram D'hondt (Belgian Biodiversity Platform) |
| 15 | EFSA PLH generic opinion requiring a full PRA | EFSA PRA | Risk assessment | Sara Tramontini (EFSA) |
| 16 | German–Austrian Black List Information System | GABLIS | Impact assessment | Wolfgang Rabitsch (EAA) |
| 17 | GB Non-Native species Rapid Risk Assessment (GB NNRA) | GBNNRA | Risk assessment | Niall Moore (NNSS) |
| 18 | Generic ecological impact assessments of alien species in Norway | Norwegian IAS | Impact assessment | Hanno Sandvik (Norwegian Biodiversity Information Centre) |
| 23 | Generic impact scoring system | GISS | Impact assessment | Wolfgang Nentwig (University of Bern) |

The representative expert for selected protocols was invited to complete a case study template which provided an opportunity for detailed consideration of the protocol in the context of the minimum standards. An overview summarizing the level of compliance with the minimum standards was achieved by cross checking the protocol (in discussion with the representative expert) with the minimum standards (Tables 4.3 and 4.4).

### Task 4.2a: Case studies of selected protocols

Detailed comments on each protocol were collated by dissemination of a template for completion by the representative expert. Particular attention was given to consideration to key recommendations or intentions for the protocol to meet (or not) the minimum standards. The experts were also asked to provide a list of species which had been assessed through the protocol. This information was informative for Task 5.

# 5. ISEIA (Invasive Species Environmental Risk Assessment)

**Brief description:**

The ISEIA scheme refers to four main criteria that together cover (the last) step of the invasion process (i.e. the potential of spread, the colonization of natural habitats, adverse impacts on native species, and impacts on ecosystems). Its numeric output allows for the allocation of non-native species to different list categories (white, watch and black lists), as defined by their level of environmental risk and current invasion stage. ISEIA can be used for any taxonomic group, geographic area and type of environment, though most of the guidance is based on the situation in Belgium and terrestrial and freshwater environments.

**Reference or weblink:**

http://ias.biodiversity.be.

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | No | None of these elements are explicitly asked for. However, defining elements such as taxonomy and geographic scope are implicitly assumed when doing an assessment. |
| Documents information sources | Yes | The guidelines explicitly state that data sources refer to published literature as much as possible (including peer-reviewed journals, books, grey sources (reports, etc.) and dedicated on-line databases). |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | No | *Spread* and *impacts* are included, but *entry* and *establishment* are not. (For species currently absent from Belgium, ISEIA thus assumes their hypothetical presence). |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | *Spread*, *impact* and the actual distribution of species form ISEIA's main elements. The potential distribution is implicitly covered. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | No | No distinction is made among intentional and unintentional *spread*. *Entry* is not covered at all by ISEIA. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | Adverse ecological impacts on native species and ecosystems form two of the four main criteria in ISEIA. |
| Can broadly assess environmental impact with respect to ecosystem services | No | 'Ecosystem services' are not mentioned as such. They are only indirectly covered (above). |
| Includes status (threatened or protected) of species or habitat under threat | Yes | Adverse impacts on biodiversity and ecosystems are explicitly scored against their conservation value (both for species and habitats). |
| Includes possible effects on climate change in the forseeable future | No | Climate change is not referred to in ISEIA. |
| Broadly assesses adverse socio-economic impact | No | ISEIA assesses environmental risks only. |
| Provides a summary of the different components of the asssessment in a consistent and interpretable form and an overall summary | Yes | ISEIA yields a numeric score for each of its four criteria, and then summarizes these into a total score. |
| Includes uncertainty | No | ISEIA does not explicitly allow for a measure of (un)certainty to be provided. |
| Can be completed even when there is a lack of data or associated information | Yes | An assessor is encouraged to base answers on data, but is not obliged to do so. The protocol will still yield output in such cases. |
| Quality Assurance (peer-review etc) | Yes | The intended use for ISEIA is through a multi-expert panel reaching consensus. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendations: Considerable adjustments should be made for ISEIA to become compliant with the minimum standards, such as the inclusion of entry and establishment risks, adverse impacts other than environmental impacts, consideration of climate change, inclusion of ecosystem services assessment, uncertainty measures, etc. The lack of completeness already inspired a review and extension of ISEIA, and this led to the *Harmonia*$^{+}$ protocol. However, *Harmonia*$^{+}$ diverges substantially from ISEIA and so is considered as a separate case study.

Intentions: No relevant amendments are envisaged at this stage.

**List of high and medium impact species assessed by the protocol:**

The application of the ISEIA scheme to approximately 100 species for the Belgian territory led to the lists of species available on http://ias.biodiversity.be/species/all. Some example species of these lists are:

High impact (black list species):

*Rosa rugosa* (rugosa rose)
*Pseudorasbora parva* (topmouth gudgeon)
*Callosciurus erythraeus* (Pallas's squirrel)

Medium impact (watch list species):

*Anser indicus* (bar-headed goose)
*Psittacula krameri* (ring-necked parakeet)
*Quercus rubra* (red oak)

# 8. EPPO Decision-support scheme for quarantine pests

**Brief description (including taxonomic breadth, geographic scope):**

The EPPO Decision-support scheme for quarantine pests (EPPO DSS) is a comprehensive framework for Pest Risk Analysis (PRA) which has been developed by EPPO through the past 10 years through its international Panel on Pest Risk Analysis Development. The EPPO DSS has been updated in 2011 in order to be consistent and complete in its questions and guidance (Kenis, Bacher et al. 2012). Pests as defined by the IPPC (including viruses, bacteria, nematodes, insects, etc. as well as plants) are the target of the EPPO DSS. The scheme asks questions on the probability of entry, establishment, spread and impacts on agriculture, the environment as well as on socio-economic impacts. The EPPO DSS is currently used by EPPO to perform PRAs at the EPPO scale. The scheme is used in EPPO countries and has also been adapted in the UK and in the Netherlands. PRAs produced with the EPPO DSS represent scientifically based justifications to the listing of species as quarantine pests, in line with the World Trade Organization requirements. The Pest Risk Management part is designed to identify preventive measures to the entry of the species assessed.

**Reference or weblink:**

EPPO (2011) Decision-support scheme for quarantine pests. PM 5/3(5). 44 pp.

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Yes | Such information is provided in the categorization part. For plants as pest, a mention is made to the use of the species considered (e.g. for ornament, phytoremediation). |
| Documents information sources | Yes | Scientific literature, grey literature as well as personal communication are provided to justify any statement. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Yes | Dedicated questions consider the probability of entry of the species assessed, its probability of establishment and spread and the magnitude of impacts. For each question, a rating should be provided on a 5 scale basis and guidance is provided as well as examples for the different ratings. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | The actual distribution of the species assessed is accurately assembled with references for each distribution record. The scheme also provides guidance on the relevance and possibility to undertake climatic projection. The spread potential, both through natural and human assisted means is assessed, and tools for modelling spread are also available. Economic impacts (including environmental and social impacts) are also assessed. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | Each potential pathway of entry is assessed, and both intentional and unintentional pathways are considered. Relevant unlikely pathways are listed as well. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | A specific section is considering environmental impacts, including negative impacts on native biodiversity, alteration of ecosystem processes and patterns and conservation impacts. |
| Can broadly assess environmental impact with respect to ecosystem services | No | Although ecosystem services are mentioned, they are not assessed. |
| Includes status (threatened or protected) of species or habitat under threat | Yes | The impacts on habitats of high conservation value (including all officially protected nature conservation habitats) and on rare or vulnerable species (including all species classified as rare, vulnerable or endangered in official national or regional lists within the PRA area) are included. |
| Includes possible effects on climate change in the foreseeable future | No | Such information can be answered in the current scheme and projections of the species potential distribution under climate change scenarios can be undertaken, but this is not mandatory. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Broadly assesses adverse socio-economic impact | Yes | Economic impacts (on crop yield and/or quality of cultivated plants, on increases in production costs including control costs) as well as social impacts (on human well-being, on landscape effects, on loss of employment, on products and services such as water quality, animal grazing, hunting and fishing) are considered. |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | At each stage a summary and a combination of all the answers is made. The ratings and levels of uncertainty of each section can be visualized. A PRA report is elaborated in addition to the full PRA record. |
| Includes uncertainty | Yes | A level of uncertainty (low, medium, high) is provided for each question. Uncertainty is then summarized, such summary can be done through the software Genie. |
| Can be completed even when there is a lack of data or associated information | Yes | Ratings and justification may be completed, even when there is a lack of data. |
| Quality Assurance (peer-review etc) | Yes | Each PRA undergoes a comprehensive review process. After an Expert Working Group has elaborated a PRA, the document is sent for review to core members on PRA as well as to the dedicated EPPO Panel, and is then approved by the EPPO Working Party on Phytosanitary Regulations and by the EPPO Council. The full PRA and PRA report are then published on the EPPO website, with a datasheet on the species. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: To meet the minimum standards, the EPPO DSS would need to include elements on climate change and on ecosystem services.

Intention: To enhance the protocol to include climate change and ecosystem services.

**List of species assessed as high and medium impact by the protocol:**

Five EPPO PRAs are performed every year since 2008. High and medium impacts invasive alien plants for which an EPPO PRA is available are:

*Baccharis halimifolia* (sea myrtle)
*Cabomba caroliniana* (green cabomba)
*Crassula helmsii* (New Zealand pygmy weed)
*Eichhornia crassipes* (water hyacinth)
*Heracleum persicum* (Persian hogweed)
*Heracleum sosnowskyi* (Sosnowsky's hogweed)
*Hydrocotyle ranunculoide*s (floating pennywort)
*Ludwigia peploides* & *L. Grandiflora* (water primrose)
*Lysichiton americanus* (American skunk cabbage)
*Parthenium hysterophoprus* (Santa Maria feverfew) (to be approved and published)
*Polygonum perfoliatum* (mile a minute)
*Pueraria lobata* (kudzu)
*Senecio inaequidens* (narrow leaved ragwort)
*Sicyos angulatus* (burr cucumber)
*Solanum elaeagnifolium* (silver leaved nightshade)

# 11. Fish Invasiveness Screening Kit (FISK) v2

**Brief description:**

FISK v2 is a risk identification, decision-support tool for assessing the likelihood of a non-native freshwater fish becoming invasive in the selected risk assessment area (Copp, Vilizzi et al. 2009, Copp 2013). During the development of a full risk scheme for non-native freshwater fishes (Copp, Garthwaite et al. 2005), FISK (v1) was developed as an adaptation of the Weed Risk Assessment (WRA) (Pheloung, Williams et al. 1999, Pheloung 2001), but improved by the incorporation confidence (certainty) rankings for each response (Yes/No/Don't Know) to each question. Like the WRA, FISK is provided in Excel® with a VisualBasic driven drop-down menu system for inputting responses to questions. FISK questions examine the biogeography and history of the species, the presence of "undesirable traits" and species biology and ecology, and relies on the generally accepted premise that weeds in other parts of the world have an increased chance of being weedy (i.e. invasive) in other areas with similar environmental conditions. To broaden the geographical applicability of FISK to warm temperate and sub-tropical areas, review and revision of FISK v1 questions, guidance and user interface functionality resulted in FISK v2 (Lawson, Vilizzi et al. 2012). FISK is currently used both as a stand-alone screening tool to identify potentially invasive fishes (Copp 2013) and as a screening module within full risk analysis schemes, e.g. the GB non-native risk assessment scheme (Baker, Black et al. 2008, Mumford, Booy et al. 2010) and the European Non-native Species in Aquaculture Risk analysis Scheme (ENSARS) (Copp and Godard 2014).

**Reference or weblink:**

www.cefas.defra.gov.uk/our-science/ecosystems-and-biodiversity/non-native-species/decision-support-tools.aspx

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | All elements are mentioned, except socio-economic benefits. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Documents information sources | Yes | The literature used should be from peer-reviewed sources, though 'grey' literature and other available information may be used (with caution) when information on a species is lacking. With each response, the assessor is expected to provide a justification for the response. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Partly | Likelihood *per se* is not assessed, questions query whether the species has entered, established, spread and/or had impacts in locations similar to the RA area. The guidance text refers to "moderate-to-high" levels in providing the assessor with guidance on how to respond to questions on these topics. |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Partly | See comments here above. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | No | FISK does not address pathways of entry. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Partly | Q12 is as follows: In the species' introduced range, are there impacts to rivers, lakes or amenity values?<br>Guidance to Q12 is as follows: Documented evidence that the species has altered the structure or function of a natural ecosystem. |
| Can broadly assess environmental impact with respect to ecosystem services | No | This is encompassed in Q12, i.e. amenity (see above) |
| Includes status (threatened or protected) of species or habitat under threat | No | |
| Includes possible effects on climate change in the forseeable future | No | |
| Broadly assesses adverse socio-economic impact | No | This is included in Q12 (see above) |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Partly | FISK provides an output score that summarizes responses to the questions, both overall and for three categories of question (affected sectors): Aquaculture, Environment, Nuisance. |
| Includes uncertainty | Yes | Each question requires the assessor to indicate the certainty level associated with their response: very uncertain, mostly uncertain, mostly certain, very certain. |
| Can be completed even when there is a lack of data or associated information | Yes | |
| Quality Assurance (peer-review etc) | Yes | Of all known applications of FISK to multiple species (about 16 or 17 RA areas), only two have not yet been subjected to peer review (by a journal). |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendations: Considerable adjustments would need to be made to FISK to become compliant with the minimum standards.

Intentions: FISK is not a full risk assessment, but a risk identification tool whose purpose is to identify species that are likely to be invasive. As such, FISK is a screening tool and not a full risk analysis scheme. No relevant amendments are envisaged at this stage.

**List of high and medium impact species assessed by the protocol:**

*Acipenser ruthenus* (sterlet sturgeon)
*Amatitlania nigrofasciata* (convict cichlid)
*Ambloplites rupestris* (rock bass)
*Ameiurus melas* (black bullhead)
*Aspius aspius* (asp)
*Babka gymnotrachelus* (racer goby)
*Carassius auratus* (goldfish)
*Carassius carassius* (crucian carp)
*Carassius gibelio* (Prussian carp)

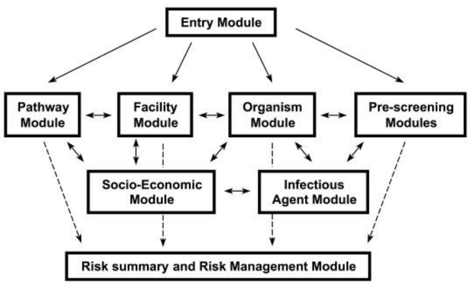
| | |
|---|---|
| *Channa striata* | (striped snakehead) |
| *Cichla ocellaris* | (peacock cichlid) |
| *Clarias batrachus* | (Philippine catfish) |
| *Clarias gariepinus* | (North African catfish) |
| *Coregonus peled* | (peled) |
| *Cyprinus carpio carpio* | (common carp) |
| *Cyprinus carpio haematopterus* | (Amur carp) |
| *Esox lucius* | (northern pike) |
| *Gambusia affinis* | (mosquitofish) |
| *Gambusia holbrooki* | (eastern mosquitofish) |
| *Gymnocephalus cernua* | (ruffe) |
| *Hemiculter leucisculus* | (sharpbelly) |
| *Hypomesus nipponensis* | (Japanese smelt) |
| *Hypophthalmichthys molitrix* | (silver carp) |
| *Hypophthalmichthys nobilis* | (bighead carp) |
| *Ictalurus punctatus* | (channel catfish) |
| *Lates niloticus* | (Nile perch) |
| *Lepomis macrochirus* | (bluegill) |
| *Leuciscus leuciscus* | (common dace) |
| *Micropterus dolomieu* | (smallmouth bass) |
| *Micropterus salmoides* | (largemouth black bass) |
| *Misgurnus anguillicaudatus* | (pond loach) |
| *Morone americana* | (white perch) |
| *Mylopharyngodon piceus* | (black carp) |
| *Oncorhynchus mykiss* | (rainbow trout) |
| *Opsariichthys uncirostris* | (three-lips) |
| *Oreochromis aureus* | (blue tilapia) |
| *Oreochromis mossambicus* | (Mozambique tilapia) |
| *Oreochromis niloticus* | (Nile tilapia) |
| *Parachromis managuensis* | (jaguar guapote) |
| *Perca flavescens* | (American yellow perch) |
| *Perca fluviatilis* | (European perch) |
| *Phoxinus phoxinus* | (Eurasian minnow) |
| *Pimephales promelas* | (fathead minnow) |
| *Poecilia latipinna* | (sailfin molly) |

| | |
|---|---|
| *Poecilia latipinna x P. velifera* | (sailfin molly) |
| *Poecilia reticulata* | (guppy) |
| *Pseudorasbora parva* | (topmouth gudgeon) |
| *Pterygoplichthys disjunctivus* | (vermiculated sailfin catfish) |
| *Rhodeus ocellatus ocellatus* | (rosy bitterling) |
| *Rutilus rutilus* | (roach) |
| *Salmo trutta trutta* | (sea trout) |
| *Salvelinus fontinalis* | (brook trout) |
| *Sander lucioperca* | (pike-perch) |
| *Sarotherodon melanotheron melanotheron* | (blackchin tilapia) |
| *Scardinius erythrophthalmus* | (rudd) |
| *Silurus glanis* | (wels catfish) |
| *Tilapia rendalli* | (redbreast tilapia) |
| *Tilapia zillii* | (redbelly tilapia) |
| *Xiphophorus hellerii* | (green swordtail) |
| *Xiphophorus hellerii X maculatus* | (red swordtail hybrid) |
| *Xiphophorus variatus* | (variable platyfish) |

## 13. European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS)

**Brief description:**

The European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS) was developed in response to European 'Council Regulation No. 708/2007 of 11 June 2007 concerning use of alien and locally-absent species in aquaculture' to provide protocols for identifying and evaluating the potential risks of using non-native species in aquaculture (Copp, Britton et al. 2008, Copp, Russell et al. 2014). ENSARS is modular in structure, having been adapted from schemes developed for the UK (GB NNRA) and the European and Mediterranean Plant Protection Organisation (EPPO DSS). Seven of the eight ENSARS modules contain protocols for evaluating the risks of escape, introduction to and establishment in open waters, of any non-native aquatic organism being used (or associated with those used) in aquaculture, i.e. transport pathways, rearing facilities, infectious agents, and the potential organism, ecosystem and socio-economic impacts. A concluding module is designed to summarise the risks and consider management options (Cowx, Angelopoulos et al. 2009).




ENSARS modular structure (Copp, Russell et al. 2014).

Each ENSARS question requires a response, justification for the response and an indication (ranking) of the assessor's confidence in that response. Responses to questions involve an indication of likelihood (very unlikely to very likely), magnitude (very limited to very great) or similarity (e.g. not similar to very similar), with all scores ranging from 0 to 4 and confidence rankings being from 0 to 3 (low to very high) (IPCC 2005). Each module may be used individually, and each requires a specific form of expertise, so a multi-disciplinary assessment team is required. The ENSARS has been applied to species on Annex IV of the ASR (Copp and Godard 2014).

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | The various modules cover all relevant aspects that describe the organism, including mention of its uses, though socio-economic benefits are not included in the assessment or consideration of the organism's impacts. |
| Documents information sources | Yes | This is a requirement of the scheme. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Yes | The likelihood of these aspects are addressed in the Pathways, Organism, Infectious Agents and Socio-economic assessment modules. |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | These descriptions are included in the Pathways, Organism, Infectious Agents and Socio-economic assessment modules. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | These aspects are covered in the Pathways module. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | These aspects of impact are covered in the Organism and Socio-economic impact assessment modules. |
| Can broadly assess environmental impact with respect to ecosystem services | Yes | These aspects of impact are covered in the Organism and Socio-economic impact assessment modules. |
| Includes status (threatened or protected) of species or habitat under threat | Yes | The ENSARS 'Organism' module includes a question (Q35) on how likely is the organism to consume or to parasitise an endangered or threatened native species, especially those previously subjected to little or no predation or parasitism. The assessor's justification for his/her response to this question is expected to include mention of the status of the threatened native species. |
| Includes possible effects on climate change in the foreseeable future | No | An additional set of questions could be added, as has been done with the GB NNRA, to obtain the assessor's consideration of impacts under future climatic conditions. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Broadly assesses adverse socio-economic impact | Yes | These aspects are addressed in the Socio-economic Impact module. |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | ENSARS has a summary section at the end of each module, with an overall summary of the risks of Entry, Establishment, Dispersal and Impact at the end of the Organism Impact assessment module. |
| Includes uncertainty | Yes | Each question requires the assessor to rank the level of certainty/uncertainty they have in their response. The confidence ranking system is an adapted version of the IPCC (2005) system. |
| Can be completed even when there is a lack of data or associated information | Yes | In carrying out the assessment, the risk assessor may find that certain questions cannot be answered. This may be because the question is not relevant, in which case the question can be ignored and the absence of a reply will not affect the outcome of the assessment. Alternatively, it may prove impossible to obtain the information, in which case its absence will increase the uncertainty of the assessment. |
| Quality Assurance (peer-review, etc.) | Yes | The EU Regulation on the use of aliens in aquaculture requires all MS to establish a 'Competent Authority', which is expected to subject risk assessments to ensure that RAs are peer reviewed and fit for purpose. The first application of ENSARS (i.e. Copp et al. 2014b) has passed peer review and was published on-line a few weeks ago by the journal *Fisheries Management & Ecology*. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: The only minimum requirement that is not completely covered by ENSARS protocols is the issue of climate change. This could be resolved simply by adding the same question that is now included in the rapid form of the GB NNRA:

"What is the likelihood that the risk posed by this species will increase as a result of climate change?"

Intentions: To amend ENSARS accordingly and so it would then be fully compliant.

**List of high and medium impact species assessed by the protocol:**

Medium impact fish species include:

*Acipenser baeri* (Siberian sturgeon)

*Acipenser rhuthenus* (sterlet sturgeon)

*Clarias gariepinus* (African catfish)

Ctenopharyngodon idella (grass carp)

*Hypophthalmichthys molitrix* (silver carp)

*Hypophthalmichthys nobilis* (bighead carp)

*Oncorhynchus mykiss* (rainbow trout)

*Salvelinus fontinalis* (brook trout)

*Sander lucioperca* (pikeperch)

*Silurus glanis* (European catfish)

Medium impact invertebrate species include:

*Crassostrea gigas* (Pacific cupped oyster)

*Ruditapes philippinarum* (Japanese [Manila] clam)

Moderately high impact fish species include:

*Carassius auratus* (goldfish)

*Cyprinus carpio* (common carp)

Moderately high impact invertebrate species include:

*Procambarus clarkii* (red swamp crayfish)

## 14. Harmonia$^{+}$

**Brief description:**

The *Harmonia*$^{+}$ protocol brings together about thirty key questions deemed relevant for assessing the risk of potentially invasive organisms to a particular area (D'hondt, Vanderhoeven et al. 2014). *Harmonia*$^{+}$ can essentially be used for any taxonomic group, geographic area and type of environment, though most of the guidance is currently based on the situation in Belgium and the terrestrial environment.

The use of Harmonia$^{+}$ is flexible in the sense that it allows both for rapid risk screening and detailed risk analysis reports. In the former case, an assessment is restricted to answering only the compulsory key questions (a minimal assessment). In the latter case, the provided answers are supported by textual annotations, the inclusion of which is explicitly encouraged for in the guidance. The compliance screening (below) departs from such a maximal assessment.

**Reference or weblink:**

*Harmonia*$^{+}$ can be accessed as a pdf document and online fillable form through http://ias.biodiversity.be/harmoniaplus.

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Yes/Partly | Taxonomy and geographic scope are compulsory elements for an assessment. The others are not (history, range and benefits), though an assessor is encouraged to include them. |
| Documents information sources | Yes | An assessor is expected to document information sources that support his/her answers. These sources should be evidence-based, though no further restrictions are imposed on the exact type of source used. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Yes | Entry (referred to as *introduction* in *Harmonia*$^{+}$), *establishment*, *spread* and *impacts* form the very backbone of *Harmonia*$^{+}$, and are covered in different modules. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | These elements are covered by different questions. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | Questions on *introduction* distinguish among (1) natural (2) unintentional human, and (3) intentional human pathways of entry. Questions on *spread* distinguish among (1) natural, and (2) human-mediated dispersal. |
| Can broadly assess environmental impact with respect to biodiversity and <u>ecosystem patterns and processes</u> | Yes | The module on *environmental impacts* asks for effects on native biodiversity as well as ecosystem integrity. |
| Can broadly assess environmental impact with respect to ecosystem services | No | 'Ecosystem services' are not mentioned as such in *Harmonia*$^{+}$. They are covered only indirectly by considering ecosystem integrity (above). |
| Includes status (threatened or protected) of species or habitat under threat | Yes | The severity of risk within the *environmental impacts* module explicitly depends on whether the species or habitat under threat is of conservation concern. |
| Includes possible effects on climate change in the forseeable future | No | The protocol was chosen not to make a reference to climate change, under the argument that such an inclusion would increase overall uncertainty. |
| Broadly assesses adverse socio-economic impact | Yes | In fact, *Harmonia*$^{+}$ is constructed to include such impacts as much as possible. In total, 12 questions deal with (cultivated) *plant impacts*, (domesticated) *animal impacts*, *human impacts* and *infrastructural impacts*. |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | The online *Harmonia*$^{+}$ form allows for a textual digest of the answers provided, as well as a numeric analysis. |
| Includes uncertainty | Yes | An assessor is explicitly asked to indicate a level of confidence with every answer provided. |
| Can be completed even when there is a lack of data or associated information | Yes | An assessor is encouraged to base answers on data, but (s)he is not obliged to do so. The protocol will still yield output in such cases. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Quality Assurance (peer-review etc) | No | The protocol (questionnaire) does not come with a fixed process of using it. Essentially, users are free to organize the scoring process as they want it. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: Three adjustments would seem needed for *Harmonia+* to become fully compliant with the minimum standards.

- Some minimum standards that currently are not compulsory for, but may become mentioned in, an assessment should become explicitly asked for. These elements notably are: invasion history, distribution range and socio-economic benefits.
- Ecosystems should become differently treated in *Harmonia*$^{+}$, as to accommodate for ecosystem services. This would probably be a matter of re-phrasing questions, and adjusting current guidance. It may invoke the addition of a few questions.
- Climate change should be included. This would need some adjustments in the overall guidance, pinpointing that an assessor needs to answer questions with a climatically changed world in mind.

Intentions: Given the very recent date of *Harmonia*$^{+}$ (March 2014), and the fact that it has not been published yet (apart from the online report), such changes could in effect still be made.

**List of high and medium impact species assessed by the protocol:**

A preliminary use of the *Harmonia*$^{+}$ protocol by several external test experts on a set of five species yielded the following perceived risks for the Belgian territory.

High impact: *Procambarus clarkii* (Louisiana crayfish), *Lithobates catesbeianus* (American bullfrog), *Ludwigia grandiflora* (Water primrose).
Medium impact: *Nyctereutes procyonoides* (Raccoon dog), *Threskiornis aethiopicus* (Sacred ibis).

More in depth assessment is ongoing for 23 non-native plant and animal species for which in depth literature review has been performed (see reports at: http://ias.biodiversity.be/species/risk). Although preliminary analyses demonstrate that all 23 species have medium to high environmental impact, it is currently not possible to assign those species unequivocally to one of the two categories. This information will be available before the end of the year.

These species are as follows:

*Callosciurus erythraeus* (Pallas's squirrel)
*Carpobrotus* spp. (hottentot fig)
*Cervus Nippon* (sika deer)
*Crassula helmsii* (New Zealand pigmyweed)
*Egeria densa* (Brazilian waterweed)
*Hydrocotyle ranunculoides* (floating pennywort)
*Lagarosiphon major* (curly waterweed)
*Lithobates catesbeiana* (American bullfrog)
*Ludwigia grandiflora* (water primrose)
*Ludwigia peploides* (water primrose)
*Muntiacus reevesi* (Reeves's muntjac)
*Myocastor coypus* (coypu)
*Myriophyllum aquaticum* (water milfoil)
*Myriophyllum heterophyllum* (water milfoil)
*Neogobius melanostomus* (round goby)
*Neovison vison* (American mink)
*Nyctereutes procyonoides* (racoon dog)
*Oxyura jamaicensis* (ruddy duck)
*Perccottus glenii* (Chinese sleeper)
*Procambarus clarkia* (red swamp crayfish)
*Sciurus carolinensis* (grey squirrel)
*Sciurus niger* (fox squirrel)
*Threskiornis aethiopicus* (African sacred ibis)

## 15. EFSA PLH generic opinion requiring a full PRA

**Brief description:**

The EFSA PLH scheme for PRA was developed and published in 2010 (Panel 2010), followed by the guidance on environmental risk assessment (EFSA Panel on Plant Health 2011, EFSA Panel on Plant Health 2012) and the guidance on methodology for evaluation of risk reduction options. The three guidance documents are still in use but the practice requires them to be adapted according to needs/mandate/resources.

**Reference or weblink:**

http://www.efsa.europa.eu/it/efsajournal/doc/1495.pdf

http://www.efsa.europa.eu/it/efsajournal/doc/2460.pdf

http://www.efsa.europa.eu/it/efsajournal/doc/2755.pdf

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | Socio-economic benefits are not included in the EFSA PLH mandate. |
| Documents information sources | Yes | In chapter “2. Methodology and data”<br>EPPO PQR, EUROSTAT, the CABI Crop Protection Compendium, EUROPHYT are the main sources and additional ones are included on a case by case basis.<br>Most of the times, the literature selection starts by applying systematic literature search for which the specific strings are given in appendix.<br>In addition, information and data can be collected directly from the Member States via surveys and in some cases non-published information/data obtained as “personal communications” with experts on the topic can be added. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Yes | |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | The analysis in the entry section is repeated for each of the identified main pathways. The same is done under spread. EUROPHYT data are used in support. The indication of intentional/unintentional is usually not provided, but trade and interception data are instead considered. In some cases the entry with passengers is mentioned. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | As indicated in the ERA PLH scheme and developed in the *Pomacea* case study (EFSA Panel on Plant Health 2014), the impact on traits, biodiversity components and ecosystem services are considered. The analysis requires the definition of a scenario under which to conduct the assessment, the quantification of the relationship between pest density and impact on each selected ecosystem trait and the assessment on the expected reduction in the provision level of each ecosystem service (or in the biodiversity component) in presence of the pest. |
| Can broadly assess environmental impact with respect to ecosystem services | Yes | As indicated in the ERA PLH scheme.<br>This aspect cannot be disconnected from the analysis of ecosystem patterns and processes, as explained above. |
| Includes status (threatened or protected) of species or habitat under threat | Unclear | The analysis at species level is not necessarily included, as the scheme focuses more on the analysis of processes and effects on populations. |
| Includes possible effects on climate change in the foreseeable future | Unclear | Whether to undertake a climate change analysis is considered on a case by case basis (e.g. in case of pests damaging plants under stress conditions, the increasing frequency or duration of drought periods due to climate change could be an aspect to be mentioned in the pest risk assessment). Though, such analysis is not compulsory. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Broadly assesses adverse socio-economic impact | No | Outside EFSA remit. |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | At the end of each section (entry, establishment, spread, impact) a summary with justification of the selected rating and uncertainties is provided. Descriptors for the rating are provided in appendix and quantitative / semi-quantitative / repeatable protocols for applying experts judgment are also followed according to the needs (e.g. use of expert knowledge on elicitation methods, probability distribution, etc.). |
| Includes uncertainty | Yes | Uncertainty rating provided at the end of each PRA section (entry, establishment, spread, impact) and for each risk reduction option. |
| Can be completed even when there is a lack of data or associated information | Yes | Justifications concerning the method applied and the excluded questions are provided in the section on methodology and in each specific paragraph on more punctual issues. |
| Quality Assurance (peer-review, etc.) | Yes | Each opinion produced by a PLH working group, when ready, is reviewed and adopted (by vote) by the PLH Panel, composed by 21 members. Panel members have the possibility to express an opinion which diverges from an adopted opinion in form of a minority opinion, included in the body of the final document. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: To meet the minimum standards, the EFSA PLH would need to include elements on status (threatened or protected) of species or habitat under threat, climate change and socio-economic impacts.

Intentions: No relevant amendments are envisaged at this stage.

**List of high and medium impact species assessed by the protocol:**

All assessments produced by the EFSA PLH Panel are available in the EFSA journal http://www.efsa.europa.eu/en/plh/plhscdocs.htm

EFSA protocol for ERA has been implemented with its first application on *Pomacea* (apple snail) case study (EFSA Panel on Plant Health 2014).

## 16. German-Austrian Black List Information System GABLIS

**Brief description:**

The German-Austrian Black List Information System (GABLIS) is a Black List approach, i.e. species are assessed and prioritized according to their negative impact on all elements of biodiversity (genes, species, and ecosystems) (Nehring, Essl et al. 2010, Essl, Nehring et al. 2011, Nehring, Essl et al. 2013, Nehring, Kowarik et al. 2013, Rabitsch, Gollasch et al. 2013). Socio-economic impacts (incl. human health) are intentionally excluded in the assessment, but have to be documented in the accompanying data sheet, including benefits that may be obtained from the use of the species. The system can be applied without modification to all taxonomic groups and environments and to all species if present or absent in the assessment region. There are five basic impact criteria and six complementary ecological criteria that have to be answered "Yes/Assumed/Unknown/No". Assessments are based on qualitative or semi-quantitative available evidence (scientific or expert opinion). Based on the level of certainty of the impact, the species is listed either in a Black, Grey or White List. "Yes" means that there is scientifically sound evidence of the impact and leads to the Black List. "Assumed" means less confidence about the impact and species may be placed on the Grey List. The Black and Grey List are subdivided according to the distribution of the species and the availability of management techniques (BL-Warning List, BL-Action List, BL-Management List; GL-Observation List, GL-Operation List).

