UK NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME
USER MANUAL

Version 3.3, Dated 28.2.2005

Prepared by CABI Bioscience (CABI), Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Centre for Ecology and Hydrology (CEH), Central Science Laboratory (CSL), Imperial College London (IC) and the University of Greenwich (UoG) under Defra Contract CR0293[1]

ABSTRACT

In response to a key recommendation from the Defra Review of Non-Native Species Policy, Defra funded a one-year project starting in January 2004 to develop a scheme for assessing the risks posed by any non-native organism to species, habitats or ecosystems in all or part of the UK. The work was undertaken by a consortium of six UK institutes/universities (CABI Bioscience (CABI), Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Centre for Ecology and Hydrology (CEH), Central Science Laboratory (CSL), Imperial College London (IC) and the University of Greenwich (UoG)) coordinated by CSL. The project benefited from the unique breadth of expertise available from consortium members enabling the direct utilisation of state of the art national and international research and practical experience in the assessment and management of invasive non-native species. The European and Mediterranean Plant Protection Organisation pest risk assessment scheme was considerably extended in scope and functionality to generate the UK non-native risk assessment scheme.

This scheme provides the first structured framework for evaluating the potential for any non-native organism, whether intentionally or unintentionally introduced, to enter, establish, spread and cause significant impacts in all or part of the UK. In addition, specialist modules permit the relative importance of introduction pathways, the vulnerability of receptors and the consequences of policies to be assessed and appropriate risk management options selected. These modules can also be used in stand-alone mode. Spreadsheets for summarising the level of risk and uncertainty, invasive attributes and economic impact have been created. New methods for quantifying economic impact and summarising risk and uncertainty have been pioneered. Examples of best practice are given and recommendations for improving the functionality and user-friendliness of the scheme are proposed in a specification for an electronic toolkit.

[1] A full list of contributors is given in Annex 1a and 1b.

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EXECUTIVE SUMMARY

In response to a key recommendation from the Defra Review of Non-Native Species Policy in 2003, this project has developed a scheme for assessing the risks posed by any non-native organism to species, habitats or ecosystems in all or part of the UK. The work was undertaken by a consortium of six UK institutes/universities (CABI Bioscience (CABI), Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Centre for Ecology and Hydrology (CEH), Central Science Laboratory (CSL), Imperial College London (IC) and the University of Greenwich (UoG)). Coordinated by CSL, this one-year contract with Defra, which began in January 2004, benefited from additional ongoing national and international research on invasive alien species by consortium members. Contributions from other individuals and organisations were also received.

The project generated one principal output, the UK non-native risk assessment scheme, with four examples of best practice. Six additional modules provide methods for identifying invasive attributes, evaluating pathways of introduction, determining the vulnerability of receptors, quantifying economic impacts, summarising risks and uncertainties and selecting risk management options. A series of examples demonstrate how the modules should be applied. Six annexes provide the names of the contributors, a short glossary of terms, a list of the species studied when developing the scheme, recommendations for future work, specifications for an electronic toolkit and a list of the Excel files required to use the scheme and read the examples of best practice.

The UK non-native risk assessment scheme is based on internationally recognised procedures developed by the European and Mediterranean Plant Protection Organisation (EPPO) following International Plant Protection Convention standards for pest risk analysis. In the initial phase of the project, the UK scheme was enhanced and tested by conducting risk assessments for 33 non-native species that are already present in the UK or that could be intentionally or unintentionally introduced. The species were selected from 12 different taxon-habitat combinations to ensure the scheme is as generic as possible.

The scheme is divided into two principal parts. In the first part, the assessor determines whether a detailed risk assessment is warranted by quickly answering a series of fourteen questions. The second part contains the detailed risk assessment scheme with fifty-one questions designed to assess the potential for entry and establishment, the capacity for spread and the extent to which significant economic, environmental or social impacts may occur. The assessor is required to choose one of five levels of responses (very low, low, medium, high, very high) and one of three levels of uncertainty (low, medium, high), justifying these with a written, referenced comment. Guidance is provided on the procedures that should be adopted when information is lacking or highly uncertain. Four examples of best practice have been included: Japanese knotweed (*Fallopia japonica*), an insect fungal pathogen (*Metarhizium anisopliae*), topmouth gudgeon (*Pseudorasbora parva*) and the Indian house crow (*Corvus splendens)*. The scheme is provided as a spreadsheet template with a manual describing the procedures that should be followed.

Three of the modules are designed to assist with the risk assessment by helping to determine whether the species has invasive attributes (Module 1), to quantify economic impacts (Module 4) and to summarise risk and uncertainty into the low, medium and high categories specified by the Defra contract (Module 5). Module 1 was adapted from the Pheloung *et al* (1999) spreadsheet, originally created for plants invading Western Australia, to score the invasive attributes of non-native freshwater fish and plants in the UK. Module 4 provides a guide to the level of impacts appropriate for minimal, minor,

moderate, major or massive responses to the impact questions and is based on the Australian and New Zealand Risk Management Standard. Eight additional questions can be answered to quantify impacts over time. Responses for the topmouth gudgeon are provided as an example. Although assessors are required to provide their own judgement of overall risk, Module 5 provides a summary of risk based on two additional techniques: score averaging and conditional probability. Score averaging often under-estimates high risk and over-estimates low risk. This project showed that the linear mapping of scores to conditional probabilities provides an important new approach to solve this problem. For each of the examples of best practice, risk summaries based on the assessor's opinion, score averaging and conditional probabilities are compared.

Two of the modules provide a different perspective on non-native risk assessment, enabling the relative importance of introduction pathways (Module 2) and the vulnerability of receptors (Module 3) to be assessed. The modules are each illustrated with two examples: human assisted introduction of non-native fish species and ship-assisted transfer of non-native avian species for pathway risk assessment and slow flowing watercourses and oak trees/oak woodland for the receptor risk assessment scheme.

Once the risk assessment has been completed and a summary of the risks and uncertainties has been made, the assessor is asked whether risk management options should be selected. Module 6 provides a logical framework for selecting risk management options. Developed from another EPPO scheme, the principal modification has been to ensure that reliable, cost-effective options for intentional as well as unintentional introductions can be identified.

Although Excel templates were constructed, with the limited resources available, the consortium was unable to develop a sophisticated, user-friendly electronic toolkit for the risk assessment scheme. However, various alternatives were explored and specifications for such a toolkit were prepared. Mind mapping software was found to have considerable potential, combining a dynamic graphical presentation of the scheme with the ability to calculate risk and uncertainty scores.

In addition to the need for an electronic toolkit, the consortium highlighted the gaps and key areas for future work that should be undertaken to validate our work and enhance its functionality. While it is important to stress that the risk assessment procedures are time consuming and require a sufficient level of expertise, there remains considerable scope for increasing the scheme's user-friendliness. The scheme also needs further testing with a wider range of intentional and unintentional introductions from different taxon/habitat combinations. To improve consistency, examples of each level of response for each question need to be given. Once a large set of consistently produced risk assessments is available, additional techniques for summarising risk and uncertainty and prioritising non-native species, pathways and receptors for action can be exploited.

In presenting this non-native risk assessment scheme to those concerned with the assessment and management of non-native species in the UK, the consortium expresses its desire that as many experts as possible test this scheme, provide feedback on their experiences and share their risk assessments. At present, no mechanism exists to provide advice, receive comments, collate risk assessments or enhance the risk assessment scheme. We greatly hope that resources will be made available to ensure the long-term development of this vital tool for combating invasive and potentially invasive non-native species in the UK.

OBJECTIVES

The UK Non-Native Organism Risk Assessment Scheme provides a procedure for the assessment of the risks posed by any non-native organism to species, habitats or ecosystems in all or part of the UK. Risk assessments of the pathways that may carry non-native organisms and of receptors that may be vulnerable to non-native invasion can also be carried out by this scheme. In addition to the assessment of specific cases, it can also be used to help inform policies on invasive non-native species.

BACKGROUND

The UK Non-Native Organism Risk Assessment Scheme has been produced by a consortium of six UK institutes/universities (CABI Bioscience (CABI), Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Centre for Ecology and Hydrology (CEH), Central Science Laboratory (CSL), Imperial College London (IC) and the University of Greenwich (UoG)) coordinated by CSL during a one year contract with Defra starting in January 2004. A number of other individuals and organisations have also contributed to this work. A full list of contributors is given in Annex 1a and 1b.

The scheme responds to a key recommendation of the Defra Review of Non-Native Species Policy (Defra, 2003) to "*develop comprehensive, accepted risk assessment procedures to assess the risks posed by non-native species*".

The pest risk assessment scheme constructed by the European and Mediterranean Plant Protection Organisation (EPPO, 1997, and in prep) provided the basis for the UK Non-Native Organism Risk Assessment scheme. The Monitoring and Risk Assessment Sub-group of the Defra Review had already found that the EPPO pest risk assessment scheme structure was a useful basis on which to assess the risk posed by the Indian House Crow (*Corvus splendens*), Muntjac (*Muntiacus reevesi*) and two plant species (*Uncinia rubra* and *Azolla filiculoides*). This led to their conclusion (Sub-recommendation 2.2) that plant health risk assessment schemes are a good basis for the development of a generic scheme suitable for all taxa. The EPPO scheme has also been successfully adapted for freshwater invasive fish risk assessment (IFRA) by CEFAS (Copp *et al*. 2005). EPPO itself, through its expert Panel on Invasive Alien species, is now revising the pest risk assessment scheme and has found that, with minor adaptations, it can be made suitable for the assessment of non-native plants.

The EPPO scheme closely follows the international standard for phytosanitary measures (ISPM 11) on pest risk analysis produced by the International Plant Protection Convention (IPPC) (FAO, 2003). IPPC standards are recognised by the Sanitary and Phytosanitary Agreement of the World Trade Organization (WTO, 1994)

Ongoing work by consortium members in various national and international fora has been applied in adapting the EPPO scheme to make it relevant to all non-native organisms. Early drafts were tested with a range of taxon-habitat combinations (see list in Annex 3; the risk assessments themselves are available on a separate CD) and a number of amendments were suggested. These have been taken into account in this final version.

The consortium recognises that further work, outside the limits of the initial project, should be undertaken to improve the scheme and make it easier to use. Recommendations for future work are given in Annex 4.

The project was required to identify the key elements, which should be included in an electronic toolkit (see Annex 5). During the project, it became clear that Microsoft Word provides a poor template both for the risk assessor entering responses to the questions in the scheme and for those reading the outputs. As a result, the Consortium constructed a simple electronic toolkit prototype in Microsoft Excel for the main risk assessment scheme and its modules. These Excel files were used to prepare the examples of best practice. A list of these Excel files is given in Annex 6. This user manual provides the full text of the scheme and should be consulted when undertaking risk assessments using the Excel files.

Please send any comments, corrections or additions to the scheme to: Chris Bear, Defra European Wildlife Division, 1/08b Temple Quay House, 2 The Square, Bristol, BS1 6EB

INTRODUCTION

Before starting to use the UK Non-Native Organism Risk Assessment Scheme, the assessor should have:

- A specific objective that requires the assessment of the risks posed by:
  - one or more non-native species
  - the pathway or pathways on which they may be carried
  - the receptor or receptors that may be vulnerable
  - a change or changes in non-native policy
- Basic information on the non-native species, pathways, receptors or policies concerned that is sufficient to determine whether a detailed risk assessment is warranted.
- Expertise in the subject of the risk assessment, or access to expertise.
- This User Manual, which provides a detailed guide to the scheme and its modules
- The Microsoft Excel© version of the scheme, which is used for entering information (see Annex 6).

The scheme is divided into two principal parts:

- Section A - a simple, predominantly binary, scheme, which is designed to determine whether a detailed risk assessment is warranted
- Section B – a detailed scheme that contains a series of questions that mainly requires the assessor to choose between five levels of responses (very low, low, medium, high, very high) and three levels of uncertainty (low, medium, high).

Throughout the scheme, the assessor is required to provide written comments, justifying the answers given to each question. Where possible, a literature reference should be given or a personal communication noted.

Four examples of best practice have been included as Excel files (see Annex 6):

- Japanese knotweed (*Fallopia japonica)*
- An insect fungal pathogen (*Metarhizium anisopliae)*
- topmouth gudgeon (*Pseudorasbora parva)*
- Indian house crow (*Corvus splendens)*

APPLICATION

The scheme is primarily designed to assess whether non-native species that are absent from all or part of the UK can enter, establish, spread and cause unacceptable impacts.

The risks posed by widespread non-native species can still be analysed by this scheme, but it is essential that the objectives are formulated so that the exercise is worthwhile, e.g. to determine whether impacts are likely to increase in the near future or whether there are significant additional habitats or geographical areas where new invasions can occur. From the same perspective the scheme can also be used to analyse the risks posed by species that are native or doubtfully native. This is an important attribute of the scheme because there is no agreed definition for non-native species and the origins and modes of entry of many species are uncertain.

UNCERTAINTY

Section B and the modules require much more detailed information on the non-native species, pathways, receptors or policies concerned. Even where information is lacking, the assessor should make every effort to provide a response to each relevant question. Once all available sources have been searched, expert judgement may have to be applied. Useful information can sometimes be obtained by reference to closely related organisms. Where such indirect information is used, this should be recorded during the assessment and taken into account in the final evaluation. Following the completion of risk assessments with high levels of uncertainty, information sources should be actively reviewed and, if necessary, the assessments revised.

Those making decisions based on risk assessments with high levels of uncertainty should take into account Guiding Principle 1 of the CBD (Convention on Biological Diversity) guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species (CBD, 2004): "*Given the unpredictability of the pathways and impacts on biological diversity of invasive alien species, efforts to identify and prevent unintentional introductions as well as decisions concerning intentional introductions should be based on the precautionary approach, in particular with reference to risk analysis, in accordance with the guiding principles below. The precautionary approach is that set forth in principle 15 of the 1992 Rio Declaration on Environment and Development and in the preamble of the Convention on Biological Diversity. The precautionary approach should also be applied when considering eradication, containment and control measures in relation to alien species that have become established. Lack of scientific certainty about the various implications of an invasion should not be used as a reason for postponing or failing to take appropriate eradication, containment and control measures.*"

Decision makers should also keep in mind the Interdepartmental Liaison Group on Risk Assessment (UK-ILGRA, 2004) interpretation of the precautionary principle. The precautionary principle should be invoked when: "*there is good reason to believe that harmful effects may occur to human, animal or plant health, or to the environment and the level of scientific uncertainty about the consequences or likelihood of the risk is such that the best available scientific advice cannot assess the risk with sufficient confidence to inform decision making*". Methods for dealing with uncertainty and taking into account the precautionary principle are also described by DETR *et al.* (2000).

DEFINITIONS

Various terms are used throughout the scheme. Annex 2 provides a short glossary following, as far as possible, the terms used by Defra (2003). There remains considerable debate over the precise meaning of terms among invasion biologists. This is reflected not only in the literature but also the documents and standards of the IPPC and the CBD. For

example, Defra (2003) has taken a different direction from most sources by avoiding the term “alien” and replacing this with the term “non-native”. The term “pest”, which is commonly used in some sources, receives only limited use, as it is not commonly applied to some taxonomic groups (e.g. fish).

MODULES

The scheme also has six modules that are linked to the main scheme:

Module 1: Invasive Attributes Spreadsheet based on Pheloung *et al.* (1999)

- to help determine whether an organism has intrinsic attributes that indicate that it could threaten species, habitats or ecosystems (Section A, Question 8).
    - Examples for fish and plants have been prepared.

Module 2: Pathway Risk Assessment Module

- to provide a rapid assessment of the risks posed by a pathway (Section A, Question 1b).
- to summarise a pathway risk assessment based on a large number of non-native organism risk assessments for species which might travel along the pathway (Section B, following question 2.20)
- to help assessors identify potential pathways by which non-native organisms can enter the UK (Section B, question 1.1).
- two pathway risk assessment examples have been prepared in Excel format:
    - The human-assisted introduction of non-native fish species into the UK and between water bodies
    - Ship-assisted transfer of non-native avian species between other countries and the UK.

Module 3: Receptor Risk Assessment Module

- to provide a rapid assessment of the vulnerability of the receptor (Section A, Question 1c)
- to help identify receptors when undertaking a detailed assessment of likely impacts (Section B, especially Question 2.12)
- two receptor risk assessment examples have been prepared in Excel format:
    - Oak trees and oak woodland
    - Slow flowing watercourses

Module 4: Economic Impact Assessment Module

- to assist with responses to the economic impact questions (Section B, Question 2.5-2.14) by providing examples for each level of risk and likelihood
- where values can be estimated, to provide a method for quantifying impacts over time
- one quantified economic impact assessment example has been prepared in Excel format:
    - topmouth gudgeon (*Pseudorasbora parva)*

Module 5: Summarising Risks and Uncertainties Module

- to summarise the risk assessment into low, medium and high categories, as required by the Defra contract, based on the responses to each question in Section B. A summary of the level of uncertainty is also provided.
- examples are given for each of the species assessed in the main scheme:
    - Japanese knotweed (*Fallopia japonica)*

- An insect fungal pathogen (*Metarhizium anisopliae)*
- topmouth gudgeon (*Pseudorasbora parva)*
- Indian house crow (*Corvus splendens)*

Module 6: Risk Management Module

- to provide a method for identifying which management options, on their own or in combination, are likely to be efficient, reliable and cost effective.

