Framework and guidelines for conducting risk analyses under the NEM: BA Alien and Invasive Species Regulations of 2014

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Summary

This report presents a framework for analysing the risk of alien taxa under the NEM:BA Alien and Invasive Species Regulations of 2014. In outlining a series of questions related to a taxon's likelihood of invasion and the consequences thereof, i.e. the potential impacts, the report provides a structure for collating data relevant to the process of listing taxa as well as a process for developing recommendations.

Introduction

Species are being moved around the world by humans (both accidentally and deliberately) in increasing numbers, and in new ways. When introduced to new biogeographical regions, some of these alien taxa establish and spread without further human assistance (i.e. they become invasive). While many alien taxa are highly beneficial, some alien taxa can have significant negative impacts on the recipient environment and socio-economy. In order to deal with such undesirable consequences and to mitigate future impacts, frameworks for the regulation of alien taxa have been developed all over the world. Such regulations often include lists of species for which certain activities are prohibited or restricted. Decisions on these lists require a scientific analysis of risk.

The process of risk analysis is composed of risk assessment, risk management, and risk communication. In the context of alien taxa: risk assessment consists of the likelihood and consequences of a given alien taxon causing negative impacts; risk management deals with options to reduce the risk including within the context of potential benefits; and finally risk communication is about how the information is made accessible (see Annexure 1 for a glossary).

The purpose of this report is to present a framework for the analysis of the risks associated with alien taxa and to provide a structure for collating evidence for listing alien taxa. The report aims to ensure that this process is done in a transparent and repeatable manner that aligns with national and international agreements, policies and best practices.

The risk analysis framework presented here is specifically designed for the purpose of listing alien species under the regulatory framework of the National Environmental Management: Biodiversity Act (NEMBA, Act 10 of 2004) Alien and Invasive Species Regulations (Department of Environmental Affairs 2014). The regulations prescribe specific management actions and require cognisance of the benefits to stakeholders. While the risk analysis concepts are imbedded in various scientific literature, we present the applicability and guidance of a practical framework. We also provide guidance on risk scoring (how to assess each point) and determining a confidence score (how confident you are in giving a specific score).

Structure of the framework

The framework is divided into five sections: 1) *Background* (BAC) provides information on the assessor, the taxon under consideration and information needed to analyse the risk; 2) *Likelihood* (LIK) assesses biological, ecological and behavioural traits of the taxon that could lead to its arrival, establishment and spread; 3) *Consequences* (IMP) include the recorded and likely impacts of the taxon; 4) *Risk management* (MAN) includes questions related to the ability to control a taxon in the context of whether the taxon is beneficial in some situations and results in a recommendations for listing taxa; 5) *Reporting* provides guidance on how to communicate the outcomes of the analysis. Section 2) and 3) together form the Risk assessment, and 4) includes Risk management considerations. All the sections together form the Risk analysis (Figure 1, Table 1).

Figure 1. A schematic of the risk analysis framework described here. For each chapter there are a number of questions (see Table 1).

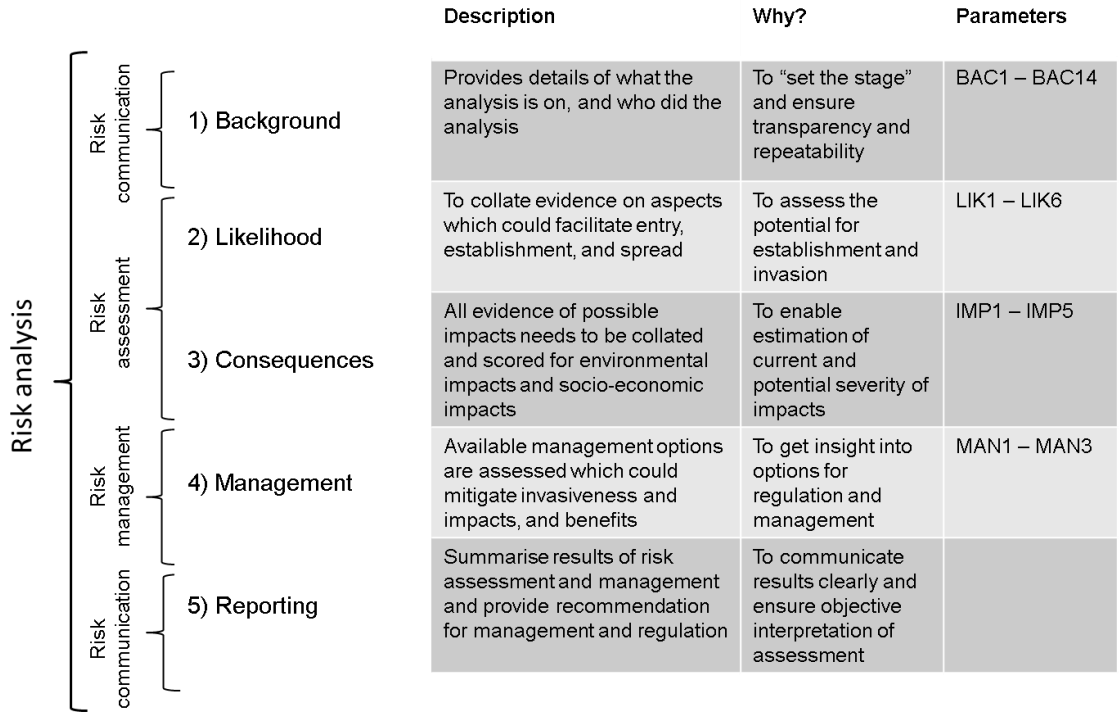

Table 1. A list of questions as part of the risk analysis.

Parameter	Question	Definition and purpose
BAC1	Name of assessor(s)	To identify the person who performed the assessment
BAC2	Contact details of assessor(s)	For means of contacting the assessors in case of questions, further information required, or if the assessment needs revision
BAC3	Name(s) and contact details of expert(s) consulted	Identifies experts which were consulted
BAC4	Scientific name of *Taxon* under assessment	Gives information on the species, sub-species, variety, genus, or other taxonomic entity under assessment
BAC5	Synonym(s) considered	Information on which synonyms were considered for the assessment
BAC6	Common name(s) considered	Information on which common names were considered for the assessment
BAC7	What is the native range of the *Taxon*?	Information on the distribution range of the taxon is I Important for the assessment as the framework is designed for alien species specifically
BAC8	What is the global alien range of the *Taxon*?	This is crucial as for some questions, only information in the alien range is considered
BAC9	Geographic scope = the *Area* under consideration	Delimits the assessment area
BAC10	Is the *Taxon* present in the *Area*?	Crucial for management recommendations (e.g., prevention vs. control)

Parameter	Question	Definition and purpose
BAC11	Availability of physical specimen	To link the identification of the taxon to a physical sample, i.e. so that in the future if need be it will be possible to determine what the *Taxon's* identity was compared to at the initial identification. I.e. if it turns out in future that the identification could be wrong, we need to be able to understand why it was identified as that particular *Taxon*
BAC12	Is the *Taxon* native to the *Area* or part of the *Area*?	Important for management as this framework only deals with alien species
BAC13	What is the *Taxon's* introduction status in the *Area*?	Can aid management decisions
BAC14	Primary (introduction) pathways	This information will be used to answer questions on likelihood of entry
LIK1	Likelihood of entry via unaided primary pathways	The probability of the T*axon* to arrive and enter an area without human assistance
LIK2	Likelihood of entry via human aided primary pathways	The probability of the *Taxon* to arrive and enter an area human aided
LIK3	Habitat suitability	Forms part of the likelihood of a *Taxon* to establish
LIK4	Climate suitability	Forms part of the likelihood of establishment
LIK5	Unaided secondary (dispersal) pathways	Assesses spread potential
LIK6	Human aided secondary (dispersal) pathways	Assesses spread potential aided by humans
IMP1	Environmental impact	Includes impacts caused by the *Taxon* on the environment through different mechanisms
IMP2	Socio-economic impact	Includes impacts caused by the *Taxon* on different socio-economic sectors
*IMP3	Closely related species' environmental impact	If no data on the *Taxon* itself is available, this includes impacts caused by related taxa on the environment through different mechanisms
*IMP4	Closely related species' socio-economic impact	If no data on the *Taxon* itself is available, this includes impacts caused by related taxa on different socio-economic sectors
IMP5	Potential impact	Assesses the potential impact of the T*axon* in the A*rea* if invasive
#MAN1	What is the feasibility of stopping future immigration?	Important for effectiveness of control, as new influx of propagules needs to be stopped to control the *Taxon* effectively and sustainably
#MAN2	Benefits of the *Taxon*	Socio-economic and environmental benefits are included to assess the need of stakeholders for the *Taxon*
#MAN3	Eradication feasibility	To provide indication of feasibility to eradicate the *Taxon*

*not assessed if IMP1 and IMP2 can be filled in respectively, i.e. information on impact is available for the *Taxon*
#not assessed if risk is low for the *Taxon*

Scope of assessment

The region under assessment is referred to as the *Area* in the remainder of the document and in the framework (see BAC9). In most cases assessments will be done on the level of a country (in this case South Africa), but the only criterion is that the *Area* is clearly specified (e.g. it could be a province of South Africa).

The taxon under assessment is referred to as the *Taxon* (see BAC4-BAC6). The *Taxon* can be a species, sub-species, genus or any other taxonomic level. Risk analyses are mostly carried out on individual species, but this is not always appropriate, e.g. if the taxonomy of a group is not well resolved; if species are difficult to distinguish but the whole group (i.e., genus or family) is of potential concern (e.g. certain invertebrate plant pests like mites or rust fungi); and if there are important differences between sub-species.

Guidance on scoring risk and confidence

A thorough literature review on the *Taxon* should be conducted to find all relevant information. If no information is published on the *Taxon*, closely related taxa should be considered, for example congeners. If this is the case, it needs to be clearly indicated in the comments of the respective questions where such information was used. Experts on the *Taxon* should be consulted, especially if the *Taxon* is data deficient or data are not readily available, including indigenous knowledge where the *Taxon* is native. Some information can be extracted from national and international databases on native and alien species, e.g. the Global Invasive Species Database, Global Biodiversity Information Facility, and the Red List of Threatened Species. A list of potential sources of information can be found in the Supplementary Material Appendix S1. It is also possible to assess the respective taxa in expert groups, e.g. through workshops and working groups.

Unless otherwise specified, each question should have one answer out of the response options provided (in the *Response* box on the *Answer sheet*), with a corresponding estimate of the confidence in the answer (in the *Confidence* box on the *Answer sheet*, see Guidance on confidence scoring in Supplementary Material Appendix S2). In each case, a short description on why the *Response* was chosen must be provided in the *Rationale/Comments* section on the *Answer sheet*, including names of experts consulted for the respective questions, a summary of the main sources of information, and citations that were used to help answer the question. List relevant references used for each question in the *References* section, providing the full reference including authors, year, title, journal (if applicable), issue and page numbers, and a web-links for websites (e.g. a digital object identifier for books, databases, and journal articles).

The confidence score should give an indication regarding the certainty of the answer, in other words, how confident the assessor is that the answer provided is correct. This generally depends on the amount and quality of data available on the *Taxon*. Guidance on confidence rating is based on the one described in the EPPO pest risk assessment decision support scheme (Hawkins et al. 2015), and given in the Supplementary Material (Appendix S2).

All these sections are mandatory and have to be filled in.

Data sources

Some useful data sources to answer certain questions are given in the Supplementary Material Appendix S1. The scientific literature should be taken into account, and primary sources used and cited where possible. However, databases on alien species contain a lot of useful information on many taxa, too. This table is not an inclusive list of all potential sources which can and should be considered for risk analyses, and it does not replace the reference list which needs to be provided by the assessor as support for answering the questions outlined in the framework.

Risk analysis framework

The questions are described here in detail. For each question, a section in the Answer sheet needs to be filled in, generally consisting of Response, Confidence, Comments/Rationale, and References. Unless otherwise stated, all these sections need to be filled in.

1) Background

The background gives important information on the assessor, the *Area*, and the *Taxon*.

BAC1 Name of assessor(s)
Give the full name and surname of the main assessor and any additional assessors. The lead assessor takes responsibility for the assessment and is the author/assessor for correspondence. Add more lines if more assessors were involved.