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Yes | All these elements are described. Socio-economic benefits are described as well, but not used for the assessment. There is a list of possible benefits to choose from, e.g. aquaculture, fisheries, forestry, horticulture, game, agriculture, etc. |
| Documents information sources | Yes | Used information for all statements is provided in the reference section. All sources are allowed (scientific and grey literature, expert opinion). |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | No | There is no formal assessment of the likelihoods, but establishment, spread and impact are included in the assessment, whereas entry is not. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes description of the actual and potential distribution, spread and magnitude of impact | Partly | The actual distribution, spread and magnitude of impact are described. The potential distribution, spread and impact are only implicitly covered, e.g. also in relation to climate change. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | Multiple pathways are mentioned; only if the pathway is "trade" this has an influence on the assessment |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | Effects on species and on ecosystem functions are included. |
| Can broadly assess environmental impact with respect to ecosystem services | No | Ecosystem services are not mentioned as such in GABLIS and are only covered indirectly, when assessing other impacts. |
| Includes status (threatened or protected) of species or habitat under threat | Yes | The scheme considers whether one population of a native species is locally endangered by an alien species and if invasion into new areas or similar habitats is likely to increase the risk of extinction of the native species in large parts of its range. |
| Includes possible effects on climate change in the foreseeable future | Yes | The scheme considers whether the species establishment is facilitated by climate change. |
| Broadly assesses adverse socio-economic impact | No | Positive or negative socio-economic impacts are mentioned, but not used for the assessment |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | 2-page fact-sheet with data and references and overall listing assessment (black list) |
| Includes uncertainty | Yes | Uncertainty of impacts is related to the final listing category (high certainty: Black List, less certainty: Grey List). |
| Can be completed even when there is a lack of data or associated information | Yes | It is mentioned if there are incomplete data and this is included in the assessment procedure |
| Quality Assurance (peer-review etc) | Partly | It is suggested that the assessment shall be based on wider consultations, but it is not obligatory |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendations: GABLIS would need to include the likelihood of entry. It does explicitly exclude assessment of possible adverse socio-economic impacts.

Intentions: Further developments of GABLIS are intended to better accommodate all taxa (e.g. fungi) and to consider EU Regulation requirements, e.g. regarding the likelihood of entry, the more detailed incorporation of pathways into the assessment protocol and the possibilities to include ecosystem services into the assessment (or not).

**List of high and medium impact species assessed by the protocol:**

Full GABLIS-assessments were executed so far for approximately 80 vascular plants, 70 vertebrates and 50 species not yet present in Germany (see references).

Examples include:

Black List-Warning List: *Pueraria lobata* (kudzu)
Black List-Action List: *Crassula helmsii* (New Zealand pigmyweed)
Black List-Management List: *Ailanthus altissima* (tree of heaven)
Grey List-Watch List: *Asclepias syriaca* (common milkweed)
Grey List-Operation List: *Ambrosia artemisiifolia* (ragweed)

# 17. GB NNRA (Great Britain Non-native Species Risk Assessment)

**Brief description:**

Risk assessment for any non-native organism that poses a threat to Great Britain (but note the risk assessment area can be redefined to any area – from part of a country to several states or indeed the whole EU).

The protocol was first devised in 2004 and was based on the EPPO DSS (this version of the GBNNRA is referred to as the 'original' protocol). There have been several alterations to the protocol since then, notably in 2011-12, when several questions were added on environmental impact, climate change and research (referred to as the 'updated' protocol). Finally, in June 2014, following the recommendations from the workshop (Task 3), the protocol had several further additions to meet the minimum standards and is now called Version 2. Comments below refer to the 'updated' protocol.

**Reference or weblink:**

**http://www.nonnativespecies.org/index.cfm?sectionid=51**

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Mostly | Socio-economic benefits are not currently considered, but all other aspects listed are. Note: The protocol has been altered in June 2014 (V2) to include this element. |
| Documents information sources | Yes | The protocol uses peer-reviewed publications, grey literature and even personal communications. All sources are clearly documented within the text and in a bibliography at the end of the document.<br>All risk assessments are peer-reviewed with the reviewer specifically asked whether the documentation is up to date, not missing any key publications, data is correctly interpreted, etc. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Yes | Entry is covered by 11 questions (per pathway chosen), establishment by 17 questions, spread by 9 questions and impact by 18 questions. |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | As well as providing a score, the risk assessment also requires comments (referenced where appropriate) to substantiate/justify the score. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | Multiple entry pathways can be considered – usually in order of importance. Spread is divided into 'natural' spread and human-induced spread. Both intentional and unintentional are considered, as appropriate. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | Of the 18 questions on impact there are: 5 general questions, 7 relating to environmental impact, 5 relating to economic impact and 1 question relating to social impact. The environmental impact questions include impact on ecosystem patterns and processes. |
| Can broadly assess environmental impact with respect to ecosystem services | No | This is not explicit within the scheme [though it has been added in Version 2 – in June 2014]. |
| Includes status (threatened or protected) of species or habitat under threat | Yes | This is included in the scheme in parts of 2 questions. |
| Includes possible effects on climate change in the foreseeable future | Yes | Included in the scheme (there are 3 questions), not explicit in the original scheme. |
| Broadly assesses adverse socio-economic impact | Yes | The protocol asks risk assessors if there are any human health/social impacts in a single question and asks the assessor to outline the economic impacts over 5 questions. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | There is a summary section at the end of the risk assessment in which the risk assessor summarises the risks of:<br>Entry<br>Establishment<br>Spread<br>Impact<br>Overall Risk |
| Includes uncertainty | Yes | All of the questions (including the summary questions) include a measure of confidence on a 4 point scale [in the original scheme this was described as uncertainty]. |
| Can be completed even when there is a lack of data or associated information | Yes | |
| Quality Assurance (peer-review etc) | Yes | There is an extensive QA/review process. All risk assessments are peer -reviewed by 1-3 reviewers. The draft assessment and the peer-review are then scrutinised by an expert panel. Risk assessments also have a period of public comment before they are finalised. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: To meet the minimum standards, the GB NNRA would need to include elements benefits and ecosystem services.

Intentions: Additional questions have now (June 2014) been added (Version 2) including description of benefits (Question 9) and explicit reference to ecosystem services (Questions 2.18 & 2.19). Therefore subsequent risk assessments should be fully compliant with the minimum standards.

**List of high and medium impact species assessed by the protocol:**

Species assessed as posing a high risk:

*Crepidula fornicata* (slipper limpet)

*Didemnum vexillum* (carpet sea-squirt)

*Dikerogammarus haemobaphes* (demon shrimp)

*Dikerogammarus villosus* (killer Shrimp)

*Dreissena polymorpha* (zebra mussel)

*Pacifastacus leniusculus* (signal crayfish)

*Procambarus clarkii* (red swamp crayfish)

*Rapana venosa* (rapa whelk)

*Rhododendron ponticum* (rhododendron)

Species assessed as posing a medium risk:

*Allium triquetrum* (three-cornered garlic)

*Bombus terrestris terrestris* or *dalmatinus* (bumblebee)

*Bubo bubo* (eagle owl)

*Caprella mutica* (Japanese skeleton shrimp)

*Crassostrea gigas* (Pacific oyster)

*Orconectes limosus* (spiny-cheek crayfish)

*Orconectes virilis* (virile crayfish)

*Pelophylax ridibundus* (marsh frog)

*Potamopyrgus antipodarum* (New Zealand mudsnail)

*Procambarus* spp. (marbled crayfish)

*Vespa velutina* (Asian hornet)

## 18. Norwegian alien species impact assessment

**Brief description:**

The Norwegian alien species impact assessment has been used to produce lists and assessments of alien species in Norway in 2012 (Sandvik, Sæther et al. 2013). The set of criteria is applicable to all taxa and habitats. It has been applied to mainland Norway and to Svalbard (Spitzbergen); within these two regions, all multicellular alien species known to be present have been assessed in addition to a sample of multicellular alien species not yet present (horizon scanning).

The set of criteria assesses the negative ecological impact of alien species along two separate axes, viz. invasiveness and effect. Effects on all elements of biodiversity are considered (genes, populations, species, and habitat types). There are three criteria to assess invasiveness (likelihood and extent/velocity of establishment and expansion) and six criteria to assess ecological effects. Based on documented evidence, each species is assigned to one out of four partial categories for each of the nine criteria, the thresholds between which are defined numerically (for invasiveness) or semi-quantitatively (for effects). A score is provided for invasiveness (roughly as the product of likelihood of establishment and velocity of expansion) and for effect (as the maximum score attained by the six criteria). Based on the invasiveness scores and effect scores, the species are assigned to one out of five impact categories: no known impact (NK), low impact (LO), potentially high impact (PH), high impact (HI), and severe impact (SE). The latter two categories constitute the Black List.

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | Socio-economic benefits may be briefly mentioned in appropriate cases, but are not described in detail. |
| Documents information sources | Yes | Documentation of whatever sources are used is required. There is no restriction on the type of source (peer-reviewed literature, reports, museum collections etc.), except that they must be accessible for verification. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Partly | Fulfilled for alien species already present. However, alien species that are *not yet present* (horizon scanning) are assessed *as if they were already present*, i.e. their likelihood of entry assessment; this likelihood is *described* in the species description, but is not *quantified* and does not affect the final score of the species. |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Yes | This information is documented and can affect the final impact score. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | Yes | For species already present, each pathway is reported together with introduction period and frequency. For species not yet in the country, likely pathways are reported. Assessment is not done for each pathway *separately*, but for the *sum* of all intentional and unintentional pathways of entry and spread. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | Quantifies ecological and genetic effects on native species; effects on ecosystem patterns and processes are quantified in terms of state changes to habitat types. |
| Can broadly assess environmental impact with respect to ecosystem services | No | Ecosystem services are not assessed within this scheme; such impacts can be *described* in the species description, but would not affect the final score of the species. |
| Includes status (threatened or protected) of species or habitat under threat | Yes | Effects on threatened or rare species or habitat types receive a greater weight. |
| Includes possible effects on climate change in the foreseeable future | Yes | Predictable effects within a 50-year timeframe are taken into account. |
| Broadly assesses adverse socio-economic impact | No | Socio-economic impacts are not considered; they are *described* in the species description, but do not affect the final score of the species. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | For each species, a summary text of the assessment is available.<br>Each species receives a code which gives consistent (comparable) and interpretable information about the invasion potential and ecological effect, including the criteria on which this score is based. [There are five final impact categories (SE=severe, HI=high, PH=potentially high, LO=low, NK=no known impact), which are combined with the score for invasion potential (1-4) and ecological effect (1-4), each of which is supplemented by the letter (a-i) of the criterion according to which the score was obtained; e.g., HI:2(b),4(e).] |
| Includes uncertainty | Yes | Uncertainty is incorporated into the assessment by means of providing confidence intervals or prediction intervals for the estimates underlying the partial scores. |
| Can be completed even when there is a lack of data or associated information | Yes | Lack of information on single effect criteria does not pose any problem because the *maximum* score (rather than average or sum) is used. In the total absence of data on a species, information on closely related and ecologically similar species is to be used. |
| Quality Assurance (peer-review etc) | Yes | All taxa are assessed by panels, the members of which agree on the score given to each species. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: The Norwegian RA would need to include socio-economic impacts and ecosystem services.

Intentions: The Norwegian RA was commissioned as a purely ecological set of criteria, and therefore does not meet the minimum standards related to the assessment of socio-economic impacts and ecosystem services. No relevant amendents are envisaged at this stage.

**List of high and medium impact species assessed by the the protocol:**

106 species with severe impacts

110 species with high impacts

198 species with potentially high impacts

Listings are available in: Gederaas et al (2013) *Alien species in Norway: with the Norwegian Black List 2012*. Trondheim: Norwegian Biodiversity Information Centre.

http://artsdatabanken.no/Article/Article/133437

# 23. Generic Impact Scoring System GISS

**Brief description:**

The Generic Impact Scoring System (GISS) is a semi-quantitative scoring system which measures the impact of alien and invasive species as environmental and economic impact in 12 impact categories (Kumschick and Nentwig 2010, Nentwig, Kühnel et al. 2010). As a generic system, it allows a direct comparison of species and it can be used for all taxonomic groups of animals and plants (Kumschick, Alba et al. 2011). GISS primarily allows ranking and prioritization of species according to their impact, but can also be used to establish black lists or warning lists on country level.

GISS is characterized by (1) a systematic consideration of the total impact an alien and invasive species has and (2) by relying primarily on scientifically published information. Impact is measured in 12 categories, each with five intensity levels. By adding the impact scores of a given species, a total impact value is obtained. By default, all 12 impact categories are considered equally important, but it is possible to give different weights to selected impact categories.

GISS asks for known impact in the environmental range (on plants or vegetation, on animals through predation or parasitism, on other species through competition, through transmission of diseases or parasites to native species, through hybridization, on ecosystems) and in the economic range (on agricultural production, on animal production, on forestry production, on human infrastructure and administration, on human health, on human social life), thus, including socio-economic aspects. The assessor has to attribute a given impact to five intensity levels and to three confidence levels.

The primary outcome of a GISS application is the sum of total impact scores of a given alien species. This value can be used for ranking and prioritization of species, for black lists or warning lists, and for management recommendations. Depending on the area assessed, it is applicable on a large scale (e.g., Europe) or on country level.

The application of GISS is performed with this questionnaire which includes detailed descriptions of all impact categories and intensity levels. This makes GISS a robust impact assessment that allows a quick screening of all alien species with known impact. About 350 terrestrial and aquatic species of invertebrate and vertebrate animals as well as vascular plants have been scored so far (Vaes-Petignat and Nentwig 2014).

**Compliance with minimum standards including brief comments:**

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | Socioeconomic benefit is described as usage for which the species had been introduced but it is recognised that other benefits might arise beyond those for which the species as introduced. |
| Documents information sources | Yes | GISS relies on published information sources, primarily scientific literature. |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | No | GISS only assesses impact. |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Partly | GISS includes description of the actual distribution and magnitude of impact, but no forecast on potential distribution and spread. |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | No | GISS documents pathways but does not analyse them. Spread is not included. |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Yes | |
| Can broadly assess environmental impact with respect to ecosystem services | No | |
| Includes status (threatened or protected) of species or habitat under threat | Yes | |
| Includes possible effects on climate change in the foreseeable future | No | |
| Broadly assesses adverse socio-economic impact | Yes | |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Yes | This is achieved by a compilation of the scores in a table, by a calculation of scores for impact on environment and on socio-economy, and by giving the total score value. Also confidence levels are given for all steps. A verbal conclusion text is added. |

| Minimum standard | Compliance Yes/No/Unclear | Comments |
|---|---|---|
| Includes uncertainty | Yes | GISS includes uncertainty as confidence level. It is given by the assessor for all 12 major categories on a 3 level scale, and calculated for the 6 environment and the 6 socio-economic categories separately, as well as for the total score. |
| Can be completed even when there is a lack of data or associated information | Partly | Lack of data is regarded as no data available, thus impact level 0. This allows completing the assessment even if no impact can be considered. Insofar, the answer is yes. Because we do not include expert opinion (=unpublished information), the answer could also be no. |
| Quality Assurance (peer-review etc) | Yes | The assessment is performed by one assessor who signs the assessment. It is then reviewed by one reviewer who also signs. |

**Key recommendations and intentions for the protocol to meet (or not) minimum standards:**

Recommendation: To meet the minimum standards, the GISS would need to include elements on likelihood of entry, establishment, spread but also climate change.

Intentions: GISS is an impact assessment protocol and does not meet minimum standards for a risk assessment, especially likelihood of entry, establishment, spread, reaction to climate change. No relevant amendments are envisaged at this stage.

**List of high and medium impact species assessed by the protocol:**

About 350 terrestrial and aquatic species of invertebrate and vertebrate animals as well as vascular plants have been scored so far (Nentwig, Kühnel et al. 2010, Vaes-Petignat and Nentwig 2014). They cover a wide range from no impact to highest impact (http://neobiota.pensoft.net/articles.php?id=1275).

## Task 4.2b: Evaluation of assessments

The case studies confirmed that the GB NNRA, EPPO DSS, Harmonia+ and ENSARS came close (compliant with more than ten minimum standards) to meeting the minimum standards (Tables 4.3 and 4.4, see conclusion at bottom of the table) and are hereafter referred to as "substantially compliant".

**Table 4.3:** Summary of the assessment of minimum standard for FISK (horizon scanning protocol) and the EPPO DSS , the EFSA PRA, Harmonia+ and the GBNNRA (risk assessment protocol).

| Minimum standard | FISK | EPPO DSS | EFSA PRA | Harmonia+ | GBNNRA |
|---|---|---|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | Partly | Partly | Partly | Partly |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Partly | ✓ | ✓ | ✓ | ✓ |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Partly | ✓ | ✓ | ✓ | ✓ |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | | ✓ | ✓ | ✓ | ✓ |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Partly | ✓ | ✓ | ✓ | ✓ |
| Can broadly assess environmental impact with respect to ecosystem services | | | ✓ | | Partly |
| Broadly assesses adverse socio-economic impact | | ✓ | | ✓ | ✓ |
| Includes status (threatened or protected) of species or habitat under threat | | ✓ | | ✓ | ✓ |
| Includes possible effects on climate change in the foreseeable future | | | | | ✓ |

| Minimum standard | FISK | EPPO DSS | EFSA PRA | Harmonia+ | GBNNRA |
|---|---|---|---|---|---|
| Can be completed even when there is a lack of data or associated information | ✓ | ✓ | ✓ | ✓ | ✓ |
| Documents information sources | ✓ | ✓ | ✓ | ✓ | ✓ |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | Partly | ✓ | ✓ | ✓ | ✓ |
| Includes uncertainty | ✓ | ✓ | ✓ | ✓ | ✓ |
| Quality Assurance (peer-review etc) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Number of minimum standard complainces | 4 | 11 | 10 | 11 | 12 |
| Inclusion within Task 5 | No | ✓ | No | ✓ | ✓ |

**Table 4.4:** Summary of the assessment of minimum standards for GISS, ENSARS, ISEIA, GABLIS, and the Norwegian IAS (impact assessment tools)

| Minimum standard | GISS | ENSARS | ISEIA | GABLIS | Norwegian RA |
|---|---|---|---|---|---|
| Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits) | Partly | Partly | | ✓ | ✓ |
| Includes the likelihood of entry, establishment, spread and magnitude of impact | | ✓ | | | |
| Includes description of the actual and potential distribution, spread and magnitude of impact | Partly | ✓ | ✓ | Partly | ✓ |
| Has the capacity to assess multiple pathways of entry and spread in the assessment, both intentional and unintentional | | ✓ | | ✓ | |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | ✓ | ✓ | ✓ | ✓ | ✓ |
| Can broadly assess environmental impact with respect to ecosystem services | Partly | ✓ | | | |
| Broadly assesses adverse socio-economic impact | ✓ | ✓ | | | |
| Includes status (threatened or protected) of species or habitat under threat | ✓ | ✓ | ✓ | ✓ | ✓ |
| Includes possible effects on climate change in the foreseeable future | | Partly | | ✓ | ✓ |
| Can be completed even when there is a lack of data or associated information | Partly | ✓ | ✓ | ✓ | ✓ |
| Documents information sources | ✓ | ✓ | ✓ | ✓ | ✓ |
| Provides a summary of the different components of the assessment in a consistent and interpretable form and an overall summary | ✓ | ✓ | ✓ | ✓ | ✓ |

| Minimum standard | GISS | ENSARS | ISEIA | GABLIS | Norwegian RA |
|---|---|---|---|---|---|
| Includes uncertainty | ✓ | ✓ | | ✓ | ✓ |
| Quality Assurance (peer-review etc) | ✓ | ✓ | ✓ | Partly | ✓ |
| Number of minimum standard compliances | 7 | 12 | 7 | 9 | 10 |
| Inclusion within Task 5 | No | ✓ | No | No | No |

### Amendments recommended for risk assessment protocols

Minimum standard on ecosystem services - GB NNRA, EPPO DSS, Harmonia+ do not currently consider impacts on ecosystem services. However, assessment of ecosystem services could be incorporated into these protocols and there is a willingness to do so. Indeed an example of the way in which the EPPO DSS could be expanded to include ecosystem services has been considered in detail (Table 4.5). Such an approach could be adopted more widely.

**Table 4.5:** The impacts of *Parthenium hysterophorus* on ecosystem services. This assessment is made for the endangered area (see Q 3.11 within EPPO DSS) including the Mediterranean basin and the most thermophilous parts of the temperate EPPO region. The different categories of ecosystem services have been taken from the Economics of Ecosystems & Biodiversity website (TEEB 2010), and from the EFSA guidance on the environmental risk assessment of plant pests (EFSA on Plant Health 2011). For each ecosystem service, an assessment on a 5 grid scale (minimal, minor, moderate, major, massive) is provided, with an assessment of uncertainty (low, medium, high) and a justification. The overall impacts of *P. hysterophorus* on ecosystem services are considered to be major to massive.

| Provisioning services | | |
|---|---|---|
| Food | Major to massive<br>Low uncertainty | *P. hysterophorus* is a serious problem in pastures (see Q. 6.01) and reduces livestock production. It also competes with cultivated crops (e. g. cereals, orchards, vegetables) causing important yield reduction. |
| Raw materials (fibres, wood, biofuels, ornamental resources). | Minimal<br>Medium uncertainty | No impacts have been reported on raw materials. |

| | | |
|---|---|---|
| Biochemical, natural medicines, etc. | Minor<br>High uncertainty | *P. hysterophorus* has no recorded impacts on biochemical and natural medicines, although by outcompeting other species in grasslands and other natural or semi-natural ecosystems, the plant may be detrimental to natural medicines.<br>On the other hand, *P. hysterophorus* is used as a medicinal plant used in India against dysentery and for its properties as antitumor. It is also externally used in the Caribbean and in Central America against skin disorders (Oudhia, 2014). |
| Fresh water | Minimal<br>Low uncertainty | No impacts have been reported on global hydrological cycle. |
| Regulating services | | |
| Air quality regulation | Major<br>Low uncertainty | The pollen of *P. hystyerophorus* being highly allergenic, its presence in the air greatly reduces air quality (see Q. 6.10). |
| Climate regulation | Minor<br>High uncertainty | No impacts on climate regulation have been explicitly reported. The species may lower the formation of shrub or tree communities, thus impeding the capture of CO2, changing the land use and potentially impacting the locally temperatures and precipitations. |
| Water regulation and cycling | Minimal<br>Low uncertainty | No impacts on water regulation are reported. |
| Soil formation | Minor<br>Medium uncertainty | No direct impact on soil formation have been reported, though, if the species outcompetes other species including through allelopathy, this may have effects on soil formation. |
| Erosion regulation | Minimal<br>Low uncertainty | No impacts on erosion regulation are reported. |
| Nutrient cycling | Minor to moderate<br>Medium uncertainty | If *P. hysterophorus* attains high densities, it may have an impact on nutrient cycling (see Q 6.08.04). |
| Photosynthesis and primary production | Minor to moderate<br>Medium uncertainty | Pollen from *P. hysterophorus* can reduce the chlorophyll content of the leaves in which it comes in contact (see Q. 6.08.01). |
| Pest and disease regulation | Major<br>Low uncertainty | *P. hysterophorus* is a reservoir for many pests (see Q. 6.01). |
| Pollination | Major<br>Low uncertainty | Pollen from *P. hysterophorus* can interfere with pollination and fruit set of other species, both wild and cultivated (see Q. 6.01 and 6.08.06). |

| Habitat or supporting services | | |
|---|---|---|
| Habitats for species | Moderate<br>Low uncertainty | *P. hysterophorus* has been recorded in protected areas which contain unique habitats and species (see Q. 6.08.07 and 6.08.01). More generally, the plant is able to outcompete other species (see Q 6.08.01). |
| Maintenance of genetic diversity | Minor<br>Medium uncertainty | The plant is able to outcompete other species (see Q 6.08.01), though it is not reported to threaten rare species (see Q 6.08.08). |
| Cultural services | | |
| Recreation and mental and physical health | Major to massive<br>Low uncertainty | *P. hysterophorus* occurs in recreation areas. Although the species would not impact directly recreational activities, its human health impact may have deleterious consequence on the frequentation of certain areas (see Q. 6.10).<br>Its human health impacts through dermatitis and respiratory allergies have led to the death or to the suicide of people (see Q. 6.10). |
| Tourism | Minor to moderate<br>Medium uncertainty | *P. hysterophorus* may occur in touristic areas. Although the species would not impact directly touristic activities, its human health impact may have deleterious consequence on the frequentation of touristic sites (see Q. 6.10). |
| Aesthetic appreciation and inspiration for culture, art and design | Minor<br>Medium uncertainty | Dense patches of the plant would create a negative visual effect (see Q. 6.10). |
| Spiritual experience and sense of place | Minimal<br>High uncertainty | No information is available on this point. |

Minimum standard on socio-economic benefits (included within minimum standard on description) - GB NNRA and Harmonia[+] both currently lack inclusion of description of socio-economic benefits but both acknowledge a willingness to include this aspect going forward. This would be a straightforward modification since it is not required that the socio-economic benefits are considered for the risk score but are instead described qualitatively. The EPPO DSS and ENSARS already consider such benefits.

Minumum standard on possible effects of climate change in the foreseeable future - This was another minimum standard that was rarely met although the GB NNRA does now include climate change considerations. ENSARS, Harmonia[+] and EPPO fail to include climate change considerations within their protocols. However, as is acknowledged in the ENSARS case study, this aspect could be resolved by adding the same question that is now included in the rapid form of the GB (NAPRA) risk questionnaire: "What is the likelihood that the risk posed by this species will increase as a result of climate change?"

Minimum standard on inclusion of status (threatened or protected) of species or habitat under threat – This minimum standard was comprehensively met by the impact assessment protocols (Table 4.5) and three of the five risk assessment protocols (Table 4.4) but the EFSA PRA and FISK (horizon scanning tool) did not include status (threatened or protected) of species or habitat under threat. Consideration of status of species or habitats under threat is important because such species or habitats may be less resilient to biological invasions.

### Considerations on the relevance of regional or member state risk assessments

The GB NNRA undertakes risk assessments with specific emphasis on level of invasion risk to Great Britain. Therefore, it is necessary to be cautious in extrapolation of the outcomes of the GB NNRA to Europe. However additional information could be requested to increase the relevance of regional or member state risk assessments. The GB Non-Native Species Secretariat is considering such an approach which they refer to as an "EU IAS Risk Assessment Chapeau" (Box 4.1). For some species such a chapeau would provide a straightforward solution to extending the applicability of a regional risk assessment to Europe. However, for poorly studied species such extrapolation is difficult and potentially lacking rigour. It would be necessary to consider mechanisms for evaluating such an approach but an expert committee (with representation from across Europe) could review such supporting information alongside the full risk assessment. Consideration of biogeographic regions could be advantageous for providing context to risk assessments and assist extrapolation of the assessment beyond a single member state.

**Box 4.1:** Proposed EU IAS Risk Assessment Chapeau - supporting information to increase the relevance of regional or member state risk assessments

**RUDDY DUCK**

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

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

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

*4: UK, France, Netherlands, Belgium.*

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

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

| |
|---|
| In which EU Biogeographic areas could this species establish?<br>*Atlantic, Mediterranean, Continental, Pannonian, Boreal and possibly Alpine.*<br>In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.<br>*27 MS. All the remaining member states apart from Luxembourg which may not have sufficient suitable wetlands.*<br>In how many EU member states could this species have adverse impacts in the future [given current climate] (where it is not already established)? List them.<br>*If this species became established in Spain it would be highly invasive there. If the white-headed duck were to be restored to its former EU range it would also be invasive in other member states: Italy, Portugal, France, Hungary, Greece, Romania, Bulgaria, Slovenia, Croatia and Cyprus.*<br>Are there any benefits or uses associated with this species?<br>*Apart from keeping in wildfowl collections there are no significant benefits provided by this species in the EU.* |

## Summary: Task 4

None of the risk assessment methods currently available with European applicability meet the minimum standards agreed through Task 3. The three aspects which were most consistently lacking from the protocols were:

17. Description of socio-economic benefits;
18. Assessment of environmental impact with respect to ecosystem services;
19. Consideration of climate change.

Arguably consideration of ecosystem services causes the greatest challenge. The concept of ecosystem services is relatively new and so it is not surprising that only one (EFSA PLH) of the protocols included consideration of ecosystem services. The EFSA PLH scheme for PRA includes detailed and consistent consideration of ecosystem services. Indeed this protocol includes time-frame and considers various types of ecosystem services (except those linked to social and cultural services). Some protocols, such as GISS and the EPPO DSS consider various environmental impacts linked to ecosystem services but currently ecosystem services would not be quoted as such in the assessment. All protocols need to include a qualitative and broad description of impacts on ecosystem services if the minimum standard is to be met. It is foreseen that dedicated guidance on how to assess the impact on ecosystem services in the context of EU IAS RAs would need to be developed.

In conclusion, of the ten protocols assessed in detail only four (GB NNRA, EPPO DSS, Harmonia$^+$ and ENSARS) were "substantially compliant" with the minimum standards, and are to be considered within Task 5. However, of these only the GB NNRA and EPPO DSS have published IAS risk assessments. Harmonia$^+$ has preliminary risk assessments completed for five species and a further 23 species are currently undergoing assessment. The risk assessments undertaken using the ENSARS protocol are not publically available and so it is difficult to stringently review the assessments of individual species for subsequent inclusion within Task 5. However, further consideration is given to all four protocols within Task 5.

# Task 5: Screening of potential IAS of EU Concern and proposal of a list

## Task Overview

Prioritisation of potential "IAS of EU concern" is essential to both target IAS interventions at the species constituting the highest risks and for allocating the limited resources available based on feasibility of outcomes (Shine, Kettunen et al. 2010). At EU level prioritisation will only be possible with a robust common framework for IAS risk assessment and hence the outputs from Tasks 1 to 4 underpin Task 5. However, it is important to note that although risk management is not considered within this framework it would be an important factor in determining the definitive list of "IAS of EU concern". Therefore, to overcome this clear shortcoming, we suggest that sound scientific information on risk management is duly taken into account in the decision process for listing "IAS of EU concern" following the assessment of risks based on the agreed minimum standard criteria.

## Task 5.1: Compile the list of species for screening

We cross tabulated the risk assessment methods against the agreed minimum standards for the list of 80 species provided by the Commission. Additionally we also screened and included IAS identified from additional risk assessment methods.

The list of 80 species (Table 5.1) provided for this purpose by the Commission includes species formerly risk assessed according to the following methodologies: the EPPO pest risk assessments, the Belgian (ISEIA), British and Irish methodologies. The original list of species was obtained from the EC (and included a compilation of lists from a range of sources).

**Table 5.1:** List of 80 species provided by the Commission

| | Scientific name | Common name |
|---|---|---|
| 1 | *Acer negundo (Negundo aceroides)* | Boxelder |
| 2 | *Acer rufinerve* | Redvein Maple |
| 3 | *Ailanthus altissima* | Tree-of-heaven |
| 4 | *Akebia quinata* | Five-leaf akebia |
| 5 | *Alopochen aegyptiacus* | Nile goose |
| 6 | *Ambrosia artemisiifolia* | Common ragweed |
| 7 | *Ameiurus nebulosus* | Brown bullhead |
| 8 | *Aster novi-belgii agg.* | New York aster |
| 9 | *Azolla filiculoides* | Water fern |
| 10 | *Baccharis halimifolia* | Eastern Baccharis |
| 11 | *Bidens frondosa* | Devil's beggartick |
| 12 | *Branta Canadensis* | Canada goose |
| 13 | *Buddleja davidii* | Butterfly-bush |
| 14 | *Cabomba caroliniana* | Green Cabomba |
| 15 | *Callosciurus erythraeus* | Pallas's squirrell |
| 16 | *Callosciurus finlaysoni* | Finlayson's squirrel |
| 17 | *Capra hircus* | Feral goat |
| 18 | *Castor Canadensis* | Canadian beaver |
| 19 | *Cervus Nippon* | Sika deer |
| 20 | *Cornus sericea* | red osier dogwood |
| 21 | *Corvus splendens* | Indian house crow |
| 22 | *Cotoneaster horizontalis* | Rockspray cotoneaster |
| 23 | *Crassula helmsii* | Australian swamp stonecrop |
| 24 | *Echinocystis lobata* | Wild cucumber |
| 25 | *Egeria densa* | Brazilian Waterweed |
| 26 | *Eichornia crassipes* | Water hyacinth |
| 27 | *Elodea Canadensis* | Canadian water/pondweed |
| 28 | *Elodea nuttallii* | Nuttall's water-weed |
| 29 | *Epilobium ciliatum* | Northern willowherb |
| 30 | *Eriocheir sinensis* | Chinese mittencrab |
| 31 | *Fallopia japonica, F. sachalinensis & F. x bohemica* | Japanese knotweed |
| 32 | *Helianthus tuberosus* | Jerusalem artichoke |
| 33 | *Heracleum mantegazzianum* | Giant hogweed |

| | Scientific name | Common name |
|---|---|---|
| 34 | *Heracleum persicum* | Persian hogweed |
| 35 | *Heracleum sosnowskyi* | Sosnowski's hogweed |
| 36 | *Hydrocotyle ranunculoides* | Floating pennywort |
| 37 | *Impatiens glandulifera* | Himalayan Balsam |
| 38 | *Lagarosiphon major* | Curly waterweed |
| 39 | *Lepomis gibbosus* | Pumpkinseed fish |
| 40 | *Lithobates (Rana) catesbeianus* | North American bullfrog |
| 41 | *Ludwigia grandiflora* | Water-primrose |
| 42 | *Ludwigia peploides* | Floating primrose-willow |
| 43 | *Lupinus polyphyllus* | Large-leaved Lupine |
| 44 | *Lysichiton americanus* | American skunk cabbage |
| 45 | *Mahonia aquifolium* | Oregon-grape |
| 46 | *Mephitis mephitis* | Skunk |
| 47 | *Muntiacus reevesii* | Muntjac deer |
| 48 | *Myopsitta monachus* | Monk parakeet |
| 49 | *Myriophyllum aquaticum* | Parrot's feather |
| 50 | *Myriophyllum heterophyllum* | Watermilfoil |
| 51 | *Nasua spp.* (max 2 species) | Coati |
| 52 | *Neovison (Mustela) vison* | American mink |
| 53 | *Nyctereutes procyonoides* | Raccoon dog |
| 54 | *Ondatra zibethicus* | Muskrat |
| 55 | *Oxyura jamaicensis* | Ruddy duck |
| 56 | *Persicaria perfoliata* (*Polygonum perfoliatum*) | Asiatic tearthumb |
| 57 | *Persicaria wallichii* | Himalayan knotweed |
| 58 | *Pimephales promelas* | Fathead minnow |
| 59 | *Procyon lotor* | Raccoon |
| 60 | *Prunus serotina* | Black cherry |
| 61 | *Pseudorasbora parva* | Stone moroko |
| 62 | *Psittacula krameri* | Rose-ringed parakeet |
| 63 | *Pueraria lobata* | Kudzu Vine |
| 64 | *Rattus norvegicus* | Brown rat |
| 65 | *Rattus rattus* | Black rat |
| 66 | *Robinia pseudoacacia* | Black locust |

| | Scientific name | Common name |
|---|---|---|
| 67 | *Rosa rugosa* | Japanese rose |
| 68 | *Rudbeckia laciniata* | Cutleaf |
| 69 | *Sargassum muticum* | Japweed, wireweed |
| 70 | *Sciurus carolinensis* | Grey squirrel |
| 71 | *Senecio inaequidens* | Narrow-leaved ragwort |
| 72 | *Sicyos angulatus* | Star-cucumber |
| 73 | *Solanum elaeagnifolium* | Silver-leaved Nightshade |
| 74 | *Solidago Canadensis* | Goldenrod |
| 75 | *Solidago gigantean* | Late goldenrod |
| 76 | *Tamias sibiricus* | Siberian chipmunk |
| 77 | *Threskiornis aethiopicus* | Sacred ibis |
| 78 | *Trachemys scripta* | Common slider |
| 79 | *Umbra pygmaea* | Eastern mudminnow |
| 80 | *Xenopus laevis* | African clawed frog |

## Task 5.2: Assess the species assessments against the minimum standards

The main objective of the study was "to analyse a set of species that have been risk assessed using a protocol meeting the minimum standards" identified and discussed in task 3 "and assess whether they would meet the European Commission proposed criteria for inclusion in the list of IAS of EU concern". Therefore, two steps were undertaken to assess species for consideration for inclusion on the list of proposed "IAS of EU concern":

**Step 1 – selecting species with risk assessments substantially complying with the minimum standards**

As a result of the analysis in Task 4, it is apparent that none of the existing protocols screened, tested and discussed within Task 3 meet the full set of minimum standards agreed during the dedicated Task 3 workshop held in Brussels. As a consequence, it is not possible to select for inclusion any of the species from the list of 80 species provided by the EC, nor to suggest the integration to the list of any further species evaluated through such "incomplete" risk assessment protocols. In fact, according to the tender "Should Task 4 establish that one or more of these methodologies do not meet the minimum standards, the species assessed using that methodology/ies should be removed from the list". In addition, according to the tender "The resulting list shall only include species that have been risk assessed using one of the methodologies that passed the test of Task 4".