ACKNOWLEDGEMENTS

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Our work on this project benefited from a number of additional ongoing national and international research projects on invasive alien species undertaken by consortium members. We are very grateful for the funding for these projects provided by Defra Divisions (Plant Health and Fish II) and the EC (5th, 6th Framework Research Programmes).

We would also like to thank members of the EPPO Pest Risk Analysis Panel who originally developed the risk assessment and risk management scheme, members of the Monitoring and Risk Assessment Sub-Group of the Defra Non-Native Species Policy Review Group who recommended this approach, Pheloung, Williams and Halloy for providing an open version of their Excel scoring sheet for our adaptations, the Joint Nature Conservation Committee and the Countryside Council for Wales for valuable advice and the project steering group for their support and constructive comments.

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Name of Organism, Pathway, Receptor or Policy:

Authors:
Date:
Draft:

DECISION-MAKING SCHEME

Stage 1: Initiation

Describe the Objectives of the Risk Assessment
Name the organism*, pathway, receptor or policy assessed ***Include the Species Name, Authority, Synonyms, Common Names, Order & Kingdom**

1. Give the reason for performing the Risk Assessment. Is it due to the identification of:

an organism?	**Go to 1(a)**
a pathway?	**Go to 1(b)**
a receptor ?	**Go to 1(c)**
a policy change?	**Go to 1(d)**

1 (a) A Risk Assessment initiated by the identification of a harmful or potentially harmful organism that is non-native or not ordinarily resident in the risk assessment area:

- an established infestation or an outbreak has been discovered in the Risk Assessment area;
- the organism has been detected in an imported consignment;
- the organism has been identified as a risk by scientific research;
- the organism has invaded a new area, other than the Risk Assessment area;
- the organism is reported to be more damaging in a new area than in its area of origin;
- the organism is observed to be detected more frequently in trade;
- a request is made for an assessment of the likely future spread and impacts of an organism in the Risk Assessment area;
- a request or licence application is made for the intentional import and/or release of an organism;
- a previous Risk Assessment is being re-evaluated.

Record the Reason and **Go to 2**

1 (b) A Risk Assessment initiated by the identification of a pathway:

- trade is proposed or initiated in a new commodity
- a pathway other than a commodity has been identified, e.g. natural spread, packing material, mail, passenger baggage, illegal imports/releases etc
- a request is made for the intentional import of an organism that may provide a pathway for non-native organisms

Record the Reason, prepare a list of non-native organisms likely to be associated with the pathway, prioritise them based on known invasiveness and expert judgement and **Go to 2**

To provide a rapid assessment of the risks posed by a pathway:
GO TO THE PATHWAYS RISK ASSESSMENT MODULE

1 (c) A Risk Assessment initiated by the identification of a receptor:

- a request is made to determine the threat posed by a non-native organism or organisms to a particular receptor (species, community, habitat, ecosystem, human activity etc);

Prepare a list of pathways that may bring non-native organisms in contact with the receptor and list the non-native organisms that may be associated with the pathways, prioritising them based on known invasiveness and expert judgement and
Go to 2

To provide a rapid assessment of the risks posed to a receptor:
GO TO THE RECEPTOR RISK ASSESSMENT MODULE

1 (d) A Risk Assessment initiated by a change or changes in policy:

- regulations are being revised
- a proposal is made by another country or by an international organisation
- a dispute arises

Prepare a list of receptors, the pathways that may bring non-native organisms in contact with the receptors and list the non-native organisms that may be associated with the pathways, prioritising them based on known invasiveness and expert judgement and **Go to 2**

2. Clearly define the Risk Assessment area and **Go to 3**
Note: The Risk Assessment area can be the UK, one or more devolved authorities, or other parts of the UK.
Note: For intentional introductions, specify the intended and unintended habitats.

Earlier analysis

The organism, or a very similar organism, may have been subjected to the Risk Assessment process before, nationally or internationally. This may partly or entirely remove the need for a new Risk Assessment.

3. Does a relevant earlier Risk Assessment exist?
if yes Go to 4
if no or unknown Go to 5

4. Is the earlier Risk Assessment still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct organism)?
if entirely valid End
if partly valid proceed with the assessment, but compare as much as possible with the earlier assessment. Go to 5
if not valid Go to 5

Stage 2: Organism Risk Assessment

Section A: Organism screening (criteria of a potentially harmful non-native species)

At the outset, it may not be clear which non-native organism(s) identified in Stage 1 require(s) a risk assessment. The screening process examines each organism to determine whether it poses sufficient risk to warrant a detailed risk assessment. In the evaluation of a pathway, a number of individual risk assessments may be necessary for the various organisms potentially associated with the pathway. The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the screening process.

Identify the organism

The identity of the organism should be clearly defined to ensure that the assessment is being performed on a distinct organism and that the biological and other information used in the assessment is relevant to the organism in question. The taxonomic unit for the organism is generally the species. The use of a higher or lower taxonomic level should be supported by a scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the conclusions of the risk assessment. If this is not possible because the causal agent of particular symptoms has not yet been fully identified, then it should have been shown to produce consistent symptoms and to be transmissible.

5. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?
if yes indicate the correct scientific name and taxonomic position Go to 7
if no Go to 6
Note: The taxonomic source used to confirm identity should be provided.

6. Attempt to redefine the taxonomic entity so that the above criteria are satisfied. Is this possible?
Note: If the identity of an organism is unclear, a risk assessment may still be undertaken based on a closely related species, the attributes of a genus or a higher taxon. If so this must be made very clear and the title of the Risk Assessment should reflect this.
Note: If a species being assessed is known to belong to a species complex and is therefore difficult to identify precisely, the assessment should be undertaken on the species known to be the most damaging.
Note : a Risk Assessment can be conducted on an agent causing particular symptoms, which has not yet been fully identified if it has been shown to produce consistent symptoms and to be transmissible.
if yes Go to 7
if no Go to 20

Confirm the Organism's Potential for causing Harm to Species, Habitats or Ecosystems

7. Is the organism in its present range (including areas where it has spread or been successfully introduced beyond its natural range) known to be invasive, i.e. to threaten species, habitats or ecosystems?

Note: It may be the case that the organism is known to be harmful in the areas where it occurs, and therefore to be potentially harmful in the Risk Assessment area. In other cases, organisms not known to be harmful in the areas where they occur might nevertheless have the potential to become harmful in the Risk Assessment area. This possibility should also be considered.

Note: For the purpose of advising policy and practice as regards the Import of Live Fish Act (ILFA) 1980 and related legislation (i.e. Prohibition of Keeping or Release of Live Fish [Specified Species] Order 1998' and [Amendment] (England) Order, 2003), risk assessments of freshwater fishes should proceed to Question 8 regardless of the response to Question 7.

if yes Go to 9
if no or uncertain Go to 8

8. Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?

Note: For each taxon/habitat combination, intrinsic attributes need to be listed. For example, the Pheloung et al. Weed Risk Assessment scheme lists undesirable traits for plants.

LINK TO INTRINSIC ATTRIBUTES SPREADSHEETS FOR FISH AND PLANTS

if yes or uncertain, the organism may be harmful to species, habitats or ecosystems in the Risk Assessment area. Go to 9

if no Go to 20

Presence or absence in the Risk Assessment area and regulatory status

This section considers the geographic distribution of the organism in the Risk Assessment area.

9. Does the organism occur outside effective containment in the Risk Assessment area?

if yes Go to 10
if no Go to 11

10. Is the organism widely distributed in the Risk Assessment area?
Note: *If the organism is widespread in the Risk Assessment area and appears to have reached the limits of its potential range either outdoors or in protected conditions, e.g. glasshouses, then a full detailed risk assessment is not normally necessary. However, a detailed assessment of possible further spread and additional impacts of widespread organisms under new management procedures, revised policies or climate change may still be required.*
if no Go to 11
if yes and the effects of future conditions, new management procedures or policies are being considered Go to 19
if yes and the effects of future conditions, new management procedures or policies are not being considered Go to 20

Potential for establishment and spread in the Risk Assessment area

For a herbivore, predator or parasite to establish in the Risk Assessment area it must find suitable species in the form of food plants, prey or hosts for survival, development and multiplication. Non-parasitic plants must find suitable habitats. The organism must also find environmental conditions suitable for survival, development, multiplication and spread, either in natural or in protected conditions, e.g. glasshouses. If the organism requires another species for critical stages in its life cycle such as reproduction (e.g. pollinators), spread (e.g. seed dispersers) and transmission, (e.g. vectors), then a suitable species must already be present in the Risk Assessment area or the species in its present range must also be introduced.

11. 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 the Risk Assessment area, in the open, in protected conditions or both?

*Note: Some organisms require more than one species (for herbivores, predators and parasites**)** or suitable habitat to survive, develop and multiply and they must also occur in the same part of the Risk Assessment area as the major species/habitat.*
if yes Go to 12
if no Go to 20

12. 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)?
if yes Go to 13
if no Go to 14

13. Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in the Risk Assessment area or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.
if yes Go to 14
if no Go to 20

14. Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment area or sufficiently similar for the organism to survive and thrive?
if yes Go to 16
if no Go to 15

15. Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?
if yes Go to 16
if no Go to 20

16. 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?
if yes Go to 17
if no Go to 20

17. Can the organism spread rapidly by natural means or by human assistance?

If yes Go to 18
If no Go to 20

Potential economic, environmental and social importance

There may be clear indications that the organism is likely to cause unacceptable harm to species, habitats and ecosystems in the Risk Assessment area. Climatic and cultural conditions in the Risk Assessment area should be considered to decide whether economic, environmental and/or social damage may occur. The effect of the presence of the organism in the Risk Assessment area on exports should also be considered.
Note: When performing a Risk Assessment on an organism that is transmitted by a vector, consider also any possible damage that the vector may cause. Consider also the extent to which the organism itself can act as a vector for other harmful organisms.

18. Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment area ?
Note: The harm caused by the organism in its present range has already been considered in question 7.
Note: Consider also the potential loss of export markets.
if yes or uncertain Go to 19
if no Go to 20

19. **This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate. Go to Section B**

If undertaking the assessment of several organisms on a pathway, then Go to 3 or STOP

20. **This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.** However, if this is the first time that the decision-making scheme has directed you to this point, then it may be worth returning to the question that led you here and continuing through the scheme in case the remaining questions strongly indicate categorization as a potential harmful non-native organism. In this latter case, seek a second opinion to decide whether the answers that led you to this point could be given a different reply.

If undertaking the assessment of several organisms on a pathway, then Go to 3 or STOP

Section B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences

Introduction

This part of the risk assessment process evaluates:

- **the probability of the organism entering and becoming established in the Risk Assessment area**
- **the possible economic, environmental and social impacts.**

The level of risk posed by the organism is then estimated and key areas of uncertainty are identified. The estimate of the level of risk can be used to determine whether it is necessary to take measures to reduce the risks, to identify appropriate measures and to ensure that these measures are appropriate to the level of risk.

In the case of an organism that is intentionally imported and released into the Risk Assessment area:

- **entry is certain and establishment in the intended habitat is to be expected. In such cases, the assessment should concentrate on determining the likelihood of spread into and establishment in unintended habitats.**

In cases where the organism has already entered and is widely established and the aim is to assess future spread and impacts:

- **go straight to 2.1.**

The evaluations should be conducted by or with an expert or experts who can make estimates based on the information available. Uncertainty can be expressed by giving a range of scores. Particular attention should be given to any especially high or especially low responses to questions. A reference or a comment should always be provided to support each response.

Answer as many of the questions as possible insofar as they are relevant to the organism concerned. If you cannot answer a particular question, do not give a response. Note whether this is because of lack of information, high uncertainty or because the question is irrelevant to the organism concerned. In some cases, useful information can be obtained by reference to closely related organisms, but the use of information on related organisms as a substitute for the species assessed should be made transparent in the accompanying notes.

1. Probability of entry and establishment

Probability of Entry

For species imported for release, answer question 1.1 but only answer the remaining questions in the entry section if it is important to determine whether other entry pathways may influence the risks posed by the species to unintended habitats. Otherwise, go directly to the establishment section (1.15). Spread from the intended habitat to unintended habitats is considered by questions 2.1 and 2.2.

Identification of pathways

1.1 List the pathways that the organism could be carried on

How many relevant pathways can the organism be carried on?
(very few - 0, few - 1, moderate number - 2, many - 3, very many – 4)

Note: A pathway can be natural spread or any form of human activity that could transport the organism from a particular origin, e.g. animals, plants and plant products moving in trade, any other traded commodity, containers and packing, ships, planes, trains, road transport, passengers, mail, exchange of scientific material, illegal imports etc. Note that similar means of transport from different origins can present greatly different probabilities of introduction, depending on the concentration of the organism in the area of origin. The pathways given should only be those already in operation, or proposed. However, pathways that have been closed by regulations should also be considered since the risk assessment may be needed to support existing measures. Detection records are a useful indicator of an organism's ability to be associated with a pathway.
Note: A rapid assessment of the risks posed by a pathway can be undertaken using the Pathway Risk Assessment Module (see Section A, 1b). This module also contains a list of the principal pathways that may be used by non-native species.

1.2 Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments. You may wish, using *a priori* knowledge, to begin with pathways that appear, or are thought to be, most important. If these pathways involve different origins and end uses, then it is sufficient to consider only the realistic worst-case pathways. Questions 1.3-1.14 on pathways are then considered for each pathway in turn, as appropriate, starting with the most important. If the answer to any of questions 1.3, 1.5, 1.7 or 1.14 is that that stage in the pathway is impossible, the pathway could not act as a means of entry and another pathway should be considered by returning to this point.

1.3 How likely is the organism to be associated with the pathway at origin?

Note: *Does the organism occur in the area of origin? Is the organism in a life stage that would be associated with commodities, containers, or conveyances? Is seasonal timing appropriate for the organism to be associated with the pathway at origin? Do seeds, germ cells, spores or other propagules have access to commodities, containers, or conveyances?*

if possible give score (very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4) and go to 1.4
if impossible for the organism to be associated with the pathway at origin go to 1.2

1.4 Is the concentration of the organism on the pathway at origin likely to be high?
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.5 How likely is the organism to survive existing cultivation or commercial practices?
Note: *these are practices mainly in the country of origin, such as pesticide application (including herbicides, piscicides and parasite treatments), removal of substandard produce, kiln-drying of wood, heat-treatment of water, cultural methods, sorting and cleaning of commodities.*

if possible give score (very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4) and go to 1.6
if impossible for the organism to survive existing cultivation or commercial practices go to 1.2 and select next pathway

1.6 How likely is the organism to survive or remain undetected by existing measures?
Note: *existing measures (e.g. inspection, testing or treatments) are most probably being applied as a protection against other (harmful non-native) organisms; the assessor should bear in mind that such measures could be removed in the future if the other organisms were to be re-evaluated.*
The likelihood of detecting the organism during inspection or testing will depend on a number of factors including:

- *ease of detection of the life stages that are likely to be present. Some stages are more readily detected than others, for example insect adults may be more obvious than eggs, adult plants may be more obvious than seeds or bulbs etc ;*
- *location of the organism on the commodity - surface feeders may be more readily detected than internal feeders;*
- *symptom expression - many diseases may be latent for long periods, at certain times of the year, or may be without symptoms in some hosts or cultivars and virulent in others;*
- *distinctiveness of symptoms - the symptoms might resemble those of other organisms or sources of damage such as mechanical or cold injury;*
- *the intensity of the sampling and inspection regimes;*
- *distinguishing the organism from similar organisms.*

(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.7 How likely is the organism to survive during transport /storage?
Note: *consideration should be given to:*

- *speed and conditions of transport;*
- *vulnerability of the life-stages likely to be transported (for plants viability of seeds or other propagules, for aquatic organisms, tolerance of low oxygen or elevated salinity levels, for all animals tolerance of low or elevated temperatures);*
- *whether the life cycle is of sufficient duration to extend beyond time in transit;*
- *prevalence of the organism likely to be associated with a consignment.*
  Detection data can be used to estimate the ability of an organism to survive in transit.

if possible give score (very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4) and go to 1.8
if impossible for the organism to survive during transport /storage go to 1.2 and select next pathway

1.8 How likely is the organism to multiply/increase in prevalence during transport /storage?
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.9 What is the volume of movement along the pathway?
Note: *the volume of material being moved.*
(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)

1.10 How frequent is movement along the pathway?
(very rarely - 0, rarely - 1, occasionally - 2, often - 3, very often - 4)

1.11 How widely could the organism be distributed in the Risk Assessment area?
Note: *the more scattered the destinations, the more likely it is that the organism might find suitable habitats.*
(not widely - 0, limited - 1, moderately widely - 2, widely - 3, very widely - 4)

1.12 How likely is the organism to arrive during the months of the year most appropriate for establishment?
Note: *introduction at many different times of the year will increase the probability that entry of the organism will occur at a life stage of the organism or the host suitable for establishment.*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.13 How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat?
Note: *consider whether the intended use of the commodity would destroy the organism or whether the processing, planting or disposal might be done in the vicinity of suitable habitats.*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.14 How likely is the organism to be able to transfer from the pathway to a suitable habitat?
Note: *consider innate dispersal mechanisms or the need for vectors, and how close the pathway on arrival is to suitable habitats.*

if possible give score (very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4) and go to 1.15 (or 1.2 if additional pathways are to be considered)

if impossible for the organism to be able to transfer from the pathway to a suitable habitat go to 1.2 but continue to 1.15 if this is the only possible pathway and there is any uncertainty

Note: *the precautionary approach suggests that if this is the only possible pathway and the organism has got this far along the pathway then you need to be absolutely certain that transfer is impossible before stopping the risk assessment*

Summarise the potential for entry

Establishment

In the case of organisms imported for release, the assessment of the probability of establishment concerns the unintended habitat.