BAC2 Contact details of assessor(s)
Add more lines if more assessors were involved.

BAC3 Name(s) and contact details of expert(s) consulted
This can include internal (within same organisation or group of assessors) or external (including international) experts or reviewers, which influenced, commented or amended the document before submission. In the comments, outline the kind of contribution these experts made. Add additional lines if several experts were consulted.

BAC4 Scientific name of Taxon *under assessment*
The biological entity under consideration. The full scientific (binomial) name as well as taxonomic authority is required. In most cases, this will be a species, but it could be another taxonomic level (e.g. genus or sub-species). Mention the taxonomic level under comments. The organism under assessment will be called the "*Taxon*" in the rest of the document. Check ITIS (http://www.itis.gov/) or a taxon specific taxonomic database for the correct nomenclature, and note the validity of the name under comments. Note in the references which database was used for the species identification/name.

BAC5 Synonym(s) considered
List synonyms of the scientific (Latin) name of the *Taxon* which were considered for this assessment. Only list names included in the literature search, not synonyms which were not considered. Check for synonyms in ITIS (http://www.itis.gov/) or a taxon specific taxonomic database. Note in the references which database was considered.

BAC6 Common name(s) considered
List common names of the *Taxon* which were considered for this assessment. Only list names included in the literature search, not all recorded common names. In the comments, indicate where the common names are used, and which languages were considered.

BAC7 What is the native range of the Taxon*?*
The *Taxon's* biogeographic distribution provides useful context for understanding the actual and potential range of the *Taxon*. Here, a description in words is required, which can aid the literature search. If the *Taxon's* native range includes the *Area* or part of the *Area*, see BAC12.
A map of the native range should be provided, if possible. If the map is available in a file, please insert a low res copy (<1MB) as an appendix to the Answer sheet and provide the file name and (if possible) a link to a higher resolution copy.

BAC8 What is the global alien range of the Taxon*?*

This includes the *Taxon's* global alien range, including the range within the *Area*. The distribution of the *Taxon's* introduced range provides useful context for understanding the actual and potential range of the *Taxon* and provides guidance for the literature search. For example, we are only interested in negative impacts caused in the alien range for the impact scoring and classification, even though some species also have undesirable effects in the native range under certain conditions.
A map of the alien range should be provided, if possible. If the map is available in a file, please insert a low res copy (<1MB) as an appendix to the Answer sheet and provide the file name and (if possible) a link to a higher resolution copy.

BAC9 Geographic scope = the Area *under consideration*

Specify the geographic entity under consideration, i.e. the geographic scope of the assessment. In most cases this will be the whole of South Africa, but can also be only a part of the country, for example a single province, a national park or a river catchment. The region under assessment will hereafter be referred to as the "*Area*". The *Taxon* should generally only be assessed in its alien range.

BAC10 Is the Taxon *present in the* Area*?*

Note if the Taxon is present anywhere in the Area. In the case where the presence of the species is not confirmed but a record has been noted, include field visits, as appropriate.

BAC11 Availability of physical specimen

In the Response, state if a physical sample was collected in the *Area* (yes/no). The name of the herbarium/museum and its accession number / record of the *Taxon* in the *Area* should be provided in the respective section. The record should have been checked by a national and/or international taxonomic expert, and the person at the herbarium/museum who identified the sample and date should also be given.
If the *Taxon* has not previously been reported as present in the *Area* and the identity is not certain OR if no herbarium or museum record is available, contact a relevant specialist. Record all information that can be obtained from the specialist; including a reference to some herbarium or museum, so that in the future if need be it will be possible to determine what the *Taxon's* identity was compared to at the initial identification, i.e. if it turns out in future that the identification could be wrong, we need to be able to understand why it was identified as that particular *Taxon*.

BAC12 Is the Taxon *native to the* Area *or part of the* Area*?*

Indicate whether the *Taxon* is native or alien and select one of the answers provided for each (yes, no, or don't know). If native to parts of the *Area*, specify its native and alien range in the Comments. If alien to the whole or parts of the *Area*, clarify under BAC7 that only alien ranges are considered for this assessment. If the *Taxon* is native to the whole of the *Area*, it should not be considered for listing under the NEMBA Regulations in that *Area* and does not go through the assessment process. For species native to the mainland but alien on the off-shore islands, listing should only be considered for the islands, i.e. the *Area* (as specified under BAC7) should be the islands.

BAC13 What is the Taxon's *introduction status in the* Area*?*

If the *Taxon* is present in the *Area*, define its introduction status as follows (according to Blackburn et al. 2011; described in more detail in Supplementary Material Appendix S4):

- alien in cultivation/captivity: individuals transported beyond the limits of its native range and in captivity, quarantine or cultivation, i.e., individuals provided with conditions suitable for them, but explicit measures of containment or explicit measures to prevent spread are in place
- alien in the wild: individuals transported beyond the limits of native range and directly released into the new environment, or individuals escaped from cultivation/captivity, but incapable of surviving for a significant period or, if surviving in the wild, no reproduction or, if reproduction occurring, population not self-sustaining
- established: individuals surviving in the wild in locations where introduced, reproduction occurring, and population self-sustaining
- invasive: self-sustaining populations in the wild with individuals surviving and reproducing a significant distance from the original point of introduction, i.e. dispersal happening.

Give information on each step in the invasion continuum and select one of the answers provided for each (yes, no, or don't know).

BAC14 Primary (introduction) pathways

List historical, currently known and potential future entry pathways for the *Taxon*. The pathway classification is based on the one accepted by the Convention on Biological Diversity (CBD), and is given in Appendix S3 (modified from Essl et al. 2011). Provide information on all categories and, if available, on the sub-categories in the Response.

2) Likelihood

This section deals with the likelihood of the *Taxon* to enter (LIK1 & LIK2), establish (LIK3 & LIK4) and spread (LIK5 & LIK6) in the *Area*, which is representing the steps alien taxa need to take in order to become invasive. This section therefore assesses the likelihood of the *Taxon* to become invasive.
All the answers are described in scenarios for each level separately, with each level being an order of magnitude more likely than the next lower level. If the answer is unknown, it is set as p=1 due to the precautionary principle (i.e., a high likelihood is assumed if not known).
Generally, all the answers in this section are structured in the same way, and they follow the logic described here:

- Extremely unlikely ($p < 0.000001$): less likely than winning the lottery if you play it once
- Very unlikely ($0.000001 \leq p < 0.0027$): less likely than a new person you meet having their birthday on the same day as yours
- Unlikely ($0.0027 \leq p < 0.027$): less likely than rolling 2 sixes when playing dice
- Fairly probable ($0.027 \leq p < 0.5$): less likely than getting heads when flipping a coin, i.e., fifty-fifty
- Probable ($p \geq 0.5$): more likely than fifty-fifty (it is likely to happen in more than 5 times out of 10)

The probability levels p represent the likelihood of an event happening, and will be used to calculate a final likelihood of an invasion to occur (see Figure 2 and Table 2).

The questions in this section represent the invasion process, with two questions for each step in the process (i.e., entry, establishment, and spread). Each answer to the questions in this section is attached to a probability value p as indicated in brackets in the response options (i.e., Extremely unlikely: $p < 0.000001$; Very unlikely: $0.000001 \leq p < 0.0027$; Unlikely: $0.0027 \leq p < 0.027$; Fairly probable: $0.027 \leq p < 0.5$; Probable: $p \geq 0.5$; Don't know: $p = 1$).

Figure 2 illustrates how to calculate a final Likelihood score from the answers provided in LIK1-LIK6. Subsequently, this value can be transcribed into a Likelihood description as in Table 2, which feeds into the Risk assessment (Table 3).

LIK1 Likelihood of entry via unaided primary pathways

Estimate the probability that the *Taxon* enters the *Area* from outside the *Area* through unaided pathways within the timespan of a decade. Consider the unaided pathways mentioned under BAC14. Features of the *Taxon* which favour unaided entry include presence in neighbouring countries and regions, water or wind dispersed propagules (e.g. floating propagules), the ability to fly long distances, the ability for fish to move from one river catchment where introduced, to another via connected

waterways. Animal dispersal is also considered here, except domestic and farm animals which are included under LIK2. The following factors can aid entry via animals: edible parts (e.g. fruits) which are eaten by animals, propagules with spines/barbs/sticky substances which can attach to animals, very small propagules which can get stuck in fur and feathers, pests attached to plants or animals. List the pathways and corresponding likelihoods in the comments section. In the response, give the highest likelihood for any pathway. The assessment should be based on the likelihood of entry based on current and future pathways.
If the *Taxon* is present in the *Area* (see BAC10), the probability of entry should be set as 1, and the answers given can inform risk management but are not included in the likelihood calculation.

Response options:
Extremely unlikely ($p < 0.000001$): the *Taxon* and its propagules are highly sessile and are known never to disperse on its own – proof is required for inability to move, otherwise classify as "Very unlikely".
Very unlikely ($0.000001 \leq p < 0.0027$): the *Taxon* and its propagules are sessile and do not usually disperse on their own
Unlikely ($0.0027 \leq p < 0.027$): the *Taxon* is sessile, but it can disperse during one specific life stage, dispersal capabilities are slow and short distance
Fairly probable ($0.027 \leq p < 0.5$): the *Taxon* is highly mobile during at least one of its life stages and can reach a high dispersal capability during one of its life stages
Probable ($p \geq 0.5$): highly mobile *Taxon* with dispersal capability fast and over large distances
Don't know ($p= 1$): no information is available on the unaided pathways available to the *Taxon*

LIK2 Likelihood of entry via human aided primary pathways
Estimate the probability that the *Taxon* enters the *Area* from outside the *Area* through the pathways mentioned under BAC14 which are human mediated (as opposed to unaided, which are covered in LIK1) within the timespan of a decade. List the pathways and corresponding likelihoods in the comments section. This also includes entry from neighbouring countries. In the response, give the highest likelihood for any pathway. The assessment should be based on the likelihood of introductions based on current and future pathways. For taxa which are already present in the *Area*, mainly focus on unintentional pathways.

Response options:
Extremely unlikely ($p < 0.000001$): There is currently no human aided entry pathway available/in use for the *Taxon*, and no future pathway is expected to arise
Very unlikely ($0.000001 \leq p < 0.0027$): There is currently a human aided entry pathway available/in use, but the *Taxon* is highly sensitive to movement and is unlikely to arrive alive at any life stage
Unlikely ($0.0027 \leq p < 0.027$): There is a human aided entry pathway available/in use which is infrequently used, and/or future new pathways are expected to arise; also, the *Taxon* is not expected to arrive in high numbers
Fairly probable ($0.027 \leq p < 0.5$): Several human aided entry pathways are available/in use but not regularly used, and/or some potentially lead to a high number of introductions
Probable ($p \geq 0.5$): Several human aided entry pathways available and regularly used for the *Taxon*, and high numbers of individuals expected.
Don't know ($p= 1$): no information is available on the human aided pathways used by the *Taxon*

LIK3 Habitat suitability
Indicate the likelihood of the *Taxon* to find suitable habitats in the *Area* for survival and reproduction. Habitat includes the presence of suitable food items, hosts, pollinators, seed dispersers, and other biotic conditions. If the *Area* encompasses multiple habitats, consider those that are most likely suited and mention in the comments section which habitats were assessed. Thus also take the habitat specificity of the *Taxon* into account. Artificial habitats include for example (with increasing degree of artificiality) gardens, zoos, greenhouses, indoor habitats.