Due to the lack of risk assessment protocols compliant with the minimum standards, it was not possible to obtain a consolidated list of species as initially foreseen. Indeed in Task 4 we outlined how the protocols discussed during the workshop comply (or not) the minimum standards and provide recommendations for modification of the protocols to achieve compliance with the minimum standards (we did not consider this further in Task 5). As an example of the added value of this study, the GB NNRA has already been amended in order to fully comply with the set of minimum standard criteria defined in Task 3. Additionally the refined GB NNRA (e.g. with the chapeau and the other questions on climate changes etc.) has been implemented to assess the impact of *Oxyura jamaicensis* in Europe (see Annex 7). EPPO has also responded by refining the EPPO DSS and has initiated the process to implement for a number of plants. It should also be noted that the EPPO PRA for *Parthenium hysterophorus* includes information with respect to ecosystem services and climate change.

To overcome the above mentioned constraints, we proceeded with the analysis of the list of species (Table 5.1) against those protocols for risk assessment that were considered as "substantially compliant". In fact, four key risk assessment methods, namely the EPPO DSS, GB NNRA, Harmonia+ and ENSARS were selected as they meet "most" minimum standards (see discussion in Task 4). The process of cross-checking the species list (Table 5.1) was commenced (and validated) at the workshop (Task 3) as the purpose was to ensure moderation and consensus across the project consortium and expert group. The lists generated from the four "substantially compliant" systems (EPPO DSS, GB NNRA, Harmonia+ and ENSARS) have thus been cross-tabulated against the list of 80 species provided by the Commission.

**Constraints in relation to Harmonia+ and ENSARS**

Harmonia$^{+}$ assessments are currently ongoing in Belgium and definitive results, although informally anticipated for some species (*Lithobates catesbeiana*, *Ludwigia grandiflora*, *Nyctereutes procyonoides*, *Procambarus clarkii* and *Threskiornis aethiopicus*), will not be available until the end of 2014, thus have not been taken into account in the list.

ENSARS has been used to assess a number of species, mostly (but not all) freshwater fish and freshwater invertebrates listed in Annex IV of the European Commission (EC) Council Regulation No 708/2007 concerning the use of alien and locally absent species in aquaculture. Thus, to avoid possible interpretation problems between the above mentioned provision, and the new EU Regulation on IAS, we did not consider the Annex IV species for inclusion on the list of proposed "IAS of EU concern". The only species risk assessed within ENSARS and not listed in Annex IV, namely *Procambarus clarkii* (target area: Italy), is already included in the list as a result of the risk assessment conducted within the GB NNRA system (target area GB).

The resulting consolidated list of proposed "IAS of EU concern" includes all IAS alien to the EU and considered by the four "substantially compliant" risk assessments, with caveats reported above, as having a medium to high impact. Species considered as having a low impact, on the basis of assessments carried out at the national level, have been listed separately because the arguments for their exclusion from the list should not be considered definitive. For example, further consideration is required particularly with regard to relevance of the assessment to other member states because a species may be considered of low impact in one region but not in another.

**Step 2 – selecting species complying with the criteria outlined in the proposed Regulation**

From the list derived through step 1, the species complying with the criteria outlined in the proposed Regulation (Table 5.2) were selected.

Paragraph 2 of article 4 of the proposed Regulation provides additional guidance stating "Invasive alien species shall only be included on the list referred to in paragraph 1 if they meet all of the following criteria:

a) they are, having regard to scientific evidence available, found to be alien to the territory of the Union excluding the outermost regions;

(b) they are, having regard to scientific evidence available, found to be capable of establishing a viable population and spreading in the environment under current or foreseeable climate change conditions anywhere in the Union excluding the outermost regions;

(c) it is demonstrated by a risk assessment performed pursuant to Article 5(1) that action at Union level is required to prevent their establishment and spread.

**Table 5.2:** Criteria outlined in Articles 4 and 5 of the proposed Regulation (COM(2013)620 final) relevant to developing the list of proposed "IAS of EU concern".

| Article | Relevant text |
|---|---|
| Article 4 | 1. A list of invasive alien species of Union concern shall be adopted, and updated, by the Commission by means of implementing acts on the basis of the criteria in paragraph 2. The implementing acts shall be adopted in accordance with the examination procedure referred to in Article 22(2).<br><br>2. Invasive alien species shall only be included on the list referred to in paragraph 1 if they meet all of the following criteria:<br><br>(a) they are, having regard to scientific evidence available, found to be alien to the territory of the Union excluding the outermost regions;<br><br>(b) they are, having regard to scientific evidence available, found to be capable of establishing a viable population and spreading in the environment under current or foreseeable climate change conditions anywhere in the Union excluding the outermost regions;<br><br>(c) it is demonstrated by a risk assessment performed pursuant to Article 5(1) that action at Union level is required to prevent their establishment and spread .<br><br>3. Member States may submit to the Commission requests for the inclusion of invasive alien species on the list referred to in paragraph 1. Those requests shall include all of the following criteria:<br><br>(a) the name of the species;<br><br>(b) a risk assessment performed in accordance with Article 5(1);<br><br>(c) evidence that the species complies with the criteria set out in paragraph 2.<br><br>4. The list referred to in paragraph 1 shall comprise a maximum of fifty species including any species which may be added as result of the |

| | |
|---|---|
| | emergency measures foreseen by Article 9. |
| Article 5 | 1. The Commission or the Member States, as relevant, shall carry out the risk assessment referred to in Article 4(2)(c) and (3)(b) having regard to the following elements:<br><br>(a) a description of the species with its taxonomic identity, its history, native range, potential range;<br><br>(b) a description of its reproduction and spread patterns including an assessment of whether the environmental conditions necessary for reproduction and spread exist;<br><br>(c) a description of the potential pathways of entry and spread, both intentional and unintentional, including where relevant the commodities with which the species are generally associated;<br><br>(d) a thorough assessment of the risk of entry, establishment, spread in relevant biogeographical regions in current conditions and in foreseeable climate change conditions;<br><br>(e) a description of the current distribution of the species including whether the species is already present in the Union or in neighbouring countries;<br><br>(f) a description of the negative impact on biodiversity and ecosystem services, including on native species, protected sites, endangered habitats, on human health and the economy including an assessment of the magnitude of future impact;<br><br>(g) a quantified forecast of the damage costs at Union level demonstrating the significance for the Union, so as to further justify action because the overall damage would outweigh the cost of mitigation;<br><br>(h) a description of the possible uses and benefits deriving from those uses of the species. |

## Task 5.3: Propose list of IAS of EU Concern

Using the information derived from tasks 5.1 and 5.2 we developed a preliminary list of proposed "IAS of EU concern" (with accompanying caveats).

The level of impact is expressed in different ways within the four systems (see description below) and it should be noted that the relevant protocols are all affected by some inherent shortcomings briefly summarised through a number of caveats (reflecting the gaps for compliance with the minimum standards, and the geographic scope of the assessments themselves). The list of proposed "IAS of EU concern" has been organised within three broad taxonomic groups, taking into account major environmental contexts: plants, vertebrates, and invertebrates. The member states where the species is known to be established is also specified in the tables according to information from the following sources: CABI invasive species compendium, DAISIE database, EPPO data sheets, GB Non-Native Species Information Portal, GISD and NOBANIS databases.

### 1. IAS with "substantially compliant" RA, complying with the criteria

In total 50 species are listed of which 37 are from GB NNRA, 18 from EPPO, and one from ENSARS (Table 5.3). Six of the species were assessed within more than one system. The list includes 14 species not already included in the original list of 80 species provided by the EC. These additional species were identified from the selected risk assessment protocols as posing a high to medium impact (they are indicated in the table below with an asterisk). In total, the draft list of proposed "IAS of EU concern" includes 25 plant species, 12 vertebrate species, and 13 invertebrate species. There are similar numbers of terrestrial and freshwater species (24 and 20 respectively) but only six marine species.

**Table 5.3:** Draft list of proposed "IAS of EU concern" including scientific and common name alongside description of the type of organism (plant, vertebrate, invertebrate) and environment (terrestrial - T, Freshwater - F, Marine - M). Information is provided on the number of and countries wherein the species is currently established, the risk assessment method (GB NNRA, EPPO DSS, Harmonia+, ENSARS) and caveats associated with the minimum standards or geographic limitations of the risk assessment.

| | Scientific name | Common name | Broad group | Environment | Number of and countries wherein the species is currently established | Method | Caveats |
|---|---|---|---|---|---|---|---|
| 1 | *Ambrosia artemisiifolia* | Common ragweed | Plant | T | 19: AT, BE, CZ, DE, DK, ES, FI, FR, HR, HU, IT, LV, NL, PL, RO, SK, SL, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 2 | *Azolla filiculoides* | Water fern | Plant | F | 19: BE, CZ, BG, DE, DK, GR, ES, FR, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 3 | *Baccharis halimifolia* | Eastern Baccharis | Plant | T | 6: BE, ES, FR, IT, NL, UK | EPPO DSS | **1, 2** |
| 4 | *Branta canadensis* | Canada goose | Vertebrate | F | 12: BE, DE, DK, FI, FR, IE, LT, LV, NL, PL, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 5 | *Cabomba caroliniana* | Green Cabomba | Plant | F | 6: AT , BE, FR, HU, NL, SE, UK | EPPO DSS, GB NNRA* | **1, 2, 3** |
| 6 | *Caprella mutica* * | Japanese Skeleton Shrimp | Invertebrate | M | 5: BE, UK, NL, IR, DE | GB NNRA | |
| 7 | *Cervus nippon* | Sika deer | Vertebrate | T | 11: AT, CZ, DE, DK, EE, FR, IE, LT, PL, SK, UK | GB NNRA | **1, 2, 4, 5** |
| 8 | *Corvus splendens* | Indian house crow | Vertebrate | T | 2: IE, NL | GB NNRA | **1, 2, 4, 5** |
| 9 | *Crassostrea gigas* * | Pacific Oyster | Invertebrate | M | 14: BE, DK, UK, HR, FR, DE, GR, IT, MT, NL, PT, RO, SI, ES | GB NNRA | |
| 10 | *Crassula helmsii* | Australian swamp stonecrop | Plant | F | 11: AT, BE, DE, DK, ES, FR, IE, IT, NL, PT, UK | EPPO DSS, GB NNRA | **1, 2, 4, 5** |

| | Scientific name | Common name | Broad group | Environment | Number of and countries wherein the species is currently established | Method | Caveats |
|---|---|---|---|---|---|---|---|
| 11 | *Crepidula fornicata ** | Slipper Limpet | Invertebrate | M | 9: BE, DK, UK, FR, DE, GR, IT, MT, NL, ES | GB NNRA | |
| 12 | *Didemnum vexillum ** | Carpet Sea-squirt | Invertebrate | M | 5: ES, FR, NL, UK, IR | GB NNRA | |
| 13 | *Eichhornia crassipes* | Water hyacinth | Plant | F | 5: ES, FR, IT, PT, RO | EPPO DSS | **1, 2, 4** |
| 14 | *Elodea canadensis* | Canadian water/pondweed | Plant | F | 22: AT, BE, BG, CZ, DE, DK, EE, GR, FI, FR, HU, IE, IT, LT, LU, LV, NL, PL, PT, RO, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 15 | *Eriocheir sinensis* | Chinese mittencrab | Invertebrate | F | 16: BE, CZ, DE, DK, EE, ES, FI, FR, IE, LV, LT, NL, PL, PT, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 16 | *Fallopia japonica, F. sachalinensis & F. x bohemica* | Japanese knotweed | Plant | T | 25: AT, BE, BG, CZ, DE, DK, EE, ES, FI, FR, HR, HU, IE, IT, LT, LU, LV, NL, PL, PT, RO, SE, SI, SK, UK | GB NNRA | **1, 2, 4, 5** |
| 17 | *Heracleum mantegazzianum* | Giant hogweed | Plant | T | 18: AT, BE, CZ, DE, DK, EE, FI, FR, HU, IE, IT, LV, LU, NL, PL, SE, SK, UK | EPPO DSS | **1, 2, 3** |
| 18 | *Heracleum persicum* | Persian hogweed | Plant | T | 3: DK, FI, SE | EPPO DSS | **1, 2, 3** |
| 19 | *Heracleum sosnowskyi* | Sosnowski's hogweed | Plant | T | 5: EE, FI, HU, LT, LV, PL | EPPO DSS | **1, 2, 3** |
| 20 | *Hydrocotyle ranunculoides* | Floating pennywort | Plant | F | 9: BE, DE, ES, FR, IE, IT, NL, PT, UK | EPPO DSS, GB NNRA | **1, 2, 3, 4, 5** |
| 21 | *Lagarosiphon major* | Curly waterweed | Plant | F | 10: AT, BE, DE, ES, FR, IE, IT, NL, PT, UK | GB NNRA | **1, 2, 4, 5** |

| | Scientific name | Common name | Broad group | Environment | Number of and countries wherein the species is currently established | Method | Caveats |
|---|---|---|---|---|---|---|---|
| 22 | *Lithobates (Rana) catesbeianus* | North American bullfrog | Vertebrate | F | 7: BE, DE, GR, FR, IT, NL, UK | GB NNRA | **1, 2, 4, 5** |
| 23 | *Ludwigia grandiflora* | Water-primrose | Plant | F | 8: BE, DE, ES, FR, IE, IT, NL, UK, | EPPO DSS, GB NNRA | **1, 2, 4, 5** |
| 24 | *Ludwigia peploides* | Floating primrose-willow | Plant | F | 8: BE, GR, ES, FR, GR, IT, NL, PT, UK | EPPO DSS | **1, 2** |
| 25 | *Lysichiton americanus* | American skunk cabbage | Plant | T | 10: BE, CH, DK, DE, FI, FR, IE, NL, SE, UK | EPPO DSS, GB NNRA* | **1, 2, 3** |
| 26 | *Muntiacus reevesii* | Muntjac deer | Vertebrate | T | 4: BE, IE, NL, UK | GB NNRA | **1, 2, 4, 5** |
| 27 | *Myopsitta monachus* | Monk parakeet | Vertebrate | T | 9: AT, BE, CZ, ES, FR, DE, IT, NL, UK | GB NNRA | **1, 2, 4, 5** |
| 28 | *Myriophyllum aquaticum* | Parrot's feather | Plant | F | 9: AT, BE, DE, FR, IE, IT, NL, PT, UK | GB NNRA | **1, 2, 4, 5** |
| 29 | *Orconectes limosus* * | Spiny-cheek Crayfish | Invertebrate | F | 9: AT, UK, FR, DE, IT, LV, LT, NL, PL | GB NNRA | |
| 30 | *Orconectes virilis* * | Virile Crayfish | Invertebrate | F | 1: NL | GB NNRA | |
| 31 | *Oxyura jamaicensis* | Ruddy duck | Vertebrate | F | 5: FR, IE, NL, SE, UK | GB NNRA | |
| 32 | *Pacifastacus leniusculus* * | Signal Crayfish | Invertebrate | F | 17: AT, BE, CZ, DK, UK, FI, FR, DE, IT, LV, LT, NL, PL, PT, SI, ES, SE | GB NNRA | |
| 33 | *Parthenium hysterophorus* * | Whitetop Weed | Plant | T | Not established in the EU | EPPO DSS | |
| 34 | *Persicaria perfoliata (Polygonum perfoliatum)* | Asiatic tearthumb | Plant | T | Not established in the EU | EPPO DSS | **1, 2, 3** |

| | Scientific name | Common name | Broad group | Environment | Number of and countries wherein the species is currently established | Method | Caveats |
|---|---|---|---|---|---|---|---|
| 35 | *Potamopyrgus antipodarum* * | New Zealand Mudsnail | Invertebrate | F | 19: AT, BE, CZ, DK, UK, EE, FI, FR, DE, IR, IT, LV, LT, NL, IR, PO, RO, SI, SE | GB NNRA | |
| 36 | *Procambarus clarkii* * | Red Swamp Crayfish | Invertebrate | F | 9: PT, BE, ES, UK, FR, DE, IT, NL, PL | GB NNRA, ENSARS | **5** |
| 37 | *Procambarus spp.* * | Marbled Crayfish | Invertebrate | F | 3: IT, DE, NL | GB NNRA | |
| 38 | *Procyon lotor* | Raccoon | Vertebrate | T | 13: AT, BE, CZ, DE, DK, ES, FR, HU, LU, NL, PL, SI, SK | GB NNRA | **1, 2, 4, 5** |
| 39 | *Pseudorasbora parva* | Stone moroko | Vertebrate | T | 16: AT, BE, BG, CZ, DE, DK, GR, ES, FR, HU, IT, NL, PL, RO, SK, UK | GB NNRA | **1, 2, 4, 5** |
| 40 | *Psittacula krameri* | Rose-ringed parakeet | Vertebrate | T | 12: AT, BE, DE, DK, EE, GR, FR, IT, NL, PT, SI, UK | GB NNRA | **1, 2, 4, 5** |
| 41 | *Pueraria lobata* | Kudzu Vine | Plant | T | 1: CH, IT | EPPO | **1, 2, 3** |
| 42 | *Rapana venosa* * | Rapa Whelk | Invertebrate | M | 3: GR, IT, SI | GB NNRA | |
| 43 | *Sargassum muticum* | Japweed, wireweed | Plant | M | 11: BE, DE, DK, ES, FR, IE, IT, NL, PT, SE, UK | GB NNRA | **1, 2, 4, 5** |
| 44 | *Senecio inaequidens* | Narrow-leaved ragwort | Plant | T | 12 : AT, BE, DE, DK, ES, FR, HU, IT, LU, NL, SE, UK | EPPO DSS | **1, 2, 3** |
| 45 | *Sicyos angulatus* | Star-cucumber | Plant | T | 13: AT, BG, CZ, DE, GR , ES, FR, GR, HR, HU, IT, MD, PL, RO, RS, RU, SK, UE, UK | EPPO DSS | **1, 2, 3** |

| | Scientific name | Common name | Broad group | Environment | Number of and countries wherein the species is currently established | Method | Caveats |
|---|---|---|---|---|---|---|---|
| 46 | *Solanum elaeagnifolium* | Silver-leaved Nightshade | Plant | T | 5 : CY, GR, ES, FR, GR, HR, IT, MK, RS | EPPO DSS | **1, 2** |
| 47 | *Solidago nemoralis* * | | Plant | T | Not established in the EU | EPPO DSS | |
| 48 | *Tamias sibiricus* | Siberian chipmunk | Vertebrate | T | 8: BE, DE, DK, FR, IE, IT, NL, UK | GB NNRA | **1, 2, 4, 5** |
| 49 | *Threskiornis aethiopicus* | Sacred ibis | Vertebrate | T | 5: FR, IT, NL, PT, ES | GB NNRA | **1, 2, 4, 5** |
| 50 | *Vespa velutina* * | Asian hornet | Invertebrate | T | 4: ES, FR, IT, PT | GB NNRA | **2, 5** |

(1) climate change effect not considered, (2) impact on ecosystem services not considered, (3) socio-economic benefits not considered, (4) threatened or protected species or habitats not considered, (5) geographical scope limited

* GB NNRA in progress and caveats to be reviewed on completion

## 2. IAS with compliant risk assessment but not yet validated

For one of the species for which there was not an available risk assessment within the four selected systems, we undertook a full risk assessment taking into account all minimum standard criteria, derived from the GB NNRA system, updated with the chapeau shown in task 4 and the additional questions formulated to ensure the full range of minimum standard criteria are satisfied. The objective was to test the new minimum standard criteria and their applicability to real case situations, so to provide the EC with a full risk assessment which otherwise was not yet available because of the caveats outlined within task 3 and 4. The risk assessment focuses on the Grey squirrel (*Sciurus carolinenis*) and the outcome of the assessment was to deem this species high impact (Annex 8). However, as it was not developed through the same procedure as the other risk assessments developed within the GB NNRA and EPPO DSS, it was not included in the draft list of proposed "IAS of EU concern". Nevertheless we recommend the Commission to validate and integrate the risk assessment for the grey squirrel in the definitive list. For other species, a risk assessment is currently in progress within the EPPO, GB NNRA or Harmonia+ systems.

## 3. IAS with "substantially compliant" risk assessments, but possibly not complying with criteria (low impact in at least part of the EU)

A number of species assessed within the GB NNRA system were considered as having a low impact (Table 5.4), and for this reason they have not been included in the list of proposed "IAS of EU concern". However, it should be clearly recognized that IAS with low impact in UK, may still have high impact elsewhere. Therefore, given the geographic constraints of the GB NNRA and lack of compliance with some of the minimum standards (specifically in this regard consideration of climate change effects), it is worth considering other available national impact assessments for these species for integration alongside the GB NNRA risk assessment. It is worth considering that one taxon, *Trachemys scripta elegans*, is already included in the EU Wildlife Trade Regulations.

**Table 5.4:** Species designated as low impact through the GB NNRA

| Scientific name | Common name | Broad group |
|---|---|---|
| *Eucalyptus glaucescens* | | Plant |
| *Eucalyptus gunnii* | | Plant |
| *Eucalyptus nitens* | | Plant |
| *Mephitis mephitis* | Skunk | Vertebrate |
| *Nasua nasua* | Coati | Vertebrate |

| Scientific name | Common name | Broad group |
|---|---|---|
| *Ruditapes philippinarum* | Manilla Clam | Invertebrate |
| *Trachemys scripta* | Common slider | Vertebrate |
| *Wasabia japonica* | Wasabi | Plant |
| *Xenopus laevis* | African clawed frog | Vertebrate |

## 4. IAS with "substantially compliant" risk assessments, but not complying with criteria (the native IAS)

Risk assessments are also available for a number of species through the GB NNRA which are alien to the UK but native within the EU (Table 5.5). A few additional species native in the EU have on-going but not yet finalised risk assessments namely *Astacus astacus* (noble crayfish), *Astacus leptodactylus* (Turkish crayfish) and *Triturus carnifex* (Italian crested newt).

**Table 5.5:** Species native in the EU with a GB NNRA risk assessment

| Scientific name | Common name | Broad group |
|---|---|---|
| *Allium triquetrum* | Three-cornered Garlic | Plant |
| *Bubo bubo* | Eagle Owl | Vertebrate |
| *Dikerogammarus haemobaphes* | | Invertebrate |
| *Dikerogammarus villosus* | Killer Shrimp | Invertebrate |
| *Dreissena polymorpha* | Zebra Mussel | Invertebrate |
| *Pelophylax ridibundus* | Marsh Frog | Vertebrate |
| *Rhododendron ponticum* | Rhododendron | Plant |

## 5. IAS with ongoing "substantially compliant" risk assessments

There are 29 additional species which could be included within the list of proposed "IAS of EU concern" for which an assessment is currently being undertaken, but incomplete, within the four "substantially compliant" risk assessment protocols (Table 5.6). However, it is currently not possible to include them within the list of proposed "IAS of EU concern" until the assessment is complete and validated. For example a risk assessment is currently in progress under the GB NNRA system for a number of additional species including one vertebrate and three plants. Similarly, risk scoring is currently in progress for a 23 species under the Harmonia$^{+}$ system and these will be available by the end of 2014. The literature review for these 23 species is already available at:

http://ias.biodiversity.be/species/risk. A few additional species were assessed as having a low impact, but have not been included in the table above, as the relevant risk assessment procedure is not yet finalised for example, *Hydropotes inermis* (Chinese water deer).

**Table 5.6:** Species for which a risk assessment is currently in progress. The asterisk indicates those species already included in the list of proposed "IAS of EU concern", thus the relevant information could be used to integrate the past RAs.

| Scientific name | Common name | Broad group | Method |
|---|---|---|---|
| *Alopochen aegyptiacus* | Nile goose | Vertebrate | GB NNRA |
| *Callosciurus erythraeus* | Pallas's squirrel | Vertebrate | Harmonia$^{+}$ |
| *Carpobrotus spp.* | Hottentot fig | Plant | Harmonia$^{+}$ |
| *Cervus nippon** | Sika deer | Mammals | Harmonia$^{+}$ |
| *Corbicula fluminea* | | Invertebrate | GB NNRA |
| *Crassula helmsii** | New zealand pigmyweed | Vascular plants | Harmonia$^{+}$ |
| *Cynomys ludovicians* | Black-tailed Prairie Dog | Vertebrate | GB NNRA |
| *Dreisena bugensis* | Quagga mussel | Invertebrate | GB NNRA |
| *Egeria densa* | Brazilian Waterweed | Plant | GB NNRA, Harmonia$^{+}$ |
| *Elodea nuttallii* | Nuttall's water-weed | Plant | GB NNRA |
| *Garra rufa* | Doctor fish | Vertebrate | GB NNRA |
| *Homarus americanus* | American lobster | Invertebrate | GB NNRA |
| *Hydrocotyle ranunculoides** | Water pennywort | Vascular plants | Harmonia$^{+}$ |
| *Lagarosiphon major** | Curly waterweed | Vascular plants | Harmonia$^{+}$ |
| *Ludwigia peploides** | Water primrose | Vascular plants | Harmonia$^{+}$ |
| *Muntiacus reevesi** | Reeves' muntjac | Mammals | Harmonia$^{+}$ |
| *Myocastor coypus* | Coypu | Vertebrate | Harmonia$^{+}$ |
| *Myriophyllum aquaticum** | Parrotfeather | Vascular plants | Harmonia$^{+}$ |
| *Myriophyllum heterophyllum* | Variable watermilfoil | Plant | Harmonia$^{+}$, EPPO |
| *Neovison vison* | American mink | Vertebrate | Harmonia$^{+}$ |
| *Nyctereutes procyonoides* | Raccoon dog | Vertebrate | Harmonia+ |
| *Orconectes rusticus* | Rusty crayfish | Invertebrate | GB NNRA |
| *Oxyura jamaicensis** | Ruddy duck | Birds | Harmonia$^{+}$ |
| *Paralithodes camtschaticus* | Red king crab | Invertebrate | GB NNRA |
| *Percottus glenii* | Amur sleeper | Vertebrate | Harmonia$^{+}$ |
| *Robinia pseudoacacia* | Black locust | Plant | GB NNRA |
| *Sarracenia purpurea* | | Plant | GB NNRA |

| Scientific name | Common name | Broad group | Method |
|---|---|---|---|
| *Sciurus carolinensis* | Grey squirrel | Vertebrate | Harmonia$^+$ |
| *Sciurus niger* | Fox squirrel | Vertebrate | Harmonia$^+$ |

An additional species is being risk assessed under the Harmonia$^+$ system but has not been included in the table above because is native in the EU (*Neogobius melanostomus*, round goby).

## 6. IAS for which a "substantially compliant" risk assessment is not available

For a total of 44 species on the original list there was no risk assessment available through the four "substantially compliant" protocols (Table 5.7). However, this does not mean that they should be excluded but risk assessments for these species should be prioritized. Indeed the project team has already begun the process for a number of the species. For example a draft risk assessment for *Myriophyllym heterophyllym*, water milfoil, has been prepared by Germany, but no official EPPO PRA is currently available (it is planned for the end of 2014), similarly, a risk assessment for *Nyctereutes procyonoides*, raccoon dog, in Belgium is ongoing within Harmonia$^+$.

It should be noted that several of the species within Table 5.6 have been assessed with impact assessments that, although not fully compliant with the proposed minimum standard, provide considerable and detailed guidance on potential negative effects of these species to European biodiversity (e.g. GABLIS). Indeed this highlights the value of national or regional impact assessments in prioritizing species for full risk assessment at a European or biogeographical scale.

**Table 5.7:** Species from the list of 80 provided by the EC lacking a risk assessment from the four selected protocols (EPPO DSS, ENSARS, GB NNRA, Harmonia$^+$) and so not included within the draft list of proposed "IAS of EU concern"

| Scientific name | Common name | Broad group |
|---|---|---|
| *Acer negundo (Negundo aceroides)* | Boxelder | Plant |
| *Acer rufinerve* | Redvein Maple | Plant |
| *Ailanthus altissima* | Tree-of-heaven | Plant |
| *Akebia quinata* | Five-leaf akebia | Plant |
| *Alopochen aegyptiacus* | Nile goose | Vertebrate |
| *Ameiurus nebulosus* | Brown bullhead | Vertebrate |
| *Aster novi-belgii agg.* | New York aster | Plant |
| *Bidens frondosa* | Devil's beggartick | Plant |
| *Buddleja davidii* | Butterfly-bush | Plant |

| Scientific name | Common name | Broad group |
|---|---|---|
| *Callosciurus erythraeus* | Pallas's squirrell | Vertebrate |
| *Callosciurus finlaysoni* | Finlayson's squirrel | Vertebrate |
| *Capra hircus* | Feral goat | Vertebrate |
| *Castor canadensis* | Canadian beaver | Vertebrate |
| *Cornus sericea* | Red osier dogwood | Plant |
| *Cotoneaster horizontalis* | Rockspray cotoneaster | Plant |
| *Echinocystis lobata* | Wild cucumber | Plant |
| *Egeria densa* | Brazilian Waterweed | Plant |
| *Elodea nuttallii* | Nuttall's water-weed | Plant |
| *Epilobium ciliatum* | Northern willowherb | Plant |
| *Helianthus tuberosus* | Jerusalem artichoke | Plant |
| *Impatiens glandulifera* | Himalayan Balsam | Plant |
| *Lepomis gibbosus* | Pumpkinseed fish | Vertebrate |
| *Lupinus polyphyllus* | Garden Lupine | Plant |
| *Mahonia aquifolium* | Oregon-grape | Plant |
| *Mephitis mephitis* | Skunk | Vertebrate |
| *Myriophyllum heterophyllum* | Watermilfoil | Plant |
| *Nasua spp. (max 2 species)* | Coati | Vertebrate |
| *Neovison (Mustela) vison* | American mink | Vertebrate |
| *Nyctereutes procyonoides* | Raccoon dog | Vertebrate |
| *Ondatra zibethicus* | Muskrat | Vertebrate |
| *Persicaria wallichii* | Himalayan knotweed | Plant |
| *Pimephales promelas* | Fathead minnow | Vertebrate |
| *Prunus serotina* | Black cherry | Plant |
| *Rattus norvegicus* | Brown rat | Vertebrate |
| *Rattus rattus* | Black rat | Vertebrate |
| *Robinia pseudoacacia* | Black locust | Plant |
| *Rosa rugosa* | Japanese rose | Plant |
| *Rudbeckia laciniata* | Cutleaf | Plant |
| *Sciurus carolinensis* | Grey squirrel | Vertebrate |
| *Solidago canadensis* | Goldenrod | Plant |
| *Solidago gigantea* | Late goldenrod | Plant |
| *Trachemys scripta* | Common slider | Vertebrate |

| Scientific name | Common name | Broad group |
|---|---|---|
| *Umbra pygmaea* | Eastern mudminnow | Vertebrate |
| *Xenopus laevis* | African clawed frog | Vertebrate |

## 7. IAS prioritized for future risk assessment

Two additional species should be prioritized for future screening according to the GB Non-Native Species Secretariat: *Herpestes javanicus* (small Indian mongoose) and *Leiothrix lutea* (red-billed leiothrix) – neither of these species have been assessed yet.