Suitability of the abiotic environment

1.15 How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?

Note: the climatic conditions in the Risk Assessment area to be considered may include those in protected cultivation. When comparing climates in an organism's current distribution with those in the Risk Assessment area, it is important to ensure that, as far as possible, the variables selected are relevant to the organism's ability to exploit conditions when these are favourable for growth and reproduction and to survive unfavourable periods, such as those of extreme cold, heat, wetness or drought.

(not similar - 0, slightly similar - 1, moderately similar - 2, similar - 3, very similar - 4)

1.16 How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?

Note: *For plants the major abiotic factor to be considered is soil type and soil water balance; others are, for example, environmental pollution, topography. For aquatic species, water temperature, salinity, pH, current, and water body type must be considered.*

(not similar - 0, slightly similar - 1, moderately similar - 2, similar - 3, very similar - 4)

Availability of critical species (for herbivores, predators and parasites) or suitable habitats (for non-parasitic plants)

1.17 How many species (for herbivores, predators and parasites**)** or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the number.

Note: Herbivores, predators and parasites require these species for food or as hosts to survive, develop and multiply. Non-parasitic plants must find suitable habitats.

*Note: Some organisms require more than one species (for herbivores, predators and parasites**)** or suitable habitats (for non-parasitic plants) to survive, develop and multiply.*

Note: the taxonomic level at which these critical species are considered should normally be the species. The use of higher or lower taxonomic levels should be scientifically justified. The organism should be able to complete its life cycle or multiply using the species considered under natural conditions. Some other species might also prove to be suitable in the absence of the usual species. Additionally, it may be appropriate to make a difference between major and minor critical species when answering this question. Great care must be exercised when taking into account species that have been shown to be suitable only in experimental conditions. Habitat types may be described in general terms, e.g. woodland, or by noting the dominant or keystone species, e.g. oak woodland.

(very few - 0, few - 1, moderate number - 2, many - 3, very many - 4)

1.18 How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?
Note: For non-parasitic plants, consider both cultivated and uncultivated habitats. Synchrony in the species' life cycles may also be important (e.g. some fungi may require their hosts to be present at a particular stage in their life cycle for successful infection). If the organism requires more than one species (for herbivores, predators and parasites) or suitable habitat (for non-parasitic plants) to survive, develop and multiply, how widespread are these species/habitats in the Risk Assessment area?
(very rare - 0, rare - 1, occasional - 2, frequent - 3, widespread - 4)

1.19 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 risk assessment area?
Note: Other critical species made be required for growth (e.g. root symbionts), reproduction (e.g. pollinators or egg incubators, for example, certain mussel species are required by fish of the Genus Rhodeus spp.), spread (e.g. seed dispersers) and transmission (e.g. vectors).
Note: *Consider whether the species is present in the Risk Assessment area,whether it could be introduced or whether another species could be found.*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

Presence of competitors and natural enemies

1.20 How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?
Note: *Take into account both the organism's competitive ability, e.g. for plants, the extent to which it can build up monospecific stands, and the existence of strong native competitors.*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.21 How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?
Note: Consider the number of natural enemy species, their population densities, their effectiveness as herbivores (for plants) predators or parasites.
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

Management Practices

1.22 If there are differences in man's management of the environment/habitat in the Risk Assessment area from that in the area of present distribution, are they likely to aid establishment? (specify)
Note: *Factors that should be considered include time of year that the crop or aquacultural species is grown, soil preparation or drain-down regime, method of planting or stocking, irrigation or feeding, whether grown under protected conditions, surrounding crops or water bodies (i.e. general landscape features), management during the growing season, time of harvest, method of harvest, soil-water balance, fire regimes, disturbance, proximity to roads and/or human habitation, etc.*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.23 How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.24 How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?
(very rarely - 0, rarely - 1, occasionally - 2, often - 3, very often - 4)

Intrinsic attributes of the organism favouring establishment

1.25 How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?
Note: *Consider characteristics that would enable the organism to reproduce effectively in a new environment, such as parthenogenesis/self-crossing, short life cycle, number of generations per year, resting stage, high intrinsic rate of increase, self fertility, vegetative propagation, etc. (specify)*
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.26 How likely is it that the organism's capacity to spread will aid establishment?

Note: Spread includes movement by natural means and through human activity. Consider both the rapidity of spread and the potential distances covered.
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.27 How adaptable is the organism?
Note: *is the species polymorphic, with, for example, subspecies, pathotypes? Is it known to have a high mutation rate? Does it occur in a wide range of climate and habitats? Such evidence of variability may indicate that the organism has an ability to withstand environmental fluctuations, to adapt to a wider range of habitats or hosts, to develop pesticide resistance and to overcome host resistance.*
Note: useful information may be obtained from an intrinsic attributes spreadsheet if one has been prepared to answer question 8 in Section A.
(not adaptable - 0, slightly adaptable - 1, moderately adaptable - 2, adaptable - 3, very adaptable - 4)

1.28 How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?
Note: If very small populations are known to survive for long periods in an organism's current area of distribution, then such evidence may be used to answer this question
(**very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4**)

Other factors influencing the probability of establishment

1.29 How often has the organism entered and established in new areas outside its original range as a result of man's activities?
Note: *"Areas" in this question generally refers to countries, but also where there are borders within large countries. If this has happened even once before, then it is important proof that the organism has the ability to pass through most of the steps in this section (i.e. association with the pathway at origin, survival in transit, transfer to the habitat at arrival and successful establishment). If it has occurred often, then this suggests an aptitude for transfer and establishment.*
(very rarely - 0, rarely - 1, occasionally - 2, often - 3, very often - 4)

1.30 How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?

Note: some organisms can be eradicated at any time (low score), others at an early stage (medium score) and others never (high score). Similarly, outbreaks of some organisms may be difficult to find and/or delimit (high score). This question is particularly important for intentionally imported organisms that may need to be eradicated from the intended habitat as well as the unintended habitat.

(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

1.31 Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)?
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)

Summarise the Potential for Establishment

2. Spread, economic, environmental and social impact assessment

The main purpose of this section is to determine whether the entry and establishment of the organism will have unacceptable economic, environmental or social consequences. It may be possible to do this very simply if sufficient evidence is already available and unambiguous or the risk presented by the organism is widely agreed. Extreme replies to key questions may be sufficient to justify a simple and rapid decision.

Identify the species, habitats and ecosystems affected in the Risk Assessment area, noting whether wild or cultivated, outdoors or in protected environments (e.g. glasshouses). Consider these in answering the following questions. To account individually for all species, habitats and ecosystems that might be affected by the assessed species may be laborious, and it is desirable to focus the assessment as much as possible. According to the species concerned, the study of a single worst-case may be sufficient. Alternatively it may be appropriate to consider all potentially affected species, habitats and ecosystems together in answering the questions once. Only in certain circumstances will it be necessary to answer the questions by separately detailing the impacts on each species, habitat and ecosystem.

Expert judgement is used to provide an evaluation of the likely scale of impact. If precise economic evaluations are available, then details should be provided.

The replies should take account of both short-term and long-term effects and all aspects of economic, environmental and social impact. Module 4 provides advice when selecting responses to the impact questions and for quantifying impacts.

When performing a Risk Assessment on an organism that is transmitted by a vector, consider also any possible damage that the vector may cause.

Spread Potential

Spread potential is an important element in determining how fast impacts occur and how readily an organism can be contained in addition to influencing the probability of establishment (see question 1.26). In the case of species that are intentionally imported and released, the assessment of spread concerns spread from the intended habitat to an unintended habitat where the organism may establish. Further spread may then occur to other unintended habitats. Certain organisms may not cause injurious effects immediately after they establish, and in particular may only spread after a certain time. In assessing the probability of spread, this should be considered, based on evidence of such behaviour. The nature and the extent of the intended habitat and the nature and amount of the intended use in that habitat should also be taken into account when assessing the probability of spread.

2.1 How rapidly is the organism liable to spread in the Risk Assessment area by natural means?
Note: *consider the suitability of the natural and/or managed environment, potential vectors of the organism in the Risk Assessment area, and the presence of natural barriers. Spread depends on the capacity of an organism to be dispersed (e.g. wind dispersal) as well as on the quantity of organisms that can be dispersed (e.g. volume of seeds).*

(very slow - 0, slow - 1, intermediate - 2, rapid - 3, very rapid - 4)

2.2 How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?
Note: *consider the potential for movement with commodities or conveyances. As in 2.1, consider the capacity to be spread as well as the quantity that can be spread.*
Pets with a large ultimate size are more likely to be released.
(very slow - 0, slow - 1, intermediate - 2, rapid - 3, very rapid - 4)

2.3 How difficult would it be to contain the organism within the Risk Assessment area?
Note: consider the biological characteristics of the organism that might allow it to be contained in part of the Risk Assessment area; consider the practicality and costs of possible containment measures.
(very easily - 0, easily - 1, with some difficulty - 2, difficult - 3, very difficult - 4)

Conclusion regarding areas endangered by the organism

2.4 Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.

Note: The area endangered by the organism may be the entire Risk Assessment area, or parts thereof (such as nationally or internationally recognised conservation areas). It can be defined ecoclimatically, geographically, by the distribution of a critical species habitat, ecosystem or by a man-made production system (e.g. protected cultivation such as glasshouses).

Impact Assessment

Start by answering Questions 2.5 - 2.8 and 2.11 - 2.14 . If any of the responses to the principal questions 2.6 - 2.9, 2.12 and 2.14 is "massive" or "very likely", the evaluation of the other (subsidiary) questions in this section may not be necessary and you can go to 2.20 unless a detailed study is required. Module 4 (Economic Impact Assessment) provides guidance on the selection of responses to the impact questions.

In cases where the organism has already entered and is established in the Risk Assessment area, responses to questions 2.5, 2.11 and 2.13, which refer to impacts in its existing range, should be based on an assessment of current impacts in the Risk Assessment area in addition to impacts elsewhere. The other questions in this section (2.6, 2.12, 2.14 etc) ask specifically about the whole Risk Assessment Area (not just the part which it currently colonises) and responses should be based on an assessment of both current and future impacts, e.g. due to the further spread of the organism, climate change, land use change, policy changes, loss of chemical control methods etc.

Economic effects

2.5 How important is economic loss caused by the organism within its existing geographic range?
Note: Take particular note of information on economic impacts from areas where it has entered and established through human activities.
(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)

2.6 Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe)
Note: The ecological conditions in the Risk Assessment area may be adequate for the organism to survive but may not be suitable for populations to build up to levels at which significant damage is caused. Rates of growth, reproduction, longevity and mortality may all need to be taken into account to determine whether these levels are exceeded. Consider also effects on non-commercial crops, e.g. private gardens, amenity plantings.

To quantify economic effects, go to the Economic Impact Assessment Module

(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)

2.7 How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area?

(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)

2.8 How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?
Note: *consumer demand could be affected by loss in quality and/or increased prices.*

(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)

2.9 How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets? (describe) *Note*: *consider the extent of any measures likely to be imposed by trading partners.* **(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)**
2.10 How important would other economic costs resulting from introduction be? (specify) *Note: costs to the government, such as research, advice, publicity, certification schemes; costs (or benefits) to the crop protection industry.* **(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)**
Environmental effects
2.11 How important is environmental harm caused by the organism within its existing geographic range? *Note*: *effects may include: reduction of keystone species; reduction of species that are major components of ecosystems, and of endangered species; significant reduction, displacement or elimination of other native species; indirect effects on communities (species richness, biodiversity); significant effects on designated environmentally sensitive areas; significant change in ecological processes and the structure, stability or processes of an ecosystem (including further effects on plant species).* *Organisms that principally have economic effects, e.g. on crop yield or quality, may, by themselves or through control measures, also have environmental side-effects. If the main effects are already large and unacceptable, then detailed consideration of such side-effects may not be necessary.* **For a list of biological receptors, especially the UKBAP habitats, go to Module 3 (Receptor Risk Assessment)** **(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)**
2.12 How important is environmental harm likely to be in the Risk Assessment area? *See note for 2.11* **(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)**

Social effects
2.13 How important is social and other harm caused by the organism within its existing geographic range? *Note : Social impact is defined as the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs and generally cope as members of society. Includes cultural impacts involving changes to the norms, values, and beliefs that guide individual action.*[2] *Social effects may arise as a result of impacts to commercial or recreational values, life support/human health, biodiversity, aesthetics or beneficial uses. Social effects could be, for example, changing the habits of a proportion of the population (e.g. limiting the supply of a socially important food), damaging the livelihood of a proportion of the human population, affecting human use (e.g. water quality, recreational uses, tourism, animal grazing, hunting, fishing). Effects on human or animal health, water table, tourism could also be considered as appropriate by other agencies/authorities.* **(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)**
2.14 How important is the social harm likely to be in the Risk Assessment area? *See note for 2.13* **(minimal - 0, minor - 1, moderate - 2, major - 3, massive - 4)**
Genetic effects
2.15 How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious? **(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)**
Ease of and consequences for control
2.16 How probable is it that natural enemies, already present in the Risk Assessment area, will have little or no affect on populations of the organism if introduced? *Note: For plants, natural enemies include herbivores. See also response to question 1.21.* **(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)**
2.17 How easily can the organism be controlled? *Note*: *See also response to question 1.23. Difficulty of control can result from such factors as lack of effective chemical products against this organism, resistance to pesticides, occurrence of the organism in natural habitats or amenity land, simultaneous presence of more than one stage in the life cycle, absence of resistant cultivars.* **(very easily - 0, easily - 1, with some difficulty - 2, difficult - 3, very difficult - 4)**
2.18 How likely are control measures to disrupt existing biological or integrated systems for control of other organisms? **(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)**

[2] Guidelines and Principles for Social Impact Assessment. Prepared by the Interorganisational Committee on Guidelines and Principles for Social Impact Assessment. May 1994. http://www.nmfs.noaa.gov/sfa/social_impact_guide.htm

Vector/host potential

2.19 How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?
(very unlikely - 0, unlikely - 1, moderately likely - 2, likely - 3, very likely - 4)
Note: Consider the extent to which the economic, environmental and social impacts caused by the other damaging organisms will be increased by the presence of such a new food source, host, symbiont or vector.
It may be necessary to conduct separate risk assessments on the other damaging organisms, e.g. parasites and pathogens, with and without their vectors.

Refine the area endangered by the organism

2.20 Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur.

Summarise the impact assessment

For pathway/policy risk assessment

Assess the potential for entry, establishment and economic/environmental/social impacts of another organism by returning to 1.3 or stop

To summarise a pathway risk assessment based on several non-native organism risk assessments for species which might travel along the pathway:

GO TO THE PATHWAY RISK ASSESSMENT MODULE

To summarise a receptor risk assessment based on several pathway and organism risk assessments:

GO TO THE RECEPTOR RISK ASSESSMENT MODULE

Conclusion of the risk assessment

Entry

Evaluate the probability of entry and indicate the elements that make entry most likely or those that make it least likely. List the pathways in order of importance.

Establishment

Evaluate the probability of establishment, and indicate the elements that make establishment most likely or those that make it least likely.

Spread, economic, environmental and social impact

List the most important potential economic, environmental and social impacts in the Risk Assessment area. Highlight those parts of the endangered area most likely to be impacted.

Overall Conclusions of the risk assessment
The assessor should provide an overall conclusion on the level of risk (low, medium or high) based on his/her own judgement.

The scheme also generates a separate risk rating based on the responses to all the questions:
LINK TO SUMMARISING RISKS AND UNCERTAINTIES MODULE

Overall Conclusions on Uncertainty
The assessor should consider the quality and quantity of the information used to answer the questions, and give an overall judgement of the reliability of the risk assessment.

Additional information gathering activities and research to reduce the uncertainties should be listed and prioritised.

The scheme also generates a separate uncertainty rating based on the responses to all the questions:
LINK TO SUMMARISING RISKS AND UNCERTAINTIES MODULE

Risk management
The risk assessor should give an opinion as to whether the pest, pathway or pathways assessed are appropriate for the selection of management options.
Parts of this risk assessment will be needed in considering the management of the risks posed by the organism or pathway.
LINK TO RISK MANAGEMENT MODULE

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Module 1: Invasive Attributes Spreadsheet based on Pheloung *et al.* (1999)

Two spreadsheets have been prepared to help determine whether freshwater fishes and plants have intrinsic attributes that indicate that they could threaten species, habitats or ecosystems (see annex 6).