Response options:
Extremely unlikely ($p < 0.000001$): the *Taxon* is extremely specialised and there is no suitable habitat in the *Area*, none of the key conditions for the *Taxon's* survival are met

Very unlikely (0.000001 ≤ p < 0.0027): the *Taxon* is highly specialised, but there is reason to assume that it might adapt to some biotic habitat conditions; only highly artificial habitats which are rare or difficult to maintain are suitable.
Unlikely (0.0027 ≤ p < 0.027): the *Area* provides habitat that is only partly suitable to the *Taxon*; certain artificial habitats are suitable
Fairly probable (0.027 ≤ p < 0.5): the key conditions are met, but only in a marginal part of the *Area*; also non-artificial habitats suitable.
Probable (p ≥ 0.5): all key biotic habitat conditions are met in a large part of the *Area*.
Don't know (p= 1): no information is available on habitat requirements of the *Taxon*

LIK4 Climate suitability

Indicate the likelihood of the *Taxon* to find suitable climate in the *Area* for survival and reproduction. Use the native and alien ranges as references for the *Taxon's* distribution, as obtained in BAC7 and BAC8. As a minimal standard, use published maps of climate zones to check whether the climate in the *Area* is suitable for the *Taxon*. Such maps include the following:
- Koeppen-Geiger climate zones, updated by Peel et al. (2007)
- Richardson and Thuiller (2007) maps of global locations that match South African climates

Climate models are more desirable and lead to a higher confidence in the assessment.
If the *Area* encompasses multiple climate zones, consider those that are most likely suited and mention in the comments section which climatic zones were assessed. For species already present in the *Area*, the answer cannot be "extremely unlikely".

Response options:
Extremely unlikely (p < 0.000001): The *Area* provides no suitable climate (including artificially created environments)
Very unlikely (0.000001 ≤ p < 0.0027): The *Area* provides no suitable climate, but suitable climate can be artificially created in small (<5%) parts of the *Area*.
Unlikely (0.0027 ≤ p < 0.027): The *Area* provides little (<5%) climatic overlap with the known distribution of the Taxon, excluding artificially created suitable habitats.
Fairly probable (0.027 ≤ p < 0.5): The main climatic requirements are met in a marginal (>5% but <20% - one fifth) part of the *Area*.
Probable (p ≥ 0.5): The main climatic requirements are met in a larger part (>20%) of the *Area*.
Don't know (p= 1): no information is available on the climatic requirements of the *Taxon*

LIK5 Unaided secondary (dispersal) pathways

This includes the unaided pathways currently or potentially bringing the *Taxon* from the occupied regions to elsewhere within the *Area*. It excludes unaided pathways bringing propagules from areas outside of the *Area* into the *Area* (covered in LIK1). Indicate the probability that the *Taxon* disperses naturally from a population within the *Area* to currently unoccupied regions and habitats. Mention details of the expected dispersal pathways and mechanisms in the comments section. More precisely, try to estimate the probability that the *Taxon* can disperse > 50 km in a decade. Features of the *Taxon* which favour unaided dispersal include water or wind dispersed propagules (e.g. floating propagules), the ability to fly long distances, the ability for fish to move from one river catchment where introduced, to another via connected waterways. Animal dispersal is also considered here, except domestic and farm animals which are included under LIK6. The following factors can aid dispersal by animals: edible parts (e.g. fruits) which are eaten by animals, propagules with spines/barbs/sticky substances which can attach to animals, very small propagules which can get stuck in fur and feathers, pests attached to plants or animals.

Response options:
Extremely unlikely (p < 0.000001): the *Taxon* and its propagules are highly sessile and are known never to disperse on their own – proof is required for inability to move, otherwise classify as "Very unlikely".
Very unlikely (0.000001 ≤ p < 0.0027): the *Taxon* and its propagules are sessile and do not usually disperse on their own
Unlikely (0.0027 ≤ p < 0.027): the *Taxon* is sessile, but it can disperse during one specific life stage, dispersal capabilities are slow and short distance
Fairly probable (0.027 ≤ p < 0.5): the *Taxon* is mobile and can reach a high dispersal capability during one of its life stages

Probable (p ≥ 0.5): highly mobile *Taxon* with dispersal capability fast and over large distances
Don't know (p= 1): no information is available on unaided dispersal pathways used by the *Taxon*

LIK6 Human aided secondary (dispersal) pathways

This includes the human aided pathways currently or potentially bringing the *Taxon* from the occupied regions and habitats elsewhere within the *Area*. This question does not include dispersal from outside of the *Area* to the *Area* as this is covered in LIK2. Indicate the probability that the *Taxon* gets dispersed from a population within the *Area* to uninvaded habitats. Intentional and unintentional pathways need to be considered. Mention details of the expected pathways in the comments section. The likelihood score relates to the proximity of the *Taxon* to human and domestic/farm animals and frequency of contact, which allows it to be dispersed in these kinds of dispersal pathways, as well as traits and features of the *Taxon* which facilitate for it to be moved around.
More precisely, try to estimate the probability that human-mediated dispersal takes (propagules of) the *Taxon* > 50 km in a decade.
Features of the *Taxon* which favour human aided dispersal include edible parts (e.g. fruits), propagules with spines/barbs/sticky substances which can attach to clothing, vehicles and boats, building materials, very small propagules which can get stuck in clothing/shoes or with movement of ornamental plants and be transported unnoticed. Dispersal by domestic and farm animals is included here.

Response options:

Extremely unlikely (p < 0.000001): the *Taxon* is not present in places accessible by humans, domestic and/or farm animals
Very unlikely (0.000001 ≤ p < 0.0027): the *Taxon* is only present in places humans, domestic and/or farm animals can reach with difficulty, and/or has no features which make it likely to be dispersed human aided
Unlikely (0.0027 ≤ p < 0.027): the *Taxon* is present in places where humans, domestic and/or farm animals occasionally occur, and/or has features which make it possible to be dispersed human aided, but only exceptional cases
Fairly probable (0.027 ≤ p < 0.5): the *Taxon* is present in places easily accessible by humans and/or it or its propagules are easily moved, i.e. it possesses some feature mentioned above
Probable (p ≥ 0.5): the *Taxon* is present in a place frequented by humans, and it or its propagules are easily and regularly moved due to features mentioned above
Don't know (p= 1): no information is available on the human aided pathways used by the *Taxon*

3) Consequences

In this section, all evidence of impacts in the global alien range (including the *Area*) available for the *Taxon* needs to be collated and scored for environmental impacts and socio-economic impacts. Data on the impacts of the *Taxon* itself from the *Area* or other alien regions are the most desirable (IMP1a)-k) and IMP2a)-f)). Only if no data are available on the *Taxon* in any alien range globally should it be classified as Data Deficient (DD) under IMP1 and IMP2.
If this is the case, i.e. no data are available for the Taxon on impacts anywhere in its global alien range, look for data of congeners or other closely related species with similar life history traits and fill in IMP3 and IMP4.
Additionally consider data in the native range of the *Taxon*, and/or estimate the magnitude of impact possible for the *Taxon* in the *Area* based on biological, ecological and behavioural traits in IMP5.
The environmental impact (IMP1) is based on the Environmental Impact Classification of Alien Taxa (EICAT) system by Blackburn *et al.* (2014), Hawkins *et al.* (2015), and the socio-economic rating (IMP2) based partly on the Generic Impact Scoring System (GISS) by Kumschick *et al.* (2015) and Nentwig *et al.* (2016).

Due to the lack of comprehensive impact studies for most species in many regions, the assessment of consequences includes information on impact available from the literature in the *Area* and other alien ranges of the *Taxon* (IMP1 and IMP2). Additionally, if no data is available on impact for the *Taxon*, information of closely related species is included (IMP3 and IMP4). These measures (IMP1-4 respectively) give the currently recorded evidence of impact. For a measure of future potential and currently unrecorded impact of the *Taxon* in the *Area*, IMP5 includes considerations on the *Taxon*'s traits, behaviour and ecology and considers impacts recorded in the native range.

Fill all results as described below from IMP1-5 into Figure 3 in the answer sheet to calculate maximum impact levels for the *Taxon*. For the consequence score, the maximum impact level should be taken between all the impact measures (IMP1-5). This impact level is then used to calculate the risk score as described in Table 3.

IMP1 Environmental impact

The consequence assessment is based on the Environmental Impact Classification of Alien Taxa (EICAT) scheme. EICAT classifies taxa into minimal concern (MC), minor (MN), moderate (MO), major (MR), massive (MV) according to the magnitude of impact they cause. Detailed descriptions of all the impact levels are given in IMP1a)-IMP1k) below.
Fill in the Answer sheet for each of the mechanisms as described below (IMP1a-IMP1k). Then use the scheme provided in Figure 3 to calculate the environmental impact score (IMP1), which is basically the maximum of all the mechanisms. Report on the maximum impact found in any of the mechanisms for the global alien range in the Response for IMP1, and the main mechanism affected in the Rationale, but provide information on all the sectors and impact scores in IMP1a)-IMP1k), including detailed information on the references used for the assessments. If impact assessments have been conducted previously for the *Taxon* and are available in the literature, information can be extracted from there and no detailed search is needed.
If no data on impact are available for the *Taxon* anywhere in the global alien range for any of the mechanisms described, mark the *Taxon* as Data Deficient (DD) here and additionally fill in IMP3, i.e. consider information on closely related taxa.

IMP1a Competition

What is the evidence in the global alien range of the *Taxon* for impact through competition?
Does the *Taxon* compete with native taxa for resources (e.g. food, water, space), leading to deleterious impact on native taxa somewhere in its global alien range?
Classify the Taxon in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Competition resulting in replacement or local extinction of one or several native species; changes in community composition are irreversible	Competition resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Competition resulting in a decline of population size of at least one native species, but no changes in community composition	Competition affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	Negligible level of competition with native species; reduction of fitness of native individuals is not detectable

IMP1b Predation

This consists of the *Taxon* preying on native taxa somewhere in its global alien range, and includes direct and indirect effects (e.g. via mesopredator release), leading to deleterious impact on native taxa.

Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Predators directly or indirectly (e.g., via mesopredator release) resulting in replacement or local extinction of one or several native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Predators directly or indirectly (e.g., via mesopredator release) resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Predators directly or indirectly (e.g., via mesopredator release) resulting in a decline of population size of at least one native species but no changes in community composition	Predators directly or indirectly (e.g., via mesopredator release) affecting fitness (e.g., growth, reproduction) of native individuals without decline of their populations	Negligible level of predation on native species

IMP1c Hybridisation

The *Taxon* hybridises with native species somewhere in its global alien range, leading to deleterious impact on native species.

Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Hybridisation between the alien taxon and native species is common in the wild; hybrids are fully vigorous and fertile; pure native species cannot be recovered by removing the alien, resulting in replacement or local extinction of native species by introgressive hybridisation (genomic extinction)	Hybridisation between the alien taxon and native species is common in the wild; F1 hybrids are vigorous and fertile, however offspring of F1 hybrids are weak and sterile (hybrid breakdown), thus limited gene flow between alien and natives; individuals of the alien taxon and hybrids discernible from pure natives, pure native populations can be recovered by removing the alien and hybrids.	Hybridisation between the alien taxon and native species is regularly observed in the wild; hybrids are vigorous, but sterile (reduced hybrid fertility),limited gene flow between alien and natives, local decline of populations of pure native species, but pure native species persists	Hybridisation between the alien taxon and native species is observed in the wild, but rare; hybrids are weak and never reach maturity (reduced hybrid viability), no decline of pure native populations	No hybridisation between the alien taxon and native species observed in the wild (prezygotic barriers), hybridisation with a native species might be possible in captivity

IMP1d Transmission of disease

The *Taxon* transmits diseases to native species somewhere in its global alien range, leading to deleterious impact on native species.

Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Transmission of diseases to native species resulting in replacement or local extinction of native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Transmission of diseases to native species resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Transmission of diseases to native species resulting in a decline of population size of at least one native species, but no changes in community composition	Transmission of diseases to native species affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	The alien taxon is not a host of diseases transmissible to native species or very low level of transmission of diseases to native species; reduction of fitness of native individuals is not detectable

IMP1e Parasitism

The *Taxon* parasitizes native species somewhere in its global alien range, leading directly or indirectly (e.g. through apparent competition) to deleterious impact on natives.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Parasites or pathogens directly or indirectly (e.g., apparent competition) resulting in replacement or local extinction of one or several native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Parasites or pathogens directly or indirectly (e.g., apparent competition) resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Parasites or pathogens directly or indirectly (e.g., apparent competition) resulting in a decline of population size of at least one native species but no changes in community composition	Parasites or pathogens directly or indirectly (e.g., apparent competition) affecting fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	Negligible level of parasitism or disease incidence (pathogens) on native species, reduction of fitness of native individuals is not detectable

IMP1f Poisoning/toxicity

The *Taxon* is toxic, or allergenic by ingestion somewhere in its global alien range, inhalation or contact to wildlife, or allelopathic to plants, leading to deleterious impact on native species.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
The alien taxon is toxic/allergenic by ingestion, inhalation, or contact to wildlife or allelopathic to plants, resulting in replacement or local extinction of native species; changes in community composition are irreversible	The alien taxon is toxic/allergenic by ingestion, inhalation, or contact to wildlife or allelopathic to plants, resulting in local or population extinction of at least one native species (i.e., species vanish from communities at sites where they occurred before the alien arrived), leading to changes in community composition, but changes are reversible when the alien taxon is removed	The alien taxon is toxic/allergenic by ingestion, inhalation, or contact to wildlife or allelopathic to plants, resulting in a decline of population size of at least one native species, but no changes in community composition (native species richness)	The alien taxon is toxic/allergenic by ingestion, inhalation, or contact to wildlife or allelopathic to plants, affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	The alien taxon is not toxic/allergenic/ allelopathic, or if it is, the level is very low, reduction of fitness of native individuals is not detectable

IMP1g Bio-fouling

The accumulation of individuals of the *Taxon* on wetted surfaces leads to deleterious impact on native species somewhere in its global alien range.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Bio-fouling resulting in replacement or local extinction of one or several native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Bio-fouling resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Bio-fouling resulting in a decline of population size of at least one native species, but no changes in community composition	Bio-fouling affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	Negligible level of bio-fouling on native species; reduction of fitness of native individuals is not detectable

IMP1h Grazing/herbivory/browsing

Grazing, herbivory or browsing by the *Taxon* leads to deleterious impact on native plant species somewhere in its global alien range.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Herbivory resulting in replacement or local extinction of one or several native plant species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Herbivory resulting in local or population extinction of at least one native plant species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Herbivory resulting in a decline of population size of at least one native species, but no changes in community composition	Herbivory affects fitness (e.g., growth, reproduction, defence, immunocompetence) of individual native plants without decline of their populations	Negligible level of herbivory on native plant species, reduction of fitness on native plants is not detectable

IMP1i Chemical, physical or structural impact on ecosystem

The *Taxon* causes changes to either: the chemical, physical, and/or structural biotope characteristics of the native environment; nutrient and/or water cycling; disturbance regimes; or natural succession, leading to deleterious impact on native species somewhere in the *Taxon's* global alien range.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Many changes in chemical, physical, and/or structural biotope characteristics; or changes in nutrient and water cycling; or disturbance regimes; or changes in natural succession, resulting in replacement or local extinction of native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes (abiotic and biotic) are irreversible	Changes in chemical, physical, and/or structural biotope characteristics; or changes in nutrient cycling; or disturbance regimes; or changes in natural succession, resulting in local extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien taxon is removed	Changes in chemical, physical, and/or structural biotope characteristics; or changes in nutrient cycling; or disturbance regimes; or changes in natural succession, resulting in a decline of population size of at least one native species, but no changes in community composition	Changes in chemical, physical, and/or structural biotope characteristics; or changes in nutrient cycling; or disturbance regimes; or changes in natural succession detectable, affecting fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	No changes in chemical, physical, and/or structural biotope characteristics; or changes in nutrient cycling; or disturbance regimes; or changes in natural succession detectable, or changes are small with no reduction of fitness of native individuals detectable

IMP1k Interaction with other alien species

The *Taxon* interacts with other alien taxa, (e.g., through pollination, seed dispersal, habitat modification), facilitating deleterious impact on native species somewhere in its global alien range. These interactions may be included under other impact mechanisms (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien species.

Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Interaction of an alien taxon with other aliens (e.g., pollination, seed dispersal, habitat modification) facilitates replacement or local extinction of one or several native species (i.e., species vanish from communities at sites where they occurred before the alien arrived), and produces irreversible changes in community composition that would not have occurred in the absence of the species. These interactions may be included under other impact categories (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien taxa.	Interaction of an alien taxon with other aliens (e.g., pollination, seed dispersal, habitat modification) facilitates local or population extinction of at least one native species, and produces changes in community composition that are reversible but would not have occurred in the absence of the species. These interactions may be included under other impact categories (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien taxa.	Interaction of an alien taxon with other aliens (e.g., pollination, seed dispersal, habitat modification) facilitates a decline of population size of at least one native species, but no changes in community composition; changes would not have occurred in the absence of the species. These interactions may be included under other impact categories (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien taxa.	Interaction of an alien taxon with other aliens (e.g., pollination, seed dispersal) affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native species' individuals without decline of their populations; changes would not have occurred in the absence of the species. These interactions may be included under other impact categories (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien taxa.	Interaction of an alien taxon with other aliens (e.g., pollination, seed dispersal) but with minimal effects on native species; reduction of fitness of native individuals is not detectable

IMP2 Socio-economic impact

Assess the socio-economic impact of the *Taxon* in its global alien range (i.e. everywhere it has been introduced outside of its native range). Perform a generic impact scoring on the *Taxon* as described in IMP2a) to IMP2g) below. This concerns impacts on the following sectors:

(a) agriculture
(b) animal production
(c) mariculture/aquaculture
(d) forestry
(e) infrastructure
(f) human health
(g) human social life

Fill in the Answer sheet for each of the sectors (IMP2a-IMP2g), and use Figure 3 to calculate the main socio-economic impact score. Report on the maximum impact found in any of the sectors and any alien range in the Response to IMP2, and the main sector affected in the Rationale, but provide information on all the sectors and impact scores in IMP2a)-2g), including detailed information on the references used for the assessments.

If no data on impact are available for the *Taxon* in any part of its alien range globally on any of the sectors described below, mark the *Taxon* as Data Deficient (DD) here and additionally fill in IMP4.

IMP2a Impacts on agricultural production

This concerns impacts through damage to crops or plantations, but also to horticultural and stored products. Impacts include competition with weeds, direct feeding damage (from feeding traces which reduce marketability to complete production loss) but also reduced accessibility, usability or marketability through contamination. Impacts include the need for applying pesticides which involve additional costs, also by reducing market quality. Impacts usually lead to an economic loss.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2b Impacts on animal production

Impacts through competition with livestock, transmission of diseases or parasites to livestock and predation of livestock. Intoxication of livestock through changes in food palatability, secondary plant compounds or toxins, weakening or injuring livestock, e.g. by stinging or biting. Also impacts on livestock environment such as pollution by droppings on farmland which domestic stock are then reluctant to graze. Hybridization with livestock. Impacts include the need for applying pesticides which involve additional costs, also by reducing market quality. Impacts usually lead to an economic loss.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2c Impacts on mariculture/aquaculture

Impacts through competition with taxa in mariculture/aquaculture, transmission of diseases or parasites to taxa in mariculture/aquaculture and predation of cultured taxa. Also impacts on culture environment such as pollution by droppings in water. Hybridization with cultured taxa. Impacts include reduction in market quality. Impacts usually lead to an economic loss.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2d Impacts on forestry production

Impacts on forests or forest products through plant competition, parasitism, diseases, herbivory, effects on tree or forest growth and on seed dispersal. Impacts may affect forest regeneration through browsing on young trees, bark gnawing or stripping and antler rubbing. Damage includes felling trees, defoliating them for nesting material or causing floods. Impacts include the need for applying pesticides which involve additional costs, also by reducing market quality. Impacts usually lead to an economic loss.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2e Impacts on human infrastructure and administration

Impacts include damage to human infrastructure, such as roads and other traffic infrastructure, buildings, damps, docks, fences, electricity cables (e.g. by gnawing or nesting on them) or through pollution (e.g. by droppings). Impacts through root growth, plant cover in open water bodies or digging activities on watersides, roadside embankments and buildings may affect flood defence systems, traffic infrastructure or stability of buildings. Impacts may affect human safety and cause traffic accidents. Impacts include the need for applying pesticides, their development costs and further registration or administration costs, as well as costs for research and control. Impacts usually lead to an economic loss.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2f Impacts on human health

Injuries (e.g. bites, stings, scratches, rashes), transmission of diseases and parasites to humans, bioaccumulation of noxious substances, health hazard due to contamination with pathogens or parasites (e.g. of water, soil, food, or by faeces or droppings), as well as secondary plant compounds, toxins or allergen substances such as pollen. Impacts include the need for applying pesticides which due to their low selectivity and/or residues may have side-effects on humans. Via health costs, impacts usually lead to economic costs.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Major impacts, fatal issues, high economic costs.	Major impacts with high damage, often occurring or with high probability, but rarely fatal, major economic costs.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP2g Impacts on human social life

Noise disturbance, pollution of recreational areas (water bodies, rural parks, golf courses or city parks), including fouling, eutrophication, damage by trampling and overgrazing, restrictions in accessibility (e.g. by thorns, other injuring structures, successional processes, or recent pesticide application) to habitats or landscapes of recreational value. Restrictions or loss of recreational activities.
Classify the *Taxon* in an impact level according to the descriptions below. If no data is available, the Response is Data Deficient (DD).

Massive (MV)	Major (MR)	Moderate (MO)	Minor (MN)	Minimal Concern (MC)
Major impacts with complete destruction and loss of recreational value, major economic loss.	Major impacts with high damage, often occurring or with high probability, recreational value of a location strongly affected, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, in the range of native species, only locally, negligible economic loss.

IMP3 Closely related taxons' environmental impact

This section is only considered if the Response is Data Deficient (DD) in IMP1.
Consider here data of congeners or other closely related taxa with similar life history traits and their environmental impacts in their global alien range. In detail, perform a classification of impacts as described in IMP1a-IMP1k for closely related and similar taxa. Note which taxa was/were considered in the Rationale, and report on the details of the different impact mechanisms on the Answer sheet. In the Response to IMP3, note the maximum impact found in any mechanism.

IMP4 Closely related taxons' socio-economic impact

This section is only considered if the Response is Data Deficient (DD) in IMP2.
Consider here data of congeners or other closely related taxa with similar life history traits and their socio-economic impacts in their global alien range. More specifically, perform a classification of impacts as described in IMP2a-IMP2f for closely related and similar taxa. Note which taxa was/were considered in the Rationale, and report on the details of the different sectors on the Answer sheet. In the Response to IMP4, note the maximum impact found on any sector.

IMP5 Potential impact

Ideally, experiments should be performed on impacts of taxa for which no information is available regarding consequences of invasions, but this is hardly feasible for all taxa. Therefore, if no data is available on impacts in any introduced region of the *Taxon* and any closely related taxon, use data from the native range of the *Taxon* and/or estimate the magnitude of impact possible for the *Taxon* in the *Area* based on its life history traits and trait based models for other taxa.

In detail, estimate the potential of the *Taxon* to cause any impact in the magnitudes as described under IMP1 and IMP2 in the *Area*, including impacts for which no evidence has been recorded yet. Assume the *Taxon* is established and abundant in the *Area*, and consider the highest impact possible under any of the mechanisms and to any sector. Here we consider the life history traits of the *Taxon* which could lead to impact, including undesirable traits, as well as the recipient systems, meaning the recipient habitat and community. In some cases, impacts caused in the native range can be useful indicators of impact, for example impacts on agriculture.

Undesirable traits include (but do not exclusively consist of): produces spines, thorns or burrs, allelopathic, parasitic, unpalatable to grazing animals, toxic to animals, host for recognised pests and pathogens, causes allergies or is otherwise toxic to humans, creates a fire hazard in natural ecosystems, grows on infertile soils, shade tolerant plant at some stage of its life cycle.

Also consider here feeding habits, novelty aspects, functional traits, and studies performed on other groups and taxa considering trait-impact relationships.