## Further considerations

Geographical scope - Some species, such as *Eichornia crassipes*, are considered of low impact within the GB NNPRA (because the assessment focusses on the UK only, where this species is not able to establish) while it is considered high within the EPPO DSS (which considers regions beyond the EU (particularly of relevance in this case are countries such as Tunisia, Algeria, Morocco, Israel, Jordan and Turkey). A broad range of impacts have been documented through the EPPO DSS including the impact on phytoplankton and invertebrates communities coupled with consequences for ecosystem processes, but not the impacts on rare species and habitats. Similar discrepancies can be observed compared to other systems, which are apparently a consequence of the climatic suitability of the area considered in the risk assessment rather than any bias in the protocols themselves, such as Siberian chipmunks considered medium impact in the UK, but so far low impact on the continent (White List in GABLIS).

Wildlife Trade Regulation - With the exception of *Lithobates (Rana) catesbeianus and Oxyura jamaicensis*, none of the species already included in the EU Wildlife Trade Regulations are actually included in this list, as they have not yet been subject to a risk assessment under the four selected systems. More in detail, *Trachemys scripta* was risk assessed through the GB NNRA, but is only considered low impact in the UK. *Sciurus carolinenis* was risk assessed under this project, but the risk assessment has not yet been validated, *Oxyura jamaicensis, Sciurus carolinenis* and *Sciurus niger* are also being assessed for Belgium within Harmonia$^{+}$.

## Summary: task 5

In conclusion, we present a draft list of proposed “IAS of EU concern” which requires further review.

Although none of the existing risk assessment protocols screened and discussed within earlier tasks met the full set of agreed minimum standards, a draft list of proposed “IAS of EU concern” was constructed based on the four risk assessment methods (EPPO DSS, GB NNRA, Harmonia+ and ENSARS) that were considered as “substantially compliant” because they met more than ten of the minimum standards and based on their compliance with the criteria for listing. In this way, a list of 50 proposed “IAS of EU concern” was derived. These species were considered as alien to the EU and having a high to medium impact within at least one of the four selected protocols. In total, there are 25 plant species, 12 vertebrate species, and 13 invertebrate species. However, the list is accompanied by notes relevant to the main shortcomings for each risk assessment such as the limited geographic scope of some of the risk assessments and other information gaps (e.g. no assessment on climate change effect and no explicit mention of ecosystem services).

For another 29 species, there are risk assessments currently under development within the various selected protocols. Therefore, it was not possible to consider their inclusion at this stage but the risk assessments are outlined as pending. Additionally, some species were excluded from the list because the relevant completed risk assessment designated the species as having a low impact or because there is currently no compliant risk assessment available or under development. However, given the various caveats outlined it is important to recognise that this does not mean that they have no impact in the EU, and further dedicated risk assessment should be undertaken in the future. Finally, eight species with risk assessments (GB NNRA) are native to Europe and as such were not fulfilling the criteria in Regulation.

## Recommendation for further development of the list of “IAS of EU concern”

Given the need to ensure a reliable and effective system to support the development and maintenance of the list of “IAS of EU concern”, it is important not only to propose a risk assessment system, but also the full procedure for the assessment exercise, with the aim to ensure transparency and full consistency among assessments. The objective is also to set a European standard, which might be recognized by other regions which then would be encouraged to follow. For this purpose we suggest a procedure for supporting a list of “IAS of EU concern” similar to the procedure already successfully adopted and implemented by the EPPO Panel on Invasive Alien Plants as well as the IUCN red listing process.

## EPPO Panel on Invasive Alien Plants

In practice, the EPPO Panel on Invasive Alien Plants decides on priority species for which an EPPO PRA should be performed. This is done by completing a prioritization report following the EPPO Priorization process for invasive alien plants (EPPO, 2012), which has specifically been designed to (i) to produce a list of invasive alien plants that are established or could potentially establish in the area under assessment; and (ii) to determine which of these have the highest priority for a Pest Risk Analysis (PRA).

When the Panel on Invasive Alien Plants, composed of experts on the issue nominated by countries select on the plants for which an EPPO PRA should be performed, the decision is submitted to the EPPO Working Party on Phytosanitary Regulations for validation. Once the plant species on which an EPPO PRA should be performed has been validated, an Expert Working Group (EWG) is convened, composed of experts knowledgeable about the plant, the habitat invaded, climatic projection tools, and the EPPO DSS (5 to 8 participants in general). Prior to the 4 days EWG, a draft PRA is prepared and circulated with all the available bibliography through the EPPO extranet to the participants of the EWG. During the EWG, experts provide their expertise and confront their views in the elaboration of the PRA. Additional work may be required to complete the PRA after the EWG, and all versions of the PRA are shared and commented by the participants. The PRA is then circulated to additional experts when relevant, and is then peer reviewed by EPPO experts to ensure consistency across the different EPPO PRAs. All contributions to the PRA are acknowledged in the document. The PRA integrating all comments is then presented for final review to the EPPO Panel on Invasive Alien Plants. A short PRA report, presenting the main findings of the PRA is then submitted to the EPPO Working Party on Phytosanitary Regulations, and the final decision is presented to the EPPO Council for unanimous approval by the 50 member c ountries. The full PRA document, the PRA report, as well as a datasheet presenting the species are then published on the EPPO website, and if the species qualified as a quarantine pest following the PRA, it is recommended for regulation.

## IUCN Red Listing Process

The Red List approach developed by the IUCN is summarised in Fig. 5.1. This approach might provide some alternative or complimentary elements to the EPPO panel and so form a good basis for discussion of a possible approach for supporting the list of “IAS of EU concern”, particularly in relation to roles and responsibilities.

1) The work for the Red List is coordinated by the IUCN taxonomic Specialist Groups (SG) (http://www.iucn.org/about/work/programmes/species/who_we_are/ssc_specialist_groups_and_red_list_authorities_directory), and by the Red List Unit in Cambridge (RLU);

2) The chair and Red List authority of the taxonomic SG identify the assessors, that can be a few individuals (e.g. in the small mammals SG they usually identify 3-4 assessors), or through workshops (the experts attending the workshop are all identified as assessors);

3) The assessors perform the assessment, posting a draft assessment on the Species Information System (SIS) platform, and reviewing the draft until an assessment is produced that is fully agreed. The SIS plays an important role in the process, storing the information, so that any future change of the assessment can be mapped against the previous assessments.

4) The chair and RL authority carry out a peer-review, or ask other experts, not involved in the assessment, to do the critical review. In case there are changes to the assessment, they contact the assessor and again review until they reach an agreement.

5) The final assessment is sent to the RLU for a consistency check, where the assessment is screened to see if the criteria have been applied.

Once this process is completed, the assessment is posted, and all the names of the assessors and reviewers are reported (see any IUCN RL profile). The assessment includes a rationale (justification), that is a summary of the entire profile (not a copy and paste of the key points of the assessment; see any IUCN RL profile).

The procedure for supporting the list of "IAS of EU concern" could be based on a similar process, implementing a protocol that meets the minimum standards identified and discussed within the previous tasks. To test the efficacy and practicalities of the process a tentative "IAS List Unit" (IAS LU) could be established, including a few key representative experts, to develop a detailed procedure, including the production of detailed criteria, a peer review process, and a consistency check. Other experts should be identified for undertaking the assessments, while other 2-3 reviewers (not in the IAS LU) should be identified for independent evaluation. The entire exercise could then be applied to a few species. For this purpose, some of the main European and global IAS databases (e.g. GISD, CABI, DAISIE, EASIN) could be identified as the reference platform, possibly to be adapted to store the assessments in a format that allows tracking of any changes or update. Also, to test the coherence of the results a few parallel assessments could be foreseen.

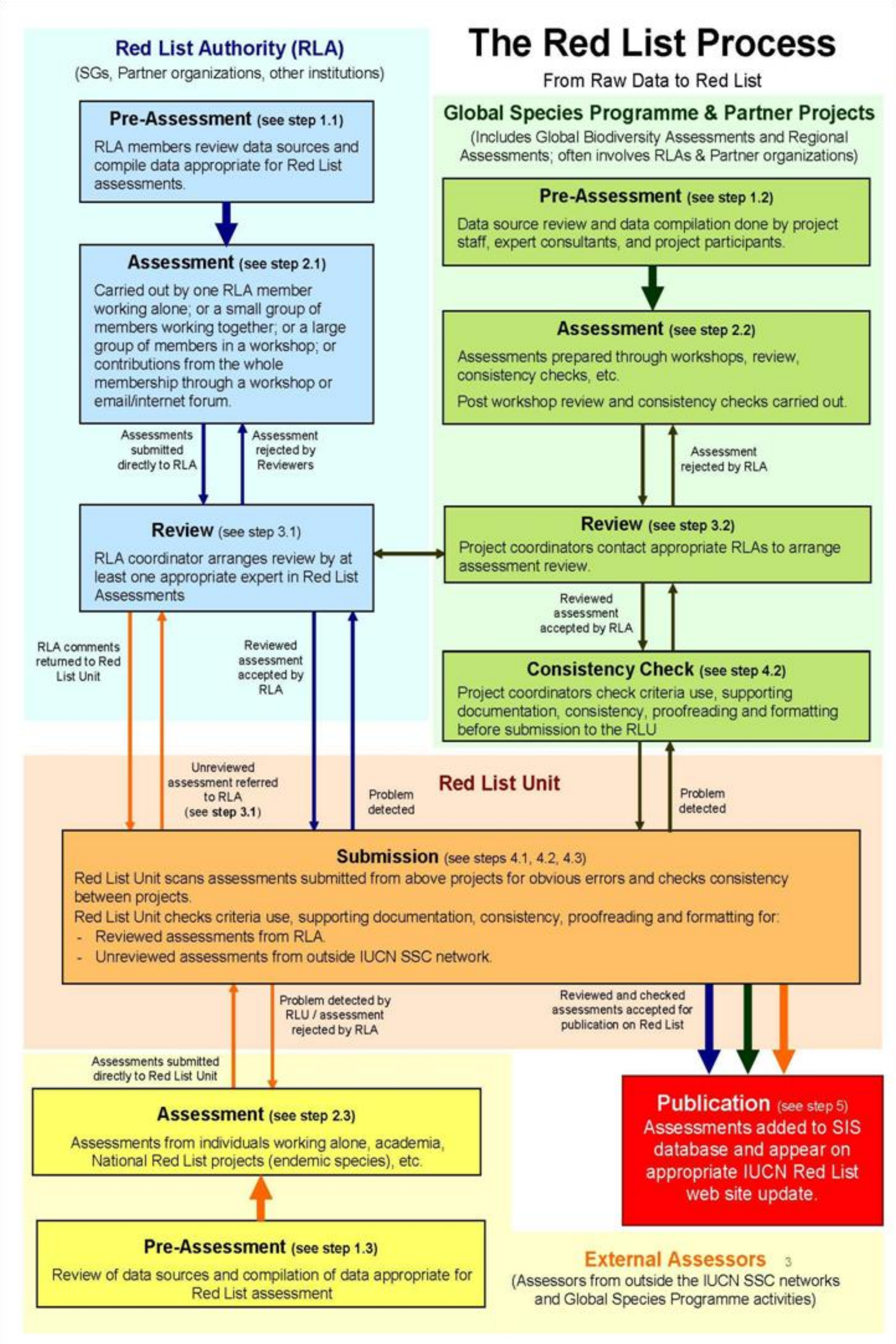



**Figure 5.1:** Detailed schematic highlighting the Red List approach developed by the IUCN

# Conclusions

There are many different approaches to risk assessments of alien species however many lack key features that were agreed through an expert workshop to constitute "minimum standards" according to a given framework based on the forthcoming EU Regulation. A number of protocols have been devised for impact assessment and, although they do not include consideration of the likelihood of introduction and establishment, these provide a detailed and useful basis upon which to review impacts including aspects that could be incorporated into full risk assessments. The risk assessment methods based on the protocol devised by EPPO, namely GB NNRA and ENSARS, provide a basis on which to begin developing a list of "IAS of EU concern". Harmonia+ is a new and promising risk assessment method. It will be essential to consider the relevance of this protocol as one of the key players going forward. However, even for these comprehensive and detailed protocols that were designed for specific purposes there remain challenges. These protocols need further development to include consideration of ecosystem services, climate change, socio-economic benefits and to address the full EU territory. As these criteria are encompassed it will be necessary to critically test and evaluate the performance of these modified protocols through scientific expert review.

Risk assessment protocols that meet the minimum standards will only be the first step in developing a definitive list of "IAS of EU concern". Further consideration will need to be given to a range of factors. Perhaps one of the most important relates to risk management and risk communication which was out of scope of this report. In total 50 species are included within the draft list of proposed "IAS of EU concern" and these were identified through the "substantially compliant" risk assessments as posing a medium to high risk on biodiversity and/or human health and the economy. However this does not necessarily mean they should be included in the final list of "IAS of EU concern". Before the final list is determined there will need to be a process of validation and review. Indeed the "substantially compliant" risk assessment for each species should be reviewed to consider and address the existing caveats derived from comparison with the agreed minimum standards. Relevant scientific experts should be invited to carry out this process. Additionally risk management factors should be taken into account, such as how widespread the species is within the EU, what benefits are associated with the species and the cost-benefit of adding the species to the list of "IAS of EU Concern". Risk management can provide a gainful leverage, e.g. when focusing on IAS not yet widespread or even not yet established, while complete eradication of widespread and well-established species often is impossible.

It will be essential to develop a transparent process for consolidating the draft list of proposed "IAS of EU concern" through involvement of different experts. The list of "IAS of EU concern" will need to be reviewed on a regular basis to ensure it remains current as the number of new arrivals escalates on an annual basis. Considering the dynamics of biological invasions in general and new arrivals in particular we challenge the demand to review the list as often as possible, ideally through a permanently installed workflow. Equally the knowledge underpinning our understanding of invasions and environmental change will improve and additional relevant concepts will emerge. Therefore, it will be necessary not only to review the list of IAS of concern but also the framework of minimum standards upon which it is based. Consensus workshops (Sutherland, Fleishman et al. 2011), such as the approach used in task 3, provide an adaptable, flexible and collaborative way in which to review frameworks whether lists of IAS or minimum standards for risk assessments. The high level of consensus (in most cases unanimous agreement) achieved in the task 3 workshop and throughout this project provides evidence of the effectiveness of the approach employed.

We conclude by suggesting as priorities:

1. Further development of the list of proposed “IAS of EU concern” through scientific expert review based on the framework provided by the new EU Regulation. This should also include species not yet present in the EU identified by a horizon scanning exercise.

2. Support of development to modify GB NNRA, Harmonia$^{+}$ or other risk assessment protocols within their mandate to comply with the new EU Regulation, including the development of appropriate guidance on the interpretation and use of minimum standards where required.

3. Validation and review of the list of proposed “IAS of EU concern” by relevant scientific experts to address the existing caveats for each risk assessment derived from comparison with the agreed minimum standards.

4. Support for national impact assessments to continue and eventually modify their methods as scientific basis for EU assessments. These assessments should serve as source to identify potential additional “IAS of EU concern” and evaluation of the list.

5. Re-assessment of risks of IAS at the EU level (with consideration of biogeographic regions) through a scientific expert panel using the modified GB NNRA, Harmonia$^{+}$ or other risk assessment protocols within their mandate that comply with the new EU Regulation.

6. Consideration of the establishment of a review process for evaluating the list of proposed “IAS of EU concern” after 2016.

# Annex 1: List of references and online-sources dealing with IAS-risk assessment protocols and applications based on a Web of Science literature research and selected based on expert opinion regarding their relevance for the current tender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# Annex 2. Results from the pre-workshop survey

| 2. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should the EU develop a totally new EU-wide Risk Assessment system tailored for the new IAS-regulation? | 8 | 9 | 8 | 25 |
| Should the EU use one or several existing Risk Assessments? | 13 | 3 | 9 | 25 |
| Should a Risk assessment state which environments are covered (e.g. marine/freshwater/terrestrial)? | 22 | 2 | 1 | 25 |
| Should a Risk Assessment include a broad taxonomic range (e.g.all animals)? | 15 | 8 | 2 | 25 |
| Should a Risk Assessment state the taxonomic breadth? | 23 | 0 | 2 | 25 |
| Should a Risk Assessment include a list of the terminology used? | 19 | 3 | 3 | 25 |
| Should there be a definition of content (i.a. Risk Assessment and Impact Assessment, amongst others)? | 22 | 0 | 3 | 25 |
| Should a Risk Assessment contain a description of the biology of the species assessed (e.g. history/native range/potential range)? | 18 | 4 | 3 | 25 |
| Should a Risk Assessment contain peer reviewed literature? | 22 | 1 | 2 | 25 |
| Should a Risk Assessment contain other information sources inc. internet sources? | 21 | 0 | 4 | 25 |
| Should a Risk Assessment contain room for comments? | 20 | 1 | 4 | 25 |
| Additional comments | | | | 14 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 3. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment assess the likelihood of future introductions (e.g. pathway analysis/geographic proximity)? | 22 | 0 | 3 | 25 |
| Should a Risk Assessment assess the likelihood of future establishment (e.g. climate matching/ habitat matching)? | 23 | 0 | 2 | 25 |
| Should a Risk Assessment assess the likelihood of future spread (e.g. dispersal ability/human-aided dispersal including accidental, agricultural and industrial)? | 22 | 0 | 3 | 25 |
| Should a Risk Assessment consider the pathways of entry and spread, both intentional and unintentional? | 23 | 0 | 2 | 25 |
| Additional comments | | | | 7 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 4. For Ecology/biodiversity risks, as a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment assess the impact of biodiversity? | 22 | 0 | 3 | 25 |
| Should a Risk Assessment assess the impact on specific elements of biodiversity considered (i.e. rare, keystone, red list, protected species)? | 15 | 2 | 8 | 25 |
| Should a Risk Assessment assess the impact on ecosystem function? | 20 | 0 | 5 | 25 |
| Should a Risk Assessment assess impact thresholds? | 10 | 2 | 13 | 25 |
| Should a Risk Assessment explain impact thresholds? | 11 | 2 | 12 | 25 |
| Additional comments | | | | 9 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 5. For Socio-Economic risks, as a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment consider economic sectors (e.g. agriculture, tourism and plant and animal health)? | 23 | 1 | 1 | 25 |
| Should a Risk Assessment describe the known uses and social and economic benefits deriving from those uses? | 10 | 10 | 5 | 25 |
| Should a Risk Assessment describe adverse impacts on biodiversity and the related ecosystem services? | 20 | 0 | 5 | 25 |
| Should a Risk Assessment assess whether human health has been affected (e.g. pathogen reservoir, allergic reactions, intoxication)? | 23 | 0 | 2 | 25 |
| Should a Risk Assessment consider human wellbeing and sustainable development (e.g. food security, cultural and natural heritage and climate change mitigation)? | 17 | 1 | 7 | 25 |
| Additional comments | | | | 9 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 6. For Cost-Benefits, as a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment consider an assessment of monetary cost-benefit analysis? | 5 | 10 | 10 | 25 |
| Should a Risk Assessment consider a broader cost-benefit analysis? | 9 | 8 | 8 | 25 |
| Should a Risk Assessment consider the potential costs of damage? | 12 | 2 | 11 | 25 |
| Additional comments | | | | 11 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 7. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment assess how future climate change affects risk? | 15 | 4 | 6 | 25 |
| Should a Risk Assessment include projections of the likely future distribution of the species? | 18 | 3 | 4 | 25 |
| Should a Risk Assessment assess impacts of potential future impacts on protected sites, endangered habitats or species, number of MS at risk and biogeographic areas considered? | 14 | 5 | 6 | 25 |
| Should a Risk Assessment assess potential of indirect impacts (e.g. meso-predator release or meltdown)? | 11 | 4 | 10 | 25 |
| Should a Risk Assessment assess potential future changes in anthropogenic pressures and how they affect risk (e.g. land use change, pollution, fragmentation and eutrophication)? | 11 | 5 | 9 | 25 |
| Additional comments | | | | 8 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 8. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment assess whether there has been bias in assessment due to lack of evidence? | 23 | 1 | 1 | 25 |
| Should a Risk Assessment assess distribution and range in the context of potential management measures? | 13 | 7 | 5 | 25 |
| Should a Risk Assessment assess potential control and eradication options? | 13 | 7 | 5 | 25 |
| Additional comments | | | | 8 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 9. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment be applicable to a broad range of taxa? | 17 | 5 | 3 | 25 |
| Should a Risk Assessment be applicable to all environments? | 16 | 5 | 4 | 25 |
| Should a Risk Assessment be compatible between taxa and habitats and so should they be used for prioritisation? | 15 | 3 | 7 | 25 |
| Should a Risk Assessment be compliant with other international/EU conservation systems? | 14 | 3 | 8 | 25 |
| Should a Risk Assessment state explicitly rules about weighting? | 17 | 2 | 6 | 25 |
| Should a Risk Assessment state all quantitative methods explicably? | 17 | 4 | 4 | 25 |
| Should a Risk Assessment have explicit quality control procedures (e.g. peer review, multi-assessor comparisons)? | 20 | 1 | 4 | 25 |
| Should a Risk Assessment include a gap analysis? | 14 | 3 | 8 | 25 |
| Should a Risk Assessment seek to include stakeholders? | 4 | 14 | 7 | 25 |
| Should a Risk Assessment need explicit means to quantify uncertainty? | 17 | 4 | 4 | 25 |
| Additional comments | | | | 9 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 10. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment state the origin of underpinning data explicitly (e.g. peer-reviewed data, non-peer-reviewed data, expert opinion)? | 23 | 2 | 0 | 25 |
| Should a Risk Assessment have all relevant data cross-referenced? | 14 | 4 | 7 | 25 |
| Additional comments | | | | 3 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

| 11. As a minimum standard, | | | | |
|---|---|---|---|---|
| Answer Options | Yes | No | Not sure | Response Count |
| Should a Risk Assessment consider their compliance to EU Directives (e.g. Water Framework Directive, Habitat Directive, Marine Framework Directive, Aquaculture Regulation)? | 6 | 6 | 13 | 25 |
| Should a Risk Assessment consider its legal status (i.e. is it legally binding)? | 9 | 7 | 9 | 25 |
| Should a Risk Assessment consider the World Trade Organisation compliance regulations? | 10 | 6 | 9 | 25 |
| Additional comments | | | | 5 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

# Annex 3. Workshop programme

## IAS Risk Assessment Workshop

27/28th March 2014

Guimard Building, Room 0/2

Rue Guimard 10, Brussels

## Agenda

**Note: Please can everyone bring their laptops and a USB stick**

## Day 1

**10.45 – Welcome Coffee**

**11.00 - Welcome from the European Commission and round of introductions**, TBC, EC and Helen Roy, Group lead and Principal Scientist, CEH

**11.10 - Introduction to the project "Invasive Alien Species – Framework for the identification of invasive alien species of EU concern"** Helen Roy, CEH

**11.15 - Existing risk assessment methodologies on IAS (Task 1)** Marc Kenis, Head Risk Analysis and Invasion Ecology, CABI

**11.30 - Q&A**

**11.40 - Draft minimum standards for risk assessment methodologies (Task 2)** Wolfgang Rabitsch, Senior Expert, Environment Agency Austria.

**12.00 - Q&A**

**12.10 – Socio-economic impacts of IAS in risk assessment methodologies** Marianne Kettunen, Senior Policy Analyst, IEEP

**12.25 - Q&A**

**12.35 - 13.15 Lunch**

**13.15 - BREAK-OUT SESSION 1: Critically examine the minimum standards (led by Wolfgang Rabitsch and Helen Roy)**

Break into two groups (allocation to groups in advance) in two separate rooms. Both groups will assess the suitability of the minimum standards according to four topics: Entry, Establishment and Spread, Impact, and Uncertainty.

Both groups will work on all four topics in order for everyone to provide their views on the key issues.

**1. Entry** – Chair: Marc Kenis, Rapporteur: Sarah Brunel – 45 mins

**2. Establishment and Spread –** Chair: Sarah Brunel, Rapporteur: Marc Kenis – 45 mins

**3. Environmental Impact** –Chair: Etienne Branquart, Rapporteur: Marianne Kettunen - 60 mins

**4. Socio-Economic Impact** – Chair: Marianne Kettunen, Rapporteur: Etienne Branquart – 30 mins

**Group 1 will work on topic 1 and 2 - ROOM GUIMARD 0/3**

**Group 2 will work on topic 3 and 4 - ROOM GUIMARD 4/42**

**14.50 – 15.00 *Coffee Break***

**Group 1 will work on topic 3 and 4 - ROOM GUIMARD 4/42**

**Group 2 will work on topic 1 and 2 - ROOM GUIMARD 0/3**

**16.30 Plenary** – Each rapporteur will report back to the whole group on the outcomes of session 1: Topic 1 - Sarah Brunel Topic 2 - Marc Kenis Topic 3 - Etienne Branquart Topic 4 - Marianne Kettunen

**17.00 – 17.30 Coffee Break**

**17.30 – Consensus approach to finalising the minimum standards** Helen Roy and Wolfgang Rabitsch

**19.00 – End of meeting – Head straight out for group dinner.**

## Day 2

**9.00 - Introduction to day 2** Helen Roy, CEH

**9.05 – Continuation of Consensus approach to finalising the minimum standards** Helen Roy and Wolfgang Rabitsch

**10.00 – 10.20 Coffee Break**

**10.20 – Presentation on two-step risk analysis process: quick screening and detailed risk analysis tools** Etienne Branquart, Cellule Interdépartementale sur les espèces invasives, Service Public de Wallonie (BE)

**10.35 – Q&A**

**10.40 – Screening risk assessment methodologies against agreed minimum standards and an introduction to EPPO protocols (Task 4)** Sarah Brunel, Scientific Officer, EPPO

**10.55 – Q&A**

**11.00 – BREAK-OUT SESSION 2: Screening risk assessment methodologies against agreed minimum standards (led by Helen Roy and Marc Kenis)**

Break-out into two groups. Each group will test different risk assessment methodologies against the agreed minimum standards.

**Group 1 – Chair: Wolfgang Rabitsch, Rapporteur: Riccardo Scalera - 80 mins**

**Risk Assessments (5-10 minute presentations plus rapid review against minimum standards):**

GABLIS – Wolfgang Rabitsch

Black List Norway – Hanno Sandvik

ISEIA – Etienne Branquart

**Group 2 – Chair: Piero Genovesi, Rapporteur: Sarah Brunel - 80 mins**

**Risk Assessments (5-10 minute presentations plus rapid review against minimum standards):**

EPPO – Sarah Brunel (consolidation from earlier session)

GB – Niall Moore

Scoring system – Wolfgang Nentwig

**12.10 – Plenary** – Both rapporteurs will report back on the outcome of session 2

Group 1 – Riccardo Scalera – 20 mins

Group 2 – Sarah Brunel - 20 mins

**12.35 – Q&A**

**12.45 – 13.20 Lunch**

**13.20 – Start screening list of IAS of EU concern (Task 5)** Led by Marc Kenis, Wolfgang Rabitsch and Karsten Schönrogge, CEH

Review the list of 80 species of EU concern as provided by the EC against the risk assessment methodologies identified in Task 4. This exercise will allow us to identify which of these species comply with the agreed minimum standards and therefore should remain on the list of species of EU concern.

**14.30 – Horizon scanning for future EU IAS from the perspective of Great Britain** Alan Stewart, University of Sussex, and Karsten Schönrogge

**15.30 – 15.50 Coffee Break**

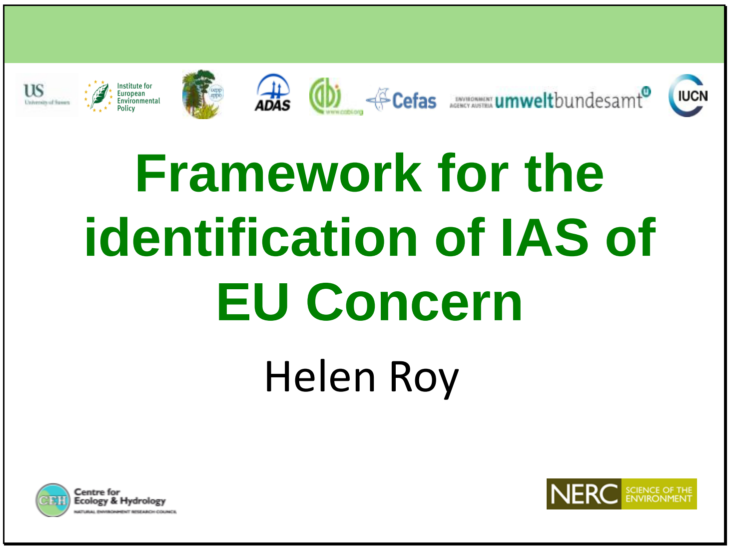
**15.50 – Discussion on methods, approaches and knowledge gaps in horizon scanning for future IAS of EU concern** Karsten Schönrogge

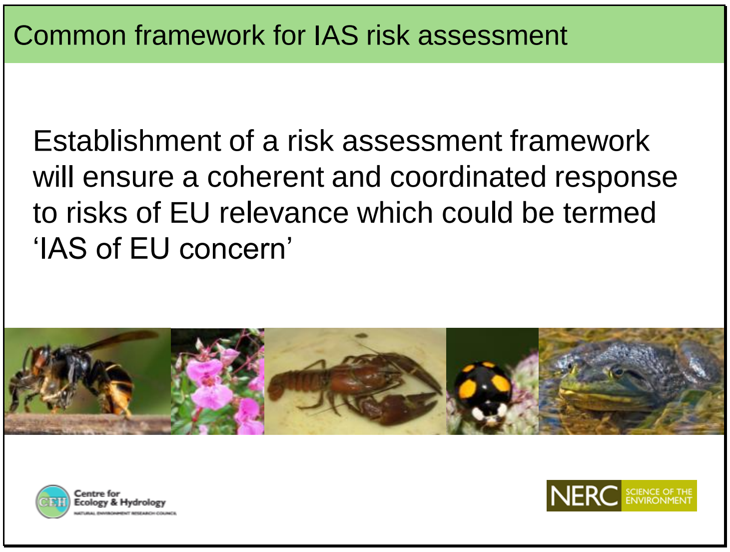
**16.20 – Next Steps and closing of the day** Helen Roy

**16.30 – End of day**

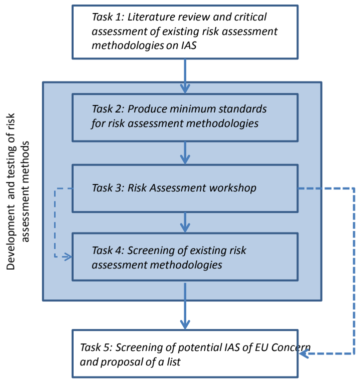
# Annex 4. Presentations from the workshop

## Introduction to the project – Helen Roy



## Tasks




## Tasks

Task 1: Literature review and critical assessment of existing risk assessment methodologies on IAS
Leading experts: Wolfgang Rabitsch (EAA), Marianne Kettunen (IEEP), Marc Kenis (CABI)

Task 2: Develop minimum standards for risk assessment methodologies
Leading experts: Wolfgang Rabitsch (EAA), Sarah Brunel (EPPO), Marc Kenis (CABI)

**Task 3: Risk Assessment workshop**
Leading experts: Ana Nieto (IUCN), James Kemp (IUCN) and Helen Roy (CEH)

Task 4: Screening of existing risk assessment methodologies
Leading experts: Helen Roy (CEH) and Sarah Brunel (EPPO)

Task 5: Screening of potential IAS of EU Concern and proposal of a list
Leading experts: Helen Roy (CEH) and Riccardo Scalera (ISSG)

## Aims

- inform the development of minimum standards necessary to ensure risk assessment methods are robust and reliable
- assess and critically review six risk assessment methods against the minimum standards and, if not compliant, providing recommendations for developing these within the framework of minimum standards
- begin to consider the approach to developing the list of IAS of EU concern

## Consensus on standards

- SurveyMonkey results suggest good agreement between experts for all categories except:
  - Socio-economic considerations
  - Management considerations
  - Legal considerations

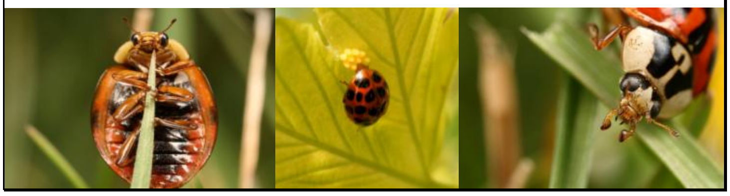
5. For Socio-Economic risks, as a minimum standard,

| Answer Options | Yes | No | Not sure | Response Count |
|---|---|---|---|---|
| Should a Risk Assessment consider economic sectors (e.g. agriculture, tourism and plant and animal health)? | 23 | 1 | 1 | 25 |
| Should a Risk Assessment describe the known uses and social and economic benefits deriving from those uses? | 10 | 10 | 5 | 25 |
| Should a Risk Assessment describe adverse impacts on biodiversity and the related ecosystem services? | 20 | 0 | 5 | 25 |
| Should a Risk Assessment assess whether human health has been affected (e.g. pathogen reservoir, allergic reactions, intoxication)? | 23 | 0 | 2 | 25 |
| Should a Risk Assessment consider human wellbeing and sustainable development (e.g. food security, cultural and natural heritage and climate change mitigation)? | 17 | 1 | 7 | 25 |
| Additional comments | | | | 9 |
| | | | *answered question* | 25 |
| | | | *skipped question* | 2 |

## Day 1

Inform the development of minimum standards necessary to ensure risk assessment methods are robust and reliable to underpin list of IAS of EU concern

Definitions and wider context...