These spreadsheets should be used in Section A (Question 8) when the organism in its present range (including areas where it has spread beyond its natural range) is not known to be invasive or its invasiveness is uncertain (Question 7).

These spreadsheets should always be used for the purpose of advising policy and practice as regards the Import of Live Fish Act (ILFA) 1980 and related legislation (i.e. Prohibition of Keeping or Release of Live Fish [Specified Species] Order 1998' and [Amendment] (England) Order, 2003) for freshwater fish.

Help in the use of these spreadsheets is provided in the excel files (see Annex 6).

Module 2: Pathway Risk Assessment Module

The Pathway Risk Assessment module is designed to enhance the main UK non-native risk assessment scheme by:

- providing a rapid assessment of the risks posed by a pathway (see Section A, Question 1b).
- summarising a pathway risk assessment that is based on a large number of non-native organism risk assessments for species that might travel along the pathway (see the end of the scheme following question 2.20)
- helping assessors identify potential pathways by which non-native organisms can enter the UK (see Section B, question 1.1).

A *pathway* here means any pathway that may be used by non-native species to enter the United Kingdom.

Two pathway risk assessment examples have been prepared in Excel format:

- The human-assisted introduction of non-native fish species into the UK and between water bodies
- Ship-assisted transfer of non-native avian species between other countries and the UK.

The module is provided as:

- an Excel spreadsheet with comments to aid answering the questions.
- A list of pathway categories which may be used by non-native species to enter the UK.

Printouts of the module are given below:

I. UK Non-Native Pathway Risk Assessment Module Spreadsheet

N	QUESTION	
	Name of Pathway:	
	Authors:	
	Date:	
P1	Has a pathway been identified? **If Yes, Go to P2** **If No, Return to Main Module**	
P2	Describe the pathway including its area of origin/end point, duration and any seasonal factors **Go to P3**	
P3	What types or taxonomic groups or organisms are likely to be associated with the pathway at the area of origin? **Go to P4**	

P4	Give a score for the diversity of organisms associated with the pathway. (Low=1, medium=2, high=3) **If no organisms are associated with the pathway, return to Main Module** **Otherwise, go to P5**
P5	Is the pathway intentional or unintentional? **If intentional (but take account of unintentionally introduced organisms – see P.16) Go to P10** **If unintentional, Go to P6**
P6	How high at origin is the concentration of organisms in the pathway? (Low=1, medium=2, high=3)
P7	How likely are any organisms to gain access to the pathway undetected by inspection and testing ? (Low=1, medium=2, high=3) **If not possible for organisms to gain entry to pathway, return to Main Module** **Otherwise, go to P.8**
P8	How likely are the organisms to survive in transit due to the prevailing conditions? (Low=1, medium=2, high=3) **If survival is impossible return to Main Module** **Otherwise, go to P9**
P9	How likely are any organisms to multiply/increase in prevalence during transport /storage? (Low=1, medium=2, high=3) **Go to P10**
P10	What is the volume of movement along the pathway? (Low=1, medium=2, high=3) **Go to P11**
P11	How frequent is movement along the pathway? (Low=1, medium=2, high=3) **Go to P12**
P12	How widely are the commodities being transported to be distributed throughout the Risk Assessment area? (Low=1, medium=2, high=3) **If pathway is intentional for non-native organisms (e.g. introduction for ornamental use), go to P.16** **Otherwise, go to P.13**
P13	How likely are any non-native organisms being transported unintentionally to arrive during the months of the year most appropriate for establishment ? (Low=1, medium=2, high=3) **Go to P14**
P14	How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer of any unintentionally introduced organisms to a suitable receptor? (Low=1, medium=2, high=3) **Go to P15**

P15	For unintentionally introduced organisms, how effective are methods of containment likely to be? (Low=1, medium=2, high=3) **Go to P16**
P16	For intentionally introduced organisms, how effective are methods of containment likely to be? (Low=1, medium=2, high=3) **Refer to Receptor Module if there is any link with a particular receptor.** **Is there any possibility of non-native organisms being introduced unintentionally?** **If Yes, go to P6** **If No, go to summary of pathway assessment.**
	SUMMARISE THE RISK ASSESSMENT FOR THE PATHWAY
	REFERENCES

II. Categories Of Pathways For Entry Of Non-Native Species Into The UK

A. UNINTENTIONAL INTRODUCTIONS

1. Transported commodities in commerce/international freight

e.g. weed or invasive plant seed contaminating commercial seed and on fur of animals, parasites of fish, pets, etc.
organisms contaminating packing material, containers, etc.

1.1 Air freight
1.2 Sea freight
1.3 Eurotunnel
1.4 Mail (not generally inspected at port of entry)

2. Ballast Water, and hull fouling

3. Passenger's belongings, baggage and clothing

3.1 Air travel
- 3.1.1 Passengers
- 3.1.2 Air crew
- 3.1.3 Aircraft waste
- 3.1.4 Pets

3.2 Sea travel
- 3.2.1 Passengers
- 3.2.2 Crew
- 3.2.3 Ship's waste
- 3.2.4 Ship stores
- 3.2.5 Pets

3.3 Eurostar
- 3.3.1 Passengers
- 3.3.2 Crew

3.3.3 Waste
3.3.4 Pets

3.4 Yachting and recreational boating

3.5 Mail

4. Habitat Alteration / Canals

B. INTENTIONAL INTRODUCTIONS

5. Agriculture and horticulture

5.1 Introduced crop plants
5.2 Ornamentals and amenities species of plants

6. Aquaculture/mariculture

7. Aquarium/Ponds/Amenity water
(Plants, fishes, waterfowl, crustaceans, molluscs, etc.)

8. Forestry

9. Wildfowl and game stocking

10. Fur farming

11. Biological Control

12. Species Conservation/education

13. Research

14. Pets, collection and domestic animals (escape/release)

Notes on pathways[3]

A. Pathway category: Unintentional

1. Transported Commodities/International Freight/
Many non-native species enter the UK each year as unintentional contaminants of global trade. A variety of non-native species can contaminate agricultural produce, nursery stock, cut flowers, timber, and bulk commodities. Furthermore, plant pest species can be transported via imports of plants and plant products (Fasham & Trumper 2001). A classic example of this case was the introduction of the New Zealand Flatworm (*Arthurdendyus triangulatus*) into the UK in growing media (e.g. soil).

2. Ballast water, and hull Fouling
Ballast is the material used to maintain stability and manoeuvrability when a vessel has little or no cargo onboard. Ballast water can act as a microcosm of the larger environment

[3] Edited from From MSc Dissertation by Cayetano(2004).

and as such provides a very good mode of introduction of invasive species into the UK. The discharge of ballast water is considered a major pathway for aquatic introductions since ballast water can contain aquatic plants, animals and pathogens. More than 42 million tonnes of ballast water from foreign sources is discharged annually in British Ports; there are now 50 identified non-native marine species in British waters (Marine Conservation Society 2001). Hull fouling, a term used to refer to the way organisms can attach themselves to the hull of a ship is another pathway for introduction of non-native marine species.

4. Habitat Alteration / Canals

Man-made canals and diversions have facilitated the introduction of several fish species and probably some plants (Mills et al. 2000). Channels and canals create artificial connections between waterways and thereby facilitate free movement of species across physical barriers. They also facilitate the transportation of species by boat, ships and other vessels.

Recreational activities

Recreational boaters transport nuisance species in bait buckets or boat wells, often without realising it. Fouling of vessel hulls, including the hulls of sea or float planes, by encrusting organisms also provides a mechanism for transfer of species. Aquatic plants, in particular, are easily transported when plant fragments get tangled on boat propellers, trailers and fishing gear of recreational boats.

B. <u>Intentional introductions</u>

5. Agriculture and horticulture

Non-native plants have been used extensively for agriculture and have been responsible for many plant introductions over the years. Seeds of other plant species have been accidentally imported with crop seeds, and some crop species themselves have become established in the wild. Examples include wild oat (*Avena fatua)*, and fodder crops such as alsike clover (*Trifolium hybridum)*.

Horticulture

Many plant species have been introduced into the UK exclusively for ornamental and amenity purposes. Nelson (1994) mentioned that an estimated 55,000 non-native plant species occur in gardens in the UK. Many of these species have escaped from private garden, parks and garden centres and have established populations in the wild. Some terrestrial species namely rhododendron *Rhododendron ponticum*, giant hogweed (*Heracleum mantegazzianum)*, Japanese knotweed (*Fallopia japonica)* and Himalayan balsam (*Impatiens glandulifera)* have been introduced in this manner (RHS 2000).

6. Aquaculture/Mariculture

Aquaculture and mariculture have long been recognised as an important vector for introductions; Elton (1958) called oyster culture “the greatest agency of all that spreads marine animals to new quarters”. It is noted in Grice (1994) that 12 of the 50 wild fish species in the UK are non-native species. Holčík (1991) estimates that in Europe over 30% of introduced inland fish species originate from aquaculture. Concerns about the over-exploitation of the native fishery resource, coupled with the opportunities for profits from commercial harvesting of non-native species, have encouraged the stocking of non-native species.

7. Aquarium/Ponds/Amenity

Canadian pondweed (*Elodea canadiensus)* and Australian stonecrop (*Crassula helmsii*), are only two examples of the many invasive ornamental aquatic plants that have been introduced in the UK (CAPM)[4]. Ornamental fish species, which have established naturalised populations, include goldfish (*Carassius auratus)* and bitterling (*Rhodeus amarus)*. In addition, large-scale planting of e.g. road verges has not only commonly included non-native species, but also non-native strains of native species. Examples of the latter include oxeye daisy (*Leucanthemum vulgare)* and red clover (*Trifolium pratense)*.

8. Forestry

Forestry industry has introduced several fast-growing non-native species into the UK. This has occurred because many of the native woodland trees are slow growing. Fast growing non- native species such as European larch (*Larix deciduas)*, Norway spruce (*Picea abies)*, western hemlock (*Tsuga heterophylla)* and lodgepole pine (*Pinus contorta)* have all been introduced into the UK (Fasham & Trumper 2001)

9. Wildfowl and game stocking

According to Fasham & Trumper (2001), the UK has a long history of introducing species for sport. Past introductions have included pheasant (*Phasianus colchicus)*, red-legged partridge (*Alectoris rufa)* among others. Mammal introductions have included three deer species introduced to deer parks: sika deer (*Cervus Nippon)*, muntjac deer (*Muntiacus reevesi)* and Chinese water deer (*Hydropotes inermis)*.

10. Fur farming

Three out of the eight mammal species introduced in the 20th century American mink (*Mustela vison*, coypu (*Myocastor coypus)* and muskrat (*Ondata zibethicus*) established wild populations after escaping from fur farms (Baker 1990). Muskrat and coypu were successfully eradicated in1938 and 1989 respectively (Gosling & Baker 1989). However, mink have become a serious threat to populations of water vole (*Arvicola terrestris)* and could also be associated with the decline of native bird colonies.

11. Biological Control

Biological control involves the introduction of a predator, parasite or pathogen of a particular pest species in order to suppress the pest species population (CABI). This method is viewed as an inexpensive and environmentally safe way to control invasive species, especially when compared to mechanical control and pesticides. Non-native biological control agent have rarely been released in the wider environment in the UK.

12. Species Conservation

Introductions of non-native species for conservation purposes are conducted to provide a refuge for species that are threatened with extinction in their native habitats. Such efforts have usually resulted in introductions into refuges near native areas. When populations of the species become stable they are reintroduced back into their native habitats when it becomes suitable (Dextrase & Coscarelli 1999). Such action is usually as part of a formal recovery plan. Nonetheless the lack of competition from predators can result in an explosion of the population of the species that is being conserved. Such population growth can have a knock on effect on native species.

[4] Center for Aquatic Plant Management's website, http://www.rothamsted.bbsrc.ac.uk/pie/JonathanGrp/JonathanInformationSheets.html

13. Research / Public Display

Several non-indigenous species imported for medical diagnostic or research purposes have escaped from research facilities (OTA 1993). In the UK one such example is the Oxford ragwort (*Senecio squalidus*) which escaped from the Oxford University laboratory.

14. Pets, collection and domestic animals (escape/release)

A number of species imported as pets have established wild populations, either through deliberate release or accidental escape. Examples of mammals and birds include feral cats (*Felix catus*), sheep (*Ovis aries*), rabbits (*Oryctolagus cuniculus*), ring-necked parakeet (*Psittacula krameri*), ruddy duck (*Oxyura jamaicensis*). Reptile and amphibian introductions have included Italian crested newt (*Triturus carnifex*), fire salamander (*Salamandra salamandra*), wall lizard (*Podarcis muralis*) and the red eared terrapin (*Trachemys scripta*)

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Module 3: Receptor Risk Assessment Module

The *Receptor Module* is designed to :

- provide a rapid assessment of the vulnerability of the receptor (See Section A, Question 1c)
- help identify receptors when undertaking a detailed assessment of likely impacts (See Section B, especially Question 2.12)
- provide a list of the main UK habitat types following the UKBAP (UK Biodiversity Action Plan) and an indication of their UKBAP status.

Receptors in this module primarily refer to those species, species groups, habitats or ecosystems that are potentially vulnerable to invasive non-native species.

This module is designed for use as an add-in to the main risk assessment scheme when a vulnerable habitat, species or other receptor has already been identified in order to provide a rapid assessment of its vulnerability (See Section A, Question 1c). In this case, the assessor starts at R7 after filling in the preliminaries on the form. One example of the use of the module in this way is provided:

- oak trees and oak woodland in the UK

It can also be used to help identify receptors when undertaking a detailed assessment of likely impacts. The identification of receptors is likely to be particularly useful when assessing environmental impacts (question 2.12). In this case, the user starts with the first question (R1). One example of the use of this module in this way is provided:

- slow-flowing water courses in the UK

The module is provided as an Excel spreadsheet with comments to aid answering the questions. Embedded documents are provided to assist the identification, characterisation and description of habitats.

Printouts of the module are provided below:

I Receptor risk assessment module

	QUESTION
	Name of Receptor:
	Authors:
	Date:
	Receptor identification and characterisation
R1	Has a receptor been identified? **If Yes, describe this is in detail and go to R7** **If No, go to R2.**
R2	Has a non-native organism or group of organisms been identified as causing potential harm in the United Kingdom? **If Yes, go to R3** **If No, go to Main Module**

R3	Are any non-native organisms identified above [R2] known to inhabit similar geographical/climatic regions to the UK? **If Yes, go to R4** **If No, return to Main Module.**
R4	Can a receptor be identified from the organism(s)' autoecology (life needs, etc.)? (What Receptor type(s) does the organism normally live/utilise – both in native and naturalised/introduced regions?) **If Yes and the Receptor is a Habitat, go to R5** **If Yes and the Receptor is a Species, go to R10** **If No, return to Main Module.** **In answering subsequent questions, any important differences between types of organisms in the scoring of assessments should be given in the right-hand column. The score should reflect the highest risks identified.**
R5	Referring to 'Categories of Habitats' identify target habitat(s) in UK for any non-native organisms Which if any of the following habitats is the organism normally found/known to inhabit : Woodland, scrub or parkland Go to Part 1 Grassland 2 Tall herb or fern communities 3 Heathland 4 Wetlands including mires, bogs, springs or fens 5 Open water or swamp, marginal and inundation 6 Coastal or marine, including estuarine 7 Bare rock exposure 8 Agricultural 9 Miscellaneous (i.e. none of the above) 10 Then Part 1 Is the organism normally found in: Broad-leaved woodland go to part 1.1 Coniferous woodland go to part 1.2 Scrub go to part 1.3 (see also Urban/heath Parkland/ grassland with scattered trees go to part 1.4 (see also urban/orchards) Etc. **Go to R6**

R6	Identify and describe the receptor in terms of habitat. With the habitat characteristics of receptors defined and classified in R6, the receptor should be described in detail. For urban/human habitats in particular, reference should be made to any assessments of impact made in the 'Impact' module. Go to R7
	Identification of Non-Native Organisms and Pathways
R7	Highlight the non-native organism or organisms that may pose a risk to the receptor and the pathway or pathways whereby they may enter the area where the receptor is present. **If the Receptor is a Habitat, go to R8** **If the Receptor is one or more Species, go to R11** **If no non-native organisms or pathways are identified, Return to the UK Non-Native Risk Assessment Scheme**
	Vulnerability of receptor to harm - (i) Habitats
R8	From 'Habitat Status' identify the status of the receptor in terms of priority for protection. This list is based on the UK Biodiversity Action Plan (www.ukbap.org.uk). The status of statutory protection of particular instances of specific habitats may be found by consulting 'Local Implementation Plans' under the Action Plan for each habitat type. **Go to R9**
R9	What is the significance of ecological impact of non-native organisms in terms of habitat change or loss? Beneficial If it increases the diversity and extent of typical habitats. No Impact No change in the diversity and extent of existing habitats. Low Adverse Impact Disturbance to and/or loss of wide-spread habitat types. Moderate Adverse Impact Temporary loss of and/or disturbance to statutorily protected or scarce habitats. High Adverse Impact Permanent loss of statutorily protected or scarce habitats including habitat types that cannot be recreated. **Go to R10**

R10	Do any non-native organisms have the potential to affect (a) a priority habitat [R8] and/or (b) have adverse impacts on habitat [R9]? If answer to either (a) or (b) is Yes, then there is probability of harm = 2 If the answer to (a) and (b) is Yes, then there is probability of significant harm = 3 If the answer is No to both, there is still a need to assess risk because there is the possibility of harm to keystone species. This requires more detailed ecological analysis beyond the scope of this scheme. Record 'possibility of harm' = 1 with uncertainty factor = 3 **Go to R11**
	Vulnerability of receptor to harm - (ii) Species
R11	Is a non-native species known to cause to harm to any of the types of plant or animal in 'Potential Target Groups' (Biodiversity Action Plan species)? **If Yes, go to R12** **If No, go Summary Assessment**
R12	Describe and assess the likelihood of overall impact on target species above: Beneficial If it increases the diversity and abundance of native and/or Protected species of fauna. No Impact No change in existing diversity and abundance of native fauna. Low Adverse impacts The loss of common species of fauna. The magnitude of this loss below a level that would permanently reduce the existing population size of the species or influence ecosystem functioning. Moderate Adverse impact The loss of common species of fauna- The magnitude of this loss at a level that would permanently reduce the existing population size of the species High Adverse impact The loss of statutorily protected and/or scarce species of fauna, and/or the loss of common species of fauna at a level that would adversely affect ecosystem functioning. **Go to R13**

R13	Do any non-native species have potential to cause harm to 'Species that have Statutory Protection' in the United Kingdom? See: http://www.ukbap.org.uk/species.aspx, http://www.jncc.gov.uk/species/protect/animals.htm, http://www.jncc.gov.uk/species/protect/plants.htm **If Yes, go to R14** **If No, go to Summary Assessment**
R14	Describe and assess the likelihood of overall harm to species with Statutory Protection **Go to Summary Assessment**
	SUMMARISE THE RISK ASSESSMENT FOR THE RECEPTOR
	References

II. List Of The Main Habitats Found In The UK

The habitat classification in the scheme follows that in the UK Biodiversity Action Plan (www.ukbap.org.uk). Other international classification schemes could be used but UKBAP follows the Natura 2000 classification on which EC- driven statutory protection is based.