Impact levels	**Massive (MV)**	**Major (MR)**	**Moderate (MO)**	**Minor (MN)**	**Minimal Concern (MC)**
Environmental impact (IMP1 & IMP3)	Causes at least local extinction of native species, and irreversible changes in community composition; even if the alien taxon is removed the system does not recover its original state	Causes changes in community composition, which are reversible if the alien taxon is removed	Causes population declines in native species, but no changes in community composition	Causes reductions in individual fitness, but no declines in native population sizes.	No effect on fitness of individuals of native species
Socio-economic impact (IMP2 & IMP4)	Major impacts with complete destruction and economic loss.	Major impacts with high damage, often occurring or with high probability, major economic loss.	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.	Minor impacts, in the range of native species, but more wide-spread, minor economic loss.	Minor impacts, similar to native species, only locally, negligible economic loss.
Potential impact (IMP5)	The *Taxon* is a transformer in its native range, has ecosystem engineering properties, or possesses other traits which suggest irreversible impacts on the community composition in the *Area* to occur. The *Taxon* is a pest of agricultural production in the native range and/or has the potential to cause high losses.	The *Taxon* has traits which suggest major impacts on native communities in the *Area*, but these impacts are likely to be reversible. The *Taxon* has traits which can lead to high losses to economy.	The *Taxon* possesses several undesirable traits. Due to the traits of the *Taxon* and/or its behavior, it is expected to reduce population sizes of at least one native species. Economic loss is expected to be medium.	The *Taxon* does not possess any traits which could lead to effects on native species population sizes, but reduction in native individuals' fitness is expected. Minor economic loss is possibly widespread.	Due to the traits of the *Taxon* no effect on native individuals' fitness is expected. No socio-economic loss is expected. The *Taxon* does not possess any undesirable traits.

Risk assessment

The risk posed by an alien *Taxon* is the likelihood the *Taxon* will become an invader and the consequences in terms of impact resulting from the introduction of the *Taxon*. The Likelihood for the risk assessment is derived from LIK1-LIK6 as described in Figure 2 and Table 2. Consequences are derived from IMP1-IMP5, as summarised in Figure 3. Table 3 summarises how risk scores are derived from Consequences and Likelihood.

If the risk of the *Taxon* to become a harmful invader is medium or high (according to Table 3), the management options section needs to be assessed. If the risk is low, the *Taxon* does not need to be listed but under certain circumstances could be monitored in the region it occurs. The Risk assessment therefore provides the evidence base for or against the listing of a *Taxon* under the NEMBA Regulations, whereas the Risk management section helps to decide which listing status could be considered (Figure 4).

4) Management

Once a risk has been identified and assessed as of concern (i.e. medium or high risk, Table 3), the next step is to consider what can be done to manage the risk. This will ultimately often require a detailed evaluation of management options, the development of costed management plans, and a process of prioritisation of different potential interventions. As with other aspects of the framework the decision of the approach to apply in practice will ultimately also be a political one that is constrained by the available resources. Therefore, the aim of this section is to provide some guidance as to what management goals should be investigated and what information is required in order to proceed further.

Generally, whether or not to list a *Taxon* under a legal framework can be derived from the risk assessment as described under section 2, 3, and in Tables 2-4. These are evidence based assessments incorporating scientific knowledge on the *Taxon*, and transferring this knowledge to the *Area* and situation at hand. Here, input from taxon specialists, ecologists, biologists and invasion scientists can be most useful. International agreements need to be considered for the listing of taxa under such regulations as such listing is generally linked with trade restrictions.

The distinction between whether or not to regulate and list a *Taxon* relies on scientific evidence. However, decisions regarding permitting or allowance of certain activities involving the *Taxon* also rely on social perceptions and benefits. Therefore, this information needs to be collected and included in the analysis, but no clear cut-off levels for decisions in terms of listing categories are given. It is the responsibility of the decision makers to take the information in this assessment and based on the best information available, make the final decision on the listing category of a species.

A decision on the listing *status*, i.e., whether a taxon should be listed as prohibited, Category 1a, 1b, 2 or 3 as outlined in the NEMBA Regulations, is not only based on scientific evidence, but often mainly relies on the value of the *Taxon*, besides some inherent features which make it more or less easy to control. Therefore, risk management considerations describing whether and how risks can be managed apply, including benefits (Table 4 and MAN questions).

Based on this information, we consider five broad recommendations. These differ based on whether the *Taxon* is already present or not, whether prevention or eradication are feasible goals, and whether the *Taxon* has benefits to the *Area* such that it might be a conflict species that could be allowed under permit in certain conditions (Figure 4).

MAN1 What is the feasibility to stop future immigration?

If the *Taxon* is already present as an alien in the *Area* (see BAC10), this is needed to determine whether eradication is a feasible goal. If the *Taxon* is not yet in the *Area* this determines whether prevention is a feasible goal.
Based on the pathways identified in BAC14 and the answers provided in LIK1 and LIK2, estimate the feasibility to stop propagules from entering the *Area*.

MAN2 Benefits of the Taxon

Taxa with significant benefits and significant costs are sometimes termed **conflict species**. The benefits might be in terms of either socio-economy or the environment. Crucially the benefits of an introduction are often spatially and temporally separated from the costs of an invasion. This section (MAN2a & MAN2b) aims at assessing socio-economic and environmental benefits to highlight potential conflicts of interest. Stakeholders might need to be consulted to answer these questions (see also Supplementary Material Appendix S7).

MAN2a Socio-economic benefits of the Taxon

Socio-economic benefits, if appropriate, should be described to ensure an objectivity and recognition of the services that may be provided by the *Taxon*. Under Rational and comments, list the benefits and the significance of each. Include here if the *Taxon* is used for any of the following: as pet, in horticulture, for fencing, shading, dune stabilisation, firewood, building material, hunting, fishing, human food, animal feed and fodder, fabric production, etc.
High benefits are expected if the *Taxon* provides a service or makes an activity possible which is not available without the *Taxon*, i.e., which is not provided by the native species in the *Area*.

Examples
- *Opuntia* ssp. are used for fencing
- some *Casuarina* spp. were introduced for dune stabilisation
- *Acacia* spp. for firewood
- Many bamboo species have shown to be useful as building material
- Galliform birds were often introduced for hunting purposes
- Trout and bass are used for fishing
- Some Drosophila flies are mass reared for livestock feed

MAN2b Environmental benefits of the Taxon

High benefits are expected if the *Taxon* provides a crucial habitat or food source to an environment. These functions might be replaceable over time by native taxa, but it indicates that current control would be detrimental to conservation or ecosystem functioning.

MAN3 Eradication feasibility

Values as described in MAN3a-MAN3e are assigned for situations where the *Taxon* has been detected, not where it could be found, in the *Area*. So this is only relevant if the *Taxon* is present in the *Area* (BAC10). Provide detailed answers to MAN3a-MAN3e in the Answer sheet and use Table 4 to calculate eradication feasibility, i.e. the sum of the answers. The Response options here lead to the final eradication feasibility score.
Additionally, consult Supplementary Material Appendix S6.

Response options:
>5 is low
4–5 is medium
<3 is high

MAN3a How accessible are populations?

Moderately accessible incursions will include regions that pose some operational difficulty, but that might not necessarily require specialised teams (e.g. a riparian area). To be rated as difficult to access, the incursion must involve at least some sites that are very difficult to access (e.g. a ravine).

Response options:
0 for easy access
1 for moderately accessible
2 for difficult to access; or don't know

MAN3b Is detectability critically time-dependent?

The objective of this question is to distinguish taxa that are readily detectable throughout the year from those that might be detectable only for short periods (e.g. following the production of new foliage or as dispersing adults). If the *Taxon* is detectable relatively briefly it provide only small windows for control prior to reproductive events

Response options:
0 for no
2 for yes; or don't know

MAN3c Time to reproduction

It will be more difficult to prevent reproduction of a *Taxon* that reproduces quickly than those that have extended juvenile periods. Default value (i.e. if unknown) is 1.

Response options:
0 for > 3 years
1 for 1–3 years; or don't know
2 for < 1 year

MAN3d Propagule persistence

Propagule persistence is often one of the most important impedance factors, since it sets the minimum duration for an eradication programme. Propagules comprise of e.g., resting stages, seeds, spores, vegetative fragments. Default value is 1.

Response options:
0 for < 1 year
1 for 1–5 years; or don't know
3 for > 5 years

MAN3e Is human-mediated dispersal a major contributor to spread?
A *Taxon* that is highly reliant upon human-mediated dispersal offers a relatively high potential for management of secondary (dispersal) pathways. It also allows for accurate tracking of propagule movements.

Response options:
0 for yes
2 for no; or don't know

5) Reporting

Figure 4 describes how to arrive at certain recommendations for Risk management and listing from the answers provided in the Risk analysis.
A summary sheet including the conclusions from each table should be provided, with short descriptions on the *Taxon* itself, impacts, risks, management options and benefits. An example is given in the Supplementary Material Appendix S5, based on the Reporting template in the Answer sheet. The full risk analysis with each question answered and all references, including detailed information on assessors, reviewers, *Taxon* and *Area*, and maps should be provided.

Testing and review of framework

This framework has been reviewed and approved by the Alien Species Risk Analysis Review Panel (ASRARP). Furthermore, it was tested on a wide variety of taxa and by representatives of various organisations, including the South African National Biodiversity Institute (SANBI), the Department of Environmental Affairs (DEA), the Centre for Invasion Biology at Stellenbosch University, and ASRARP. Comments received were subsequently addressed to improve clarity of the framework and assessment process.

All Risk analyses performed should be reviewed by ASRARP. Furthermore, Risk analysis can be updated if more information becomes available, and they should be regularly re-assessed. Cut-off levels for low, medium and high risk respectively (Table 3) can be adapted if needed or as appropriate.

Even though the Risk analysis framework presented here is mainly intended for the use as post-border assessment to underpin the listing of alien taxa under the NEMBA Regulations, it can also be used as a pre-border assessment to analyse the risk of taxa not yet present in the country.

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Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, Kühn I, Kumschick S, Mrugała A, Marková Z, Nentwig W, Pergl J, Pyšek P, Rabitsch W, Ricciardi A, Richardson DM, Sendek A, Vilà M, Wilson JRU, Winter M, Genovesi P & Bacher S (2014) A unified classification of alien species based on the magnitude of their environmental impacts. PLoS Biology 12(5): e1001850

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Department of Environmental Affairs (2014) National Environmental Management: Biodiversty Act 2004 (Act No. 10 of 2004) Alien and Invasive Species Regulations, 2014. Government Gazette Vol. 590, No. 37885

Essl F, Nehring S, Klingenstein F, Milasowszky N, Nowack C & Rabitsch W (2011) Review of risk assessment systems of IAS in Europe and introducing the German-Austrian Black List Information system (GABLIS). Journal for Nature Conservation 19: 339-350.

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Kumschick S, Bacher S, Marková Z, Pergl J, Pyšek P, Vaes-Petignat S, van der Veer G, Vilà M & Nentwig W (2015) Comparing impacts of alien plants and animals using a standard scoring system. Journal of Applied Ecology 52: 552-561

Nentwig W, Bacher S, Pyšek P, Vilà M & Kumschick S (2016) The Generic Impact Scoring System (GISS): a standardized tool to quantify the impacts of alien species. Environmental Monitoring and Assessment 188: 315

Panetta FD & Timmins SM (2004) Evaluating the feasibility of eradication for terrestrial weed invasions. Plant Protection Quarterly 19: 5-11.

Peel MC, Finlayson BL, McMahon TA (2007) Updated world map of the Koppen-Geiger climate classification. Hydrology and Earth System Sciences 11: 1633-1644

Richardson DM and Thuiller W (2007) Home away from home – objective mapping of high-risk source areas for plant introductions. Diversity and Distributions 13: 299-312

Wilson JR, Panetta FD & Lindgren C (2017) *Detecting and responding to alien plant incursions*. Cambridge University Press.