### Existing risk assessment methodologies on IAS – Marc Kenis

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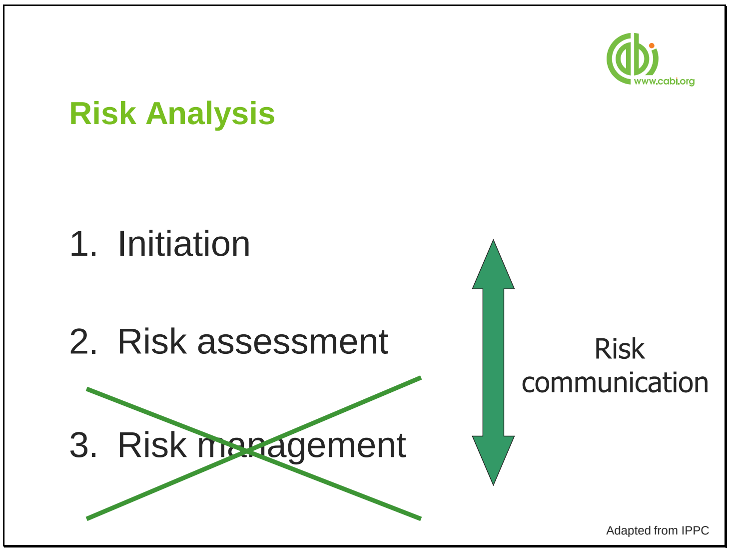
**Existing risk assessment methodologies on IAS**

Marc Kenis

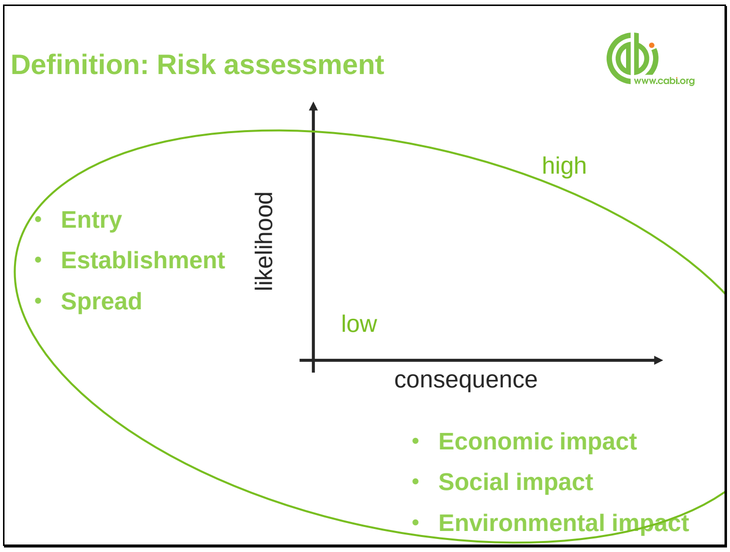



## Definition: Risk assessment

WTO: the evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences

OIE: the evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country

IPPC: the evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences



**In Europe, many « risk assessment *s.l.* » methodologies …..**
**…. With different purposes.**

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Full risk assessments

- EPPO PRA DSS
- GB NAPRA – Risk assessment template
- European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS)
- Harmonia+ (Belgium)

**In Europe, many « risk assessment *s.l.* » methodologies …..**
**…. With different purposes.**

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Full risk assessments

- EPPO PRA DSS (+ Express PRA + Prioritization for plants)
  - Always within a full pest risk analysis
  - Main purpose: assess whether a pest qualities as quarantine pest and a pest risk management is required
  - Usually done for species not yet in Europe or with very limited occurrence in Europe

oepp eppo

**In Europe, many « risk assessment *s.l.* » methodologies …..**
**…. With different purposes.**

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Full risk assessments

- GB NAPRA – Risk assessment template (+ rapid risk assessment)
  - Originate from the EPPO DDS
  - For species not yet in GB but also well established in GB (if so, likelihood of entry and establishment simplified)
  - Main purposes: to aid prioritisation, to help enable effective rapid responses and for underpinning decision-making.
  - Also used by Ireland (that also has a prioritization protocol)

NNSS
GB non-native species secretariat

## In Europe, many « risk assessment *s.l.* » methodologies …..
## …. With different purposes.

Full risk assessments

- European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS)
  - Also originate from the EPPO DDS and GB NAPRA, but with specific modules
  - Main purposes:
    - evaluating the risks of escape, introduction to and establishment in open waters, of any non-native aquatic organism being used in aquaculture.
    - evaluation of potential risks posed by transport pathways, rearing facilities, non-target infectious agents, and the potential organism, ecosystem and socio-economic impacts.
  - Includes a risk management module

## In Europe, many « risk assessment *s.l.* » methodologies …..
## …. With different purposes.

Full risk assessments

- Harmonia+ (Belgium)
  - Very new – few assessments so far
  - Risk assessment only, but can be included in a risk analysis
  - For species not yet in Belgium or with limited distribution. But can also be used for fully established spècies
  - Belgium also has a full risk analysis protocol based on IPPC

## In Europe, many « risk assessment *s.l.* » methodologies …..
## …. With different purposes.

«Impact» assessments

- GABLIS (Germany/Austria)
- ISEIA Protocol (Belgium)
- Sandvik et al. 2013 (Norway)
- Weber et al. 2005 (CH - Plants)
- FISK (UK, invasiveness, various aquatic groups)
- Kenis et al 2013 (EPPO - environmental impact of plants and plant pests)
- Brunel et al. 2010 (EPPO - prioritization plants)
- EFSA, 2011 (Environmental impact of plants and plant pests)
- Nentwig and colleagues (several papers, animals)
- Blackburn et al. (2014)
- BINPAS - Biopollution Assessment System (mainly aquatics) Etc.

## In Europe, many « risk assessment *s.l.* » methodologies ….. …. With different purposes.

«Impact» assessments

- Focus mainly on impact, often on spread, sometimes on establishment, usually not on entry
- Focus largely on species present in the RA area or in neighbouring areas … but not only
- Focus both on present and future impact

## In Europe, many « risk assessment *s.l.* » methodologies ….. …. With different purposes.

«Impact» assessments

- Focus mainly on impact, often on spread, sometimes on establishment, usually not on entry
- Focus largely on species present in the RA area or in neighbouring areas … but not only
- Focus both on present and future impact
- Always environmental impact not always socio-economic impacts
- Some based on invasion history, others on traits, or both

## In Europe, many « risk assessment *s.l.* » methodologies ….. …. With different purposes.

«Impact» assessments

- Purposes:
    - Black lists
    - Prioritisation (for management, conservation, RAs)
    - Invasiveness
    - Trade management ……

In Europe, many « risk assessment *s.l.* » methodologies …..
…. With different purposes.

«Impact» assessments

- Will not fulfill the minimum standards for full RA but ….
- …. may be better, easier or more user-friendly than full RA methodologies to assess the risk and impact of species already present



Risk/impact/invasion assessment protocols elsewhere

**Non-European (examples):**

Australia: Pheloung et al. 1999 Biosecurity Australia 2008 (plants)

Australia: Bomford 2008 (vertebrates)

USA: Kolar and Lodge 2002 (fish)

USA: Morse et al 2004 (plants)

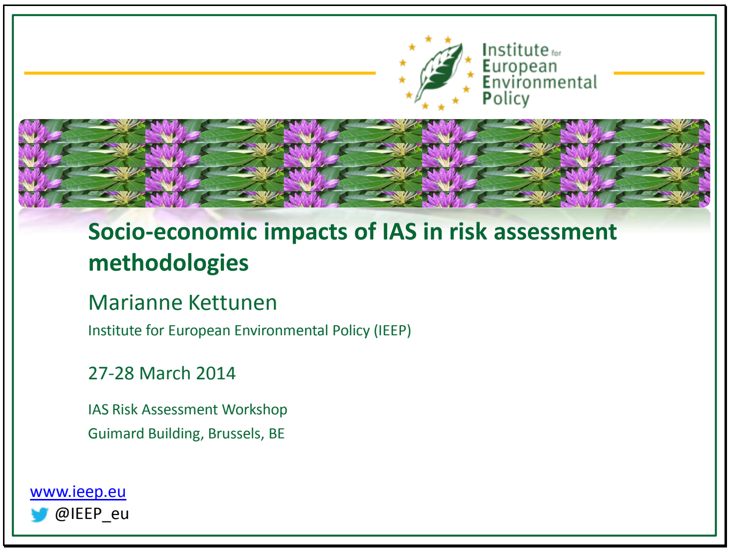
Hawaii: Denslow & Daehler 2006 (plants)

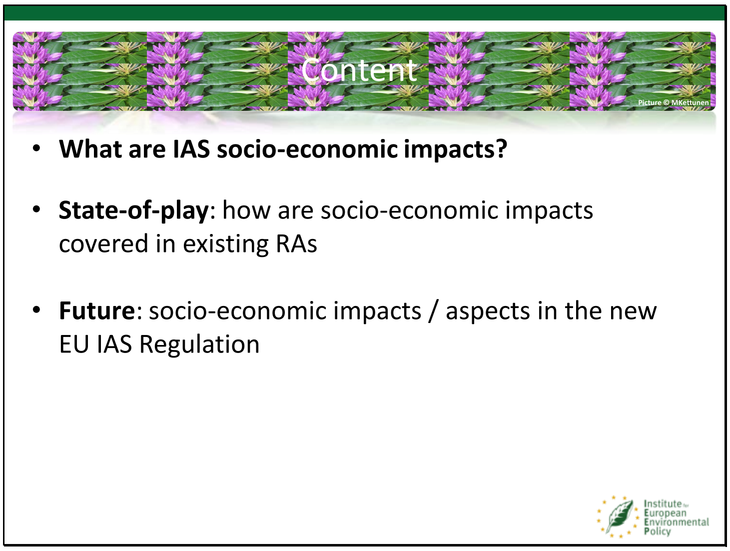
New Zealand: Williams et al., 2002 (plants)

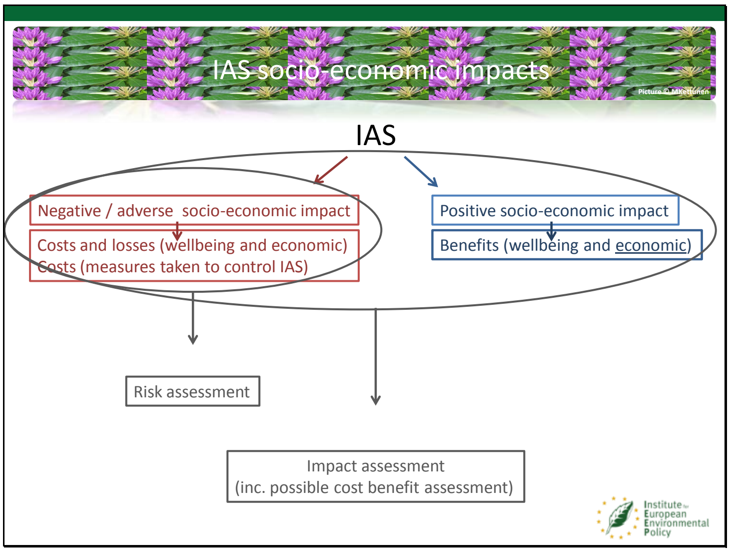
South Africa: Robertson et al (plants)

*More.... but few systems cover all taxa*

## Socio-economic impacts of IAS in risk assessment methodologies – Marianne Kettunen



## Adverse socio-economic IAS impacts

Picture © MKettunen

| | |
|---|---|
| **Negative impacts on economic sectors** | Agriculture |
| | Forestry |
| | Fisheries / aquaculture |
| | Tourism |
| | Other |
| **Negative impacts on human health** | Allergic reactions |
| | Intoxication |
| | Pathogen reservoir or vector |
| | Physical and mental wellbeing |
| **Negative impacts on wellbeing and sust. development** | Food security |
| | Water security |
| | Natural hazard mitigation |
| | Climate change mitigation and adaptation |
| | Recreation |
| | Support and/or diversification of sustainable regional development |
| | Employment |
| | Cultural and natural heritage |
| | Education, research and innovation |

Regularly one of RA criteria / methodologies (but sectors to be considered not defined)

Regularly one of RA criteria / methodologies (but health related aspects to be considered not defined)

Usually not one of RA criteria / methodologies - at least not to such level of detail

(c) (draft) Classification by M Kettunen in the context of EU IAS RA project

## Adverse IAS impacts on ecosystem services

Picture © MKettunen

| | |
|---|---|
| **Negative impacts on provisioning of resources** | Food |
| | Water |
| | Raw material |
| | Medicinal resources / biochemicals |
| | Ornamental resources |
| | Genetic resources |
| **Negative impacts on maintaining nature's regulative functions** | Climate Regulation |
| | Natural hazard regulation |
| | Water: purification |
| | Water: flow regulation |
| | Erosion |
| | Soil fertility |
| | Pollination |
| | Pest and disease control |
| **Negative impacts on maintaining cultural values** | Opportunities for recreation and tourism |
| | Aesthetic value (individual) |
| | Cultural heritage (communal) |
| **Negative impacts on fundamental natural processes** | Ecosystem processes (soil formation, nutrient cycling, primary production …) |
| | Life cycle maintenance (nursery habitats, seed dispersal …) |
| | Biodiversity maintenance and protection |

Usually not (explicitly) included in RA criteria / methodologies

(c) (draft) Classification by M Kettunen in the context of EU IAS RA project

## EU Reg. Article 5: Risk assessment

Picture © MKettunen

**" … The RA shall be carried out, across the current and potential range of IAS, having regard to the following elements**

- a description of the species (taxonomy, natural range)
- a description of its reproduction and spread patterns and dynamics including an
- assessment if environmental conditions allow reproduction and spread
- a description of the pathways of introduction and spread
- an assessment of the risk of introduction, establishment, spread in current and foreseeable climate conditions
- a description of the current distribution and a projection of its likely future distribution
- a description of the adverse impact on biodiversity and the related ecosystem services, including on native species, protected sites, endangered habitats as well as on human health, safety, and the economy, including an assessment of the potential future impact
- an assessment of the potential costs of damage
- a description of the known uses and social and economic benefits … "

Institute for European Environmental Policy

## EU Reg. Article 5: Risk assessment

RA as defined by Article 5 seems to indicate that:

- There is a need to consider adverse impacts on ecosystem services
- There is a need to consider adverse impacts on economy, human health and safety.
- Note: reference to "safety" also implies that (some) broader considerations than economic and health are taken on board, inc. food and water security, mitigation of natural hazards etc.

- Under RA also possible benefits are identified and provided information for – but ***not*** required to be assessed / compared against adverse impacts.

## From RA to broader assessment / comparison of impacts

**Article 4: List of invasive alien species of Union concern**

*"In adopting or updating the list, the Commission shall apply the criteria of paragraph 3* [ie including RA] *with due consideration to the implementation cost for the Member States, the cost of non-action, the cost-effectiveness and the socio-economic aspects …"*

↓

Comparing costs and benefits (overall impact assessment / cost benefit assessment) is ***not*** part of RA, these considerations come in later.

No clear methodology for such considerations outlined in the Reg.

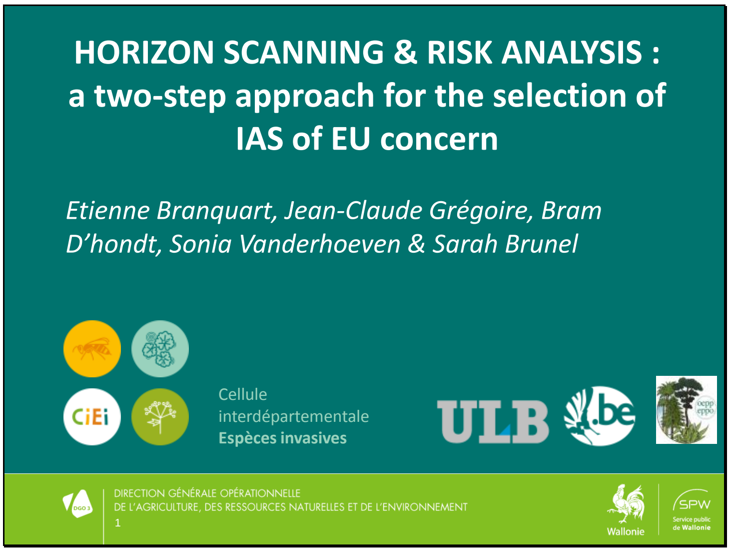
## From RA to broader assessment / comparison of impacts

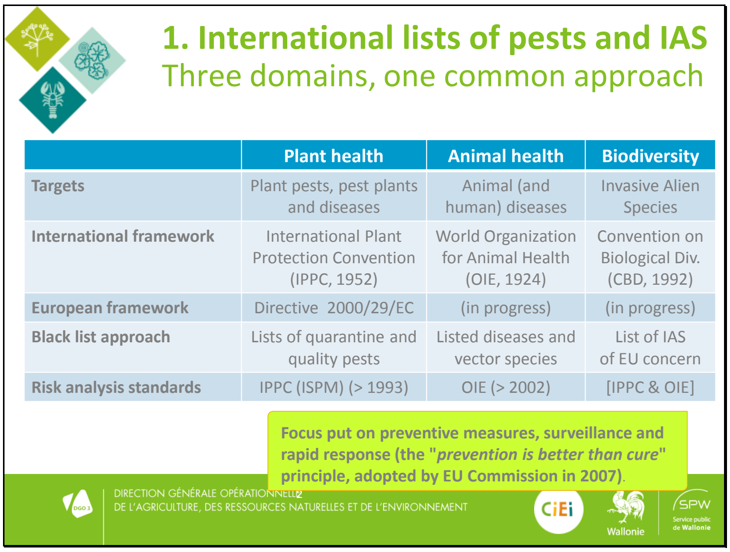
**EU Regulation preamble, recital 13**

*" In order to ensure compliance with the rules under the relevant Agreements of the World Trade Organisation and the coherent application of this Regulation, common criteria should be established to perform the **risk assessment**. Those criteria […] should encompass different aspects of the characteristics of the species, the risk and modes of introduction into the Union, the adverse economic, social and biodiversity impacts of the species, the potential benefits of uses and the costs of mitigation to weight them against the adverse impacts, as well as an assessment of the potential costs of environmental, economic and social damage demonstrating the significance for the Union, so as to further justify action. …"*

Implies that a (some kind of) assessment of costs vs. benefits is to be carried out, however not as part of RA (?)


## Two-step risk analysis process: quick screening – Etienne Branquart




| | Plant health | Animal health | Biodiversity |
|---|---|---|---|
| Targets | Plant pests, pest plants and diseases | Animal (and human) diseases | Invasive Alien Species |
| International framework | International Plant Protection Convention (IPPC, 1952) | World Organization for Animal Health (OIE, 1924) | Convention on Biological Div. (CBD, 1992) |
| European framework | Directive 2000/29/EC | (in progress) | (in progress) |
| Black list approach | Lists of quarantine and quality pests | Listed diseases and vector species | List of IAS of EU concern |
| Risk analysis standards | IPPC (ISPM) (> 1993) | OIE (> 2002) | [IPPC & OIE] |

## 1. International lists of pests and IAS
### Common principles in risk analysis

- Based on available scientific evidence
- Undertaken in an independent, objective and transparent manner
- Made of a risk assessment and a risk management modules
- Provide justification about:
  - necessity
  - proportionality
  - minimal impact on trade
  - non-discrimination
  - feasibility & cost-effectiveness

  } of proposed risk management measures with a focus on trade restriction (taking into account the acceptability of risk)

**Production cost at EU level?**
Min 20 000 EUR per species based on EPPO and EC estimates!

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## 1. International lists of pests and IAS
### Risk management in IAS Regulation

- Risk management elements do not appear as such in article 5 of the Regulation (risk assessment) but…
- Recital 11 and 13 state that risk assessment should use existing standards and be compliant with WTO rules
- Article 4 (list of IAS of EU concern) provides additional criteria for species inclusion in the list:

  *(d) it is demonstrated by a risk assessment performed pursuant to Article 5 that action at Union level is required to prevent their introduction, establishment and spread [**international trade as a pathway**];*

  *(e) it is likely that the inclusion in the list will effectively prevent, minimise or mitigate their adverse impacts [**efficiency of measures**].*

**Maybe good to consider some risk management criteria within the minimum standards**

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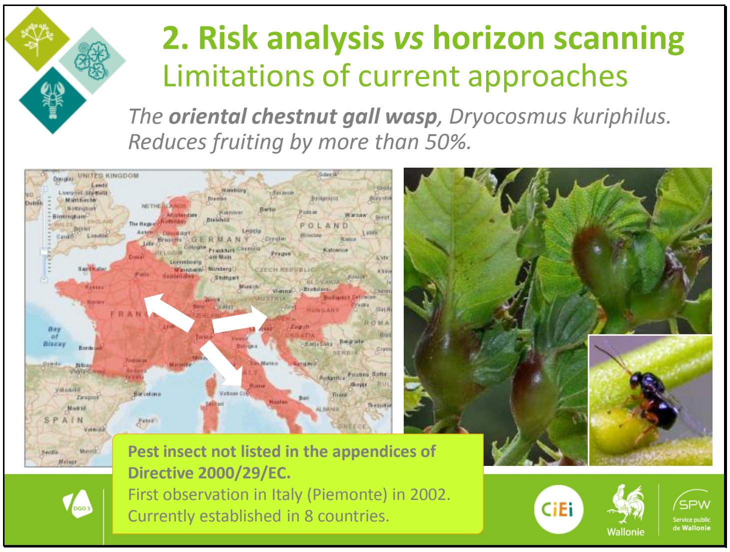
## 1. International lists of pests and IAS
### National measures


**Brief statement of grounds:**
- Necessary
- Non-discriminatory
- Proportionality

Directive 98/34/EC, provision of information in the field of technical standards and regulation.


2. Risk analysis vs horizon scanning
Limitations of current approaches
The oriental chestnut gall wasp, Dryocosmus kuriphilus.
Reduces fruiting by more than 50%.
Pest insect not listed in the appendices of Directive 2000/29/EC.
First observation in Italy (Piemonte) in 2002.
Currently established in 8 countries.
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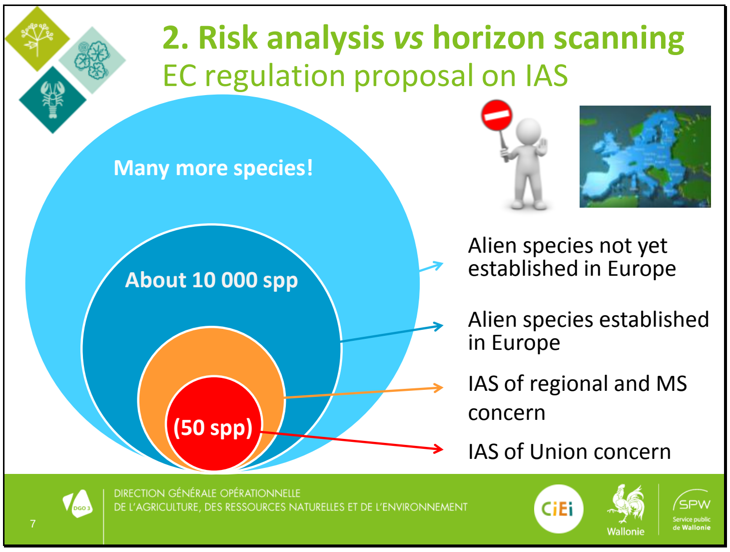
2. Risk analysis vs horizon scanning
EC regulation proposal on IAS
Many more species!
About 10 000 spp
(50 spp)
Alien species not yet established in Europe
Alien species established in Europe
IAS of regional and MS concern
IAS of Union concern
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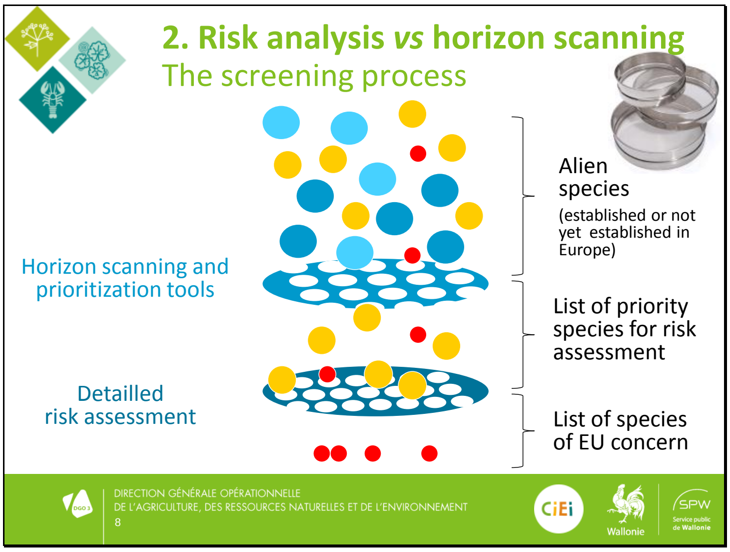
2. Risk analysis vs horizon scanning
The screening process
Alien species
(established or not yet established in Europe)
Horizon scanning and prioritization tools
List of priority species for risk assessment
Detailled risk assessment
List of species of EU concern
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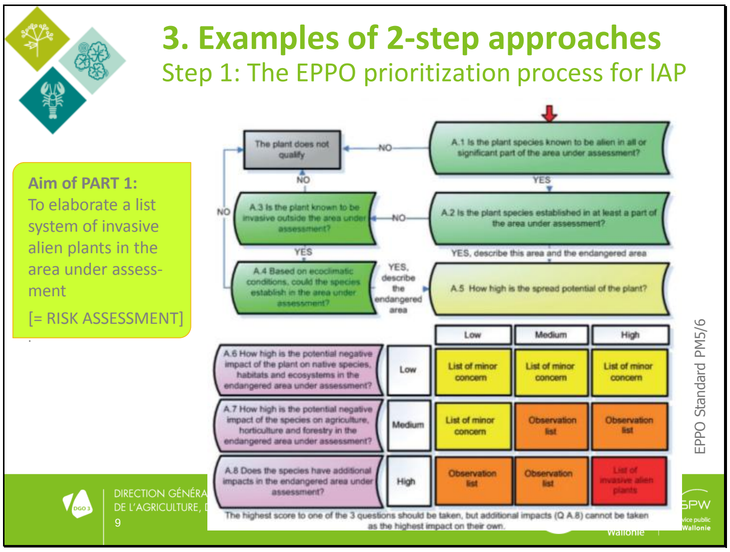
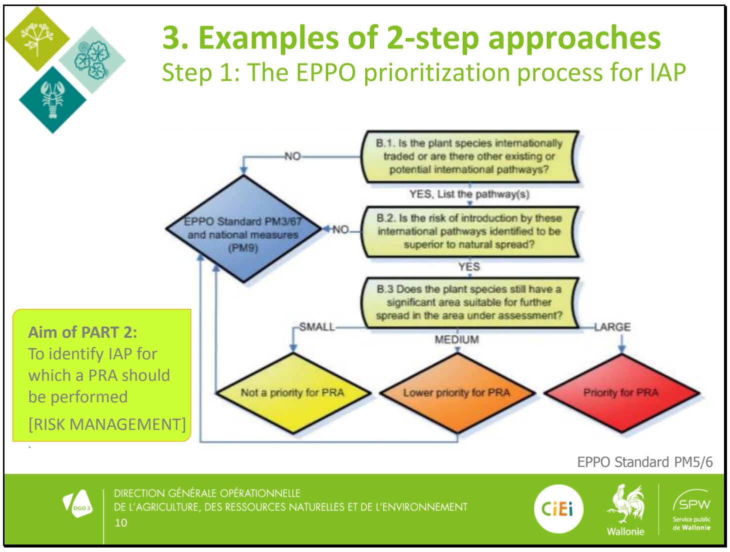

3. Examples of 2-step approaches
Step 1: The EPPO prioritization process for IAP
Aim of PART 1:
To elaborate a list system of invasive alien plants in the area under assess-ment
[= RISK ASSESSMENT]
The plant does not qualify
A.1 Is the plant species known to be alien in all or significant part of the area under assessment?
NO
YES
NO
A.3 Is the plant known to be invasive outside the area under assessment?
A.2 Is the plant species established in at least a part of the area under assessment?
YES
YES, describe this area and the endangered area
A.4 Based on ecoclimatic conditions, could the species establish in the area under assessment?
YES, describe the endangered area
A.5 How high is the spread potential of the plant?
Low
Medium
High
A.6 How high is the potential negative impact of the plant on native species, habitats and ecosystems in the endangered area under assessment?
A.7 How high is the potential negative impact of the species on agriculture, horticulture and forestry in the endangered area under assessment?
A.8 Does the species have additional impacts in the endangered area under assessment?
List of minor concern
Observation list
List of invasive alien plants
The highest score to one of the 3 questions should be taken, but additional impacts (Q A.8) cannot be taken as the highest impact on their own.
EPPO Standard PM5/6
9


3. Examples of 2-step approaches
Step 1: The EPPO prioritization process for IAP
B.1. Is the plant species internationally traded or are there other existing or potential international pathways?
NO
YES, List the pathway(s)
EPPO Standard PM3/67 and national measures (PM9)
B.2. Is the risk of introduction by these international pathways identified to be superior to natural spread?
NO
YES
B.3 Does the plant species still have a significant area suitable for further spread in the area under assessment?
SMALL
MEDIUM
LARGE
Not a priority for PRA
Lower priority for PRA
Priority for PRA
Aim of PART 2:
To identify IAP for which a PRA should be performed
[RISK MANAGEMENT]
EPPO Standard PM5/6
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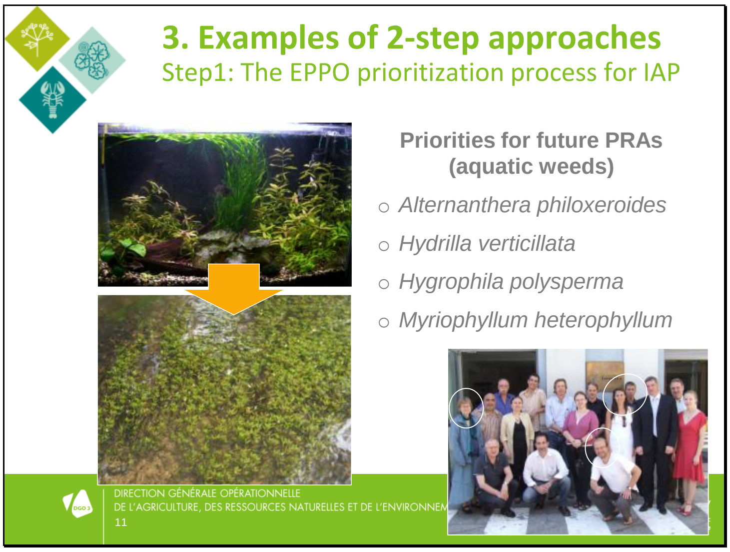
3. Examples of 2-step approaches
Step1: The EPPO prioritization process for IAP
Priorities for future PRAs (aquatic weeds)
Alternanthera philoxeroides
Hydrilla verticillata
Hygrophila polysperma
Myriophyllum heterophyllum
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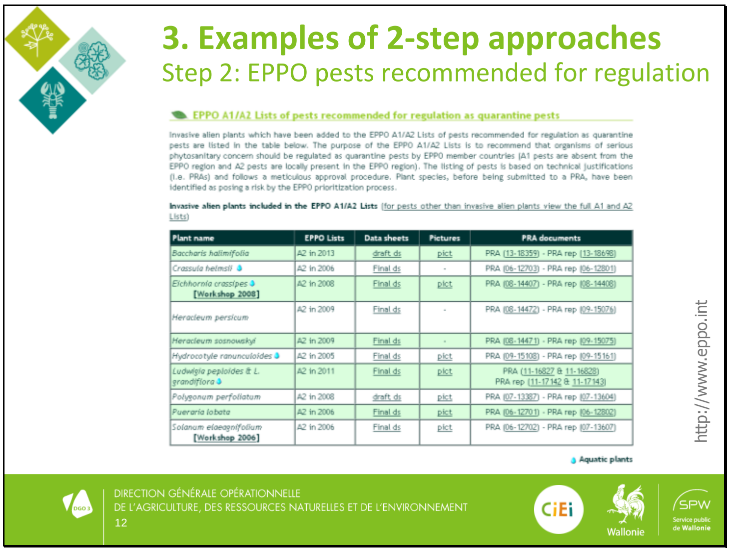
3. Examples of 2-step approaches
Step 2: EPPO pests recommended for regulation
EPPO A1/A2 Lists of pests recommended for regulation as quarantine pests
Invasive alien plants which have been added to the EPPO A1/A2 Lists of pests recommended for regulation as quarantine pests are listed in the table below. The purpose of the EPPO A1/A2 Lists is to recommend that organisms of serious phytosanitary concern should be regulated as quarantine pests by EPPO member countries (A1 pests are absent from the EPPO region and A2 pests are locally present in the EPPO region). The listing of pests is based on technical justifications (i.e. PRAs) and follows a meticulous approval procedure. Plant species, before being submitted to a PRA, have been identified as posing a risk by the EPPO prioritization process.
Invasive alien plants included in the EPPO A1/A2 Lists (for pests other than invasive alien plants view the full A1 and A2 Lists)
Plant name | EPPO Lists | Data sheets | Pictures | PRA documents
*Baccharis halimifolia* | A2 in 2013 | draft ds | pict | PRA (13-18359) - PRA rep (13-18698)
*Crassula helmsii* | A2 in 2006 | Final ds | - | PRA (06-12703) - PRA rep (06-12801)
*Eichhornia crassipes* [Workshop 2008] | A2 in 2008 | Final ds | pict | PRA (08-14407) - PRA rep (08-14408)
*Heracleum persicum* | A2 in 2009 | Final ds | - | PRA (08-14472) - PRA rep (09-15076)
*Heracleum sosnowskyi* | A2 in 2009 | Final ds | - | PRA (08-14471) - PRA rep (09-15075)
*Hydrocotyle ranunculoides* | A2 in 2005 | Final ds | pict | PRA (09-15108) - PRA rep (09-15161)
*Ludwigia peploides & L. grandiflora* | A2 in 2011 | Final ds | pict | PRA (11-16827 & 11-16828) PRA rep (11-17142 & 11-17143)
*Polygonum perfoliatum* | A2 in 2008 | draft ds | pict | PRA (07-13387) - PRA rep (07-13604)
*Pueraria lobata* | A2 in 2006 | Final ds | pict | PRA (06-12701) - PRA rep (06-12802)
*Solanum elaeagnifolium* [Workshop 2006] | A2 in 2006 | Final ds | pict | PRA (06-12702) - PRA rep (07-13607)
Aquatic plants
http://www.eppo.int
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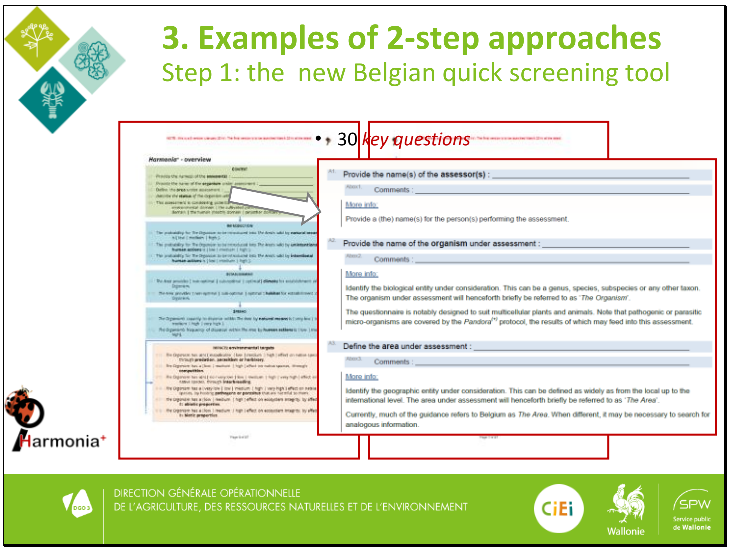
3. Examples of 2-step approaches
Step 1: the new Belgian quick screening tool
• 30 key questions
A1. Provide the name(s) of the assessor(s) :
Comments :
More info:
Provide a (the) name(s) for the person(s) performing the assessment.
A2. Provide the name of the organism under assessment :
Comments :
More info:
Identify the biological entity under consideration. This can be a genus, species, subspecies or any other taxon. The organism under assessment will henceforth briefly be referred to as 'The Organism'.
The questionnaire is notably designed to suit multicellular plants and animals. Note that pathogenic or parasitic micro-organisms are covered by the Pandora protocol, the results of which may feed into this assessment.
A3. Define the area under assessment :
Comments :
More info:
Identify the geographic entity under consideration. This can be defined as widely as from the local up to the international level. The area under assessment will henceforth briefly be referred to as 'The Area'.
Currently, much of the guidance refers to Belgium as The Area. When different, it may be necessary to search for analogous information.
Harmonia+
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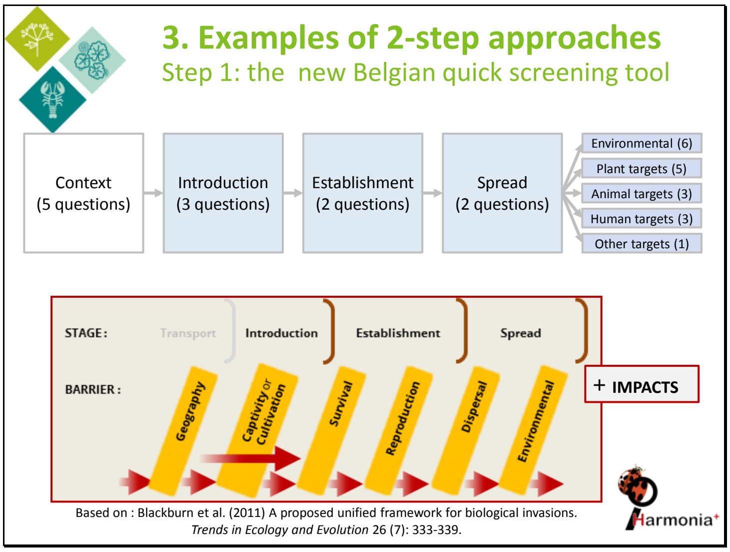
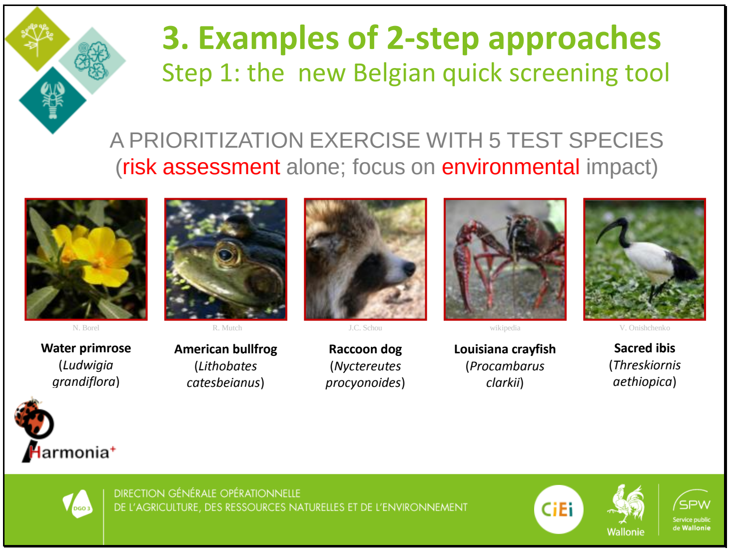