Habitat Type	***Other ecologically similar habitats***
1. Woodland and woody vegetation	
Broad-leaved woodland	
Coniferous woodland	
Scrub	Urban/heath
Parkland/ grassland with scattered trees	Urban/orchards
2. Grassland	
Acid grassland	
Neutral grassland	Improved grasslands
Calcareous grassland	
Agriculturally improved grassland	Agricultural
Wet or marshy grassland	Swamp/inundation/ grazing marsh
3. Tall Herb and Fern	
Bracken or fern dominated habitats	Woodland
Tall weed dominated communities	Agricultural/urban
4. Heathland	
Dry dwarf-shrub heath	Shrub
Wet dwarf-shrub heath	Shrub and Bogs
Lichen/bryophyte heath	
Montane heath/dwarf herb	
5. Wetlands	
Bog	Wet heath
Wet flushes and spring	Open water
Fens and mires	
Swamp	

Marginal and inundation land — Open water/springs

6. Open Water
Standing water (> 2 ha in diameter)
Ponds (< 2 ha in diameter)
Running water
Brackish or estuarine — Coastal

7. Coastal and marine

Intertidal habitats	Mud/sand	Estuarine
	Shingle/cobbles	Estuarine
	Boulders/rocks	Estuarine
	Seaweed communities	Estuarine
Supra tidal (above tide)	Saltmarsh	
	Sand dune	
	Maritime cliffs	
Sub tidal		

8. Bare rock exposure
Inland cliff
Scree or spoil
Limestone pavement
Cave
Quarry

9. Agricultural
Arable any cultivated/disturbed
[Possible further categorisation:
Sheltered/outdoor crops
Perennials-bushes-orchard trees/annuals/biannuals
Etc.]

Agricultural/amenity grassland	Neutral grassland
Meadows	Grassland
Hedges	Woodland/scrub
Orchards (see above)	Woodland/parkland

III. Details Of Status Of Habitats.

Habitat action plans are those defined under the UK Biodiversity Action Plan. For further details see the UK BAP webpages.

Habitat Type	Habitat Action Plan Broad Habitat Type	Habitat Action Plan Priority Habitats
Woodland		
Broad-leaved woodland	Broadleaved, mixed and yew woodland	Lowland beech and yew woodland Upland ashwoods Upland oakwoods Wet woodland
Coniferous woodland	Coniferous woodland Broadleaved, mixed and yew woodland	Native pine woodlands
Scrub		
Parkland Grassland with scattered trees		Lowland wood pasture and parkland
Grassland		
Acid grassland	Acid grassland	Lowland dry acid grassland
Neutral grassland	Neutral grassland	

Calcareous grassland	Calcareous grassland	Lowland calcareous grassland Upland calcareous grasslands
Agriculturally improved grassland	Improved grassland	
Wet or marshy grassland		Coastal and floodplain grazing marsh Purple moorgrass and rush pasture
Tall Herb and Fern		
Bracken or fern dominated habitats	Bracken	
Tall weed dominated communities		
Heathland		
Dry dwarf-shrub heath	Dwarf-shrub heath	Lowland Heathland Machair Upland Heathland
Wet dwarf-shrub heath	Dwarf-shrub heath	Lowland Heathland Upland heathland
Lichen/bryophyte heath		
Montane heath/dwarf herb	Montain habitats	
Wetlands		
Bog	Bogs	Blanket bog Lowland raised bog
Wet flushes and spring		
Fens and mires		Fens
Swamp		
Marginal and inundation		Reedbeds
Open Water		
Standing water	Standing open water and canals	Aquifer fed naturally fluctuating waterbodies Eutrophic standing water Mesotrophic lakes
Running water	Rivers and streams	Chalk rivers
Brackish or estuarine		Saline lagoons
Coastal and marine		
Intertidal mud/sand	Littoral sediment Supralittoral sediment	Mudflats Sheltered muddy gravels
Intertidal shingle/cobble	Littoral sediment Supra littoral sediment	Coastal vegetated shingle
Intertidal boulders/rocks	Littoral rock Supra littoral rock	Littoral/sublittoral chalk
Seaweed communities		
Saltmarsh		Coastal saltmarsh
Grazing marsh		Coastal and floodplain grazing marsh
Sand dune		Coastal sand dunes
Maritime cliffs		Maritime cliffs and slopes
Sub tidal	Continental shelf slope Oceanic seas Offshore shelf rock Offshore shelf sediment	Lophelia pertusa reefs Maerl beds Seagrass beds Sublittoral sands and gravels Sabellaria reefs Mud habitats in deep water

		Mediolus beds
Agricultural		
Arable	Arable and horticulture	Cereal field margins
Meadows		Lowland meadows Upland hay meadows
Agricultural/amenity grassland		
Hedges	Boundary and linear features	Ancient and/or species rich hedgerows
Orchards		
Miscellaneous		
Rock exposure	Inland rock	
Scree or spoil	Inland rock	
Limestone pavement		Limestone pavements
Cave	Inland rock	
Quarry	Inland rock	
Refuse tip		
Gardens	Built up areas and gardens Urban	
Wasteland	Urban	
Fences/walls	Boundary and linear features	
Dry ditch		
Bare earth bare ground		
Other habitat type		

Module 4: Economic Impact Assessment Module

This module provides assistance with responses to the economic impact questions (Section B, Question 2.5-2.14) by giving examples for each level of risk (minimal – massive) and likelihood (very unlikely - very likely).

Where values can be estimated, it also provides a method for quantifying impacts over time.
One quantified economic impact assessment example has been prepared in Excel format: (topmouth gudgeon, *Pseudorasbora parva).*

The following table is designed to be used in the impact section of the risk assessment scheme, particularly to assist with answering questions: 2.5 – 2.14

Table 1 Magnitude values for risks, using four subjectively equivalent dimensions.

Score	Description	Monetary loss and response costs	Health impact	Environmental impact	Social impact
1	**Minimal**	Up to £10k /yr	Local, mild, short-term, reversible effects to individuals	Local, short-term population loss, no significant ecosystem effect	No social disruption
2	**Minor**	£10k-£100k /yr	Mild short-term reversible effects to identifiable groups, localised	Some ecosystem impact, reversible changes, localised	Significant concern expressed at local level
3	**Moderate**	£100k-£1m /yr	Minor irreversible effects and/or larger numbers covered by reversible effects, localised	Measurable long-term damage to populations and ecosystem, but little spread, no extinction	Temporary changes to normal activities at local level
4	**Major**	£1m-£10m /yr	Significant irreversible effects locally or reversible effects over large area	Long-term irreversible ecosystem change, spreading beyond local area	Some permanent change of activity locally, concern expressed over wider area
5	**Massive**	£10m + /yr	Widespread, severe, long-term, irreversible health effects	Widespread, long-term population loss or extinction, affecting several species with serious ecosystem effects	Long-term social change, significant loss of employment, migration from affected area

These dimension values and definitions are proposed – not necessarily accepted. However, the concept of two 5 point scales for log likelihood and magnitude of risk are commonly accepted in risk management standards.

The descriptions Minimal to Massive convert to a log 1-5 scale and an approximate monetary value equivalent can be suggested by using one of the other three dimensions, as applicable. Some things like foot and mouth disease go well off the scale at the top end, but they are so extreme that it will be apparent they are high risk already.

This system is based on the Australia and New Zealand Risk Management Standard (*AS/NZS 4360 Risk Management*), but with some modification of the monetary values, and of the wording in the other three dimensions.

The score is based on log(upper monetary value)-3. Where a more precise monetary value is known the actual value with log-3 could be used.

Where a risk event is a single one-off loss it should be converted into an annualised value using the discount rate, as for the calculation of a discounted payment of a loan (see the PMT function in Excel) over an agreed time period. Selection of the time period has a major effect on the annual loss for single-point events.

Generally for new organism release (or pest invasion) it would be expected that the loss would be a continuing loss, and that it could increase in impact over time. If the magnitude is expected to change then an average annual value based on a net present value of the expected flow of loss/cost could be used as the base value to determine average annual loss over the proposed time period.

Where a loss calculation based on a numerical monetary formula is unworkable this system could substitute, with nominal monetary equivalence coming from equating the description with the monetary column values.

Table 2 Impact likelihoods with definitions.

Score	Description	Definition	Frequency definition
1	Very unlikely	This sort of event is theoretically possible, but is never known to have occurred and is not expected to occur	1 in 10,000 years
2	Unlikely	This sort of event has not occurred anywhere in living memory	1 in 1,000 years
3	Possible	This sort of event has occurred somewhere at least once in recent years, but not locally	1 in 100 years
4	Likely	This sort of event has happened on several occasions elsewhere, or on at least one occasion locally in recent years	1 in 10 years
5	Very likely	This sort of event happens continually and would be expected to occur	Once a year

The likelihood values are on a log scale of frequency and can be scored on a scale of 1-5.

This system is based on the Australia and New Zealand Risk Management Standard (*AS/NZS 4360 Risk Management*), but with some modification of the wording of definitions, and shifting of the frequencies related to some descriptions to make them less frequent. The Standard uses seven categories, including in addition 1/3 year and 1/30 year frequencies, which would be approximate intermediate values on a log scale between the three relatively frequent categories. Such intermediate values may be better expressed by uncertainty values for the likelihood categories, for example 50/50 for Likely/Possible rather than a definite 1/30 frequency estimate.

Where frequencies can be expressed more precisely then the 1-5 scale could be amended to include a decimal value for log(frequency)+5, so for example 4.6 for a frequency of 1/5 years.

Table 3 Level of risk, scored on a scale of 2-10 (additive for the two logged axis dimensions).

Classes		Minimal	Minor	Moderate	Major	Massive
	Uncertainty	p=.1	p=.5	p=.2	p=.15	p=.05
Very unlikely	p=.1	2	3	4	5	6
Unlikely	p=.4	3	4	5	6	7
Possible	p=.3	4	5	6	7	8
Likely	p=.2	5	6	7	8	9
Very likely	p=0	6	7	8	9	10

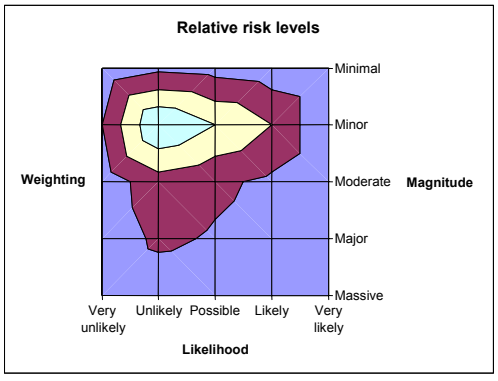
Example uncertainty levels are included for likelihood and magnitude values.

Descriptions for the values 2-10 can be used to determine risk acceptability values, as in the table below, with example descriptions of risk acceptability. "Justifiable" risk would be judged against any benefits or costs of prevention.

Table 4 Risk Acceptability Values

		Minimal	Minor	Moderate	Major	Massive
	Uncertainty	p=.1	p=.5	p=.2	p=.15	p=.05
Very unlikely	p=.1	Negligible	Negligible	Justifiable low	Justifiable low-med	Justifiable med-high
Unlikely	p=.4	Negligible	Justifiable low	Justifiable low-med	Justifiable med-high	Justifiable high
Possible	p=.3	Justifiable low	Justifiable low-med	Justifiable med-high	Justifiable high	Unacceptable
Likely	p=.2	Justifiable low-med	Justifiable med-high	Justifiable high	Unacceptable	Unacceptable
Very likely	p=0	Justifiable med-high	Justifiable high	Unacceptable	Unacceptable	Unacceptable

The uncertainty values for the individual dimensions of likelihood and magnitude can be used to express the uncertainty of the combined risk levels graphically, as seen below. This shows the extent of the uncertainty in each dimension, while focussing on the most likely outcome expected.



If estimates of the following key values can be obtained, then impacts can be quantified over time. An example of this is provided for the topmouth gudgeon (*Pseudorasbora parva*) in an accompanying spreadsheet (see Annex 6).

Key Values to be estimated when quantifying impacts
1. Area 1.1 What is the total area (or other appropriate quantity) of resource? (This should include the entire area where the resource that could be affected by the organism is present for example the total area (ha) of wheat grown in the UK or the estimated surface area of the river system (km))
1.2 What proportion of the above total is likely to be at risk from the organism? (If the spread of the organism is limited by climate or other factors the area at risk will be less than the total area)
2. Value 2.1 What is the total annual value of the resource? (Annual value may be simple to calculate if a traded commodity e.g. cereals, timber etc. If the damage is occurring to a resource that has social or other environmental value an estimate of its value e.g. the cost of replanting trees in parks or some sort of contingent value may need to be used)
2.2 What proportion of the total value of the resource is at risk? (If the organism causes a 20% reduction in yield then the figure will be 20% of the total value of the crop similarly if one in ten amenity trees are affected it will be 10% of the total value
3. Spread 3.1 How long will the organism take to spread to the entire at risk area of the resource? (If a rate of migration/spread is known an estimate of the time required to spread to the entire at risk area can be made in years)
3.2 Indicate the uncertainty of this estimate by giving a range of values. (If the rate of spread may be half this value then enter a value of 0.5 if it could be double a value of 2)
4. Control 4.1 What is (are) the cost(s) of any control action(s) that are taken in areas where the organism is endemic? **(**If the organism can be controlled by chemicals or other means use the costs available as a cost per unit area or other suitable measure)
4.2 Enter the effectiveness of the control i.e. the proportion of the damage prevented by the control action. (If the chemical control reduces the damage by 90% then a figure of 0.9 should be entered)
4 Discount rate Enter the discount rate
To calculate the potential loss for a given period the annual loss for each year of that period has to be calculated. This can be calculated using the following Loss= ((Value*Control performance)+(Area*Control cost))*(Cumulative spread) The total loss will be the sum of the losses for each of the years. However, to get a more useful indicator the Net Present Value of the losses should be calculated using the appropriate discount rate.

Module 5: Summarising Risks and Uncertainties Module

To accompany the risk assessment worksheet, three further worksheets are provided for the purpose of summarising risk. We first describe the approach that has been taken, explain the use of the worksheets, and discuss their application to four risk assessment cases studies.

1. Five-point scale. A five-point scale was selected for the assessments as it was felt by the team to provide an appropriate balance between resolution and simplicity. As discussed later, the final prognosis was presented on a three-point scale in accordance with the requirement of the tender. In different parts of the assessment the user is asked to evaluate the following attributes in response to various questions: likelihood, number, extent, frequency, speed, controllability, importance and effect. Table 1 gives an indication of the meaning of the scale points, 0 – 4, for each of these eight question types. This modifies the definitions taken from the EPPO risk assessment scheme (EPPO, in prep). The first six question types concern specific aspects of the assessment whereas the last two are more general and combine issues of extent, severity and duration. Table 1 & 2 in Module 4 give further definitions of these last two types.