Answer sheet

1. Background

BAC1 Name of assessor(s)	
Name of lead assessor	
Additional assessor (1)	
Additional assessor (2)	
BAC2 Contact details of assessor (s)	
Lead assessor	Organisational affiliation:
	email:
	Phone:
Additional assessor (1)	Organisational affiliation:
	email:
	Phone:
Additional assessor (2)	Organisational affiliation:
	email:
	Phone:
BAC3 Name(s) and contact details of expert(s) consulted	
Expert (1)	Name:
	email:
	Phone:
Expert (2)	Name:
	email:
	Phone:
Comments:	
BAC4 Scientific name of *Taxon* under assessment	
Taxon name:	Authority:
Comments:	
References:	
BAC5 Synonym(s) considered	
Synonyms:	
Comments:	
References:	
BAC6 Common name(s) considered	
Common names:	

Comments:		
References:		
BAC7 What is the native range of the *Taxon*? (add map in Appendix BAC7)		
Response:		Confidence:
Comments:		
References:		
BAC8 What is the global alien range of the *Taxon*? (add map in Appendix BAC8)		
Response:		Confidence:
Comments:		
References:		
BAC9 Geographic scope = the *Area* under consideration		
Area of assessment:		
Comments:		
BAC10 Is the *Taxon* present in the *Area*?		
Response:		Confidence:
Comments:		
References:		
BAC11 Availability of physical specimen		
Response:		Confidence in ID:
Herbarium or museum accession number:		
References:		
BAC12 Is the *Taxon* native to the *Area* or part of the *Area*?		
The *Taxon* is native to (part of) the *Area*.	Yes / No / Don't know	Confidence:
The *Taxon* is alien in (part of) the *Area*.	Yes / No / Don't know	Confidence:
Comments:		
References:		
BAC13 What is the *Taxon*'s introduction status in the *Area*?		
The *Taxon* is in cultivation/containment.	Yes / No / Don't know	Confidence:
The *Taxon* is present in the wild.	Yes / No / Don't know	Confidence:
The *Taxon* has established/naturalised.	Yes / No / Don't know	Confidence:
The *Taxon* is invasive.	Yes / No / Don't know	Confidence:
Comments:		
References:		

BAC14 Primary (introduction) pathways		
Release		Confidence:
Escape		Confidence:
Contaminant		Confidence:
Stowaway		Confidence:
Corridor		Confidence:
Unaided		Confidence:
Comments:		
References:		

2. Likelihood

LIK1 Likelihood of entry via unaided primary pathways	
Response:	Confidence:
Rationale:	
References:	

LIK2 Likelihood of entry via human aided primary pathways	
Response:	Confidence:
Rationale:	
References:	

LIK3 Habitat suitability	
Response:	Confidence:
Rationale:	
References:	

LIK4 Climate suitability	
Response:	Confidence:
Rationale:	
References:	

LIK5 Unaided secondary (dispersal) pathways	
Response:	Confidence:
Rationale:	
References:	

LIK6 Human aided secondary (dispersal) pathways	
Response:	Confidence:
Rationale:	
References:	

Figure 2 The calculation of a final likelihood score from the likelihood questions LIK1-LIK6. The likelihood descriptions to extract a Risk score for the Risk assessment in Table 3 can then be found in Table 2.

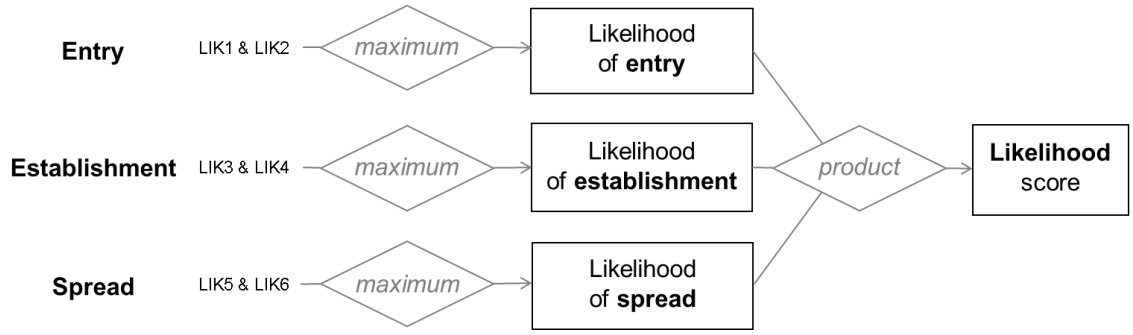


Table 2: Transcription of Likelihood scores into descriptions for the Risk score in Table 3. The Likelihood score is calculated as in Figure 2.

Likelihood score	Likelihood (description)
< 0.000001	Extremely unlikely
0.000001 ≤ p < 0.0027	Very unlikely
0.0027 ≤ p < 0.027	Unlikely
0.027 ≤ p < 0.5	Fairly probable
p ≥ 0.5	Probable

3. Consequences

IMP1 Environmental impact (Figure 3)	
Response:	Confidence:
Rationale:	
References:	
IMP1a: Competition	
Response:	Confidence:
Rationale:	
References:	
IMP1b: Predation	
Response:	Confidence:
Rationale:	
References:	
IMP1c: Hybridisation	
Response:	Confidence:
Rationale:	
References:	
IMP1d: Transmission of disease	
Response:	Confidence:
Rationale:	
References:	
IMP1e: Parasitism	
Response:	Confidence:
Rationale:	
References:	
IMP1f: Poisoning/toxicity	
Response:	Confidence:
Rationale:	
References:	
IMP1g: Bio-fouling	
Response:	Confidence:
Rationale:	
References:	

IMP1h: Grazing/herbivory/browsing	
Response:	Confidence:
Rationale:	
References:	
IMP1i: Chemical, physical or structural impact on ecosystem	
Response:	Confidence:
Rationale:	
References:	
IMP1k: Interaction with other alien species	
Response:	Confidence:
Rationale:	
References:	

IMP2 Socio-economic impact (Figure 3)	
Response:	Confidence:
Rationale:	
References:	
IMP2a: Agriculture	
Response:	Confidence:
Rationale:	
References:	
IMP2b: Animal production	
Response:	Confidence:
Rationale:	
References:	
IMP2c: Mariculture/aquaculture	
Response:	Confidence:
Rationale:	
References:	
IMP2d: Forestry	
Response:	Confidence:
Rationale:	
References:	
IMP2e: Infrastructure and administration	
Response:	Confidence:
Rationale:	

References:	
IMP2f: Human health	
Response:	Confidence:
Rationale:	
References:	
IMP2g: Human social life	
Response:	Confidence:
Rationale:	
References:	

IMP3 Closely related species' environmental impact	
Response:	Confidence:
Rationale:	
References:	

IMP4 Closely related species' socio-economic impact	
Response:	Confidence:
Rationale:	
References:	

IMP5 Potential impact	
Response:	Confidence:
Rationale:	
References:	

Figure 3: Consequences in terms of impact scores

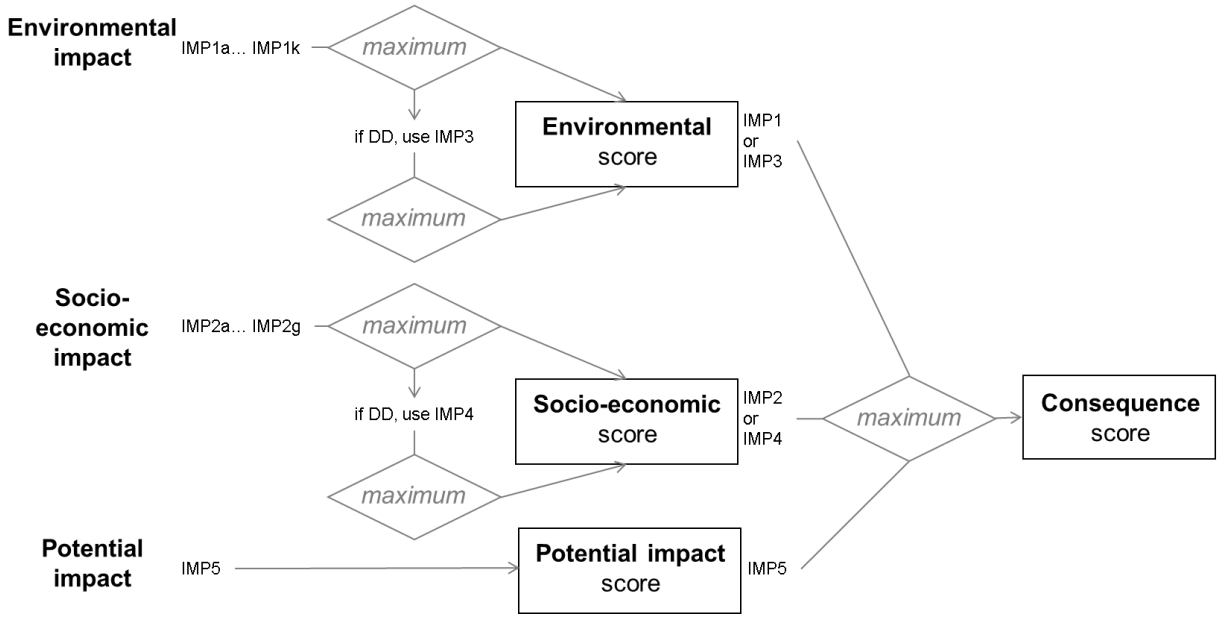


Table 3: Risk assessment outcomes considering likelihood (Figure 2 and Table 2) and consequences (outcome of Figure 3), leading to a Risk score.

		Consequences				
		MC	MN	MO	MR	MV
Likelihood	Extremely unlikely	low	low	low	medium	medium
	Very unlikely	low	low	low	medium	high
	Unlikely	low	low	medium	high	high
	Fairly probable	medium	medium	high	high	high
	Probable	medium	high	high	high	high

4. Management

MAN1 What is the feasibility to stop future immigration?	
Response:	Confidence:
Rationale:	
References:	

MAN2 Benefits of the Taxon	
MAN2a Socio-economic benefits of the *Taxon*	
Response:	Confidence:
Rationale:	
References:	
MAN2b Environmental benefits of the *Taxon*	
Response:	Confidence:
Rationale:	
References:	

MAN3 Eradication feasibility (Table 4)	
Response:	Confidence:
Rationale:	
References:	
MAN3a How accessible are populations?	
Response:	Confidence:
Rationale:	
References:	
MAN3b Is detectability critically time-dependent?	
Response:	Confidence:
Rationale:	
References:	
MAN3c Time to reproduction	
Response:	Confidence:
Rationale:	
References:	
MAN3d Propagule persistence	
Response:	Confidence:
Rationale:	
References:	
MAN3e Is human-mediated dispersal a major contributor to spread?	

Response:	Confidence:
Rationale:	
References:	

Table 4: Eradication feasibility of a *Taxon* which is present in the *Area* (modified from Wilson et al. 2017). Fill in the responses from MAN3a-MAN3e and sum up the numbers for MAN3.

Parameter	Question	Response
MAN3a	How accessible are populations?	
MAN3b	Is detectability critically time-dependent?	
MAN3c	Time to reproduction	
MAN3d	Propagule persistence	
MAN3e	Is human-mediated dispersal a major contributor to spread?	
MAN3	**SUM**	

5. Reporting

Risk Analysis summary sheet

<table>
<tr><td>Taxon:
(as in BAC4)</td><td colspan="2">Area:
(as in BAC9)</td></tr>
<tr><td colspan="3">Compiled by:
(from BAC1)</td></tr>
<tr><td>Picture of Taxon</td><td colspan="2">Alien distribution map (BAC8)</td></tr>
<tr><td colspan="2">Risk Assessment summary:
Summarise here the answers to questions under section 2) LIK and section 3) IMP, and from Table 3. Emphasise the situation in the Area, if such information is available.</td><td>Risk score:
(from Table 3)</td></tr>
<tr><td colspan="2">Management options summary:
Report on the main findings from section 4) MAN, which includes benefits and questions on the ease of control.</td><td>Risk management:</td></tr>
<tr><td colspan="2">Recommendations:
According to the decision tree as presented in Figure 4. This should also include recommendations on further studies needed, management plans, stakeholder engagement, etc.</td><td>Listing category:
(as in Figure 4)</td></tr>
</table>