3. Examples of 2-step approaches
Step 1: the new Belgian quick screening tool
Context (5 questions)
Introduction (3 questions)
Establishment (2 questions)
Spread (2 questions)
Environmental (6)
Plant targets (5)
Animal targets (3)
Human targets (3)
Other targets (1)
STAGE:
Transport
Introduction
Establishment
Spread
BARRIER:
Geography
Captivity or Cultivation
Survival
Reproduction
Dispersal
Environmental
+ IMPACTS
Based on : Blackburn et al. (2011) A proposed unified framework for biological invasions.
Trends in Ecology and Evolution 26 (7): 333-339.
Harmonia+


3. Examples of 2-step approaches
Step 1: the new Belgian quick screening tool
A PRIORITIZATION EXERCISE WITH 5 TEST SPECIES
(risk assessment alone; focus on environmental impact)
Water primrose (Ludwigia grandiflora)
American bullfrog (Lithobates catesbeianus)
Raccoon dog (Nyctereutes procyonoides)
Louisiana crayfish (Procambarus clarkii)
Sacred ibis (Threskiornis aethiopica)
Harmonia+
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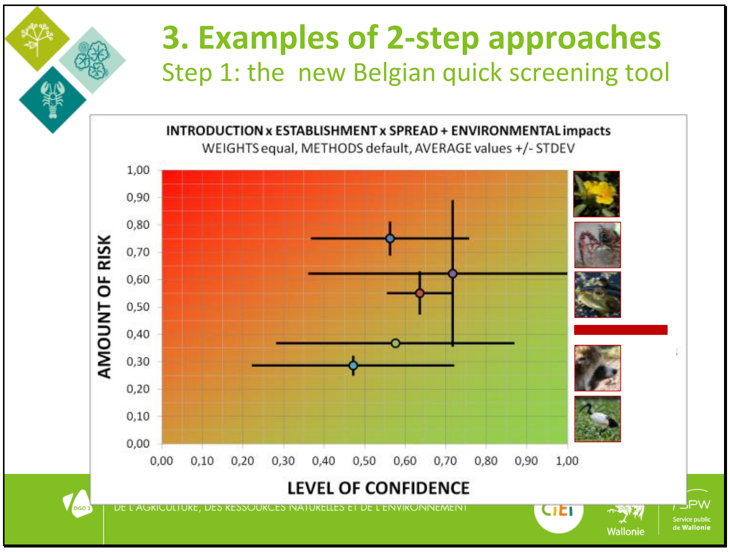
3. Examples of 2-step approaches
Step 1: the new Belgian quick screening tool
INTRODUCTION x ESTABLISHMENT x SPREAD + ENVIRONMENTAL impacts
WEIGHTS equal, METHODS default, AVERAGE values +/- STDEV
AMOUNT OF RISK
LEVEL OF CONFIDENCE
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
1,00


3. Examples of 2-step approaches
Step 2: Belgian risk analysis reports (WTO)
Risk analysis of the perennial water primrose Ludwigia grandiflora
museum
Risk analysis of the Louisiana Crayfish Procambarus clarkii
Risk analysis report of non-native organisms in Belgium
Risk analysis report of non-native organisms in Belgium - American bullfrog Lithobates catesbeianus (Shaw)
inbo
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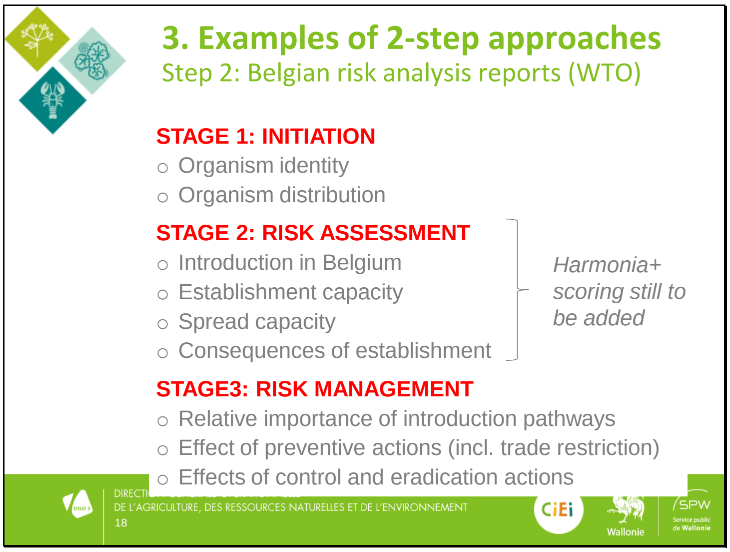
3. Examples of 2-step approaches
Step 2: Belgian risk analysis reports (WTO)
STAGE 1: INITIATION
○ Organism identity
○ Organism distribution
STAGE 2: RISK ASSESSMENT
○ Introduction in Belgium
○ Establishment capacity
○ Spread capacity
○ Consequences of establishment
Harmonia+ scoring still to be added
STAGE3: RISK MANAGEMENT
○ Relative importance of introduction pathways
○ Effect of preventive actions (incl. trade restriction)
○ Effects of control and eradication actions
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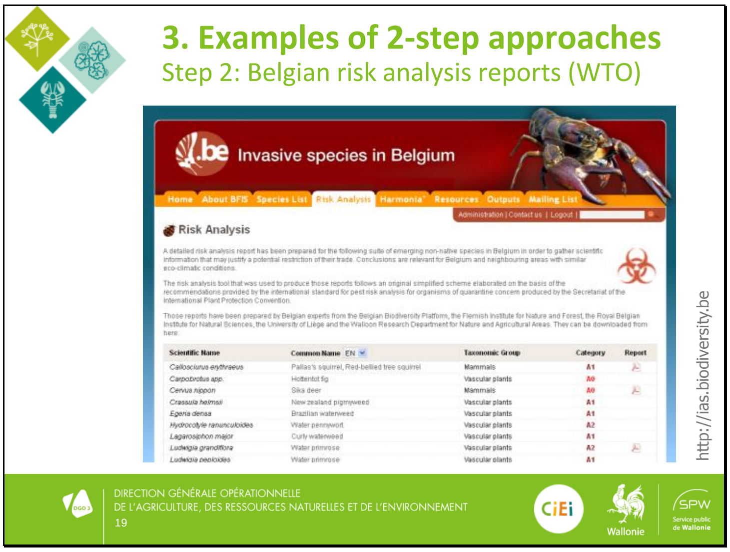
3. Examples of 2-step approaches
Step 2: Belgian risk analysis reports (WTO)
Invasive species in Belgium
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Risk Analysis
A detailed risk analysis report has been prepared for the following suite of emerging non-native species in Belgium in order to gather scientific information that may justify a potential restriction of their trade. Conclusions are relevant for Belgium and neighbouring areas with similar eco-climatic conditions.
The risk analysis tool that was used to produce those reports follows an original simplified scheme elaborated on the basis of the recommendations provided by the international standard for pest risk analysis for organisms of quarantine concern produced by the Secretariat of the International Plant Protection Convention.
Those reports have been prepared by Belgian experts from the Belgian Biodiversity Platform, the Flemish Institute for Nature and Forest, the Royal Belgian Institute for Natural Sciences, the University of Liège and the Walloon Research Department for Nature and Agricultural Areas. They can be downloaded from here:
Scientific Name | Common Name EN | Taxonomic Group | Category | Report
Callosciurus erythraeus | Pallas's squirrel, Red-bellied tree squirrel | Mammals | A1
Carpobrotus spp. | Hottentot fig | Vascular plants | A0
Cervus nippon | Sika deer | Mammals | A0
Crassula helmsii | New zealand pigmyweed | Vascular plants | A1
Egeria densa | Brazilian waterweed | Vascular plants | A1
Hydrocotyle ranunculoides | Water pennywort | Vascular plants | A2
Lagarosiphon major | Curly waterweed | Vascular plants | A1
Ludwigia grandiflora | Water primrose | Vascular plants | A2
Ludwigia peploides | Water primrose | Vascular plants | A1
http://ias.biodiversity.be
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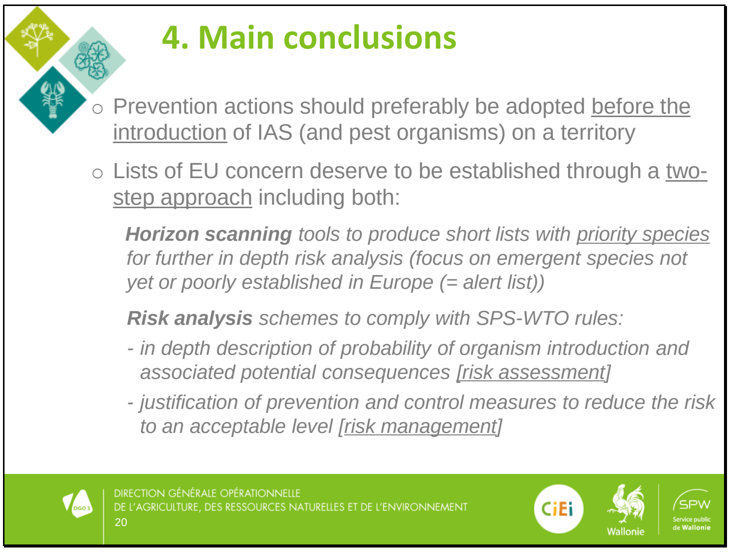
4. Main conclusions
○ Prevention actions should preferably be adopted before the introduction of IAS (and pest organisms) on a territory
○ Lists of EU concern deserve to be established through a two-step approach including both:
Horizon scanning tools to produce short lists with priority species for further in depth risk analysis (focus on emergent species not yet or poorly established in Europe (= alert list))
Risk analysis schemes to comply with SPS-WTO rules:
- in depth description of probability of organism introduction and associated potential consequences [risk assessment]
- justification of prevention and control measures to reduce the risk to an acceptable level [risk management]
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## Screening risk assessment methodologies against agreed minimum standards – Sarah Brunel

### INTERNATIONAL STANDARDS FOR RISK ASSESSMENT METHODOLOGIES

**Sarah Brunel**,
European and Mediterranean Plant Protection Organization (EPPO) &

**Etienne Branquart**,
Cellule Interdépartementale sur les espèces invasives,
Service Public de Wallonie

### NEW EU REGULATION ON IAS

- [Recital 11] The criteria to list invasive alien species considered to be of Union concern are the core instrument to apply this Regulation. In order to ensure an effective use of resources, the criteria should also make sure that the invasive alien species having the most significant adverse impact among the potential invasive alien species currently known are those that will be listed (…). The criteria should include a risk assessment pursuant to the applicable provisions under the relevant Agreements of the **World Trade Organisation** on placing trade restrictions on species.

### NEW EU REGULATION ON IAS

- [Recital 13] In order to ensure compliance with the rules under the relevant **WTO Agreements**, common criteria should be established to perform the risk assessment. Those criteria should use when appropriate existing national and international standards and should encompass:
  - the risk and modes of introduction into the EU,
  - the adverse economic, social and biodiversity impacts,
  - the potential benefits of uses and the costs of mitigation,
  - an assessment of the potential costs of environmental, economic and social damages demonstrating the significance for the Union.

## INTERNATIONAL CONTEXT

**The World Trade Organization**

The World Trade Organization (WTO) deals with the global rules of trade between nations. Its main function is to ensure that trade flows as smoothly, predictably and freely as possible. It was established in 1995 and has 159 members.

Under the **Agreement on the Application of Sanitary and Phytosanitary Measures** (SPS Agreement) negociated during the Uruguay Round in 1995, the WTO sets constraints on member states' policies relating to food safety, animal and plant health with respect to pests and diseases. Three organizations set Standards:

- **Codex alimentarus**: Not relevant for invasive alien species
- **Office International des Epizooties: Animal Health**
- **International Plant Protection Convention: Plant Health**

**CBD Convention on Biological Diversity**

## INTERNATIONAL CONVENTIONS DEFINITIONS

**(Pest) risk analysis = (pest) risk assessment + (pest) risk management (+(pest) risk communication)**

[SPS/WTO] Risk assessment: The evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing MS according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences.

[OIE] Risk assessment: Means the evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country.

[IPPC] Pest risk assessment: Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences.

[CBD] Risk assessment: relates to WTO, OIE and IPPC definitions.

## COMMON PRINCIPLES ON RISK ANALYSIS

- Based on available scientific evidence
- Undertaken in an independent, objective and transparent manner
- Provides justification about:
  - necessity
  - proportionality
  - minimal impact on trade
  - non-discrimination
  - feasibility & cost-effectiveness

  of proposed risk management measures

## INTERNATIONAL STANDARDS ON RISK ASSESSMENT

Import risk analysis of the *Terrestrial animal health code*

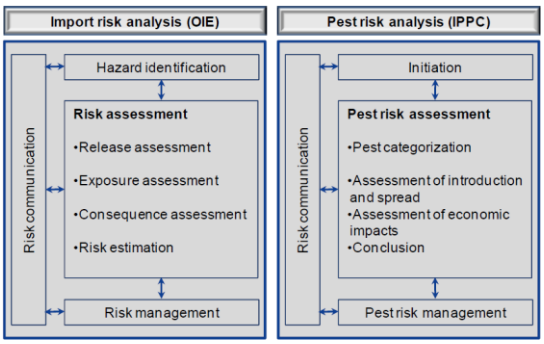
Guidelines for assessing the risk of non-native animals becoming invasive

International Standard on Phytosanitary Measures 11 Pest risk analysis for quarantine pests

## RISK ASSESSMENT: GENERAL CONSIDERATIONS

| | Office International des Epizooties (OIE) | International Plant Protection Convention (IPPC) |
|---|---|---|
| Qualitative/ quantitative | Risk assessment may be qualitative or quantitative. | / |
| Distribution of the pest under study | At least one country has demonstrated freedom or impending freedom from the disease, infection or infestation. | Pest absent from all or a defined part of the PRA area. If the pest is present but not widely distributed, it should be under official control in the near future. |
| Information used | Should be well documented and supported with references to the scientific literature including other sources (including expert opinion). | Scientific publications as well as technical information such as data from surveys and interceptions may be relevant. Expert judgement may be used if appropriate. |
| Uncertainties | Should document the uncertainties and the assumptions made and the effects of these on the final risk estimate. | Degree of uncertainty should be documented. |
| Updating | Should be amenable to updating when additional information becomes available. | / |

## RISK ANALYSIS: STRUCTURE OF INTERNATIONAL STANDARDS




EFSA Scientific Committee, EFSA Journal 2012

## Horizon scanning for future EU IAS from the perspective of Great Britain – Alan Stewart and Karsten Schönrogge

**Horizon scanning for future EU IAS from the perspective of Great Britain**

Alan Stewart, University of Sussex, UK
Karsten Schönrogge, Centre for Ecology & Hydrology, UK

IAS Risk Assessment Workshop
Brussels, 27/28th March 2014

Horizon scanning:

the systematic examination of future threats and opportunities


Review

Feature Review

A horizon scan of global conservation issues for 2014

William J. Sutherland, Rosalind Aveling, Thomas M. Brooks, Mick Clout, Lynn V. Dicks, Liz Fellman, Erica Fleishman, David W. Gibbons, Brandon Keim, Fiona Lickorish, Kathryn A. Monk, Diana Mortimer, Lloyd S. Peck, Jules Pretty, Johan Rockström, Jon Paul Rodríguez, Rebecca K. Smith, Mark D. Spalding, Femke H. Tonneijck, and Andrew R. Watkinson

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

2-day workshop at CEH
25-26 April 2013

Roy *et al*. Horizon-scanning for invasive alien species with the potential to threaten biodiversity in Great Britain (in review, *Global Change Biology*).

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Aim

To scan for IAS that:

- are likely to impact adversely on native biodiversity
  - arrive, establish, spread, impact on biodiversity
  - other impacts (agriculture, forestry, human health etc.) not considered
- are not yet established in the wild in Great Britain
  - included spp that had formed transient local populations (not persisted or been removed)
  - arrival mediated by human activity (CBD definition)
- over next decade

## Approach:

- Rapid risk assessment (based on literature review & expert opinion)
- Dynamic consensus method

2 phases:

- Initial consultation with experts *within* 5 thematic groups to derive preliminary ranked lists of IAS
- Consensus-building *across* thematic groups to compile and rank a full list of IAS

## 5 thematic groups:

Plants
Terrestrial invertebrates
Freshwater invertebrates
Vertebrates
Marine species

- 2 leaders for each group
- + 3-4 further experts in each group
- 28 participants

## 1st task (3 months pre-workshop; by email, phone):

- collate list of IAS using literature (journals, grey lit.) & expert opinion
- information on:
  - Functional group
  - Pathway
- scoring (1-5 scale) of likelihood of:
  - Arrival
  - Establishment
  - Impact on biodiversity, based on:
    - colonisation of high conservation value habitats
    - adverse impact on native species
    - alteration of ecosystem function
- scores combined (arrival x establishment x impact) (max. = 125)
- total species per group = 27 - 74

## 2nd task (at workshop)

Day 1: Thematic Group Leaders met

- Initial presentation and review of lists
- Justification and moderation of scores
- Standardisation of approach
- Agreed list produced

Day 2, am: Thematic groups met

- Add/remove species
- Consider uncertainty (often due to lack of information)
- Revise scores

Day 2, pm: All participants met

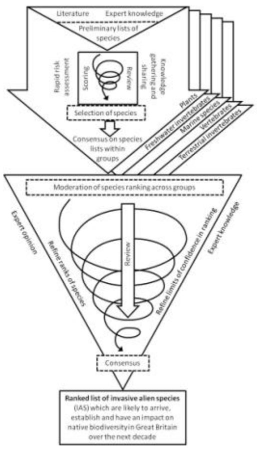
- Review, refine and rank list of IAS across all taxa/habitats
- Consensus based on expert opinion, discussion, majority vote

Collaborative review
↓
Discussion
↓
Consensus building
↓
Iteration
↓
Agreed ranked list

Task1: Preliminary consultation within thematic groups

Task 2: Consensus building across thematic groups

Output: Ranked list of IAS



## Output:

- 249 species considered
- 93 of these were agreed to constitute at least a medium risk
- Top 30 species agreed to be high risk

- 'Top' species: Quagga mussel, *Dreissena rostriformis bugensis*

- Remaining 63 species – unranked list of medium-risk spp.

## Conclusions from the horizon scanning exercise:

Strengths:
- Comparability across all taxa
- Consensus through iterative discussion

Lessons:
- Clear definitions of terms & remit
- Ranked categories (high, medium, low risk) preferable to full ranking

Issues:
- Uncertainty
- Cryptic species
- Establishing pathways (especially whether by human agency or not)
- Knowledge gaps uneven across taxa (invertebrates cf. vertebrates)
- Species in outdoor cultivation (e.g. plants, waterfowl)
- Time lags

Roy *et al*. Horizon-scanning for invasive alien species with the potential to threaten biodiversity in Great Britain (accepted, *Global Change Biology*).

# Annex 5. Publications including risk and impact assessment protocols circulated in advance of the workshop (Task 3)

| Document | Link or reference | Representative participant |
|---|---|---|
| European and Mediterranean Plant Protection Organization Guidelines on Pest Risk Analysis | http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm | Sarah Brunel (EPPO) |
| GB Non-native species Rapid Risk Assessment (NRRA) | http://napra.eppo.org/index.php | Niall Moore (NNSS) |
| Harmonia+ (and Pandora+) | http://ias.biodiversity.be/harmoniaplus | Bram D'hondt (Belgian Biodiversity Platform) |
| Generic ecological impact assessments of alien species in Norway | (Sandvik, Sæther et al. 2013)<br><br>http://www.artsdatabanken.no/File/689/Alien%20species | Hanno Sandvik (Norwegian Biodiversity Information Centre) |
| German–Austrian Black List Information System | (Essl, Nehring et al. 2011)<br><br>http://www.sciencedirect.com/science/article/pii/S1617138111000513 | Wolfgang Rabitsch (EAA) |
| Generic impact scoring system | (Nentwig, Kühnel et al. 2010, Vaes-Petignat and Nentwig 2014)<br><br>http://neobiota.pensoft.net/articles.php?id=1275 | Wolfgang Nentwig (University of Bern) |

# Annex 6. Long list of attributes derived from risk assessments.

Including comments on the exclusion or inclusion as a minimum standard alongside information on relevant aspects within the proposed Regulation. Additional information and clarification on the agreed minimum standards are provided in Table 3.5.

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Includes species description | Aspects included within minimum standard "Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)" | It is essential that the risk assessment can be read as a standalone document. Need to be very clear about the biology. It was agreed that invasion history was an important aspect of basic information. Geographic scope of the assessment provides context for understanding where the species could potentially survive and establish. Note native and potential range are included within other standards. | a description of the species with its taxonomic identity, its history, natural and potential range |
| Documents information sources | Minimum standard | The method should be based on scientific evidence. The source of information for every statement should be included and relevant references provided. | ... based on available scientific evidence … |
| Can be used for a broad range of taxa | Not a minimum standard | Unanimous agreement that different taxa can demand different approaches to risk assessment and as such there should be flexibility in approach. | - |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Includes the likelihood of entry, establishment, spread and magnitude of impact | Minimum standard | Rephrased as "Includes description of the likelihood of entry, establishment, spread (actual and potential distribution) and magnitude of impact ". Extensive discussion as to whether this minimum standard should be combined with "Includes description of (1) the actual and potential distribution; (2) the likelihood of spread; (3) the magnitude of impact". Additional discussions on entry and establishment as a separate minimum standard from spread and impact. It was agreed that a thorough assessment should be undertaken of the risk of introduction, establishment, spread in relevant biogeographical regions in current conditions and in foreseeable climate change conditions. It was also considered extremely important to include the rate of spread. | a description of its reproduction and spread patterns and dynamics including an assessment of whether the environmental conditions necessary for reproduction and spread exist;<br><br>a thorough assessment of the risk of introduction, establishment, spread in relevant biogeographical regions in current conditions and in foreseeable climate change conditions |
| Includes description of (1) the actual and potential distribution; (2) the likelihood of spread; (3) the magnitude of impact | Minimum standard | Duplicates "Includes description of the likelihood of entry, establishment, spread (actual and potential distribution) and magnitude of impact" and so merged. | |
| Has the capacity to include multiple pathways of entry and spread, both intentional and unintentional | Minimum standard | The importance of consideration of multiple pathways was highlighted as extremely important. | a description of the potential pathways of introduction and spread, both intentional and unintentional, including where relevant the commodities with |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Has the capacity to include multiple pathways of secondary spread, both intentional and unintentional | Included within "Has the capacity to include multiple pathways of entry and spread, both intentional and unintentional". | | which the species are generally associated |
| Can broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes | Minimum standard | It is more straightforward to assess species for which impacts are clearly and extensively documented than for new arrivals for which empirical evidence may be lacking. However, it is essential that lack of information does not bias the assessment. | a description of the adverse impact on biodiversity and the related ecosystem services, including on native species, protected sites, endangered habitats, as well as on human health, safety, and the economy including an assessment of the potential future impacts having regard to available scientific knowledge; |
| Broadly assesses environmental impact with respect to biodiversity and related ecosystem services | Minimum standard | Rephrased to "Can broadly assess environmental impact with respect to ecosystem services". Extensive discussion on inclusion of ecosystem services because of the current difficulty in quantifying the impacts of IAS on ecosystem services. However, it was unanimously agreed that it was important to consider impacts with respect to ecosystem services at least qualitatively. | |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Includes status (endangered or protected) of species or habitat under threat | Minimum standard | Rephrased to "Includes status (threatened or protected) of species or habitat under threat". There was not unanimous agreement on inclusion and 6 participants of 19 dissented. All participants agreed that this is an important aspect of risk assessment but some felt it was more appropriate to risk management and others felt there was insufficient scientific evidence for inclusion. Furthermore some participants were concerned by the notion that threatened species might be perceived to have higher value than others. However, it was agreed that risk assessments should at least consider this perspective even if not as a quantitative component. | a description of the current distribution of the species including whether the species is already present in the Union or in neighbouring countries and a projection of its likely future distribution |
| Has the capacity to consider future impacts due to environmental change | Minimum standard | Rephrased to "Includes possible effects on climate change in the foreseeable future". There was considerable discussion on this attribute of risk assessments. Primarily there was considerable concern over the provision of scientific evidence to underpin this minimum standard. However, it was unanimously agreed that at expert-opinion could provide a qualitative assessment. | |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Broadly assesses socio-economic impact | Minimum standard | There was considerable discussion on this attribute and consideration was given to combining this minimum standard with "Can broadly assess environmental impact with respect to ecosystem services". However, all but one of the participants agreed (with one abstaining over emphasis on “assess” as opposed to “describes”) to include this as a distinct minimum standard recognising the difficulties in quantifying and monetizing socio-economic impacts, it is foreseen that the assessment would be qualitative, not quantitative or monetary. However, for the purposes of strengthening understanding, quantitative and monetary evidence, where available, should be encouraged. | |
| Includes assessment of monetary cost of damage | Not a minimum standard | Assessment of monetary cost of damage is seen as extremely challenging. However, the participants agreed that this is important for future weighting by decision-making and as such the Regulation includes consideration through reference to "costs of damage" which includes costs beyond monetary costs. In summary it was agreed that this attribute is included within broad socio-economic considerations but it is important to note that it is possible to directly assess the costs of ecosystem services which, while often interlinked with socio-economic assessment, can provide useful perspectives on damage. | an assessment of the potential costs of damage |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Considers socio-economic benefits | Included within minimum standard "Description (Taxonomy, invasion history, distribution range (native and introduced), geographic scope, socio-economic benefits)" | | a description of the known uses and social and economic benefits deriving from those uses |
| Provides a summary of the different components of the assessment in a consistent and interpretable form | Minimum standard | Rephrased to "Provides a summary of the different components of the risk assessment and an overall summary, in a consistent and interpretable form ". Clarity in the summary of the assessment and components is regarded as essential for effective and unambiguous interpretation of the assessment. | |
| Includes measure of uncertainty | Minimum standard | Rephrased to "Includes uncertainty" because "measure" was regarded as too specific. Recommendation to refer to IPCC climate change framework which considers lack of information as uncertainty http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf. (epistemic uncertainty) but also noting that different assessors may interpret the same information differently (linguistic uncertainty). Consideration was given to combining this minimum standard with lack of data but it was agreed that the two attributes were distinct. | |
| Can deal with lack of data | Minimum standard | Rephrased to "Can be completed even when there is a lack of data or associated information". | |

| Risk assessment attribute | Minimum standard? | Comments | Relevant reference within proposed Regulation |
|---|---|---|---|
| Unbiased and objectively assesses all species regardless of current status | Not a minimum standard | It was acknowledged that it is extremely important objectively assess all species and that there is a risk that species, for which there is considerable published evidence, are ranked as higher impact than those for which there is a paucity of information.  However, this is encompassed in "Can be completed even when there a lack of data or associated information" and there is an overarching requirement for a consistent approach to assessment. It was agreed that providing a measure of whether the assessment has been done in a transparent and unbiased way would be extremely difficult. However, consideration could be included within a minimum standard on quality assurance. | |
| Compliant with WTO standards | Not a minimum standard | The participants agreed that it was important to recognise and adopt the WTO standards but that this should be as overarching guidance rather than a distinct minimum standard. | (Recital 11, 13) |
| Includes quality assurance | Minimum standard | This minimum standard was added during the workshop to encompass a number of the attributes which were disregarded as discrete minimum standards such as "Unbiased and objectively assesses all species regardless of current status". A peer review panel or other process such as review by a panel of experts to ensure the quality of the assessment is critical for quality assurance. | |

# Annex 7. Risk Assessment for *Oxyura jamaicensis* (Ruddy Duck)

**RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS**

**It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.**

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. During this process risk assessments are:

20. Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
21. Drafted by an independent expert in the species and peer reviewed by a different expert.
22. Approved by the NNRAP (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
23. Approved by the GB Programme Board for Non-native Species.
24. Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
25. Finalised by the risk assessor to the satisfaction of the NNRAP and GB Programme Board if necessary.

**Common misconceptions about risk assessments**

The risk assessments:

26. Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
27. Are advisory and therefore part of the suite of information on which policy decisions are based.
28. Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

**Period for comment**

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAP will determine whether the final risk assessment suitably takes into account the comments provided.

