Improving the methodology for rapid consequence assessment of amenity and environmental pests

Final Report for CEBRA Project 20110801

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May 2021

Acknowledgements

This report is a product of the Centre of Excellence for Biosecurity Risk Analysis (CEBRA). In preparing this report, the authors acknowledge the financial and other forms of support provided by the Department of Agriculture, Water and the Environment, and the University of Melbourne.

The authors are grateful to the DAWE staff members who conducted user testing of GISS tool and provided useful feedback

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1. Executive Summary

International standards and guidelines for assessing the potential consequences of pest and disease incursions work well when impacts are on horticultural and agricultural industries, particularly where the potential economic impacts of a pest or disease can be estimated and/or demonstrated. Difficulties arise, however, when impacts fall largely on the environment, social amenity, human wellbeing and infrastructure — in this context international guidance is less clear on appropriate methodology. In these scenarios the potential economic impacts are more difficult to evaluate and are usually subjective since the value placed on damage will differ between stakeholders. This is the case for an increasing range of pests intercepted at the Australian border, such as certain species of snails, spiders, beetles, millipedes and invasive ants. In addition, information about the biology and behaviour of these pests is often absent, or minimal at best, making decision-making surrounding biosecurity risks of these 'non-industry' pests extremely difficult.

Immediate action is taken to remove threats upon detection at the border, on the basis that the species is exotic and import conditions do not permit contamination of any biosecurity risk material. The potential biosecurity risks posed by these species must nevertheless be assessed, as a decision must be made on whether further action is required (i.e. does the consignment require treatment). Failure to assess the impacts of non-industry pest species in an appropriate, robust and reproducible manner may lead to: inconsistencies in pest regulation decisions; decisions resulting in damage to the Australian economy and environment; and unnecessary confusion and misunderstanding by domestic and international stakeholders. There is therefore a need for the department to be able to rapidly and consistently assess the potential impacts for pests whose impacts are largely on the non-industry sectors of the environment and economy, to support decision making and maintain Australia's favourable biosecurity status.

This project reviewed the large number of existing frameworks and tools that have been developed to identify pests and diseases that pose a high risk of damage to natural environments. Key criteria were identified and used to assess these frameworks and tools in order to select one that could be adopted by the Department of Agriculture, Water and the Environment (the department) to rapidly assess the impacts (i.e. potential consequences) of non-industry pests. One framework and associated tool were selected, tested and slightly-modified to make it fit for purpose. This report describes that process.

1.1 Key finding

The GISS tool is suitable for use to assess the potential impacts of non-industry pests detected at the Australian border.

The Generic Impact Scoring System (GISS) developed by Nentwig et al. (2016) for alien plants and animals was selected as the most suitable framework to identify potential non-industry impacts of species detected at the Australian border. An existing spreadsheet-based tool allows assessment of nine categories of non-industry impacts — environmental (6); human infrastructure and administration (1); human health (1); and human social life (1) — and three categories of industry impact. The tool relies on published evidence of species impacts outside its native range and can be completed within time frames that typically apply to these detections at the border (usually 24-48 hours). Some limited modifications of the tool have occurred to ensure it is fit-for purpose, while others have been suggested for future consideration including the use of the scoring function that allows prioritisation of threats.

The GISS tool was tested by several departmental staff for four typical species detected at the border and found to be suitable with minor modifications. Guidelines have been developed to assist departmental staff apply the GISS tool and the tool itself contains detailed descriptions of what should be included in assessing each impact category. The use of the GISS tool is expected to improve the consistency, rigour and transparency of decision making for non-industry pests whose impacts are on the environment, social amenity, human health and infrastructure.

It should be highlighted that the GISS tool compliments the department’s existing risk assessment methodology and is not intended to replace a full pest risk assessment (PRA). Where it is identified that a PRA is required for a species with non-industry impacts, the existing methodology can be applied to fully assess the risks of entry, establishment, spread and consequence on specific pathways.