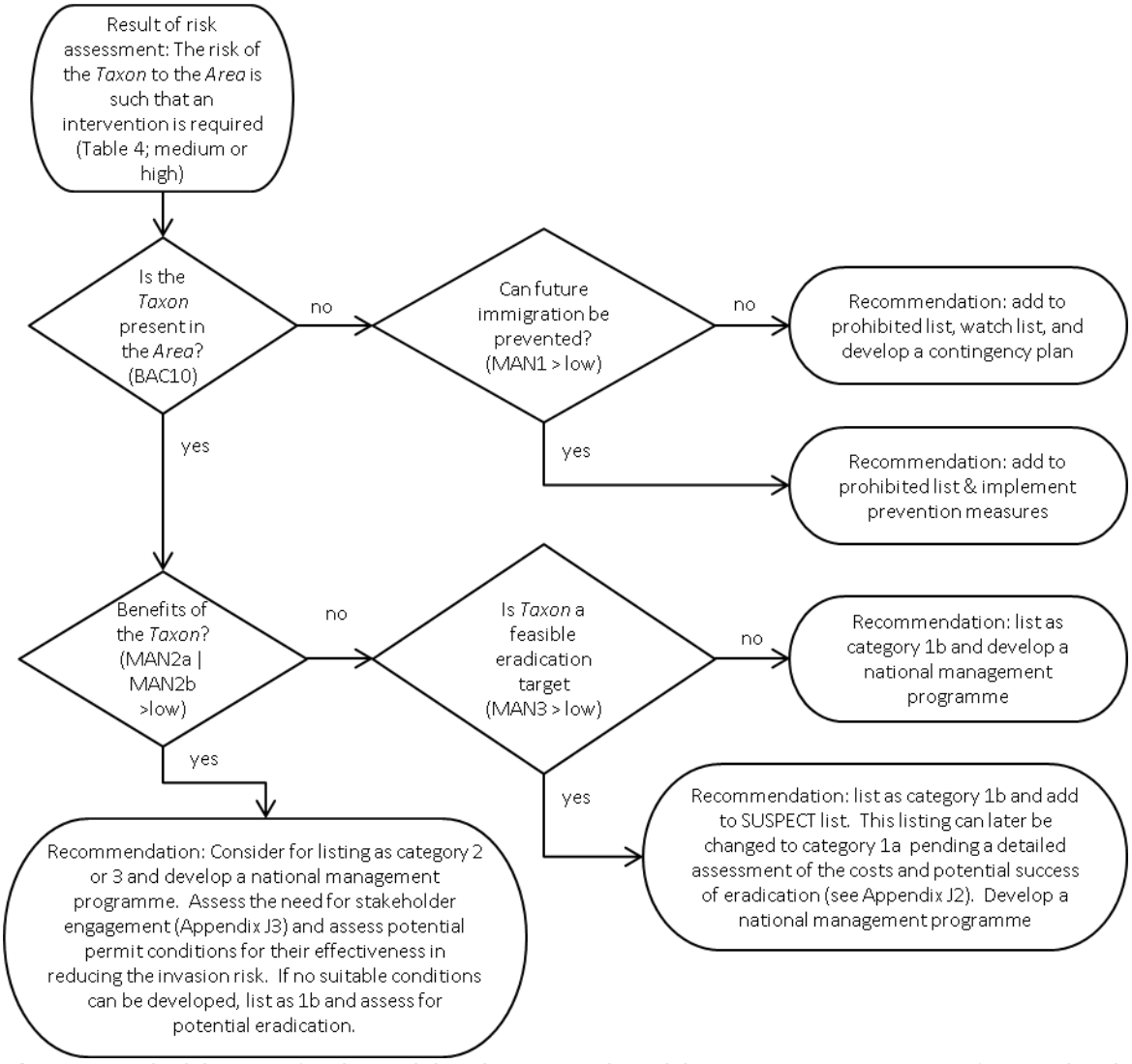


Figure 4. A decision tree for determining the appropriate risk management response for species that are considered to be of an unacceptable (medium or high) risk during the risk assessment process. The listing categories (1a, 1b, 2 and 3) are as per South Africa's NEMBA Regulations.

There are several additional considerations that will need to be made when drafting management plans, for instance:

- Will stakeholders be opposed to management (e.g. access to land)?
- Are control efforts ethical (in particular for vertebrates)?
- Might it be feasible to contain populations?
- Should resources be spent to develop new control measures (e.g. biological control)?

Such issues are important when attempting to reduce and mitigate the risks caused, but need to be considered explicitly outside of the current framework.

Supplementary to add to answer sheet

Appendix BAC7: Provide here a map of the native range, if possible. If the map is available in a file, please insert a low res copy (<1MB) and provide the file name and (if possible) a link to a higher resolution copy below.

Appendix BAC8: Provide here a map of the global alien range, including the range within the *Area*, if possible. If the map is available in a file, please insert a low res copy (<1MB) and provide the file name and (if possible) a link to a higher resolution copy below.

Annexure 1: Glossary

NEMBA Regulations: The National Environmental Management: Biodiversity Act (NEMBA, Act 10 of 2004) Alien and Invasive Species Regulations (Department of Environmental Affairs 2014)

Alien taxon: A taxon in a given area whose presence there is due to intentional or accidental introduction as a result of human activity. Taxa that have part of their native range in a given country, but whose presence in another part of the same country is attributable to human actions that enabled the taxon to overcome fundamental biogeographical barriers, are also referred to as alien here.

Area: The area of assessment for the risk analysis. Specify the geographic entity under consideration, i.e. the geographic scope of the assessment. In most cases this will be the whole of South Africa, but can also be only a part of the country, for example a single province, a national park or a river catchment. The region under assessment will be referred to as the Area in the framework.

Extralimital: A taxon that has part of their native range in a given country, but whose presence in another part of the same country is attributable to human actions that enabled the taxon to overcome fundamental biogeographical barriers

Invasive taxon: A taxon which is alien to an area and which has self-sustaining populations there with propagules spreading from the initial site of introduction.

Pathway: The processes by which taxa are moved between areas.

Primary (introduction) pathway: The combined processes by which taxa are introduced from one geographical location to another (cf. Vector). Classified into categories and sub-categories as outlined in Appendix S3.

Secondary (dispersal) pathway: The processes by which taxa disperse or are dispersed from one area of introduction to another.

Risk analysis: The process of identifying and assessing the likelihood and consequence of an event, as well as considerations as to manage and communicate the risks.

Risk assessment: The process of evaluating the likelihood and consequence of an event taking place. In this document, such an event would be an alien taxon becoming a harmful invasive species. Risk assessment is part of risk analysis. Risk analysis is comprised of risk assessment, risk management and risk communication.

Risk management: The process of assessing options by which the risks of an event (its likelihood and/or consequence) can be reduced or mitigated.

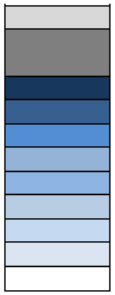
Introduction status: Whether a taxon is found in an area to which it is not native (alien), and how far along the introduction-naturalisation-invasion continuum it has reached. Ideally as per the Blackburn et al. (2011) framework (Appendix S4)

Vector: A mechanism responsible for the transport of species to new areas where they did not previously occur. A pathway (for example shipping) could have several vectors associated with it (for example in cargo, in passenger luggage, on passengers or crew themselves, in ballast water, or attached to the hull).

Supporting Material

Appendix S1: Sources of information which can be used for the risk analysis. This is not an exhaustive list, but provides a starting point on where to search for information. This table is taken from Marais, Richardson & Davies (2012) Risk assessments for invasive species in South Africa: Sources of information. Draft Report submitted to DEA on 31 October.
Additionally, consider atlases and other distribution databases, like for example SABAP2 (Southern African Bird Atlas Project; http://sabap2.adu.org.za/), SAPIA, the Red List of Threatened Species (http://www.iucnredlist.org/), and other databases on alien species (e.g., http://www.griis.org/ ; http://www.europe-aliens.org/)

Key to colouring of cells



Risk Assessments
Essential for species specific information
First choice source
Last choice source
Not a source for this category

Taxon/Group	Source	Source type	Reference	Synonyms	Invasive Elsewhere?/ Established Elsewhere?	Impacts	Native/ Indigenous range	Ecology/ Life history
Plants	Hawaiian Ecosystem at Risk (HEAR): Risk Assessments	Website	http://www.hear.org/wra/					
All	Austral Ecology	Peer-reviewed journal with many papers on invasive species	http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1442-9993/issues					
All	Biodiversity and Conservation	Peer-reviewed journal with many papers on invasive species	http://www.springerlink.com/content/0960-3115/					
All	Biolinvasion Records	Peer-reviewed journal focussing exclusively on invasive species	http://www.reabic.net/journals/bir/2012/Issue1.aspx					
All	Biological Conservation	Peer-reviewed journal with many papers on invasive species	http://www.sciencedirect.com/science/journal/00063207					

Taxon/Group	Source	Source type	Reference	Synonyms	Invasive Elsewhere?/ Established Elsewhere?	Impacts	Native/ Indigenous range	Ecology/ Life history
All	Biological Invasions	Peer-reviewed journal focussing exclusively on invasive species	http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1472-4642					
All	CABI Crop Protection Compendium	Website	http://www.cabi.org/cpc/					
All	CABI Invasive Species Compendium	Website	http://www.cabi.org/isc/					
All	Conservation Biology	Peer-reviewed journal with many papers on invasive species	Peer-reviewed journal with many papers on invasive species					
All	Delivering Alien Invasive Species Inventories for Europe (DAISIE)	Website	www.europe-aliens.org.					
All	Diversity and Distributions	Peer-reviewed journal with many papers on invasive species	http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1472-4642					
All	Global Biodiversity Information Facility (GBIF)	Website	http://www.gbif.org/					
All	Global Invasive Species Database (GISD)	Website	http://www.issg.org/database/welcome/					
All	Hawaiian Ecosystem at Risk (HEAR)	Website	http://www.hear.org/					
All	Integrated Taxonomic Information System (IT IS)	Website	http://www.itis.gov/					
All	Invasive Alien Species Indicator	Website	http://academic.sun.ac.za/iasi/					
All	North European and Baltic Network on Invasive Alien Species (NOBANIS)	Website	http://www.nobanis.org					
Amphibians	Amphibia web	Website	http://amphibiaweb.org/					
Aquatic plants	Aquatic Plant Information System Online (APIS)	Website	http://el.erdc.usace.army.mil/aqua/apis/Intro.aspx					
Aquatic species	Aquatic Invasions Research Directory	Website	http://invasions.si.edu/aird					
Aquatic species	Database on Introductions of Aquatic Species (DIAS)	Website	http://www.fao.org/fishery/dias/en					
Aquatic	Nonindigenous Aquatic Species	Website	http://nas.er.usgs.gov/					

Taxon/Group	Source	Source type	Reference	Synonyms	Invasive Elsewhere?/ Established Elsewhere?	Impacts	Native/ Indigenous range	Ecology/ Life history
species								
Arthropods	North American Non-Indigenous Arthropod Database (NANIAD)	Website	http://www.invasivespecies.org/NANIAD.html					
Birds	Introduced birds of the world: the worldwide history, distribution, and influence of birds introduced to new environments	Reference Book	Long 1981					
Birds	Naturalized birds of the world	Reference Book	Lever 1987					
Freshwater Fish	FishBase	Website	http://fishbase.org/search.php					
Freshwater Fish	Naturalized fishes of the world	Reference Book	Lever 1996					
Freshwater taxa	A handbook of global freshwater invasive species	Reference Book	Francis 2011					
Mammals	Introduced mammals of the world: their history, distribution and influence	Primary Literature	Long 2003					
Mammals	Mammal Species of the World. A Taxonomic and Geographic Reference	Primary Literature	Wilson & Reeder 2005					
Mammals	Naturalized mammals of the world	Reference Book	Lever 1985					
Marine and Freshwater species	National Exotic Marine and Estuarine Species Information System (NEMESIS)	Website	http://invasions.si.edu/nemesis/					
Marine species	Database of Global Marine Invasive Species Threats	Primary Literature: Supplementary Material	Molnar et al. 2008					
Marine species	The Baltic Sea Alien Species Database	Website	http://www.corpi.ku.lt/nemo/					
Marine species	World Register of Marine Species	Website	http://www.marinespecies.org/					
Plants	A global compendium of weeds	Reference Book	Randall et al. 2012					
Plants	Australia's Virtual Herbarium	Website	http://avh.ala.org.au					
Plants	CalFlora	Website	http://www.calflora.org/					

Taxon/Group	Source	Source type	Reference	Synonyms	Invasive Elsewhere?/ Established Elsewhere?	Impacts	Native/ Indigenous range	Ecology/ Life history
Plants	Invasive plants of the World	Reference Book	Weber 2003					
Plants	The Plant List	Website	http://www.theplantlist.org					
Plants	A new comprehensive database of alien plant species in Chile based on herbarium records	Primary Literature: Supplementary Material	Fuentes et al. 2012					
Reptiles	A quantitative climate-match score for risk-assessment screening of reptile and amphibian introductions	Primary Literature	Van Wilgen et al. 2009					
Reptiles	The reptile database	Website	http://www.reptile-database.org/					
Reptiles and Amphibians	Alien reptiles and amphibians, a scientific compendium and analyses	Reference Book	Kraus 2009					

Appendix S2: Guidance regarding the use of the confidence rating (modified from the EPPO pest risk assessment decision support scheme (Alan MacLeod 09/03/2011; revised 28/04/2011; copied from CAPRA, version 2.74; 2)).