**To find out more:** published risk assessments and more information can be found at

https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=22

| NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME |
|---|
| Name of organism: Ruddy Duck *Oxyura jamaicensis*<br>Author: Iain Henderson<br>Risk Assessment Area: All of the EU, including those areas with limited invasive populations presently occur<br>Draft: Draft 2 (30/06/2014)<br>Signed off by NNRAP: *to be completed*<br>Approved by Programme Board: *to be completed*<br>Placed on NNSS website: *to be completed* |

**SECTION A – Organism Information and Screening**

| | RESPONSE [chose one entry, delete all others] | COMMENT |
|---|---|---|
| **Stage 1. Organism Information** | | |
| 1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank? | RUDDY DUCK *Oxyura jamaicensis* | Single taxonomic entity but known to hybridise with White-headed Duck *Oxyura leucocephala*, an endangered species native to the Mediterranean and central Asia. |
| 2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on) | NOT APPLICABLE | |
| 3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment) | NO | |
| 4. If there is an earlier risk assessment is it still entirely valid, or only partly valid? | NOT APPLICABLE | |

| | RESPONSE [chose one entry, delete all others] | COMMENT |
|---|---|---|
| 5. Where is the organism native? | North America, Central America, and the Andean regions of South America. | |
| 6. What is the global distribution of the organism (excluding the European Union)? | Outside its native range (see 5), significant populations and breeding attempts only occur in the EU (UK, France, the Netherlands and Belgium). However birds appear as vagrants in a number of other countries, including Spain.<br>Some small populations elsewhere (e.g. Iceland and Morocco) appear to have died out since the start of the UK eradication programme in 2005. | |
| 7. What is the distribution of the organism in the European Union? | Approximately 40 wild birds remain in the UK. These occur in a small number of apparently separate populations, some of which may already be functionally extinct where female birds have been eradicated. The areas with these remaining populations include lowland Scotland, Northern Ireland, lowland England, and north Wales. The main viable concentrations however are found in central and southern England.<br>In Belgium, small numbers of wild birds occur in Flanders, with the main concentration in the Antwerp area.<br>In the Netherlands, a population of around 50 wild birds occurs in the west of the country.<br>In France, a population of around 250 wild birds is found mainly in Brittany, with the main wintering site south of Nantes. | |

| | **RESPONSE [chose one entry, delete all others]** | **COMMENT** |
|---|---|---|
| 8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world? | YES | Ruddy Ducks are known to threaten the White-headed Duck *Oxyura leucocephala* with extinction through genetic introgression (*Green and Hughes, 1996; Hughes et al, 2006*). White-headed Ducks were formerly found throughout southern Europe, parts of North Africa and much of Central Asia. The European breeding population is now restricted to Spain, which is the only region in its range where the White-headed Duck has expanded its breeding range and population size in recent years. More than 186 Ruddy Ducks have been sighted in Spain since 1991 (*Torres, 2013)*, with the UK being the most likely source of most of these birds. Hybridisation between the two species is known to occur to the second and possibly third generation in the wild (*Green and Hughes, 1996*), thus increasing the risk to the White-headed Duck. A total of 69 hybrids have been culled in the wild in Spain as part of a national programme to prevent genetic introgression (*Torres, 2013*). |
| **Stage 2. Screening Questions** | | |
| 9. Has this risk assessment been requested by the GB Programme Board? (If uncertain check with the Non-native Species Secretariat) | YES | |
| 10. What is the reason for performing the risk assessment? | | |

| | RESPONSE [chose one entry, delete all others] | COMMENT |
|---|---|---|
| 11. Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems? | | |
| 12. Does the organism occur outside effective containment in GB? | | |
| 13. Is the organism widely distributed in GB? | | |
| 14. Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in GB, in the open, in protected conditions or both? | | |
| 15. Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)? | | |
| 16. Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in GB or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed. | | |
| 17. Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of GB or sufficiently similar for the organism to survive and thrive? | | |

| | RESPONSE [chose one entry, delete all others] | COMMENT |
|---|---|---|
| 18. Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in GB? | | |
| 19. Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities? | | |
| 20. Can the organism spread rapidly by natural means or by human assistance? | | |
| 21. Could the organism as such, or acting as a vector, cause economic, environmental or social harm in GB? | | |

**SECTION B – Detailed assessment**

| PROBABILITY OF ENTRY | | | |
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| Important instructions:<br>29. Entry is the introduction of an organism into European Union. Not to be confused with spread, the movement of an organism within the EU.<br>30. For organisms which are already present in the EU, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry. | | | |
| **QUESTION** | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| 1.1. How many active pathways are relevant to the potential entry of this organism?<br><br>(If there are no active pathways or potential future | FEW | HIGH | The main risk of entry is by means of escapes from collections of captive waterfowl – this was the original entry pathway which allowed the species to become established in the EU. Returns from a 1995 survey |

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| pathways respond N/A and move to the Establishment section) | | | conducted in 39 European countries (*Callahan et al, 1997)* reported a total of 741 birds. However it was estimated that the true number of Ruddy Ducks at that time was in excess of 3,300 and thought to be increasing. Observed levels for duckling production suggested that the captive population had a high capacity for growth, particularly in Belgium, The Netherlands, UK, France and Germany, which held the largest captive populations. There are significant gaps in more recent data. At least 50 and probably more Ruddy Ducks are still held in private waterfowl collections in the UK (*Baz Hughes, pers. comm.).* Ruddy Ducks also occur in waterfowl collections in a number of European countries but in most cases there is no obligation to register birds and no official estimates are available. Data from *Cranswick and Hall (2010)* state that there are probably over 100 in France and between 10 and 100 in Luxemburg but no data are available for other EU states. Given the estimated numbers in the UK, France and Luxemburg, it is likely that the number of captive Ruddy Ducks across the EU will still number 1,000 or more. There is a risk that further escapes (or releases) could either bolster the remaining feral population or allow re-establishment once the current feral population has been eradicated.<br><br>Ruddy Ducks can be kept and bred in captivity in many EU states including the UK, France, Belgium, Netherlands, Denmark, Germany and Italy. The trading of Ruddy Ducks is also legal in most EU states including the Netherlands, Belgium, Italy, the UK (under licence) and France (under licence). With only two exceptions (Hungary and Latvia), no member states monitor the status and distribution of captive Ruddy Ducks |

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| | | | (*Cranswick and Hall, 2010*).<br>Most (but not all) member states have legislation prohibiting escapes or releases (*Cranswick and Hall, 2010*) but because so few member states monitor the status and distribution of captive birds, such legislation may be difficult to enforce.<br>NB The original pathway of entry involved a series of escapes (and the deliberate release of three females) from a waterfowl collection in southern England. Breeding in the wild was first recorded in 1960 (*Hudson, 1976*) and this led to the establishment of a feral population which numbered c6,000 by the year 2000 (*Kershaw and Hughes, 2002*). This was subsequently greatly reduced by an eradication programme to a current population of approximately 40 individuals. |
| 1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.<br>For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary). | 1. Escape or release of captive birds already held in EU. | | |
| Pathway name: | ESCAPE OR RELEASE OF CAPTIVE BIRDS ALREADY HELD IN THE EU | | |

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| 1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?<br>(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11) | INTENTIONAL | MEDIUM | The species was intentionally imported from the US in the 1940s and is intentionally kept in a number of waterfowl collections. The original wild population in the UK derived from a number of birds which were deliberately not pinioned which effectively meant that they were intentionally released from captivity. A small number of birds were intentionally released directly into the wild when they were released at a local reservoir in order to augment the very small exiting breeding population (*Hudson, 1976*). This scenario could still occur in a number of member states given the numbers of captive birds still held. |
| 1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?<br>Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. | VERY LIKELY | MEDIUM | Although there is no official data on numbers of captive Ruddy Ducks in the EU, it seems likely that there could be over 1,000 held in waterfowl collections in the EU. There are probably more than 100 in France alone (*Cranswick and Hall, 2010*) with at least 50 in the UK (*Baz Hughes, pers. comm.*). A high proportion of keepers will be aware of the risks posed by the escape of this species but it remains possible that small numbers may escape into the wild and if these were of mixed sexes in the same area they would have the potential to establish a feral population. It is legal to keep Ruddy Ducks in captivity in many EU countries, and although some governments ban or restrict trade, it remains legal to trade Ruddy Ducks without a licence in at nine member states including Belgium, Italy and the Netherlands (*Cranswick and Hall, 2010*). |

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| 1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)?<br>Subnote: In your comment consider whether the organism could multiply along the pathway. | NOT APPLICABLE | NOT APPLICABLE | |
| 1.6. How likely is the organism to survive existing management practices during passage along the pathway? | NOT APPLICABLE | NOT APPLICABLE | |
| 1.7. How likely is the organism to enter EU undetected? | NOT APPLICABLE | NOT APPLICABLE | |
| 1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment? | NOT APPLICABLE | NOT APPLICABLE | |
| 1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host? | VERY LIKELY | HIGH | Ruddy Ducks are highly mobile and have shown that they can transfer quickly from captivity to suitable habitat in the wild (*Hudson, 1976* and *Hughes et al, 1999*). |
| 1.10. Estimate the overall likelihood of entry into the EU based on this pathway? | VERY LIKELY | MEDIUM | Escapes from captivity were the source of the feral population which became established in the UK in the 1960s (*Hudson, 1976)* and in France, Belgium and the Netherlands in the 1990s. Although less likely to occur now due to better management of captive birds and better education regarding the risks of release, it is still very likely that small numbers of mixed sexes could escape into the wild and form a feral population. |
| 1.11. Estimate the overall likelihood of entry into the EU based on all pathways (comment on the key issues that lead to this conclusion). | VERY LIKELY | HIGH | A feral population became established in the UK in the 1960s based on this pathway, and given the numbers of captive birds in collections in the EU, this could be repeated in a number of member states. |

| **PROBABILITY OF ESTABLISHMENT** | | | |
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| Important instructions:<br>31. For organisms which are already well established in EU, only complete questions 1.15 and 1.21 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat. | | | |
| **QUESTION** | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| 1.12. How likely is it that the organism will be able to establish in the EU based on the similarity between climatic conditions in the EU and the organism's current distribution? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.13. How likely is it that the organism will be able to establish in the EU based on the similarity between other abiotic conditions in the EU and the organism's current distribution? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in the EU?<br>Subnote: gardens are not considered protected conditions | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |

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| 1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the EU? | WIDESPREAD | HIGH | Ruddy Ducks can survive on a wide range of lowland waters, and breeding pairs have been noted in several member states (Sweden, Ireland, UK, France, Belgium, Germany, Spain and the Netherlands (*Cranswick and Hall, 2010*)). In their native range Ruddy Ducks breed in a number of biogeographic regions - the Andes from southern Chile up to Colombia, parts of Central America, Mexico, United States, Canada, and a number of Caribbean islands (*del Hoyo et al, 1992)*. Given this huge range in the Americas, it is likely that this will also be the case in Europe and also large parts of Asia. |
| 1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the EU? | NOT APPLICABLE | NOT APPLICABLE | |
| 1.17. How likely is it that establishment will occur despite competition from existing species in the EU? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the EU? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.19. How likely is the organism to establish despite existing management practices in the EU? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.20. How likely are management practices in the EU to facilitate establishment? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |

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| 1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the EU? | UNLIKELY | HIGH | The UK eradication programme has seen numbers fall from around 6,000 in 2000 to a current estimate of 40 (*Henderson, 2014)*, and the biological properties of the Ruddy Duck have proved no hindrance to progress. It is expected that more control work in 2014/15 will see the population reduced still further, and it is expected that functional eradication can be achieved by the end of 2015. |
| 1.22. How likely are the biological characteristics of the organism to facilitate its establishment? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.23. How likely is the capacity to spread of the organism to facilitate its establishment? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.24. How likely is the adaptability of the organism to facilitate its establishment? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population? | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in GB? (If possible, specify the instances in the comments box.) | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur?<br>Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species. | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |
| 1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box). | NOT APPLICABLE – ALREADY ESTABLISHED | NOT APPLICABLE | |

| PROBABILITY OF SPREAD | | | |
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| Important notes:<br>32. Spread is defined as the expansion of the geographical distribution of a pest within an area. | | | |
| **QUESTION** | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| 2.1. How important is the expected spread of this organism in the EU by natural means? (Please list and comment on the mechanisms for natural spread.) | MAJOR | HIGH | Ruddy Ducks already have established feral populations in the UK, Belgium, France and the Netherlands. The UK population has fallen by 99% since 2000 as the result of a national eradication programme (*Henderson, 2014*), while the populations in France, Belgium and the Netherlands have fluctuated, but without the long-term declines achieved in the UK (*Cranswick and Hall, 2010* and *Robertson et el, 2014)*. Note that current numbers in the UK are estimated to be approximately 40 birds, with around 250 in France, 50 in the Netherlands and 12-15 in Belgium.<br>Experience has shown that Ruddy Ducks are capable of spreading throughout the EU by natural means. Initial establishment occurred in SW England in the 1960s (*Hudson, 1976*). This was followed by a rapid spread through suitable habitat in the rest of England, Wales and Scotland between the mid-1970s and the late 1990s (*Kershaw and Hughes, 2002*). Breeding populations were established in The Netherlands and France by the mid-1990s, presumably by birds migrating from the UK (*Cranswick and Hall*, *2010*) and it is known that feral Ruddy Ducks in Europe are highly mobile and capable of covering long distances in order to establish a breeding population e.g. migration to and from |

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| | | | Iceland (*Green and Hughes*, *1996* and *Muñoz-Fuentes et al, 2006*) and the close correlation between the rise and fall of the UK population and numbers being seen annually in Spain over the same period (*Henderson, 2009*, *Cranswick and Hall, 2010* and *Munoz-Fuentes et al,* |
| 2.2. How important is the expected spread of this organism in the EU by human assistance? (Please list and comment on the mechanisms for human-assisted spread.) | MINIMAL | HIGH | Once established, spread is usually by natural means, although in theory it would be possible for birds to be deliberately relocated to new areas. In addition, it remains legal to trade Ruddy Ducks without a licence in nine member states (*Cranswick and Hall, 2010*), which could potentially assist the spread of the species. |
| 2.3. Within the EU, how difficult would it be to contain the organism? | WITH SOME DIFFICULTY | HIGH | This would depend on the numbers involved and their locations. Research and experience gained from the eradication programme in the UK have shown that it is possible to significantly reduce numbers even when the population is large and widespread (*Henderson, 2009* and *Austin et al, 2014)*, but this entails significant investment in terms of time and money. In France numbers have been contained and reduced more slowly due to access difficulties surrounding the main wintering site at Lac de Grand-Lieu (*Alain Caizergues, pers. comm.*). |

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| 2.4. Based on the answers to questions on the potential for establishment and spread in the EU, define the area endangered by the organism. | MOST LOWLAND AREAS OF THE EU | HIGH | In their native range Ruddy Ducks breed in a number of biogeographic regions - the Andes from southern Chile up to Colombia, parts of Central America, Mexico, United States, Canada, and a number of Caribbean islands (*Del Hoyo et al, 1992)*. Given this huge range in the Americas (and the spread of Ruddy Ducks in NW Europe to date), it is likely that this will also be the case in the EU and that Ruddy Ducks are probably capable of colonising almost every Member State. The past presence of Ruddy Ducks in Morocco (*Hughes et al, 2006)* suggests that Ruddy Ducks are also capable of colonising Africa. |
| 2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of the EU where the species could establish), if any, has already been colonised by the organism? | 0-10 | HIGH | At present the remnant population in the UK occupies a small number of isolated pockets in Scotland, Northern Ireland, north Wales, and central and southern England. Elsewhere in Europe, Ruddy Ducks are regularly present at a number of sites in the western Netherlands, pockets of Flanders, and parts of western France. However the widespread distribution of Ruddy Ducks in the UK before the eradication programme began showed that they can inhabit a wide range of water bodies, so it is likely that the habitat currently colonised represents only a very small proportion of the suitable habitat in the EU. |
| 2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)? | 0-10 | LOW | If control were to cease immediately in all EU states, Ruddy Ducks might be expected to extend into between 8% and 10% of suitable habitat in five years, but there is a large degree of uncertainty around these figures. |

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| 2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in the EU? (Please comment on why this timeframe is chosen.) | 20 | MEDIUM | Data from the original colonisation in the UK show that numbers and spread began to increase rapidly about 15 years after first breeding in the wild (*Hughes et al, 1999*). |
| 2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism? | 10-33 | MEDIUM | |
| 2.9. Estimate the overall potential for future spread for this organism in the EU (using the comment box to indicate any key issues). | VERY LIKELY | HIGH | Based on evidence of spread during the period 1960 – 2000 and assuming that control ceases immediately. |

| **PROBABILITY OF IMPACT** |
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| Important instructions:<br>33. When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.<br>34. Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).<br>35. Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in GB separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis. |

| QUESTION | RESPONSE | CONFIDENCE | COMMENTS |
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| 2.10. How great is the economic loss caused by the organism within its existing geographic range excluding the EU, including the cost of any current management? | MINIMAL | HIGH | Outside the EU, Ruddy Ducks currently cause minimal economic loss. The only non-EU state where control of the species has taken place is Morocco, which also has an indigenous White-headed Duck population (*Cranswick and Hall, 2010*). However this has not been necessary in recent years. |
| 2.11. How great is the economic cost of the organism currently in the EU excluding management costs (include any past costs in your response)? | MINIMAL | HIGH | There is no economic cost to the EU (excluding management costs) arising from the presence of Ruddy Ducks. |
| 2.12. How great is the economic cost of the organism likely to be in the future in the EU excluding management costs? | MINIMAL | HIGH | There is no economic cost to the EU (excluding management costs) arising from the presence of Ruddy Ducks. |
| 2.13. How great are the economic costs associated with managing this organism currently in the EU (include any past costs in your response)? | MAJOR | VERY HIGH | Direct management costs to date in the UK have been a minimum of £6M (€7.2M). In Spain, management costs since 2000 are probably in the region of €0.6M (*Mario Saenz de Buruaga, pers. comm*.). Management costs for France are not available, but are estimated to lie somewhere between the costs of management in Spain and the costs of management in the UK. Thus total management costs for the EU (current and past costs) are likely to be in the region of €10-12M. |
| 2.14. How great are the economic costs associated with managing this organism likely to be in the future in the EU? | MODERATE | HIGH | Five Member States have ongoing costs in the management of Ruddy Ducks – the UK, France, Netherlands (preparatory work only to date), Belgium and Spain. These are estimated to be in the region of £500,000 (€600,000) annually. |

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| 2.15. How important is environmental harm caused by the organism within its existing geographic range excluding the EU? | MASSIVE (likely global extinction in the wild of White-headed Duck if no action taken) | VERY HIGH | Besides the population of Ruddy Ducks in the EU, they have occurred in small numbers in the past in Morocco, where there is a population of the indigenous White-headed Duck which is at risk from hybridisation. Hybridisation is known to have occurred in Morocco in a number of years between 1999 and 2006 (*Hughes et al, 2006*) which means that there is a risk that this population of the White-headed Duck will become extinct through genetic introgression. Ruddy Ducks have also been recorded occasionally in other White-headed Duck range states outside the EU including Algeria, Israel (*Hughes et al, 2006*) and Turkey (*Cranswick and Hall, 2010*) and the White-headed Duck populations in these countries would be threatened if increasing numbers of Ruddy Ducks appeared. |

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| 2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) currently in the EU (include any past impact in your response)? | MINOR | VERY HIGH | In 1982 Ruddy Ducks were first recorded in Spain (*Cranswick and Hall, 2010*) and hybridisation with the White-headed Duck was first recorded in 1991 (*Hughes et al, 1999)*. It is likely that these Ruddy Ducks arriving in Spain originated from the GB population which was rapidly expanding in size and range at that time (*Cranswick and Hall, 2010)*. A minimum of 186 Ruddy Ducks have been recorded in at least 19 provinces in Spain since 1991 (*Torres, 2013* and *Carlos Gutierrez pers. comm.*). In captivity, Ruddy Duck x White-headed Duck hybrids are fertile to at least the third generation, and a total of 69 hybrids have been recorded in seven provinces in Spain since 1991 (*Torres, 2013* and *Carlos Gutierrez, per. comm*). However, to date this control programme in Spain has been effective in preventing any extensive introgression of Ruddy Duck genes into the Spanish White-headed Duck population (*Muñoz-Fuentes et al, 2007).* |
| 2.17. How important is the impact of the organism on biodiversity likely to be in the future in the EU? | MASSIVE (likely extinction in the wild of White-headed Duck in EU if no action taken) | HIGH | If Ruddy Duck numbers are allowed to increase and their range is allowed to spread southwards to the main breeding grounds of the White-headed Duck in Spain, the likely outcome is the extinction of the White-headed Duck through genetic introgression. Hybridisation with the Ruddy Duck is now the most significant threat to the survival of the White-headed Duck (*Hughes et al, 2006*). If allowed to proceed unchecked, hybridisation between Ruddy Ducks and White-headed Ducks would be likely to lead to the extinction of the White-headed Duck through genetic introgression (*Green and Hughes, 1996*). This would occur not only in the Spanish population of White-headed Ducks. If Ruddy Ducks continued to spread east |

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| | | | it would also lead to the extinction of the other White-headed Duck populations in eastern Europe and central Asia. Precedents exist elsewhere which demonstrate the potential threat e.g. the widespread hybridisation of the introduced Mallard *Anas platyrhynchos* and the native Grey Duck *Anas s. superciliosa* in New Zealand. By the early 1990s only an estimated 15-20% of the total *A. platyrhynchos/A. superciliosa superciliosa* population in New Zealand consisted of pure *A. superciliosa superciliosa* genotypes compared to an estimated 95% in 1960 (*Green, 1992, cited in Hughes et al., 1999*). *A. platyrhynchos* is now the dominant waterbird in the wetlands of the agricultural environment of New Zealand (*Gillespie 1985, cited in Hughes et al., 1999*). *A. platyrhynchos* also threatens a number of other species/subspecies with extinction through hybridisation, including *Anas undulata* in South Africa, *Anas melleri* in Madagascar and *Anas rubripes* and *A. platyrhynchos wyvilliana* in North America (*Browne et al., 1993, cited in Hughes, 1996; and Rhymer, 2006)*. |
| 2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism currently in the EU (include any past impact in your response)? | MINIMAL | HIGH | Impacts in the UK during the period 1960 (establishment) to 2000 (peak population) and up to the present day appear to be negligible. It is assumed that the alteration of ecosystem function in other Member States would also be minimal. |
| 2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism likely to be in the EU in the future? | MINIMAL | HIGH | Based on the above, future impact within the EU also seems likely to be negligible. |

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| 2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism currently in the EU? | MINIMAL | HIGH | Ruddy Ducks currently have no significant impact on conservation status in the EU because their numbers are being controlled, but significant declines could occur in the future (see 2.21). |
| 2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the future in the EU? | MODERATE | HIGH | If Ruddy Duck numbers in the EU were to increase and hybridisation were to become more extensive this would lead to the loss of the White-headed Duck and a decline in the value of a number of SPAs (such as El Hondo and Albuferas de Adrá) where the presence of the White-headed Duck is one of the reasons for the site being designated an SPA. |
| 2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious? | MASSIVE | VERY HIGH | Ruddy Ducks are known to hybridise readily with White-headed Ducks both in the wild and in captivity. Hybrid offspring are fertile to at least the second generation in the wild (*Urdiales and Pereira, 1993*) and possibly to the third generation, thus increasing the risk to the genetic integrity of the White-headed Duck. Precedents from elsewhere (see Section 2.17) show that such genetic introgression is likely to lead to the extinction of the White-headed Duck, which would be replaced by a hybrid swarm. |
| 2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range? | MINIMAL | VERY HIGH | Ruddy Ducks are not known to cause any social harm, harm to health, or other harm beyond the threat posed to the White-headed Duck. |
| 2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)? | MINIMAL | HIGH | As far as is known the Ruddy Duck is not an important food species for any predator in the EU, nor is it a host, symbiont or vector for any other damaging organisms. |

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| 2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box) | NOT APPLICABLE | NOT APPLICABLE | No other impacts known or suspected. |
| 2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the EU? | MASSIVE | HIGH | |
| 2.27. Indicate any parts of the EU where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible). | NOT APPLICABLE | NOT APPLICABLE | |

| **RISK SUMMARIES** | | | |
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| | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| Summarise Entry | VERY LIKELY | HIGH | The most likely pathway is escapes from captivity. |
| Summarise Establishment | VERY LIKELY | HIGH | If both sexes of Ruddy Ducks were to escape from captivity in the same location, it is highly likely that they could become established in the wild. This has already occurred with the founding of the original feral population in south-west England around 1960. |

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| Summarise Spread | MODERATELY RAPIDLY | HIGH | Records from the period 1960 to 2000 showed that Ruddy Ducks are capable of spreading across large areas (*Cranswick and Hall, 2010*). In 1960 the population was restricted to a small area of south-western England and numbered around 20 birds. By 2000 the species had colonised most suitable habitat in the UK and had colonised parts of Iceland, Scandinavia, Ireland, the Netherland, and France, and numbered over 6,000. At least 186 Ruddy Ducks have been observed in Spain since 1984, with a peak of 27 in 1997 (*Torres, 2013* and *Carlos Gutierrez, pers. comm.*). It is likely that Ruddy Ducks would also have become established in Spain were it not for the control programme which resulted in the culling of almost all of these birds. |
| Summarise Impact | MASSIVE | HIGH | Threatens White-headed Duck with extinction if allowed to spread from its existing range in the UK, France, the Netherlands and Belgium, leading to Ruddy Ducks colonising large areas of western Europe followed by habitat in north Africa, eastern Europe and central Asia. If Ruddy Ducks were allowed to become widely established in other countries, their eradication would become impossible and it is likely that the White-headed Duck would become extinct through genetic introgression.<br>Besides the risk of spread from existing populations, there is also a risk that the escape or release of captive birds will result in the establishment of another feral population even if the current one is eradicated. |
| Conclusion of the risk assessment | HIGH | HIGH | |

| ADDITIONAL QUESTIONS - CLIMATE CHANGE | | | |
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| 3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism? | NONE – Ruddy Ducks are adapted to a wide range of climates within their native range and in Europe are known to have bred as far north as Iceland and as far south as France. In addition, hybridisation with White-headed Ducks is known to have occurred in Spain and Morocco, so it is assumed that Ruddy Ducks are also capable | HIGH | |

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| | of breeding further south. | | |
| 3.2. What is the likely timeframe for such changes? | NOT APPLICABLE | NOT APPLICABLE | |
| 3.3. What aspects of the risk assessment are most likely to change as a result of climate change? | NOT APPLICABLE | NOT APPLICABLE | |
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| **ADDITIONAL QUESTIONS – RESEARCH** | | | |
| 4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here. | YES – SEE COMMENTS BOX | HIGH | McCRACKEN, K G, HARSHMAN, J, SORENSEN, M D, and JOHNSON, K P (2000). Are Ruddy Ducks and White-headed Ducks the same species? *British Birds, Volume 93, pp396-398* (Confirms Ruddy Ducks and White-headed Ducks are separate species, having developed separately for between 2M and 5M years).<br>MUÑOZ-FUENTES, V, GREEN, A J, NEGRO J J (2013). Genetic studies facilitated management decisions on the invasion of the ruddy duck in Europe. Biological Invasions, Vol. 15, Issue 4, pp723-728. (Confirms Ruddy Ducks in Europe are the result of escapes from captivity). |

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# Annex 8. Risk Assessment for *Sciurus carolinensis* (Grey Squirrel)

| EUROPE NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME |
|---|
| Name of organism: *Sciurus carolinensis*<br>Author: Sandro Bertolino, Adriano Martinoli, Lucas Wauters; reviewed by John Gurnell and Peter Lurz (Great Britain)<br>Risk Assessment Area: European Union (28 Countries)<br>Draft: Draft 1 (*30/06/2014*) |

| EU CHAPPEAU | |
|---|---|
| **QUESTION** | **RESPONSE** |
| 1. In how many EU member states has this species been recorded? List them. | Great Britain, Ireland, Italy |
| 2. In how many EU member states has this species currently established populations? List them. | Great Britain, Ireland, Italy |
| 3. In how many EU member states has this species shown signs of invasiveness? List them. | Great Britain, Ireland, Italy |
| 4. In which EU Biogeographic areas could this species establish? | The suitability was evaluated with a comparison of the biogeographical regions with the European projections of the grey squirrel's climatic niche (Di Febbraro et al. 2013, see map below).<br>High climatic suitability (0.6-1.0): Atlantic, Black Sea, Continental (Western Part), Macaronesia (Azores), Mediterranean (excluding part of Spain)<br>Medium climatic suitability (0.4-0.6): Alpine (Eastern Alps), Continental (Eastern Part), Pannonian, Macaronesia (Canary Islands)<br>Low climatic suitability (<0.4): Alpine (Western Alps), Anatolian, Arctic, Boreal |
| 5. In how many EU Member States could this species establish in the | Based on simulation of the grey squirrel's climatic niche in Maxent suitability is: |

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| future [given current climate] (including those where it is already established)? List them. | High (suitability > 0.6) in United Kingdom, Ireland, Portugal, Spain, France, Italy, Netherlands, Belgium, Luxembourg, Germany, Austria, Czech Republic, Slovenia, Croatia, Denmark, Bulgaria, Hungary, Romania, Greece, Cyprus.<br>Lower (suitability < 0.6) in Sweden, Finland, Lithuania, Latvia, Estonia, Slovakia, Poland, Malta, |
| 6. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)? | The species could become invasive in most of Europe, if established (see question 5), mainly for the possibility to replace the native red squirrel that is the only native tree squirrel present in Europe. The confidence of this prediction is higher in parts of Europe where mixed broadleaves forests are dominant and lower for areas where conifers are dominant. |

| **SECTION A – Organism Information and Screening** | | |
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| **Stage 1. Organism Information** | **RESPONSE** | **COMMENT** |
| 1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank? | *Sciurus carolinensis* Gmelin, 1788.<br>EN: grey squirrel; FR: Écureuil gris; IT: Scoiattolo grigio; D: Grauhörnchen | Yes, this species can be adequately distinguished from other entities of the same genus. |
| 2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on) | NA | |

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| 3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment) | No | No risk assessment has been carried out for the whole of Europe. A Risk Assessment has been conducted in Belgium and the result was that the species has high potential of establishment and dispersal in that country. For these reasons the species was included in the Black list (Score 11) and in the Alert list (AO) for its potential high environmental hazard. In Italy, the Grey squirrel Pest Risk Assessment has been produced following three different European procedures. With the Belgian system (Invasive Species Environmental Impact Assessment) the final list score was: A2 (black list). Using the Quickscan Risk Assessment method, according to a report for the Commission for Invasive exotic species (COIE) of the Netherlands Ministery of Agriculture, Nature and Food quality, the final evaluation was that this organism could present a risk to the Risk Assessment area (Italy). With the UK non-native organism risk assessment scheme version 3.3 the final evaluation was: risk of entry: 4 (very likely), risk of establishment: 4 (very likely), risk of spread: 2 (intermediate), impacts 3 (major). |
| 4. If there is an earlier risk assessment is it still entirely valid, or only partly valid? | No | They only consider single countries. |
| 5. Where is the organism native? | | North America |

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| 6. What is the global distribution of the organism (excluding Europe)? | | The species is native to North America where it is distributed from the Gulf of Mexico, the Eastern United States to the southern part of Quebec and Ontario (Koprowski 1994).<br>Grey squirrels have been introduced to many localities of North America (USA and Canada), Australia (2 areas extinct, 1 area eradicated), and South Africa (Long 2003; Wood et al. 2007; Bertolino 2009; Peacock 2009). |
| 7. What is the distribution of the organism in Europe? | | Expanding grey squirrel populations are present in Great Britain, Ireland and Italy (O'Teangana et al. 2000; Gurnell et al. 2008b; Martinoli et al. 2010) |
| 8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world? | Yes | Grey squirrels have been introduced and established population in many localities of North America (USA and Canada), South Africa (Long 2003; Bertolino 2009) and Europe (UK, Ireland, Italy). Already reported in the IUCN list of 100 worst invasive species (Lowe et al. 2000).<br>The grey squirrel is impacting biodiversity and commercial forestry in Great Britain through bark stripping (Kenward & Parish 1986; Kenward et al. 1992; Mayle et al. 2003; Gurnell et al. 2008). Bark stripping increases the risk of fungal infections and invertebrate damage, which can reduce timber yield (Mayle 2010). Tree species, age and time of year influence the risk of squirrel damage (Mayle et al. 2008). Beech (*Fagus sylvatica*) and sycamore (*Acer pseudoplatanus*) are at the greatest risk of damage but any thin-barked tree species between 10 and 40 years old is at risk e.g. |

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| | | oak (*Quercus* spp.), sweet chestnut (*Castanea sativa*), larch (*Larix* spp.) and Norway spruce (*Picea abies*) (Mayle, 2004; Mayle & Broome 2013).<br>Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types. Grey squirrels predate eggs and fledgling of birds; at present there is little evidence of any national population declines in woodland bird species as a result of this predation, but further research is needed to exclude impacts for specific species and habitats (Amar et al., 2006; Newson et al., 2010). |
| 9. Describe any known socio-economic benefits of the organism in the risk assessment area. | None known | |
| Stage 2. Screening Questions | | |
| 10. Has this risk assessment been requested by the a Programme Board? (If uncertain check with the Non-native Species Secretariat) | NA | |
| 11. What is the reason for performing the risk assessment? | Identification of invasive alien species of EU concern | |

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| 12. Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems? | | Tree squirrels are highly adaptive and opportunistic species and viable populations could establish from few founders. The likelihood ratio for a couple of *Sciurus* spp. (*S. aberti*, *S. aureogaster*, *S. carolinensis*, *S. niger* the introduced species considered) to successfully establish a viable population is 57% and a likelihood ratio of 90% is achieved with >14 animals (Bertolino 2009). Females can have 2 litters/year with 2-5 weaned young; varying percentage of adult females reproduce in a given season, depending on food quality and quantity. Dispersal capacity is high, juveniles can move easily between 1 and 3 (5) km from the natal site (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001).<br>The species lives in deciduous, mixed and coniferous woodland habitats feeding on tree seeds and a variety of other foods (tree flowers, buds, mushrooms, berries, occasionally insects and bird eggs/young; they may sometimes feed on cereals (e.g. maize). The species is commonly found in suburban areas where it benefits from supplemental feeding (Bonnington et al.2013, 2014). |
| 13. Does the organism occur outside effective containment in Europe? | Yes | |

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| 14. Is the organism widely distributed in Europe? | Yes | Grey squirrel populations are present in Great Britain (see map in Gurnell et al. 2008b), Ireland (O'Teangana et al. 2000) and Italy (Martinoli et al. 2010) |
| 15. Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in Europe, in the open, in protected conditions or both? | Yes | The species is found in deciduous and mixed forest, farmland with small scattered woodland cover and in urban parks (open); it is also present in zoological gardens and as a pet in private houses and parks (protected conditions). |
| 16. Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)? | No | |
| 17. Is the other critical species identified in question 15 (or a similar species that may provide a similar function) present in Europe or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed. | NA | |
| 18. Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of Europe or sufficiently similar for the organism to survive and thrive? | Yes | Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013). The species is found in eco-temperate climatic zones (Gurnell 1987; Bertolino 2008); in the natural range from north to south, there are very large changes in weather (Koprowski 1994) indicating adaptability to different climatic condition. The adaptability of the species is also confirmed by a shift in its climatic niche in Europe (Di Febbraro et al. 2013). |