1.2 Recommendations

Given suitability of the GISS to assess non-industry impacts of species detected at the Australian border, it is also recommended that:

1. Wider departmental consultation on the tool and its planned use take place.

While the GISS tool has been assessed as ‘fit for purpose’ by the Plant Sciences and Risk Assessment branch in Plant Division, its use may have implications for, and/or be of interest to, various other sections in DAWE, including: Animal Division and the office of the Chief Environmental Biosecurity Officer. These and other areas of the department should be given the opportunity to understand the tool and its planned use. Any feedback from these groups on the use of the tool should be considered and the tool further modified if required.

2. Validation testing of known ‘actionable’ pest take place.

It would be a worthwhile process to reassess the impacts of species previously deemed ‘actionable’ and ‘non-actionable’ using the GISS tool. This would allow checks on consistency, both of past decisions and in terms of results from using the GISS tool.

3. Further modifications to the tool and its use be considered.

Several minor modifications were made to the GISS tool in order make it fit-for-purpose, but there are other modifications that could be made to the tool to enhance its application and consequence assessment processes. These include i) weighting non-industry impacts relatively higher than industry impacts; and ii) determining whether the entire set of impacts needs to be assessed once clear evidence of one likely impact is detected. In addition, the GISS tool has scope for the scoring system to be understood in terms of Australia’s appropriate level of protection (ALOP).

The department is currently developing a range of IT systems and solutions to modernise its work processes. There is an opportunity to incorporate the GISS tool as an assessment module in the Pest and Disease Repository to facilitate information sharing, assessment transparency and consistency.

4. Ongoing evaluation of the tool's use be undertaken.

Ongoing evaluation of the GISS tool should occur in the interests of maintaining a rigorous and transparent consequence assessment process. Evaluation would include understanding the implementation process, metrics around the tool's actual use (number of times used, time required to use tool) and ongoing feedback from staff about their experiences using the tool. It would also be beneficial to understand whether the tool has actually improved decision-making at the border — for example, whether its adoption has saved time and/or improved the quality of information provided to importers.

2. Introduction

Knowledge of the likely consequences of entry, establishment and spread of an exotic pest is required for sound decision-making in a range of situations, including when:

- an exotic pest or disease is detected at the national border, as a contaminant pest;
- reviewing biosecurity import requirements and conditions;
- import permits for new products are sought; and
- undertaking horizon scanning for potential new biosecurity threats.

In Australia, the Department of Agriculture, Water and the Environment (the department) is responsible for assessing the biosecurity risks associated with the import of a range of goods from overseas. It does so via pest risk analyses and, if necessary, imposes risk management measures in order to reduce risks to an acceptable level, known as the 'appropriate level of protection' (ALOP). As a signatory country to the World Trade Organisation Agreement on the Application on Sanitary and Phytosanitary Measures (the SPS Agreement), Australia has set an ALOP that is aimed at reducing biosecurity risks to a very low level, but not to zero.

The SPS Agreement provides a framework of rules to guide WTO members in the development, adoption and enforcement of sanitary and phytosanitary measures which may affect trade. The International Plant Protection Convention (IPPC) and World Organisation for Animal Health (OIE) develop international standards, recommendations and guidelines for plant and animal health and food safety including a methodology for estimating and combining likelihoods of pest entry, establishment and spread, and for assessing consequences. These guidelines work well when impacts of pests on horticultural or agricultural industries are being assessed. Difficulties arise, however, when impacts of pests and diseases fall largely on the environment, social amenity, human wellbeing and infrastructure (non-industry). This is the case for an increasing range of species intercepted at the Australian border, such as certain species of snails, spiders and invasive ants (Table 1). For these species, international guidance is less clear on appropriate methodology. In addition, information about pest biology and behaviour is often absent, or minimal at best, making decision-making surrounding biosecurity risks extremely difficult.

Immediate action is taken to remove threats upon detection at the border on the basis that the species is exotic and import conditions do not permit contamination of any biosecurity risk material. The potential biosecurity risks posed by these species must nevertheless be assessed, as a decision is required on whether further action is needed. For example, does the consignment on which the species was intercepted require a mandatory treatment. Failure to assess the impacts of non-industry species in an appropriate, robust and reproducible manner may lead to: inconsistencies in pest regulation decisions; decisions resulting in damage to the Australian economy and environment; and unnecessary confusion and misunderstanding by domestic and international stakeholders. There is therefore a need for the department to be able to rapidly and consistently assess the potential impacts for pests whose impacts are largely on the non-industry sectors of the environment and economy, to support decision making and maintain Australia's biosecurity status.