Confidence level	Examples
High (approx. 90% chance of assessment being correct)	There is direct relevant observational evidence to support the assessment; *and* Impacts are recorded at the typical spatial scale over which original native communities can be characterized; *and* There are reliable/good quality data sources on impacts of the taxa; *and* The interpretation of data/information is straightforward; *and* Data/information are not controversial or contradictory.
Medium (approx. 65-75% chance of assessment being correct)	There is some direct observational evidence to support the assessment, but some information is inferred; *and/or* Impacts are recorded at a spatial scale which may not be relevant to the scale over which original native communities can be characterized, but extrapolation or downscaling of the data to relevant scales is considered reliable, or to embrace little uncertainty; *and/or* The interpretation of the data is to some extent ambiguous or contradictory.
Low (approx. 35% chance of assessment being correct)	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; *and/or* Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which original native communities can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. *and/or* Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous. *and/or* The information sources are considered to be of low quality or contain information that is unreliable.

Appendix S3: Pathway categories and sub-categories (from Essl et al. 2011)

Category	Subcategory
RELEASE IN NATURE (1)	Biological control
	Erosion control/ dune stabilization (windbreaks, hedges…)
	Fishery in the wild
	Hunting in the wild
	Landscape/flora/fauna improvement
	Conservation introduction
	Release in nature for use (other than above, e.g. medical use, fur..)
	Other Intentional release
ESCAPE FROM CONFINEMENT (2)	Agriculture (including biofuel feedstocks)
	Aquaculture/mariculture
	Botanical garden/zoo/aquaria (excluding domestic aquaria)
	Farmed animals
	Forestry
	Fur farms
	Horticulture
	Ornamental purpose other than horticulture
	Pet/aquarium/terrarium species
	Research (in facilities)
	Live food and live bait
	Other escape from confinement
TRANSPORT – CONTAMINANT (3)	Contaminant nursery material
	Contaminated bait
	Food contaminant
	Contaminant on animals (except species transported by host/vector)
	Contaminant on plants (except species transported by host/vector)
	Parasites on animals
	Parasites on plants
	Seed contaminant
	Timber trade
	Transportation of habitat material (soil, vegetation…)
TRANSPORT – STOWAWAY (4)	Angling/fishing aquaculture equipment
	Container/bulk
	Hitchhikers in or on plane
	Hitchhikers on ship/boat
	Machinery/equipment
	People and their luggage/equipment
	Ship/boat ballast water
	Ship/boat hull fouling
	Vehicles (car, trains…)
	Other means of transport
CORRIDOR (5)	Interconnected waterways/basins/seas

	Tunnels and land bridges
UNAIDED (6)	Natural dispersal across borders of alien species that have been introduced trough pathways 1 to 5

Appendix S4: Invasion status according to Blackburn et al. (2011)

Figure S4. The proposed unified framework for biological invasions according to Blackburn et al (2011).

3

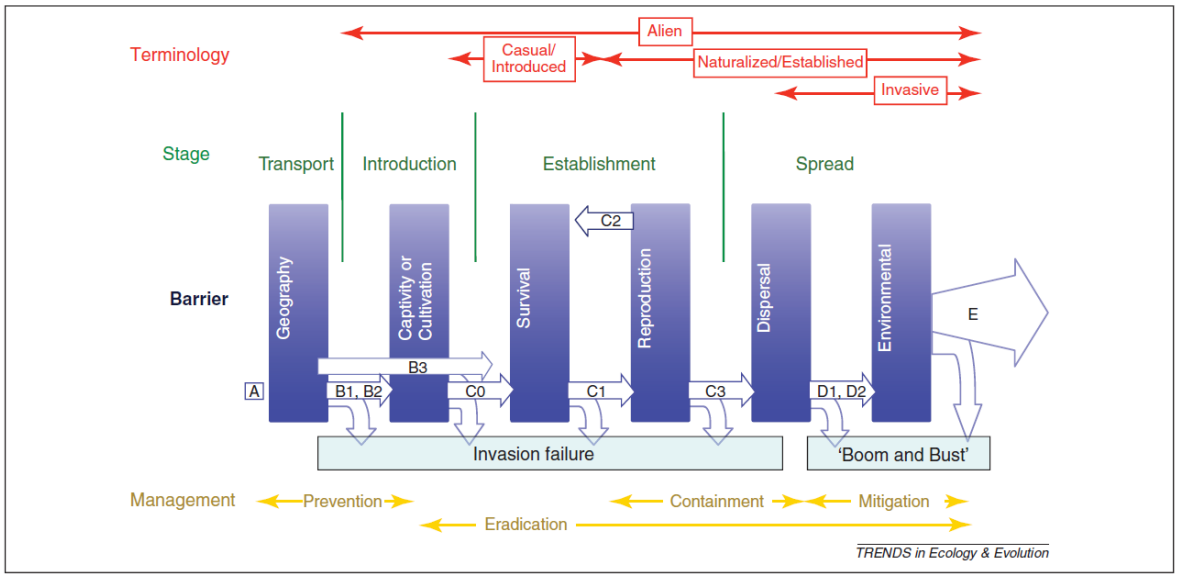


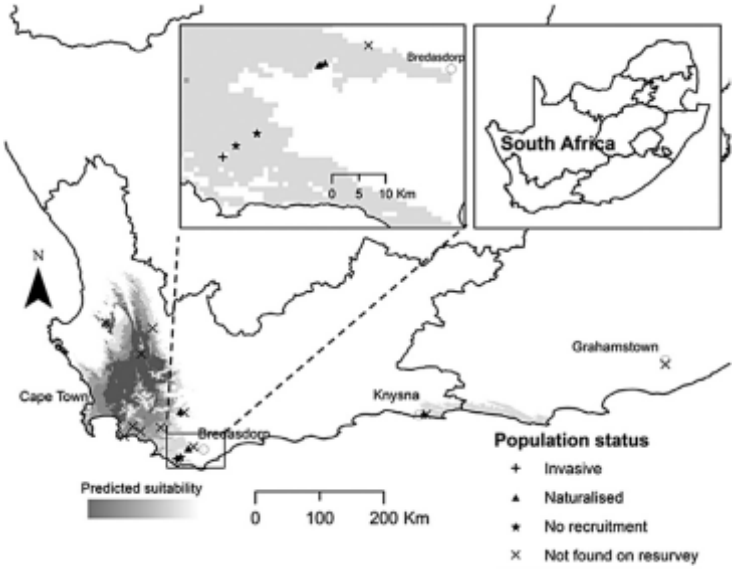
Table S4. A categorisation scheme for populations in the unified framework

Category	Definition
A	Not transported beyond limits of native range
B1	Individuals transported beyond limits of native range, and in captivity or quarantine (i.e. individuals provided with conditions suitable for them, but explicit measures of containment are in place)
B2	Individuals transported beyond limits of native range, and in cultivation (i.e. individuals provided with conditions suitable for them but explicit measures to prevent dispersal are limited at best)
B3	Individuals transported beyond limits of native range, and directly released into novel environment
C0	Individuals released into the wild (i.e. outside of captivity or cultivation) in location where introduced, but incapable of surviving for a significant period
C1	Individuals surviving in the wild (i.e. outside of captivity or cultivation) in location where introduced, no reproduction
C2	Individuals surviving in the wild in location where introduced, reproduction occurring, but population not self-sustaining
C3	Individuals surviving in the wild in location where introduced, reproduction occurring, and population self-sustaining
D1	Self-sustaining population in the wild, with individuals surviving a significant distance from the original point of introduction
D2	Self-sustaining population in the wild, with individuals surviving and reproducing a significant distance from the original point of introduction
E	Fully invasive species, with individuals dispersing, surviving and reproducing at multiple sites across a greater or lesser spectrum of habitats and extent of occurrence

Appendix S5: Summary sheet example

Risk Analysis for ***Banksia ericifolia*** **L. f.** in **South Africa**

Compiled by: Sammy the Sea-turtle



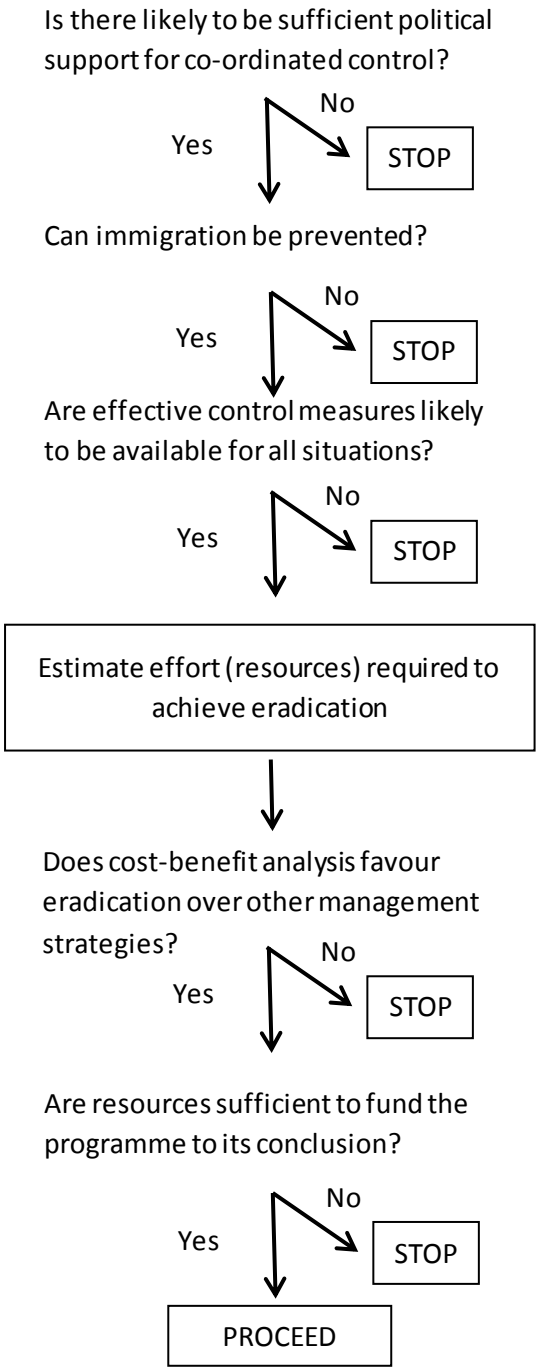
Risk Assessment: The species is found in South Africa in a limited number of sites and has been recorded as invasive in at least one. If it were widely dispersed it is fairly likely that it would occupy a large area in the Cape Floristic Region with moderate impacts primarily through out-competing native vegetation. Providing plantings are not burnt, it does not establish widely. It has not been seen to spread long distances.

Management options: The plant has been shown to be easily controlled by mechanical clearing. Given that it is easily detectable before seed-production, and has a small distribution it is suitable for eradication.

Recommendation: There is some evidence to suggest the species should be listed. It is a potential eradication target (i.e. category 1a). If it is planted under controlled conditions the risk is low and manageable. The Department should determine if there is public demand for the species and either list as 1a or 2 (with no permits issued for areas where plants are likely to be burnt).

1a

Appendix S6: A decision tree for determining eradication feasibility (redrawn from Panetta and Timmins 2004).



Appendix S7: A proposed framework for engaging stakeholders when developing management practices for alien and invasive species. Please note as this work is currently in review, this figure is currently confidential.

Novoa, A., Shackleton, R., Canavan, S., Cybèle, C., Davies, S., Dehnen-Schmutz, K., Fried, J., Gaertner, M., Geerts, S., Griffiths, C., Kaplan, H., Kumschick, S., Maitre, D.L., Measey, J., Nunes, A.L., Richardson, D.M., Robinson, T.B., Touza, J. & Wilson, J.R. (unpublished) A framework for engaging stakeholders on the management of alien species.