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| 19. Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe? | Yes | The species is present in zoological gardens and private collections; therefore, there are risks for accidental or voluntary releases. |
| 20. Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities? | Yes | The species has been introduced to many localities of North America, Australia (extinct or eradicated), South Africa, Great Britain, Ireland and Italy (Long 2003; Bertolino2009). In Europe, the grey squirrel was introduced to Great Britain on more than 30 occasions from 1876 until 1929 (Middleton1932; Shorten 1954; Gurnell 1987) and to Ireland in 1913 (O'Teangana et al. 2000). At least 20 separate introductions took place in Italy (Bertolino 2009; Martinoli et al.2010). Presently, the range of introduced grey squirrel populations covers most of England and Wales, part of Scotland, the eastern part of Ireland, as well as many areas in Northwestern Italy and a location in central Italy (Wauters et al.1997; O'Teangana et al. 2000; Bertolino 2008; Gurnell et al. 2008b; Martinoli et al. 2010) |
| 21. Can the organism spread rapidly by natural means or by human assistance? | Yes | High natural dispersal capacity (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001; Bertolino et al. 2008). Humans can further promote the spread of the species with translocation from one area to another (Shorten 1954; Martinoli et al. 2010; Signorile et al. 2014a,b) |
| 22. Could the organism as such, or acting as a vector, cause economic, environmental or social harm in Europe? | Yes | The grey squirrel is replacing the native red squirrel (*Sciurus vulgaris*) in Great Britain (Gurnell & Pepper 1993; Gurnell et al. 2008a,b), Ireland (O'Teangana et al. 2000) and Italy (Martinoli et al. |

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| | | 2010; Bertolino et al. 2014), through resource competion (Wauters et al. 2002a,b; Gurnell et al. 2004); in Great Britain and Ireland the replacement is also disease-mediated, as the species act as a reservoir host to a squirrel poxvirus that causes high mortality in red squirrels (Sainsbury et al. 2000; Tompkins et al. 2002; Rushton et al. 2006).<br><br>The species is impacting biodiversity and commercial forestry in Great Britain through bark stripping (Mayle et al. 2003; Gurnell et al. 2008; Mayle & Broome 2013). Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005) with an influence on the flora and fauna associated with specific woodland types. Squirrels predate eggs and fledgling of birds; further studies are required on whether they contribute to the decline of particular woodland bird species (Amar et al., 2006; Newson et al., 2010).<br><br>Economic impact of bark stripping damage in Great Britain. Total costs for grey squirrel management in UK forests (damage + control) is estimated at GBP 6,097,320 (Williams et al. 2010) - GBP 10 million (Anon. 2006; Mayle & Broome 2013) annually. Damage done by grey squirrels to property (damage to furniture, ornaments, cables) is estimated to be GBP 5,128,274; while the cost of removing squirrels in buildings and other infrastructure is estimated in GBP 1,914,555 (total |

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| | | damage + control GBP 7,042,829) (Williams et al. 2010). Projected annual costs for grey squirrel management in Irish (Ireland and Northern Ireland) forests is € 856,141; the cost to the agricultural sectors is € 4,580,818 and for building protection is € 988,978 (Kelly et al. 2013). In Italy limited damage to maize crops and poplar plantations are recorded (Currado 1993; Currado et al. 1997; Signorile and Evans 2007), but costs are not estimated. The species is also reported to be a garden pest by digging up bulbs and eating fruits and the bark of ornamental plants, and can damage properties, chewing timber, wires and stored goods.<br>Social conflict expected on eradication programmes that will be inacceptable for extreme animal-rights groups (Bertolino et al. 2003; Anon. 2013); however, on this aspect see the position paper of the Eurogroup for Animals (July 2013, EU Strategy on Invasive Alien Species), a leading voice for animal welfare at European Union level, which recognise that in some cases it may be more humane and have less negative impact on animal welfare to utilise a rapid lethal method than longer term controls impacting larger number of animals. |

| **SECTION B – Detailed assessment** | | | |
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| **PROBABILITY OF ENTRY** | | | |
| Important instructions:<br>36. Entry is the introduction of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe.<br>37. For organisms which are already present in Europe, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry. | | | |
| **QUESTION** | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| 1.1. How many active pathways are relevant to the potential entry of this organism?<br>(If there are no active pathways or potential future pathways respond N/A and move to the Establishment section) | few | very high | The species is already present in the Risk Assessment area with viable and spreading populations in three countries.<br>The pathway for new introduction is escapes from pet owners, deliberate release from pet owners, deliberate introductions. |
| 1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.<br>For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary). | [Pet-trade] | | The primary pathway for entry involves their escape or deliberate release from captivity (see as an example of squirrel's pathway the video on YouTube regarding an illegal release of a chipmunk, *Tamias* sp. (http://www.youtube.com/watch?v=p_Ee4Bvk-eU). The origin of the pathway is considered to be the keeping of the animals in captivity but also deliberate introductions in parks and woods. Likelihood of association is considered to remain high as long as the species continues to be kept in captivity and sold by pet shops (Bertolino 2009). Natural populations could be the source of animals for an illegal trade of the species (Signorile et al. 2014b). |
| Pathway name: | [Pet-Trade] | | |

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| 1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?<br>(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11) | intentional | very high | The species is intentionally imported and traded in many European countries (UNEP-WCMC 2010). The animals may then be released or escape. |
| 1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?<br>Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place. | moderately likely | medium | Trade statistics are not available. An internet survey conducted in May 2010, in order to investigate whether the species appears to be traded within the EU, and whether there appears to be demand for this species as a pet, found adverts for the sale of grey squirrels on Austrian, Danish, French, Great Britain, Italian, and Spanish websites; there were several advertisements for people wanting 'squirrels' in French, British, Italian, and Spanish websites (UNEP-WCMC 2010). |
| 1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host? | very likely | high | Natural populations can establish from few founders and grow quickly (Shorten 1954; Bertolino 2009; Wood et al. 2007;Signorile et al. 2014a). The species is often released in urban parks, suburban gardens, parkland, etc., which could provide suitable habitats with supplemental feeding from humans (Bonnington etb al. 2013, 2014), and from here spread to forested habitats (deciduous, mixed and coniferous woodland) (Bertolino et al. 2014). |
| 1.10. Estimate the overall likelihood of entry into Europe based on this pathway? | likely | high | The species is already present in three countries and is traded in many others. |
| *End of pathway assessment, repeat as necessary.* | | | |

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| 1.11. Estimate the overall likelihood of entry into Europe based on all pathways (comment on the key issues that lead to this conclusion). | likely | high | The principal pathway for entry is escape or release from captivity. The origin of the pathway is considered to be the keeping of the animals in captivity but also deliberate introductions in parks and woods. Likelihood of association is considered to remain high as long as the species continues to be kept in captivity and sold by pet shops (Bertolino 2009). Natural populations could be the source of animals for an illegal trade of the species (Signorile et al. 2014b).<br>The importation of the grey squirrel was suspended in the European Union in year 2012 by including it in a list of species whose introduction in Europe is suspended on the basis of the evidence that they constitute an ecological threat to biodiversity. This list is an implementation of the CITES Regulation and is directly applicable in all Member States. This, however, does not stop the movements of animals within Europe where the species is already bred and sold in many countries (UNEP-WCMC 2010). In Italy the limitation is now even more stringent. A Decree signed on 24th December 2013 by the Ministers of the Environment, Agriculture and Economic Development and published on 2nd February 2014 forbids trading, raising and keeping of grey squirrels and two other squirrel species (*Sciurus niger*, *Callosciurus erythraeus*). In UK, under the Wildlife and Countryside Act (1981) it is illegal to release non-indigenous animals into the wild, so any grey squirrels caught should be killed. |

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| **PROBABILITY OF ESTABLISHMENT** |

| Important instructions:<br>38. For organisms which are already well established in Europe, only complete questions 1.15 and 1.21 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat. For Europe mainland, grey squirrel is established only in Italy, while other populations are on islands (Great Britain, Ireland); therefore all questions were completed | | | |
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| QUESTION | RESPONSE | CONFIDENCE | COMMENT |
| 1.12. How likely is it that the organism will be able to establish in Europe based on the similarity between climatic conditions in Europe and the organism's current distribution? | very likely | very high | The species already established in Great Britain, Ireland and Italy (Bertolino 2009); only Italy is part of mainland Europe.<br>According to statistical prediction models that simulate the possible expansion of the grey squirrel from Italy, in the medium term the grey squirrel will be able to colonize the Alps, the Apennines and the bordering countries of France and Switzerland in next decades (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). These studies support the presence of suitable habitats in these areas.<br>A recent study also supports the hypothesis of a shift in the grey squirrel's climatic niche in the area of introductions. Climatic conditions in most of Europe were considered suitable for grey squirrels (Di Febbraro et al. 2013). |

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| 1.13. How likely is it that the organism will be able to establish in Europe based on the similarity between other abiotic conditions in Europe and the organism's current distribution? | very likely | very high | Temperate forests and woodlands in Europe have many tree species that are similar (same genus) than in the native area of grey squirrels and thus produce food resources similar in quantity and quality; (sub)urban park populations occur both in Europe and N. America. Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013). |
| 1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe?<br>Subnote: gardens are not considered protected conditions | very likely | very high | The species is already keeps in wildlife parks, zoological gardens, private collections and pet shops. |
| 1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Europe? | widespread | very high | The species lives in deciduous, mixed and coniferous woodland habitats, feeding on nuts, seeds, tree flowers, buds, mushrooms, berries, caterpillars, rarely on insects and bird eggs/young and sometimes on cereals (maize). The species is also regularly found in parks and towns. Therefore no single species is "vital" for its survival, development and multiplication. Suitable habitats are present and widely distributed in the Risk Assessment Area. |
| 1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in GB? | NA | | |

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| 1.17. How likely is it that establishment will occur despite competition from existing species in Europe? | very likely | very high | Outcome of competition with the only native tree squirrel species (red squirrel, *Sciurus vulgaris*) is in favour of the alien species (Gurnell & Pepper 1993; Kenward & Holm 1993; Wauters et al. 2001, 2002a, b; Gurnell et al. 2004) |
| 1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in Europe? | very likely | high | A range of potential predators exist in Europe, these include raptors, red fox (*Vulpes vulpes*), stone and pine marten (*Martes* spp.), feral and domestic cats, and potentially owls. This suite of predators has not prevented the establishment, nor the spread of the animals. Feral/domestic cats may have an impact in some urban areas (Bertolino & Genovesi 2005). Pine marten (*Martes martes*) seems to have an impact in some parts of Ireland (Sheehy et al. 2014). |

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| 1.19. How likely is the organism to establish despite existing management practices in Europe? | likely | high | A national bounty scheme in the Great Britain between 1953 and 1958 did not reduce numbers or geographic range of the grey squirrel, or damage to trees, and was stopped (Shorten 1957; Thompson & Peace 1962; Sheail 1999). Subsequent control actions in Great Britain, Ireland and Italy show that high removal rates are necessary to obtain success and that numbers return quickly to pre-control levels once killing is stopped (Lawton & Rochford 2007). The management of the grey squirrel in Italy aims to stop the spread of the species to other countries. Though successful, these management actions would stop the spread of established populations, but not the risk for Europe. The main pathway of entry is the pet trade and the risk of new introductions in other European countries continues to be present. |
| 1.20. How likely are management practices in Europe to facilitate establishment? | NA | | |
| 1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in Europe? | likely | medium | So far no eradication campaigns have been started, but control actions in the Great Britain, Ireland and Italy show that high removal rates are necessary to obtain success and that numbers return quickly to pre-control levels once killing is stopped (Lawton & Rochford 2007). Once established, grey squirrels are difficult if not impossible (with large populations) to eradicate though some success can be achieved at a local level with a high control effort (Schuchert et al. 2014) |

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| 1.22. How likely are the biological characteristics of the organism to facilitate its establishment? | very likely | very high | Can have 2 litters/year with 2-5 weaned young; varying percentage of adult females reproduce in a given season (Gurnell 1987; Koprowki 1994). The animals are attractive to humans that feed populations in urban parks or nearby. This could help small populations to overcome the first phase when extinction is possible. |
| 1.23. How likely is the capacity to spread of the organism to facilitate its establishment? | very likely | very high | Dispersal capacity high, juveniles can move easily between 1 and 3 (5) km from the natal site (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001) |
| 1.24. How likely is the adaptability of the organism to facilitate its establishment? | very likely | very high | The species could adapt to urban, suburban and more natural area, occurring in a variety of woodland habitat types |
| 1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population? | very likely | very high | Grey squirrels have proven to be very successful invaders able to start new populations and spread even from few founders with low genetic diversity (Wood et al., 2007; Bertolino 2009; Signorile et al. 2014 a,b). |
| 1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Europe? (If possible, specify the instances in the comments box.) | very likely | very high | 59 out of 74 (79.7%) introductions outside the native range in US, Canada, Europe, Australia, South Africa, were successful (Bertolino 2009). The species already established in North (Great Britain and Ireland) and South (Italy) Europe, showing its ability to adapt to European habitats |

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| 1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur?<br>Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species. | unlikely | medium | If the species does not establish, as in an urban park in Rome in the 1980s (Bertolino & Genovesi 2005), and in some areas in Great Britain (Shorten 1954) and in Australia (Long 2003), then it is probable that the introduced animals will disappear. However, the risk of new introductions will continue to remain. |
| 1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box). | likely | high | The species already established in North (Great Britain and Ireland) and South (Italy) Europe. Climatic conditions in most of Europe are considered suitable for grey squirrels (Di Febbraro et al. 2013). The species is found in eco-temperate climatic zones (Bertolino 2008, 2009); in the natural range from north to south (Koprowski 1994), there are very large changes in weather to indicate a certain adaptability of the species. The species could adapt to urban, suburban and more natural area, occurring in a variety of woodland habitat types. Grey squirrels have proven to be very successful invaders able to start new populations world-wide even from few founders with low genetic diversity (Wood et al., 2007; Bertolino 2009; Signorile et al. 2014 a,b). Humans could help the spreading feeding the animals or translocating them to new areas. It must be underlined that both Ireland and Great Britain are islands and the main risk to the rest of Europe comes from pet trade and range expansion form Italy. Grey squirrels in Italy should therefore be a priority in terms of action. |

| **PROBABILITY OF SPREAD** | | | |
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| Important notes:<br>39. Spread is defined as the expansion of the geographical distribution of a pest within an area. | | | |
| **QUESTION** | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| 2.1. How important is the expected spread of this organism in Europe by natural means? (Please list and comment on the mechanisms for natural spread.) | high | high | Active saturation dispersal, mainly of immature individuals, which will colonize new areas of suitable habitat. Information on the spread of the species are reported by Okubo et al. (1989) for England, by O'Teangana et al. (2000) for Ireland and Bertolino et al. (2014) for Italy. |
| 2.2. How important is the expected spread of this organism in Europe by human assistance? (Please list and comment on the mechanisms for human-assisted spread.) | major | high | Squirrels are often released in or near urban areas such as parks, where they could benefit from supplementary feeding by humans. This could increase survival and help to overcome first periods with very low density.<br>All 32 introductions in UK and Ireland were human mediated; at least 11 were translocations from other populations already established. (Shorten 1954). The same probably happened in north Italy (Martinoli et al. 2010) and was documented for central Italy (Signorile et al. 2014b). |

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| 2.3. Within Europe, how difficult would it be to contain the organism? | difficult | medium | Likelihood is that it could be 'contained' where it doesn't spread over large areas, partly because of seasonally high trappability, and partly because of easy recognition of the species in new areas. However, practical difficulties likely to arise because of diverse landownership patterns likely to be encountered in typical release/escape areas and because of potential public opposition to control/eradication (Barr et al. 2002; Rushton et al. 2002; Anon. 2013). |
| 2.4. Based on the answers to questions on the potential for establishment and spread in Europe, define the area endangered by the organism. | [Most of Europe] | high | See bioclimatic model for the species in Di Febbraro et al. (2013) and questions 4 and 5 of EU CHAPPEAU |
| 2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of Europe were the species could establish), if any, has already been colonised by the organism? | 10-33 | high | See distribution maps in Bertolino (2008) and bioclimatic model for the species in Di Febbraro et al. (2013). |
| 2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)? | 0-10 | high | Expansion of the colonies in North and Central Italy, Ireland and Scotland. |

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| 2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in Europe? (Please comment on why this timeframe is chosen.) | 10 | medium | In 2010 Italian authorities started a LIFE funded project (LIFE09 NAT/IT/00095 EC-SQUARE), with the aim to control the grey squirrel across different regions on Northern Italy. A second LIFE project (LIFE13 BIO/IT/000204 U-SAVEREDS) is due to start in October 2014 with the aim to eradicate the grey squirrel from central Italy (Umbria). These LIFE projects will end in 2015 and 2018 and in this timeframe information on the possibility to eradicate or control the species in Italy will become available. |
| 2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism? | 0-10 | medium | If control actions fails, the species would invade further areas in north and central Italy in this timeframe. |

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| 2.9. Estimate the overall potential for future spread for this organism in Europe (using the comment box to indicate any key issues). | rapidly | medium | Based on the results of a spatially explicit population dynamic model it is believed that in 20-40 years from 1996 the species can colonize the western Alps in the provinces of Cuneo and Turin and in about 30 years reach France (i.e. by 2026). The populations in Lombardy would take 20-40 years to colonize the area along the Ticino river and Lake Maggiore and the first grey squirrels could easily reach Switzerland in the decade 2030-2040 (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). These prediction, however, are based on modeling the spread of only three populations (Bertolino et al. 2008), while now there more than 20 populations are known for Italy (Martinoli et al. 2010) and do not assume further jumps via human-mediated translocations.<br>In case of new introduction in other countries, the likelihood of establishment is high and the spread could be from moderate to rapid, depending on the habitat. |

| **PROBABILITY OF IMPACT** |
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| Important instructions:<br>40. When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.<br>41. Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).<br>42. Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in GB separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis. |

| QUESTION | RESPONSE | CONFIDENCE | COMMENTS |
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| 2.10. How great is the economic loss caused by the organism within its existing geographic range, including the cost of any current management? | major | high | Total costs for grey squirrel management in UK forests (damage + control) is estimated at GBP 6,097,320 (Williams et al. 2010) - GBP 10 million (Anon. 2006; Mayle & Broome 2013) annually. Damage done by grey squirrels in properties (damage to furniture, ornaments, cables) is estimated to be GBP 5,128,274; while the cost of removing squirrels in buildings and other properties is estimated in GBP 1,914,555 (total damage + control GBP 7,042,829) (Williams et al. 2010). Projected annual costs of grey squirrel to the Irish (Ireland and Northern Ireland) agricultural sectors is GBP 3,635,570 (€ 4,580,818) (Kelly et al. 2013). In Italy limited damage to maize crops and poplar plantations are recorded (Currado 1998; Signorile and Evans 2007). In Italy two LIFE projects for the control of grey squirrels in north (2010-2015) and central Italy (2014-2018) cost: € 1,930,00 and € 1,433,241 respectively. |

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| 2.11. How great is the economic cost of the organism currently in Europe excluding management costs (include any past costs in your response)? | NA | | Grey squirrels damage to the timber industry through bark stripping in Great Britain is estimated at GBP 684,802 per annum; damage to buildings and other infrastructures is estimated at GBP 5,128,000 (Williams et al. 2010). Mayle and Broome (2013) give a different estimate, with economic estimates of timber revenue loss, "In 2000 the cost of grey squirrel damage to the British timber industry, based on tree loss, reduction in timber quality and reduced yield (as described above), was estimated to be up to £10 million at the end of the then current rotation for standing crops of sycamore, beech and oak (Broome A and Johnson A, unpublished)."<br>Annual impact to forestry in Ireland (Ireland and Northern Ireland combined) from grey squirrel is estimated at GBP 3,635,570 (€ 4,580,818); damage to buildings and other infrastructures is estimated at GBP 571,487 (€720,074) |
| 2.12. How great is the economic cost of the organism likely to be in the future in Europe excluding management costs? | massive | high | Damage in Great Britain and Ireland is expected to remain at the levels now estimated because eradication is not possible and control is not able to reduce damage.<br>Future damage is expected in hazelnut orchards in Piedmont (Currado et al. 1987, Currado 1993).<br>Similar cost are expected if the species will be introduced in other countries without a rapid removal of the animals. |

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| 2.13. How great are the economic costs associated with managing this organism currently in Europe (include any past costs in your response)? | major | medium | The cost of control depends on the method used (In UK poison in grey squirrel-only areas, trapping or shooting elsewhere), the trapping intensity, personnel etc. (Huxley 2003). Two reports evaluated the cost of grey squirrel management in Great Britain (Williams et al. 2010) and Ireland, extrapolating nationwide local estimates.<br><br>In Great Britain, an average price of GBP 15 per hectare is estimate as control cost to protect forestry, with an estimation of GBP 5,412,518 per annum for the whole country. Grey squirrels can do serious damage inside lofts and a total cost of GBP 1,914,555 is estimate for removing squirrels from buildings. The annual cost of grey squirrel control as part of the red squirrel protection is estimated to GBP 611,600.<br><br>The average cost of controlling grey squirrels in Northern Ireland would be GBP 2,841,300 per year and €19,579,576 per year for Ireland.<br><br>In Italy two LIFE projects for the control of grey squirrels in north (2010-2015) and central Italy (2014-2018) cost: € 1,930,00 and € 1,433,241 respectively. |

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| 2.14. How great are the economic costs associated with managing this organism likely to be in the future in Europe? | major | high | The cost for the control of grey squirrels in Great Britain and Ireland are expected to remain at the levels now estimated because eradication is not possible and thus control should be continued to reduce damage. In Italy future cost for managing the species will depends on the results of the two LIFE project but will continue because the eradication of the specie in the country is possible for most of the populations, but will require a long term strategy. Similar cost are expected if the species will be introduced in other countries without a rapid removal of the animals. |
| 2.15. How important is environmental harm caused by the organism within its existing geographic range excluding Europe? | moderate | medium | No damage is known from South Africa. In North America the grey squirrel could have an impact on the native American red squirrel (Tamiasciurus hudsonicus) *but information is still scant*. In Vancouver Island (Canada), introduced grey squirrels pose a threat to sensitive Garry Oak ecosystems. They frequently bite out the tips of the cached acorns of some oaks, including Garry oaks, and may negatively affect oak regeneration. Grey squirrels can damage and kill trees, especially young oaks, by stripping the bark. Squirrels may also eat native lily bulbs such as camas (*Camassia* spp.) in Garry oak ecosystems (http://www.goert.ca/documents/InvFS_sciucaro.pdf). |

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| 2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) currently in Europe (include any past impact in your response)? | major | high | The grey squirrel threatens the native red squirrel with extinction due to resource competition (Wauters et al. 2001, 2002a, b; Gurnell et al. 2004). In Great Britain the competitive exclusion is also mediated by a squirrel poxvirus (Sainsbury et al. 2000; Rushton et al. 2006).<br>Since the introduction of the alien species, red squirrels have gone extinct in large parts of Great Britain and in most of the area now occupied by the alien species in Piedmont, N. Italy (Gurnell et al. 2008 a,b; Bertolino et al. 2014)<br>Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types. Squirrels predate eggs and fledgling of birds; further studies are required on whether they contribute to the decline of particular woodland bird species (Amar et al., 2006; Newson et al., 2010). |
| 2.17. How important is the impact of the organism on biodiversity likely to be in the future in Europe? | major | high | If uncontrolled, the spread of the grey squirrel from Italy to France and Switzerland, and in the long term to other European countries, or the direct introduction of the species to other countries, will affect the survival of the native red squirrel. The potential impact on other species such as woodland birds or glirids is unknown but possible |

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| 2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism currently in Europe (include any past impact in your response)? | moderate | medium | Bark stripping has influenced woodland management practices in England, where a shift away from trees susceptible to squirrel damage has been observed (Mayle, 2005), with an influence on the flora and fauna associated with specific woodland types. |
| 2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in Europe in the future? | moderate/ major | medium | Bark stripping has influenced woodland management practices in England, but not in Italy. This is probably related to different woodland management practices in the two countries, with more natural forests in Italy (Kenward & Parish 1986; Kenward et al. 1992; Currado 1998). This habitat change is likely to continue in the future in Britain, while in case of introductions of the grey squirrel in other countries woodland damage and alteration will depends on local management practices. |
| 2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism currently in Europe? | moderate | high | Though not included in the Habitat Directive, the extinction of the red squirrel with its replacement by the grey squirrel decreases the conservation status of many areas. |
| 2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the future in Europe? | moderate | high | A decrease in the conservation status of many areas is expected if the red squirrel will be replaced by the grey squirrel in other parts of Scotland, Ireland, Italy and possibly in new areas of introduction. |
| 2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious? | NA | | |

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| 2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range? | minimal | low | Not known |
| 2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)? | major | very high | Vector for squirrel poxvirus which causes a lethal disease in native red squirrels (Tompkins et al. 2002) Spill-over of gastro-intestinal nematode, *Strongyloides robustus* to native red squirrels occurs in Italy (Romeo et al. 2013, 2014), this may lead to parasite-mediated competition |
| 2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box) | minimal | low | Not known |
| 2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Europe? | major | medium | Predation is only rarely a major cause of mortality in grey squirrel populations (Koprowski 1994; Gurnell 1996). However, pine marten seems to have an impact in some parts of Ireland (Sheehy et al. 2014). Parasites and pathogens present in UK, Ireland and Italy do not limit the species. |
| 2.27. Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible). | [Most of the countries (see map)] | high | The European projection of the grey squirrel's climatic niche calculated in Maxent using records from native and invasive range predicted many highly suitable areas in a large extent of Europe (see attached map from Di Febbraro et al. 2013) including most of the European countries. |

| RISK SUMMARIES | | | |
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| | **RESPONSE** | **CONFIDENCE** | **COMMENT** |
| Summarise Entry | likely | high | The grey squirrel is already present in Great Britain, Ireland and Italy. Both Ireland and Great Britain are islands and the main risk to the rest of Europe comes from pet trade and range expansion form Italy. Here the species is present in the northern part of the country close to the French and Swiss border and will spread in these countries (Bertolino et al. 20008) in a near future without an effective control in Italy. Management actions are ongoing in Italy despite a strong opposition from some animal right groups; considering the spread of the populations, control need to be continued for many years. The species is still traded in many European countries with the risk of new releases (UNEP-WCMC 2010). |

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| Summarise Establishment | likely | high | The spread from Italy to other countries is likely as well as the possibility of human-mediated releases in other European countries. In such a situation, the successful establishment of new populations is highly likely. The climatic conditions in most of Europe are considered suitable for the establishment of grey squirrel populations (Di Febbraro et al. 2013). Temperate forests and woodlands in Europe have many tree species that are similar (same genus) than in the native area of grey squirrels and thus produce food resources similar in quantity and quality. The grey squirrel is a highly adaptive and opportunistic species and viable populations could establish from few founders. Animals are often released in urban parks, suburban gardens, parkland, which could provide suitable habitats with high food availability and supplementary feeding by humans that could help to overcome first periods with very low density; from here spread to forested habitats (deciduous, mixed and coniferous woodland) is likely considering the dispersal ability of the species (Koprowski 1994; Wauters et al. 1997; Lurz et al. 2001; Bertolino et al. 2014). Humans can further promote the spread of the species with translocation from one area to another (Shorten 1954; Martinoli et al. 2010; Signorile et al. 2014) |

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| Summarise Spread | I moderately<br>II rapidly | medium | I. Typical saturation dispersal of small-sized mammals; SEPD models show typical logistic growth with slow population growth and spread in the early phase after introduction, followed by rapid increase of population size and distribution range (Lurz et al. 2001; Tattoni et al. 2006; Bertolino et al. 2008). The species already spread over large areas in Great Britain, Ireland and Italy.<br>II. Further spread of species via releases (accidental and deliberate introductions and translocations) |
| Summarise Impact | major | very high | Extinction of the native red squirrel (Gurnel & Pepper 1993; Gurnell et al. 2004; Bertolino et al. 2014); economic impacts to commercial forestry, damage to recreational trees and an influence on forestry tree species composition with a shift away from trees susceptible to squirrel damage and an impact on the flora and fauna associated with specific woodland types (Mayle 2005; Mayle & Broome 2013). |
| Conclusion of the risk assessment | high | high | A large number of scientific publications demonstrate the invasiveness of the grey squirrel, its economic impact (in Great Britain and Ireland) and mechanisms by which it replaces the native red squirrel, causing wide-scale extinction of the latter. |

| ADDITIONAL QUESTIONS - CLIMATE CHANGE | | | |
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| 3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism? | [Climate directly] | high | Squirrel populations will increase due to increased seeding of oak and warmer winters. Considering that warmer and drier conditions seem to favour the spread of the grey squirrel, the present climate change may further benefit the species in colonising new areas (Di Febbraro et al. 2013). |
| 3.2. What is the likely timeframe for such changes? | 50 - 100 years | medium | |
| 3.3. What aspects of the risk assessment are most likely to change as a result of climate change? | [Increase suitability of some habitats] | medium | |

| **ADDITIONAL QUESTIONS – RESEARCH** | | | |
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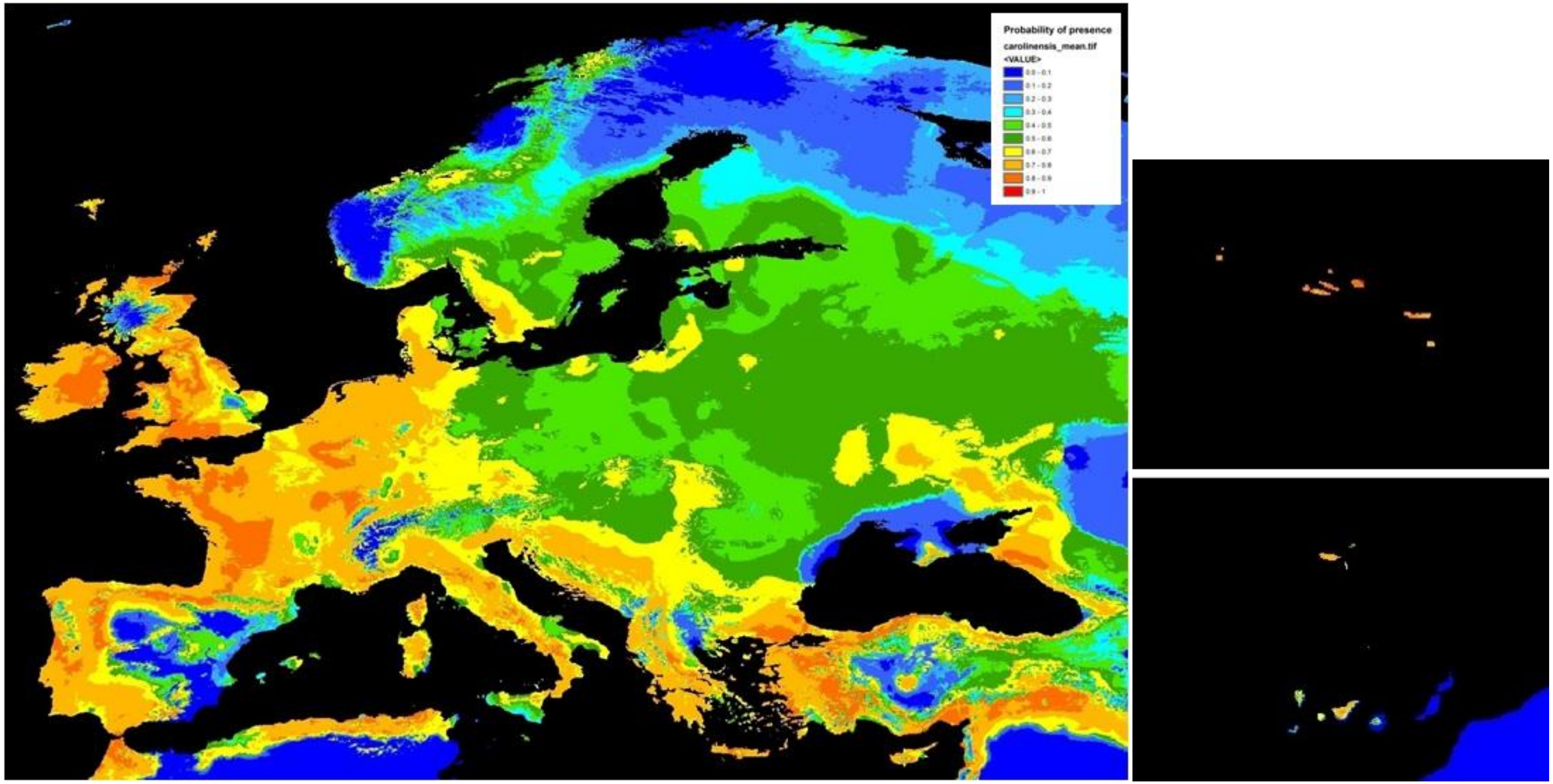
| 4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here. | [The species invasiveness is demonstrated by many papers] | high | Confidence in the risk assessment is high. A large number of scientific publications demonstrate the invasiveness of the grey squirrel, its economic impact (in Great Britain and Ireland) and mechanisms by which it replaces the native red squirrel, causing wide-scale extinction of the latter. The species is already established in large areas of Great Britain, Ireland and Italy. The European projections of the grey squirrel's climatic niche evaluated in Maxent show a high suitability for the species of most of Europe.<br>Recent, parasitological studies (Romeo et al. 2013; 2014) highlighted the introduction to Italy of the Nearctic nematode *Strongyloides robustus* by grey squirrels and its subsequent spillover to the native species. The impact of this novel parasite on red squirrels (and potentially other rodents) is still unknown, but it deserves further attention, since it may potentially exacerbate the competition between the two sciurid species |




European projections of grey squirrel's climatic niche calculated in Maxent using records from native and invasive range (Great Britain, Ireland, Italy). Maps taken from the results presented in Di Febbraro et al. (2013).

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