Table I. Some examples of non-industry pests intercepted at the border or post-border

Scientific name	Common name
Ants	
Camponotus pennsylvanicus	carpenter ant
Hypopnera eduardi	crypt ant
Lasius neglectus	invasive garden ant
Beetle	
Heterobostrychus aequalis	lesser auger beetle
Olla v-nigrum	ashy gray lady beetle
Ernocladius sp.	bark beetle
Corticinara sp.	beetle
Aridius sp.	beetle
Nistroa basselae	bele flea beetle
Snail	
Massylaea vermiculata	chocolate banded snail
Caracollina lenticula	lens snail
Discus rotundatus	rotund disc snail
Pomacea canaliculata	golden apple snail
Xerotricha conspurcata	terrestrial snail
Spider	
Hogna spp.	wolf spider
Erigone aletris	dwarf spider
Lepthyphantes sp.	dwarf spider
Termite	
Coptotermes gestroi	Asian subterranean termite
Prorhinotermes canalifrons	subterranean termite
Incisitermes immigrans	lowland tree drywood termite
Incisitermes sp.	drywood termites
Wasp	
Polistes dominula	European paper wasp
Polistes chinensis	Asian paper wasp
Chalybio bengalense	Oriental mud dauber wasp
Pachodynerus nasidens	keyhole wasp
Other	
Miomantis caffra	South African mantis
Wahlgreniella neryata	strawberry tree aphid
Centrobolus annulatus	red fire millipede
Polyxenus lagurus	bristly millipede
Scatopse sp.	black scavenger fly
Astrosimulium australense	black flies/sand flies

2.1 Objectives

The overarching objective of CEBRA 20110801 is to extend the department's ability to rapidly assess the potential environmental impacts of species intercepted at the border, when species have no known impact on agricultural and horticultural industry-related sectors of the economy. Specifically, it seeks to identify or develop a framework or tool to identify the range of possible impacts that could plausibly occur should an exotic, non-industry pest species enter, establish and spread.

The tool or framework is not intended to replace the department's existing risk analysis methodology, rather it is intended to provide rapid identification of potential consequence of species with non-industry impacts to support decision-making for species intercepted at the border. Where the department identifies a species requires further assessment, the existing PRA methodology can be applied.

2.2 Methodology

A large number of risk assessment frameworks and associated tools (hereafter frameworks when referring to both) were known to exist for the purposes of identifying and prioritising pests and diseases that post a high risk of causing damage. As a starting point, these existing frameworks were identified to understand whether any might be suitable for use in the current context, with or without modification (Chapter 3). If none were found suitable, a new risk assessment framework would be developed.

The large number of existing frameworks were collated and reviewed. Around twenty of these were selected for closer examination. The purpose of the closer examination was to assess the suitability of the different frameworks so that the most suitable ones could be identified and examined for final selection. This involved developing a set of criteria by which to assess each framework, applying the assessment criteria to each framework (Chapter 4), undertaking initial testing of those frameworks that remained and selecting the most suitable framework/s for user testing and assessment by departmental staff (Chapter 5).

One framework and associated spreadsheet-based tool were selected. Guidance materials and a case study application were provided to staff to support user testing and assessment of the tool on several pests that were typical of those intercepted at the Australian border, including pests where information on non-industry impacts was sparse. Feedback from assessors on tool performance was collected and used to confirm the utility of the tool and any modifications that would improve ease of use (Chapter 6).

3. Existing frameworks

Identifying pests and diseases that pose a high risk of causing damage is key to many international biosecurity programs. A large number of risk assessment frameworks have been developed for this purpose. They are based on the growing evidence of the biological and ecological characteristics of invasive species (e.g. Devin and Beisel, 2007) and progress with classifying and understanding the environmental and other non-market impacts of exotic pests and diseases (Pyšek et al., 2012; Pyšek et al., 2020). The many published frameworks have, in turn, been reviewed in order to understand the various approaches, assess their strengths and weaknesses, and to catalogue good practices for developing and implementing assessment frameworks.