Table 1. An indication of the meaning of the scale points for the eight types of question appearing in the assessment

	Scale point				
Type	0	1	2	3	4
likelihood	very unlikely	unlikely	moderately likely	likely	very likely
number	very few	few	moderate number	many	very many
extent	very rare	rare	occasional	frequent	widespread
frequency	very rarely	rarely	occasionally	often	very often
speed	very slow	slow	intermediate	rapid	very rapid
controllability	very easily	easily	with some difficulty	difficult	very difficult
importance	minimal	minor	moderate	major	massive
effect	minimal	minor	moderate	major	massive

2. Breakdown by major categories. The assessments were divided into four main categories: entry, establishment, spread and impact, comprising different numbers of individual questions: 17, 14, 4 and 16, respectively. The results are presented for each of these four categories, individually as well as for the assessment as a whole. In particular it was felt very important to separate spread and impact from the other categories. Entry and establishment essentially define how likely it is that an organism will invade. Impact and spread on the other hand define the magnitude of the effect should it do so.

3. Summarising scores. The assessments were summarised using two different methods of calculation: score summation and conditional probability. Both approaches were retained in these guidelines as both have advantages as well as short-comings and the utility of either cannot properly be assessed until a body of assessments is accumulated to allow evaluation.

3.1 Summation. Scores for each main category were summed and a risk rating, high, medium or low assigned according to whether the sum of the scores lay in the top, middle or lower third of the possible range. By summing the scores for all questions, the same procedure was used to arrive at risk rating for the assessment as a whole. The key advantage of summation is its simplicity and therefore ease of comprehension. Of concern, however, is that if we regard the sequence of scores as representing a range of probabilities, then summation (or averaging) is not the correct method to arrive at an overall value.

3.2 Conditional probability. As an alternative to summation, scores were treated explicitly as probabilities in order to derive an overall conditional probability that a species would be invasive given the set of scores attributed. As with the summation approach, a high, medium or low risk was assigned according to whether the final probability lay in the top, middle or lower third of the possible range (i.e. >0.666, 0.3334 – 0.666, <0.3334, respectively).

A number of assumptions must be introduced to order to apply probability theory. Scores were initially converted to probabilities using a conversion parameter. This defines the increment in probability terms for each score point increment. The set of starting probabilities are defined as the conditional probabilities that an organism is invasive given that it has a particular score for a particular question. Considering the relatively large number of questions in the assessment, the impact of any one question on the final outcome may be expected to be quite small; indeed a value of 0.017 was used for the conversion parameter in the case studies. The mid point of the scoring scale, i.e. 2, was taken to equate to an even probability, 0.5. Thus a score of 2 gives 0.5, a score of 3 gives 0.5 + 0.017 = 0.517 and a score of 4 gives 0.5 + 2*0.017 = 0.534 and so on. This approach effectively gives the same weight to all questions in the assessment and was used to calculate the overall risk. A correction was made in order to derive separate conditional probabilities for each of the four main categories. The conversion parameter was adjusted for the number of questions in the category otherwise a smaller range in outcomes would be possible when there were fewer questions and comparisons between the main categories would not be meaningful. Appendix 1 provides details of the calculation of the conditional probability.

4. Uncertainty. In recognition of the fact that some questions in the assessment can be answered with more certainty than others, an uncertainty rating was given for each question as well as a score. With the proviso that scores may not be less than 0 or greater than 4, the uncertainty associated with each question was rated as follows:

0 to indicate no uncertainty
1 to indicate that the score may vary by ± 1, and
2 that it may vary by ± 2

The overall uncertainty in an assessment was calculated in two ways. Firstly, by summation of the uncertainty scores (for each main category and for the assessment as a whole), and secondly using Monte Carlo simulation. The summation approach was the same as that used for the scoring itself with uncertainty being rated as high, medium or

low depending on whether the sum of the uncertainty ratings lay in the upper, middle or lower third of the possible range.

4.1 Monte Carlo simulation. To simulate the variation expected due to uncertainty, the scores used in the conditional probability calculations were allowed to vary within the range specified by their uncertainty rating. Each time a simulation was run, score values were sampled at random from within the appropriate range. Unless the uncertainty rating of all the scores is zero, no two runs of the model are the same and by observing the range of outcomes over a series of simulations, an indication of the variability in the risk rating can be obtained.

5. Author's rating of risk and uncertainty. Authors of the assessments were asked to provide risk and uncertainty ratings based directly on their judgement. These ratings may differ from those calculated from the individual scores for a variety of reasons and if differences do occur it should prompt consideration of why a discrepancy exists.

6. Description of the risk summary worksheets (Excel). Three worksheets summarise the risk assessment: 'score summary', 'graphical summary' and 'probability calculator'. Here we provide an explanation of their content and use.

6.1 Score summary. This displays three tables headed: 1. summarising scores by summation, 2. summarising uncertainties by summation and 3. summarising scores by conditional probability. The first table shows the figures used to calculate a risk rating by the method given in 3.1 above. The rating is displayed next to the authors risk rating for comparison. The last two columns in this table show the numbers of extreme scores (4's & 0's) in the assessment.

In a similar way, the second table gives the figures used to calculate the uncertainty rating (see point 4. above). Again, the calculated value is shown next to the author's rating.

The third table presents the results derived from the 'probability calculator' worksheet. The first two columns give the conditional probabilities; the values themselves, and expressed as risk ratings: high, medium or low (see point 3.2 above). The third and fourth columns give the same probabilities and ratings but with the introduction of stochastic uncertainty (see point 4.1 above). The 'Press F9' instruction at the bottom of the third column reminds users to press the F9 key in order to rerun the simulation. The final column gives the percentage deviation of the stochastic result from the deterministic result.

6.2 Graphical summary. A graphical summary is provided of the key information from the score summary worksheet. The upper graph compares the risk rating calculated by the two methods. The lower graph shows the stochastic result from the probability calculator. The user may wish to press the F9 key repeatedly to view a range of the variability in outcome expected.

6.3 Probability calculator. Columns A to G contain the conditional probability calculations (see point 3.2 above) and columns I to N the stochastic version of the same (see point 4.1 above). Rows 4 to 60 contain the calculation of probabilities for each of the main categories (entry, establishment, spread and impact) separately and rows 63 to 122 that for the assessment as whole. The theory underpinning the calculations is given in Appendix 1. Cell E2 contains the value of the score to probability conversion parameter.

7. Preliminary testing. The three risk summary worksheets described above (see points 6.1, 6.2 & 6.3 above) can be linked to any risk assessment worksheet, provided the assessment worksheet follows the specified format. To do so, the new risk assessment worksheet should be copied over the top of an existing one and the calculations in the risk summary worksheets are then automatically redone for the new assessment. The file may then be saved with a new name appropriate for the new assessment. Any missing values are recognised and omitted from the probability calculations but if errors occur it is possible that the layout of the risk assessment worksheet is wrong or that an unexpected entry is present. To check, the data for the probability calculations are taken from Columns F & G, Rows 29 to 89 on the risk assessment worksheet and these cells should contain either a number 0 to 4, a blank or the word, NULL.

The risk summary worksheets have been linked to four risk assessment case studies: topmouth gudgeon (*P. parva*), *Fallopia japonica*, Indian house Crow and *Metarhizium anisopliae* (specific strain).

The score to probability conversion parameter (3.2 above) was scaled using the data for topmouth gudgeon by adjusting the value such that an approximate match was obtained between the results from the conditional probability calculation and those obtained by summation. The objective is to scale the parameter to give a range of probability outcomes that provide a useful discrimination between high and low risk species, and fitting the parameter with the results for the other calculation method was taken as a starting point. In fact, the fitted value of 0.017 proved appropriate for the four case studies discussed here; this value should, however, be reviewed when more assessments have been done. Although the results from the two calculation methods were similar in some cases, the probability method is expected to be more informative. Clearly, it is important that the value of the conversion parameter is not changed from assessment to assessment otherwise comparisons cannot be made between species.

The discrepancies between the two modes of calculation were most marked, and of most practical significance, in the calculation of the overall risk rating (Table 2). Summation and averaging tends to under-estimate high risk and over-estimate low risk because the more middle-ranking scores (‘2’s and to some extent ‘1’s and ‘3’s) pull the overall value towards the middle or medium rating. When calculating conditional probabilities this does not happen; indeed, the overall risk rating is unaffected by the number of ‘2’s in the assessment.

Table 2. Comparison of Three Methods of Score Summation

	Risk rating calculated by:		
Case study	Author	Conditional probability	Summation
topmouth gudgeon (*P. parva*)	High	High	Medium
Fallopia japonica	High	High	High
Indian house crow	Medium	Medium	Medium
Metarhizium anisopliae (specific)	Low	Low	Medium

Table 2 shows that conditional probability gave an overall risk rating that is the same as that of the author but score summation gave medium for three out of four case studies

In all four case studies, the inclusion of uncertainty meant that the results for one or more of the four main categories straddled the boundary between low and medium or medium and high, that is, different realisations of the Monte Carlo simulation gave significantly different results. For the overall risk rating, topmouth gudgeon very occasionally fell in the medium category, Indian house crow occasionally in the high category and *Metarhizium anisopliae*, quite frequently in the medium category. The risk rating for *Fallopia japonica* was always high (at least in a fairly large series of runs of the model). The results suggest that the quantification of uncertainty in the risk assessment process may be worthwhile particularly as uncertainty can alter the final risk rating in some cases but not others.

8. Further work. The parameter used to convert scores to probabilities is effectively a weighting parameter but it has not been used in that way in this study except to correct each main category for the number of questions it contains. That way, each category has the same weight and so the relative importance of the main categories can then be compared. In calculating the overall risk rating, however, the same conversion parameter was used for all questions, otherwise unreasonable weight would be given to questions from smaller categories (e.g. spread with only 4 questions). More development work is needed both in relation to the assumptions used in the calculations, and to consider the issue that assessors may wish to deliberately give more weight to some questions than to others.

The work presented here assumes that all questions contribute to the assessment independently. In fact, there may be interactions. Some questions may be constraining such that an extreme low value makes the effects of other questions irrelevant and a low risk rating inevitable. Equally some questions may be so overriding that an extreme high value should always lead to a high risk rating even if other questions score very low. More work is needed to make a critical assessment of whether any such non-independence of questions could lead to misleading assessments.

A related issue concerns correlations between the answers to some questions. For example, a group of questions may be correlated and all score either high or low, depending on the assessment in question. The number of questions in this group is likely to have a fairly large effect on the overall rating. An ideal, but probably unrealistic goal might be an orthogonal (i.e. uncorrelated) set of questions, each weighted for importance. Consideration needs to be given to this problem when considering the general issue of question weighting.

The handling of uncertainty has so far been limited to enabling the user to gain an impression of the variability by repeated pressing of the F9 key to view the results of new realisations of the model. A more sophisticated approach would be to generate distributions of outcomes to determine the frequencies with which risk ratings would be expected to fall in the high, medium and low categories. In the case study of topmouth gudgeon discussed here, for example, the outcome might be 98% high, 2% medium, 0% low. A more elaborate approach could show uncertainty in more than one dimension. For example, it may be instructive to separate impact from the other main categories (entry, establishment & spread) and show the distribution of outcomes associated with impact separately from that associated with the other three main categories.

Appendix 1. Calculation of conditional probability

The scoring system is relative rather than absolute, and it can therefore be argued that a reasonable starting point when using a 0 to 4 scale is to define a score of '2' (the scale mid-point) to indicate that there is an equal chance that the species is, or is not, invasive. As is described later, the prior probability of an organism being invasive should be incorporated into the model. Potentially, this alters the conditional probability associated with a score of '2'. If, as seems likely, a prior probability cannot be estimated, the assessment remains relative rather than absolute.

Let the probability associated with a score of '2' be 0.5. The extent to which the probability is greater or less than 0.5 when scores are greater or less than '2' is defined by the score to probability conversion parameter. This defines the increment in probability terms for each score point increment.

We define two probabilities:

$P(s_i|v)$ = probability that risk component i is given a certain score, given that the species concerned poses an invasion risk.

$P(s_i|\neg v)$ = probability that risk component i is given a certain score, given that the species concerned does NOT pose an invasion risk.

It is assumed that $P(s|\neg v) + P(s|v) = 1$.

For each risk component, a likelihood ratio can be calculated, which can be thought of as the odds that a component will have a particular score, given that the species is invasive,

$$L(s_i \mid v) = \frac{P(s_i \mid v)}{P(s_i \mid \neg v)} \qquad (1)$$

The product of the likelihood ratios for all the components gives the combined odds that this set of scores will occur given that the species is invasive,

$$O(s_{1..n} \mid v) = \prod_{i=1}^{i=n} L(s_i \mid v) \qquad (2)$$

To obtain the odds that the species is invasive given the set of scores, it is necessary to consider the prior odds O(v) (i.e. the odds when no information is available) that a species is invasive,

$$O(v \mid s_{1..n}) = O(v)O(s_{1..n} \mid v) \qquad (3)$$

In the application of Bayes theorem to risk assessment in this way, the prior odds may not be particularly meaningful as, even if they could be calculated from a set of historical examples, they would depend on which species had been selected for investigation. The important thing is that the assessment is consistent and for a relative scoring system it is reasonable to arbitrarily set $O(v) = 1$ (i.e. that, initially, there is a nominally equal chance that the species is invasive or not).

Converting the odds (Eq. 3) back to a probability gives the final result, the conditional probability that a species is invasive given the set of scores obtained,

$$P(v \mid s_{1..n}) = \frac{O(v \mid s_{1..n})}{O(v \mid s_{1..n}) + 1} \qquad (4)$$

Module 6: UK Invasive Non-Native Species Risk Management Scheme Version 1.4[5]

Stage 3: Selection of Risk Management Options for Invasive Non-Native Species[6]

Introduction

This UK Non-Native Risk Management Scheme complements the UK Non-Native Risk Assessment Scheme (UKNNRA), by enabling the assessor to perform a structured analysis of the strategies that can be employed to minimise the risks posed by an invasive non-native species or pathway. The risk management scheme may be used to consider measures to counter **entry** (for species that are absent from the risk assessment area), **establishment** or **spread** (for species that have already entered) to prevent or minimise impacts. The risk management scheme explores options that can be instigated (i) at origin or in the exporting country, (ii) at the point of entry or (iii) within the importing country or invaded area.

Before considering the available risk management options, a judgement on the acceptability of the risk posed by the non-native organism or pathway is required. In this scheme, the methods whereby risk management options are selected differs according to whether the introduction is intentional or unintentional, whether the organism is absent or already present in the Risk Assessment area and the type of entry pathway. The options are structured so that, as far as possible, the least stringent are considered before the most expensive/disruptive. It is assumed that the measures that can be used against intentional introductions are restricted to prohibiting imports and to actions that can be taken in the importing country. Options to prevent unintentional entry on commodities with which the non-native organisms are closely associated are distinguished from options for countering natural spread/movement and pathways by which organisms may enter by chance, e.g. hitch-hiking in passenger baggage.

The scheme requires a judgement on the reliability of each potential measure identified. A reliable measure is understood to mean one that it is efficient, feasible and reproducible. Once all potential measures have been identified, the extent to which they are cost-effective and can be combined with other measures is evaluated. A species may enter by many different pathways and a pathway may transport many species. It is therefore important to repeat the process for all relevant species and pathways of concern.

Acceptability of the risk

It is for the country or region performing the invasive non-native species risk analysis to decide whether the risk from any species/pathway combination is acceptable. This decision will be based on the relationship between the level of risk identified in the UKNNRA (i.e. the combination of the probability of introduction/establishment/spread and the potential economic, environmental or social impact) and the importance/desirability of the activity that carries the risk of promoting the invasive non-native species. The acceptability of the risk should be evaluated whether the species is present or absent in an area.

3.1 Is the risk identified in the UKNNRA an acceptable risk?

If yes **For a species-initiated analysis, go to 3.37**

[5] Based on the Draft European and Mediterranean Plant Protection Organisation Risk Management Scheme.

[6] The numbering continues from the risk assessment scheme, so this is stage 3.

For a pathway-initiated analysis, go to 3.39

If no **Proceed through the risk management module as per instructions below**

Instructions for working through the risk management scheme
From the options below identify the circumstances that best describe the rationale for using the risk management scheme:

Analyses initiated by organisms
In the case of an analysis initiated by the **unintentional import** of an invasive non-native species, **go to question 3.2** and consider the different pathways on which the invasive non-native species may be carried into the Risk Assessment area. Thereafter continue with the questions concerned with the measures that might be applied to each pathway. Repeat the process for every major pathway.

In the case of an analysis initiated by the **intentional import** of an invasive non-native species, the focus should be on action preventing the establishment and spread of the organism in unintended habitats within the Risk Assessment area. **Go directly to question 3.28**. This still allows the option of prohibiting entry (3.36) to be considered. However, if the organism is also entering the area unintentionally, then action may be required to block unintentional pathways and steps 3.2-3.27 should also be followed.

Analyses initiated by pathways
In the case of an analysis initiated by the identification of a **pathway associated with the import of a commodity, Go to question 3.10** to consider possible measures and repeat the process as far as question 3.40 for each invasive non-native species identified as potentially associated with that commodity and presenting a risk to the Risk Assessment area. When all relevant invasive non-native species have been considered, go to 3.41 to integrate the measures for the commodity. Take account of all possible routes by which non-native species may join the pathway.

In the case of an analysis initiated by the identification of **other types of pathway**, **answer questions 3.2-3.9** and consider what measures can be taken to stop the invasive non-native species being carried into the Risk Assessment area. Thereafter continue with question 3.28 to consider what measures can be taken in the Risk Assessment area.

In considering your responses to the following questions, please note that helpful information may be obtained from the different UKNNRA stages e.g. entry, establishment, spread and impacts, whether the species has or has not already entered the risk assessment area.

Risks associated with major pathways

Types of pathways
This section explains how to analyse different types of pathways. The core of the risk management scheme was designed for commodities of particular plant and animal species and their products moving in international trade and coming from countries where the invasive non-native species of concern is known to occur. However, since the pathways identified in the invasive non-native species risk assessment are diverse, all possible

mechanisms need to be assessed for suitable measures. For example, pathways include the natural dispersal of a non-native organism from a neighbouring area, transport by human travellers (including illegal imports), vehicles, packing material and traded commodities other than plant and animal species and their products. It is important to prioritise the pathways according to their relative importance and to recognize that some important pathways may not currently be regulated, e.g. grain, wool, hides, sand and gravel.

3.2 Is the pathway a commodity of plant/animal species or plant/animal products?
If yes **go to 3.10**
If no **go to 3.3**

3.3 Is the pathway the natural spread of an invasive non-native species? Natural spread includes movement of the invasive non-native species by migration or dispersal, wind/water dispersal and transport by vectors such as insects or birds.
If yes **go to 3.4**
If no **go to 3.8**

3.4 Is the invasive non-native species already entering the Risk Assessment area by natural spread or likely to enter in the immediate future? (see answer to question 1.33)
If yes **go to 3.5**
If no **go to 3.37**

3.5 Could entry by natural spread be reduced or eliminated by control measures applied in the area of origin?
If yes **possible measures: control measures in the area of origin**
go to 3.6

3.6 Could the invasive non-native species be effectively contained or eradicated after entry? (see answer to question 2.8)
If yes **possible measures: internal containment and/or eradication campaign**
go to 3.7

3.7 Was the answer "yes" to either question 3.5 or question 3.6?
If yes **go to 3.37**
If no **go to 3.45**

3.8 Is the pathway the entry of the species with human travellers?
If yes **possible measures: inspection of human travellers, their luggage, publicity to enhance public awareness of invasive non-native species risks, fines or incentives. Treatments may also be possible**
Go to 3.29
If no **go to 3.9**

3.9 Is the pathway the entry of the species on contaminated machinery or vehicles?
If yes **possible measures: cleaning or**

disinfection of machinery/vehicles

For contaminated machinery, vehicles or other types of pathways (e.g. commodities other than plants or plant products, exchange of scientific material, packing material, grain, wool, hides, sand, gravel ...), not all of the following questions may be relevant. Adapt the questions to the type of pathway.

Go to 3.10

Existing measures

Existing measures (e.g. inspection, testing or treatments) may already be applied as a protection against other (regulated) species (see stage 2: question 1.10). The assessor should list these measures and identify their efficacy against the invasive non-native species being assessed. The assessor should nevertheless bear in mind that such measures could be removed in the future if other species are re-evaluated.

3.10 Are there any existing measures applied on the pathway that could prevent the introduction of the invasive non-native species

If yes **list the measures**
go to 3.11

Efficacy of possible measures for the pathway

The following questions examine the characteristics of the invasive non-native species to determine: if it can be reliably detected in consignments by inspection or testing; if it can be removed from consignments by treatment or other methods; if prescribed restrictions on the use and distribution of the commodity would prevent introduction; or if the invasive non-native species can be prevented from infecting/infesting consignments by treatment, production methods, inspection or isolation. "Reliably" should be understood to mean that a measure is efficient, feasible and reproducible. Measures can be reliable without being sufficient to reduce the risk to an acceptable level. In such cases their combination with other measures to reach the desired level of protection against the invasive non-native species should be considered (see question 3.31). When a measure is considered reliable but not sufficient, the assessor should indicate this. The efficiency, feasibility and reproducibility of the measures should be evaluated by the assessor for each potential management option identified.

<u>Options for consignments</u>

Detection of the invasive non-native species in consignments by inspection or testing

3.11 Can the invasive non-native species be reliably detected by a visual inspection of a consignment at the time of export?

If yes **possible measure: visual inspection.**

go to 3.12

3.12 Can the invasive non-native species be reliably detected by testing (e.g. for invasive non-native species plant seeds in a consignment)?

If yes **possible measure: specified testing.**

go to 3.13

3.13 Can the invasive non-native species be reliably detected during post-entry quarantine procedures?

If yes **possible measure: import under special licence/permit and post-entry quarantine procedures.**
go to 3.14

Removal of the invasive non-native species from the consignment by treatment or other procedures

3.14 Can the invasive non-native species be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

If yes **possible measure: specified treatment.**
go to 3.15

3.15 Does the invasive non-native species occur only on certain parts of the plant/animal or plant/animal products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?

If yes **possible measure: removal of parts of plant/animal or plant/animal products from the consignment**
Go to 3.16

3.16 Can infestation of the consignment be reliably prevented by handling and packing methods?

If yes **possible measure: specific handling/packing methods**

Go to 3.17

Prevention of establishment by restricting the use or distribution of the consignment

3.17 Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the Risk Assessment area, or limited periods of entry, and can such limitations be applied in practice?

If yes **possible measure: import under special licence/permit and specified restrictions:**
Go to 3.18

<u>Options for the prevention of infestation</u>
Prevention of infestation of the commodity

3.18 Can infestation of the commodity be reliably prevented by treatment before export?

If yes **possible measure: specified treatment and/or period of treatment**
Go to 3.19

3.19 For invasive non-native species that are pathogens of plants or animals can infestation of the plant or animal commodity be reliably prevented by growing/rearing resistant cultivars/strains/breeds?

If yes **possible measure: consignment should be composed of specified cultivars**
Go to 3.20

3.20 Can infestation of the commodity be reliably prevented by growing/rearing or storing in specified conditions (e.g. protected conditions, sterilized growing medium...)?

If yes **possible measure: specified growing conditions**
Go to 3.21

3.21 Can infestation of the commodity be reliably prevented by harvesting/marketing only at certain times of the year, at specific ages or growth stages?

If yes **possible measure: specified age, growth stage or time of year of harvest/marketing**
Go to 3.22

3.22 Can infestation of the commodity be reliably prevented by production in a certification/breeding scheme (e.g. official scheme for the production of healthy plants for planting)?

If yes **possible measure: certification/breeding scheme**
Go to 3.23

Establishment and maintenance of freedom of a crop/population, place of production or area from invasive non-native species

Note that in this set of questions invasive non-native species mobility is considered without prejudice to any other measure that can be recommended (e.g. production in a glasshouse may provide protection against highly mobile invasive non-native species).

3.23 Does the invasive non-native species have very low mobility[7]?

If yes **possible measures: crop/population free from invasive non-native species, or place of production free from invasive non-native species, or place of production free from invasive non-native species and appropriate buffer zone, or area free from invasive non-native species-**
go to 3.27

If no **go to 3.24**

3.24 Does the invasive non-native species have low to medium mobility?

If yes **possible measures: place of production free from invasive non-native species, or place of production free from invasive non-native**

[7] "Mobility" should be understood to mean the innate ability of the invasive non-native speciesto spread, the possibility of transportation by agents, e.g. vectors, and human transportation. It is assumed that organisms with low mobility are relatively easy to contain and vice versa.

species and appropriate buffer zone, or area free from invasive non-native species .
Go to 3.27

If no **Go to 3.25**

3.25 Does the invasive non-native species have medium mobility?

If yes **possible measures: place of production free from invasive non-native species and appropriate buffer zone, or area free from invasive non-native species.**
Go to 3.27

If no **Go to 3.26**

3.26 Does the invasive non-native species have medium to high mobility

If yes **Possible measure: area free from invasive non-native species-.**
Go to 3.27

3.27 Can the crop, place of production or an area be reliably guaranteed free from invasive non-native species?

If no **Possible measure identified in questions 3.23-3.26 would not be suitable.**
Go to 3.28

Consideration of other possible measures

3.28 Are there effective measures that could be taken in the importing country/Risk Assessment area to prevent establishment and/or economic or other impacts?
Note: For intentionally imported species, the following internal measures can be considered:

Measure
Publicity
Restriction on sale
Restriction on holding
Notification before import
Restriction on movement
Prevention of movement to specified areas
Prohibition to release in unintended habitats
Required growing/rearing conditions
Obligations to report findings
Surveillance and establishment of a contingency plan with eradication, containment and control measures as appropriate when the species is found outside its intended habitat

Note: Internal measures to prevent invasive non-native species establishment should be considered especially when no effective measures at or before import exist.

If yes **Measures available in the importing country/area**
Go to 3.29

Evaluation of possible measures

3.29 Have any measures been identified that will reduce the risk of introduction of the

invasive non-native species?

If yes **Go to 3.30**
If no **Go to 3.37**

3.30 Does each of the measures identified reduce the risk to an acceptable level?

If yes **Go to 3.33**
If no **Go to 3.31**

3.31 For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level?

Note: The integration of different measures at least two of which act independently and which cumulatively achieve an acceptable level of protection are known as Systems Approaches (e.g. ISPM 14: the use of integrated measures in a systems approach for Pest Risk Management).

If yes **Go to 3.33**
If no **Go to 3.32**

3.32 If the only measures available reduce the risk but not down to an acceptable level, such measures may still be applied, as they may at least delay the introduction of the invasive non-native species. In this case, a combination of measures at or before export and internal measures (see question 3.29) should be considered.

Go to 3.33

3.33 Estimate to what extent the measures (or combination of measures) being considered interfere with trade. It is necessary to consider the relationship between the negative effect on trade and the importance/desirability of that trade. If this analysis concerns an invasive non-native species already established in the Risk Assessment area but under official control, measures that are applied for international trade should not be more stringent than those applied domestically/internally.

Go to 3.34

3.34 Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

Go to 3.35

3.35 Have measures (or a combination of measures) been identified that reduce the risk for this pathway, do not unduly interfere with trade, are cost-effective and have no undesirable social or environmental consequences?

If yes **For pathway-initiated analysis, go to 3.39**
For invasive non-native species-initiated analysis, go to 3.37
If no **go to 3.36**

3.36 Envisage prohibiting the pathway

Note: Prohibition of a commodity import should be viewed as a measure of last resort. If prohibition of the pathway is the only measure identified for a commodity-initiated analysis, there will be no need to analyse any other invasive non-native species that may be carried on the pathway. If later information shows that prohibition is not the only measure for this invasive non-native species, analysis of

the other invasive non-native species associated with the pathway will become necessary.

If yes **For pathway-initiated analysis, go to 3.43**
If no **For invasive non-native species-initiated analysis go to 3.36**

3.37 Have all major pathways been analyzed (for an invasive non-native species-initiated analysis)?

If yes **go to 3.38**
If no **go to 3.1 to analyze the next major pathway**

3.38 Is the risk for all the pathways considered to be acceptable?

If yes **no further action is necessary**
If no **go to 3.42**

3.39 Have all the invasive non-native species been analyzed (for a pathway-initiated analysis)?

If yes **go to 3.40**
If no **go to 3.1 (to analyze next invasive non-native species)**

3.40 Is the risk for all the invasive non-native species considered to be acceptable?

If yes **no further action is necessary**
If no **go to 3.41**

3.41 For a pathway-initiated analysis, compare the measures appropriate for all the invasive non-native species identified for the pathway that would qualify as regulated species, and select only those that provide security against all the species. The minimum effective measures appropriate for the pathway as a whole will be the minimum measures required to counteract the species that is judged to be the most dangerous.

Go to 3.43

3.42 Indicate the relative importance of pathways

Note: the relative importance of the pathways is a key element to consider when formulating regulations.

Go to 3.43

3.43 All the measures identified as being appropriate for each pathway can be considered for inclusion in regulations in order to offer a package of potential measures. In the interests of trade and cost effectiveness, the general principle should be to apply the least stringent measure (or measures) capable of performing the task adequately. Thus, if inspection is truly reliable, it should not be necessary to consider treatment or testing. Note that some measures may counteract each other; for example the requirement for resistant cultivars may make detection more difficult. It may be that some or all of these measures are already being applied to protect against one or more other invasive non-native species, in which case such measures need only be applied if the other invasive non-native species is/are later withdrawn from the regulations.

The minimum measure applied to any invasive non-native species is the declaration in regulations that it is regulated. This declaration prohibits both the entry of the invasive non-native species in an isolated state, and the import of consignments infested by the invasive non-native species. If other measures are decided upon, they should accompany the

declaration as a regulated species. Such declaration may occasionally be applied alone, especially: (1) when the invasive non-native species concerned may be easily detected by inspection at import (i.e. general visual inspection or targeted inspection; see questions 12 and 13), (2) where the risk of the invasive non-native species introduction is low because it occurs infrequently in trade or its biological capacity for establishment is low, or (3) if it is not possible or desirable to regulate all trade on which the invasive non-native species is likely to be found. The measure may have the effect of providing the legal basis for action on detection of the invasive non-native species (or also for eradication and other internal measures), informing trading partners that the invasive non-native species is not acceptable, alerting inspectors to its possible presence in imported consignments, and sometimes also of requiring farmers, horticulturists, foresters, land managers, conservation organisations and the general public to report any outbreaks.

go to 3.44

3.44 In addition to the measure(s) selected to be applied by the exporting country, plant health regulations may require a phytosanitary certificate (PC) for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed.

go to 3.45

3.45 If there are no measures that reduce the risk for a pathway, or if the only effective measures unduly interfere with trade (e.g. prohibition) or are not cost-effective or have undesirable social or environmental consequences, then the conclusion of the invasive non-native species risk management stage may be that introduction cannot be prevented.

Conclusion of invasive non-native species Risk Management.
Summarize the conclusions of the invasive non-native species Risk Management stage. List all potential management options and indicate their effectiveness.

Monitoring and review
Performance of measure(s) should be monitored to ensure that the aim is being achieved. This is often carried out by inspection of the commodity on arrival, noting any detection in consignments or any entries of the invasive non-native species to the Risk Assessment area.
Periodically review the information supporting the invasive non-native species risk assessment to ensure that any new information that becomes available does not invalidate the decision taken.

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Defra Contract Tender CR0293:

Standard Methodology to Assess the Risks from Non-Native Species Considered Possible Problems to the Environment

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Annex 2: Glossary

Taken from Annex 4 of the Defra Non-Native Review (Defra, 2003)

Alien species: see "non-native species". "Alien species" is the equivalent term to "non-native species" used by the Convention on Biological Diversity. The term "invasive alien species" is therefore equivalent to "invasive non-native species".

Establishment: refers to the process of a non-native species in a new habitat successfully producing viable offspring with the likelihood of continued survival.

Hitch-hikers: organisms that disperse in association with other species, for example, through being attached to the outside of plants or animals.

Introduction: the deliberate or accidental release of an organism(s) into the wild in areas (*e.g.* country, region, site, *etc.*) where the species or race is not native. This movement can be either within a country or between countries or areas beyond national jurisdiction. Intentional and unintentional introductions are further explained below.

Intentional introductions: refers to the deliberate movement and/or release by humans of a non-native species outside its natural range.

Invasive non-native species means a non-native species whose introduction and/or spread threatens biological diversity. This is interpreted broadly to include threats to the entire ecosystem including human interests (*e.g.* including threats to public health and financial damage).

Native species: A species or race that occurs naturally in an area, in this case Great Britain. Often this is qualified by the addition of a cut-off date (*e.g.* since 1600).

Non-native species: refers to a species, subspecies or lower taxon, introduced (*i.e.* by human action) outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.

Risk analysis: in the field of non-native species issues, the process whereby the chances of a particular non-native species causing problems after introduction to a country are assessed, based upon previous knowledge of the behaviour of the species and its relatives in its native range and after any introductions carried out elsewhere. The CBD defines this as referring 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.

Unintentional introductions: the introduction of non-native species as the accidental or incidental consequence of human activities. This is not the same as introductions deriving from natural dispersal processes, although for some species it may be hard to distinguish unintentional introductions from natural colonisation events.