3.1 The search process

The full extent of published risk analysis frameworks relevant to this project's objectives were uncovered through a scan of the following:

- Articles which reviewed existing risk assessment frameworks: Heikkilä, 2011; EFSA, 2011; Bartz and Kowarik, 2019; and Srėbalienė et al., 2019.
- A search of relevant journals, including *Ecological Economics*, *Biological Invasions*, *Neobiota*, *PLOS Biology*, *Diversity and Distributions*, *Environmental Monitoring and Assessment*, and *Journal of Environmental Management*.
- Published frameworks identified using the search engine Google Scholar using the terms "pest risk assessment framework", "biosecurity impact assessment" and "biosecurity risk analysis" etc.
- Grey literature including general and agricultural media
- International organisations' risk assessment methodologies, especially the 'Quad' countries Australia, New Zealand, Canada and USA
- Identification of linkages with previous projects conducted by CEBRA/research and development organisations.

3.2 Summary

Following the literature scan, around twenty published frameworks that assess invasive characteristics and impact of invasive species were selected for closer examination. These frameworks are either the original exposition and application of a particular methodology, or they have built on the original methodology in some significant way. Frameworks were broadly grouped according to type of methodology — quantitative, scoring systems, semi-quantitative, and expert-opinion driven — although there is overlap. In some cases, ready-to-use tools had been developed from frameworks. A summary of the information for each framework is provided under various headings: tool, methodology and purpose; non-industry impacts; impact-scales and whether detailed descriptors of impact are supplied; whether uncertainty is considered; and current or potential applications of the framework (Appendix A). These headings were identified as the most useful for selecting a framework(s) for further assessment.

3.2.1 Quantitative

Frameworks categorised as 'quantitative' use existing biological relationships and data linked to invasive potential, and derive standardised metrics that predict likelihood and degree of impact across a range of taxa. For example, a self–organising map (SOM) was used by Worner and Gevrey (2006) to identify pest species assemblages and potential invasive insect species that threaten New Zealand, based on a large database of global presence or absence of pests. The SOM allowed each species to be ranked in terms of its risk of invasion in each region of New Zealand, based on the strength of its association with the assemblage that was characteristic for each global geographical region.

Bomford et al. (2008) also focus on the geographic range of species. They use climate matching software to predict invasiveness of reptiles and amphibians, basing their analysis on the finding that relative to failed species, successful invaders had better climate matches between the distribution where they were introduced and their geographic range elsewhere in the world. Cross-validation indicated the model correctly categorised establishment success with 78–80% accuracy.

Magee et al. (2010) developed an Index of Alien Impact (IAI) to estimate the collective ecological impact of alien species present in a particular location. The IAI estimates the collective impact of multiple alien species in a location by combining a function-based descriptor of potential ecological impact with the frequency of occurrence of individual species. Using a similar approach, Miller et al. (2010) applied the existing Relative Risk Model (Landis, 2004) to assess the risks of multiple invasive plant species to multiple rare plant species. The approach also involves the use of geographical data to characterise the likelihood that invasive species will threaten rare species, and the use of life history characteristics of invasive plants to describe the ecological consequences of their invasion.

Dick et al. (2017) derive the Relative Impact Potential (RIP) metric, an invader/native ratio based on the *per capita* effect of a predator (or other consumer) on prey (or other resources) as the density of prey increases. Under this approach ecological impacts are defined as measurable changes in populations of affected species. RIP values greater than 1 indicate the 'invader' will likely cause ecological impact, with increasing values above 1 indicating increasing impact. Uncertainty is incorporated by assuming key biological data are sampled from underlying log-normal distributions. Dickey et al. (2020) builds on this approach by incorporating changes in propagule pressure — changing predator consumption rates and prey reproduction rates — which might occur in the face of climate change.