Additional References

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Annex 3 Sample UK Non-Native Risk Assessments

Species	Taxon-Habitat	Teams	Absent	Very Rare	Limited Distribution	Wides-pread	Intentional Release	In Manual ?
Giant hogweed *Heracleum mantegazzianum*	Terrestrial Plants	CEH - CABI				√		
Himalayan balsam *Impatiens glandulifera*	Terrestrial Plants	CEH - CABI				√	√	
Japanese knotweed *Fallopia japonica*	Terrestrial Plants	CEH - CABI				√	√	**YES**
Water fern *Azolla filiculoides*	Aquatic Plants	CABI - CEH				√ (not Scotland)	√	
Australian swamp stonecrop *Crassula helmsii*	Aquatic Plants	CABI - CEH				√	√	
Floating pennywort *Hydrocotyle ranunculoides*	Aquatic Plants	CABI - CEH			√		√	
Parrot's feather *Myriophyllum aquaticum*	Aquatic Plants	CABI - CEH				√ (not Scotland)	√	
Curly waterweed *Lagarosiphon major*	Aquatic Plants	CABI - CEH				√	√	
New Zealand flatworm *Arthurdendyus triangulatus*	Terrestrial Invertebrates	CSL - IC				√ (rare England & Wales)		
Western corn rootworm *Diabrotica virgifera virgifera*	Terrestrial Invertebrates	CSL - IC		√				
Asian longhorn beetle *Anoplophora glabripennis*	Terrestrial Invertebrates	CSL - IC	√					
Small hive beetle *Aethina tumida*	Terrestrial Invertebrates	CSL - IC	√					
Chrysanthemum stem necrosis virus	Plant pathogens	CSL - CABI	√					
Rabies Lyssa Virus	Terrestrial vertebrate pathogen	CSL - IC	√					
An insect fungal pathogen *Metarhizium anisopliae*	Terrestrial invertebrate pathogen	IC - CSL	√				√	**YES** No risk

Annex 3 (Continued) Sample UK Non-Native Risk Assessments								
Species	**Taxon-Habitat**	**Teams**	**Absent**	**Very Rare**	**Limited Distribution**	**Wides-pread**	**Intentional Release**	**In Manual ?**
An insect fungal pathogen *Metarhizium anisopliae* var. *Acridum*	Terrestrial invertebrate pathogen	IC - CSL	√				√	No risk
A salmon parasite *Gyrodactylus salaris*	Aquatic vertebrate pathogen	CEFAS - CEH	√					
Crayfish plague *Aphanomyces astaci*	Aquatic invertebrate pathogen	CEFAS - CEH			√**?**			
Topmouth gudgeon *Pseudorasbora parva*	Freshwater Fish	CEFAS - CEH			√			**YES**
Blageon *Leuciscus souffia*	Freshwater Fish	CEFAS - CEH	√					No risk
Sunbleak *Leucaspius delineatus*	Freshwater Fish	CEFAS - CEH			√			
Northern redbelly dace *Phoxinus eos*	Freshwater Fish	CEFAS - CEH	√					No risk
Fathead minnow *Pimephales promelas*	Freshwater Fish	CEFAS - CEH	√ in the wild					
Rainbow trout *Oncorhynchus mykiss*	Freshwater Fish	CEFAS - CEH				√	√	
Wels catfish *Siluris glanis*	Freshwater Fish	CEFAS - CEH				√	√	
Ring-necked parakeet, *Psittacula krameri*	Birds	CSL - CEH			√			
Indian house crow *Corvus splendens*	Birds	CSL - CEH	√					**YES**
American mink *Mustela vison*	Mammals	CSL – CEH				√		
Wild boar *Sus scrofa*	Mammals	CSL - CEH		√				
Skunk *Mephitis mephitis*	Mammals	CSL - CEH	√					
A whitefly parasitoid *Eretmocerus eremicus*	Biocontrol agents	IC - CABI				√	√	No risk

Annex 3 (Continued) Sample UK Non-Native Risk Assessments								
Species	**Taxon-Habitat**	**Teams**	**Absent**	**Very Rare**	**Limited Distribution**	**Wides-pread**	**Intentional Release**	**In Manual?**
A predatory bug *Macrolophus caliginosus*	Biocontrol agents	IC - CABI	√				√	
A predatory mite *Amblyseius cucumeris*	Biocontrol agents	IC - CABI				√	√	

Annex 4: Gaps and Areas for Future Work identified by the Consortium

Risk Assessment

(enhancements of user-friendliness and further extensions are listed under the Electronic Toolkit section below, see also Annex 5)

- Additional examples of best practice required for all taxon/habitat combinations

Pathway Risk Assessment

- Additional examples required for all pathway types
- Provide a system for prioritising pathways in order of importance

Receptor Risk Assessment

- Additional examples required covering a wider range of organisms, habitats and ecosystems
- Extend the receptor risk assessment scheme to other sectors, e.g. tourism, social impacts
- Provide a system for prioritising receptors in order of importance

Impact Assessment

- Additional examples required
- Allow the costs of control and other drivers, e.g. climate change, to vary over time.
- Study retrospective examples, e.g. Dutch elm disease, to clarify how risks change over time.
- Enhancement of environmental (and social) impact analysis, giving guidance on how to value environmental resources
- Give more guidance for non-quantitative methods, e.g. with a “pick list” of the impacts to be expected at the five levels of severity.

Summarising Risk

- Greater clarification of the most appropriate methods for analysing qualitative/quantitative risk scores and uncertainty responses and their presentation to risk managers
- Enhancement of the ability to prioritise risk based on the production and comparison of many risk assessments
- Providing the ability to plot a species risk assessment on a graph with impacts on the x-axis and the probability of entry/establishment on the y-axis so that the risks posed by different species can be visualised together and uncertainties visualised as error bars
- Validation of the methods used, e.g. conduct a risk assessment for *Fallopia japonica* based on information available in 1960.

Electronic Toolkit

- General help for each question, aiding understanding of how it is to be interpreted
- Help and examples on specific taxon, habitat, pathway, and receptor level.
- Examples on each of the five levels of response and three levels of uncertainty to guide the assessor and help to ensure consistency
- A diagram showing where you are in the process when tackling each question
- Automatic links to related questions where key factors are relevant to both

- Automatic links to useful databases / other sources of information eg identification tools, monitoring and surveillance schemes such as the National Biodiversity Network
- Enhancement of the impact quantification module, and creation of other modules, e.g. To model the impact of climate change
- Allow the importation of other files from word or excel
- Allow the storage of completed risk assessments in a database to allow easy retrieval to enable comparisons and ranking of species, pathways and receptors
- Generate scores for each species, and classify them into a low, medium, high rating
- Capability of producing a report in electronic and hard copy format.

Risk Management

- Provide examples of best practice for intentional & unintentional introductions
- Provide links to the risk assessment scheme
- Explore the extent to which risk management options can be generated automatically from a risk assessment
- Provide methods for prioritising management action.

Annex 5: Specification for an Electronic Toolkit

1. Introduction

During the project, it became clear that Microsoft Word provides a poor template both for the risk assessor to enter responses to the questions in the scheme and for those reading the outputs. As a result, the Consortium constructed a simple electronic toolkit prototype in Microsoft Excel. This provides all the elements of the risk assessment scheme including all the questions. Notes and guidance are available in comment fields and can be read by placing the mouse over each question. The short responses can be selected from drop-down lists and additional information is entered in a separate cell. Links to other modules are provided and the score summaries are available in separate worksheets. Once the risk assessment has been completed, it can be printed out in a concise clear format which is easy to read and interpret.

Although this Excel template is a major advance in providing risk assessments for non-native organisms in a form that is straight-forward for the assessor and the reader, we have identified a number of ways in which an additional project could enhance its functionality and user-friendliness. In summary, these would provide:

- General help for each question, aiding understanding of how it is to be interpreted
- Help and examples on specific taxon, habitat, pathway, and receptor level.
- Examples on each of the five levels of response and three levels of uncertainty to guide the assessor and help to ensure consistency
- A diagram showing where you are in the process when tackling each question
- Automatic links to related questions where key factors are relevant to both
- Automatic links to useful databases / other sources of information e.g. Identification tools, monitoring and surveillance schemes such as the nbn
- Enhancement of the impact quantification module, and creation of other modules, e.g. To model the impact of climate change
- Allow the importation of other files from word or excel
- Allow the storage of completed risk assessments in a database to allow easy retrieval to enable comparisons and ranking of species, pathways and receptors
- Generate scores for each species, and classify them into a low, medium, high rating
- Capability of producing a report in electronic and hard copy format.

During the project, a variety of techniques were explored. These are described below.

2. Scope

2.1 The specification is based on the requirements for:

(a) graphical presentation of risk assessment scheme(s) to provide an overall view of the scheme, to indicate cross linkages and external information sources and guides and to allow the scheme to be modified without disturbing its integrity.

The project developed the use of ‘Mind Mapping’ with proprietary software (*MindManager X5 Pro* from MindJet). Many of the specifications for the toolkit follow features provide by *MindManager*, but this does not preclude use of other proprietary or custom-written software, nor does it preclude other approaches than MindMapping.

(b) tabular presentation of the risk assessments, the risk ratings and the risk summaries (qualitative and quantitative).

The toolkit should allow computation of final risk ratings from the scores to individual elements/questions in the scheme with provision for the expression of uncertainty and extreme values. The methods of risk summation adopted in the development of the scheme are further described and illustrated in Module 5.

The table could be in a word processing form (e.g. Microsoft Word table) but a spreadsheet is preferable since it provides a more powerful means of computation. *Microsoft Excel XP* is used to illustrate the specifications without prejudice to the software to be used or written for the toolkit.

2.2 It is envisaged that the spreadsheet will be generated by the graphical scheme. This was accomplished with *MindManager* using an add-in program (*Mind Plugs Excel Add-in*[8]) but the spreadsheet generated is not suitable for use in the toolkit without modification.

2.3 The spreadsheet may contain graphical elements to indicate to the user where he/she is in scheme and there should be provision for embedding source documents (e.g. working of Pheloung scheme for fish, amphibia, marine invertebrates, etc., which themselves require conversion into purpose-built electronic tools).

2.4 The Mind Maps accompanying this document in partial illustration of the specification for the toolkit may be read and printed (but not altered) using the free downloadable *MindManager Viewer*. This is available from www.mindjet.co.uk.

3. Approaches to the production of the toolkit

3.1 In relation to remarks made in 2.1., several approaches could be taken to produce the toolkit specified here:

- Using and adapting existing proprietary software as described. This may involve built-in customisation/programming functionality, e.g. Visual Basic with Excel and MindManager X5 Pro's script programming with XML, particularly to generate spreadsheets.
- Using other proprietary software for the graphical approach
- Adopting a database-driven method of generating the assessments in tabular form.
- Commissioning custom-written software according to the toolkit specification

3.2 Outputs from the toolkit (e.g. maps, spreadsheets) should be usable without purchase of software (e.g. as stand-alone Microsoft Access® modules), i.e. should be compatible with universally available Microsoft Office software or readable with software or available supplied free to users.

4. Graphical presentation of scheme

4.1 Required functions/capability

8 http://www.iaresearch.com/store/Products/Mindplugs/MindManager%20X5%20to%20Excel%20Export%20Addin.htm

The system should present the structure of the scheme taking account hierarchical relationships of questions

- The scheme should be presented as a flowchart with links/jumps between one question and the next (with options as necessary)
- Linkages between related questions should be indicated where key factors relevant to current question
- The scheme should be easily modified or extended by allowing:
    - Questions to be developed by splitting into sub-questions as necessary, e.g. By adding branches or sub-branches in the mind map. (see transparency below);
    - Questions to be modified, deleted or added without affecting the overall structure;
    - Redundancy or overlap between questions to be assessed.
- The system should include aids to decision making such as:
    - Notes to assist with assessment of risk and uncertainty rating (ultimately to appear as Comments in the spreadsheet);
    - Lists of habitats and species and additional data.
    - Links to databases of existing risk assessments
- The system should adopt the doctrine of *transparency* in the actual risk assessments:
    - When necessary a question can be split to indicate how the answer is obtained.
    - Providing links to or embedding files containing data for a specific risk assessment– Word documents, database files, spreadsheet files.
    - As well as the risk rating (0 – 4 scale), there should be a written answer to each question in explanation of the score.

4.2 Illustration of the required functionality using Mind Maps.

4.2.1 An example Mind Map of the quantitative part of the risk assessment scheme illustrates the specifications described in 2.1. (N.B. This shows an intermediate version of the risk assessment scheme for illustrative purposes only). The Mind Map may be read with the free downloadable *MindManager Viewer* available from www.mindjet.co.uk.

Example Stage 2B (2).mmap

4.2.2 Questions as branches at progressively lower levels

- The file has 'Probability of entry and establishment' and 'Spread, economic, environmental and social impact assessment' as two main branches. Questions in each part are formed as lower order branches.
- Selected branches at different levels can be hidden or revealed by clicking on (-) or (+) as appropriate at the branch nodes.
- The scheme can be revealed and understood branch by branch in 'Presentation mode' ('Modes' function at the extreme right of the main toolbar)

4.2.3 The main sections of the risk assessments can be labelled with 'Callouts' ('cartoon balloons' – different shapes may be selected)

4.2.4 In this example, notes accompanying each question are presented as 'Comments'. Passing the cursor over the Note icon reveals the Comment. If the note is long, it may be revealed in full by a mouse click.

4.2.5 Hyperlinks are provided to :

other parts of same map in a flow chart simulation (Go to *n*)

other maps/schemes (Go to *n*), e.g. Pathway module
sources of information and data required for *Transparency*
4.2.6 External Microsoft Office documents may be embedded (with appropriate icon). This is illustrated at Question 2.5.
4.2.7 Output to Excel spreadsheet. With an add-in, the scheme may be exported to Excel (see 1.1.2). With this functionality:

- Notes as 'Comments' may appear as Excel 'Comments' or as a separate column
- *Written assessments and risk and uncertainty ratings, etc. could be added at Map stage or at Spreadsheet stage. In the former, separate columns are created for the data.

4.2.8 Maps created with MindManager may be output as web pages (html) although this functionality is probably not relevant for this toolkit.

5. Spreadsheets generated directly from the graphical presentation

5.1 The example spreadsheet presented here was generated by the Excel Add-in (2.2) obtained during the project. Redundant columns from this proprietary software have been removed and column headings have been rewritten. The objective of this format is the **clear communication of the risk**.

"mindmanager2excel example.xls"

5.2 The following specifications are illustrated:
5.2.1 Columns to record the written assessments and to record ratings for risk, uncertainty, etc.
5.2.2 Comments in Mind Map are recorded as Excel Comments (revealed by cursor)
5.2.3 Rows to record risk summaries
5.2.4 Built-in calculations for summation of risk. The methods adopted in the development of the scheme are illustrated in the example of risk summation for topmouth gudgeon (*Pseudorasbora parva*)[9]. The methods provide:

- risk scores according to the five-point scale adopted in the main scheme broken down according to categories of risk (entry, establishment, spread and impacts)
- records of extreme scores, etc.
- comparison of risk summaries according to:
    - authors risk ratings;
    - simple summations; and
    - calculation of conditional probabilities (Bayesian theory)

A full description is provided in *Summarising Risk* in the **User Manual**.

5.2.5 Embedded or hyperlinked documents (illustrated here for Question 2.5)[10]
5.2.6 Selected parts of the Mind Map included as images to help the assessment. (Illustrated here for economic effects).[3]

[9] To read this file with full functionality, Microsoft Excel should be configured with the following Add-Ins in the *Tools Menu*: Data Analysis Toolpak, Data Analysis Toolpak – VBA.
[10] This feature was not generated automatically by the Excel Add-in.

5.2.7 The Excel Add-in used here also allows the hierarchy of the questions/branches to be hidden or revealed. (This may not be very useful for the toolkit.)

Annex 6: Full list of Excel files required to use the UK Non-Native Risk Assessment Scheme and to read the examples of best practice

N.	Description	File Name.xls
1	The main UK Non-Native Risk Assessment Scheme (UKNNRA)	uknnra template.xls
2	Example of the UKNNRA for Japanese knotweed (*Fallopia japonica)*	uknnra fallopiajaponica.xls
3	Example of the UKNNRA for topmouth gudgeon (*Pseudorasbora parva)*	uknnra topmouthgudgeon.xls
4	Example of the UKNNRA for Indian house crow (*Corvus splendens)*	uknnra indianhousecrow.xls
5	Example of the UKNNRA for an insect fungal pathogen (*Metarhizium anisopliae)*	uknnra metarhizium.xls
6	Invasive Attributes Spreadsheet, based on Pheloung *et al.* (1999), for fish	Fish pheloung spreadsheet topmouthgudgeon.xls
7	Invasive Attributes Spreadsheet, based on Pheloung *et al.* (1999), for UK plants	UK plant pheloung spreadsheet.xls
8	Pathway Risk Assessment Module	pathway risk template.xls
9	Pathway Risk Assessment Module example: The human-assisted introduction of non-native fish species into the UK and between water bodies	pathway ornamental fish.xls
10	Pathway Risk Assessment Module example: Ship-assisted transfer of non-native avian species between other countries and the UK.	pathway birds on ships.xls
11	Receptor Risk Assessment Module	receptor risk template.xls
12	Receptor Risk Assessment Module example: Oak trees and oak woodland	receptor oaktrees.xls
13	Receptor Risk Assessment Module example: Slow flowing watercourses	receptor slowflowing waters.xls
14	Economic Impact Assessment Module	economic risk template.xls
15	Economic Impact Assessment Module example: topmouth gudgeon (*Pseudorasbora parva)*	economic risk TopmouthGudgeon.xls
16	Summarising Risks and Uncertainties Module	uknnra template.xls
17	Summarising Risks and Uncertainties Module example: Japanese knotweed (*Fallopia japonica)*	uknnra fallopiajaponica.xls
18	Summarising Risks and Uncertainties Module example: topmouth gudgeon (*Pseudorasbora parva)*	uknnra topmouthgudgeon.xls
19	Summarising Risks and Uncertainties Module example: Indian house crow (*Corvus splendens)*	uknnra indianhousecrow.xls
20	Summarising Risks and Uncertainties Module example: An insect fungal pathogen (*Metarhizium anisopliae)*	uknnra metarhizium.xls