3.2.2 Scoring systems

This category contains the largest number of frameworks. One of the earliest is the Australian Weed Risk Assessment (WRA) framework (Pheloung et al., 1999) to screen potentially invasive plants. This widely applied framework is a spreadsheet-based scoring system based on 49 screening questions, with largely 'yes/no' answers converted to an overall score. One question specifically asks about environmental weediness, while several other questions are related to potential environmental impact. Depending on the score, species are categorised as: accept, evaluate or reject. Koop et al. (2012) build upon the Australian WRA model in developing their Plant Protection and Quarantine (PPQ) model to screen potentially invasive plants for the USA. Additional questions relate to species' capacity to cause direct and indirect damage to natural and human systems. Two risk scores result — establishment and spread potential; and impact potential. The authors claim greater accuracy than the Australian WRA when the PPQ was used to assess the same species.

The focus of the European Food Safety Authority (EFSA) plant pest risk assessment scheme is solely on environmental impacts, and claims to be the first scheme to assess the consequences of plant pests on both the structural (biodiversity) and functional (ecosystem services) aspects of the environment EFSA (2011). The user is guided by detailed explanation for answering the six primary questions and numerous sub-questions. A rating system is also included in the scheme, and is based on evaluating the level of risk and uncertainty for each question. Gilioli et al. (2014) further develops the approach of EFSA (2011) and calculate impacts as a percentage reduction in a range of environmental services, applying their framework to the citrus long-horn beetle (Gilioli et al. 2014) and demonstrates the environmental impact of apple snails if they were to establish in Europe (Gilioli et al., 2017).

Molluscs are the focus of risk assessment model developed by Cowie et al. (2009). The authors used their scoring system, based on 12 non-exclusive attributes, to create a ranked list of 46 non-marine snail species from the United States. Environmental impacts are considered under two of the questions: 'major pest elsewhere' and whether the species is a 'multi-pest'. Scores are 0, 0.1, 1 or nil, depending on whether the literature suggests the attribute will enhance their pest potential. There is no explicit weighting of attributes, although some attributes are related, thus implicitly weighting those.

The Generic Impact Scoring System (GISS) developed by Nentwig et al. (2010; 2016) for alien plants and animals is a questionnaire and excel-based tool which relies on published knowledge to understand impact of invasive species on 12 impact categories — 6 for environmental impact and 6 for socio-economic impact. Environmental impacts include: those on plants or vegetation other than competition; impacts on animals through predation, parasitism or intoxication; impacts on species through competition; transmission of diseases or parasites to native species; hybridization; and impacts on ecosystems. The GISS has been applied and further developed for a range of species including spiders (Nentwig, 2015) and aquarium species (Orfinger and Douglas Goodding, 2018).

The risk assessment system developed by Ou et al. (2008) is a mix of many different screening and ranking systems. The system developed uses primary and secondary criteria to understand plant invasiveness, including two questions related to impact on ecosystem process, native plant and animal species. The score that eventuates (the worst possible score is 100) determines the management actions that should be undertaken. The Analytic Hierarchy Process (AHP) is used to determine the weights of the criteria in the scoring system. AHP is a mathematical framework for reducing a complex multi-criterion decision to its component parts — pair-wise comparisons of criteria allows a more objective estimation of the relative importance of each criteria to the overall decision (Saaty, 1987).

3.2.3 Semi-quantitative

Frameworks classified as 'semi-quantitative' use a mix of mathematical techniques and questions to understand the impacts of invasive species. Some of the questions are answered by experts, while others are based on published findings in the literature. Many of the frameworks included in this section are also scoring systems, but are categorised separately to highlight the use of stakeholders and/or experts in the methodology. Key amongst these is the EPPO framework (Brunel et al., 2010; EPPO, 2012) and related papers (Branquart et al., 2016) which assess potentially invasive alien plants for use in prioritisation and pest risk analyses. In this approach, a decision tree is used for preliminary assessment of a risk, and a risk matrix is subsequently used to assess negative impacts of the plant against spread potential. Non-market impacts considered, include those on native species, habitats and ecosystems, human health and infrastructure, and recreational activities. Impact scales are low, medium and high, and detailed definitions of impacts are supplied.

Skurka Darin et al. (2011) developed a tool known as WHIPPET (Weed Heuristics: Invasive Population Prioritization for Eradication Tool) to prioritise weed populations, rather than species, for eradication. The final criteria used to determine species for eradication relate to impact, invasiveness and feasibility of eradication. These, and their sub-criteria, were selected based on literature review and expert opinion. The AHP process was used to assign weights to decision criteria. WHIPPET was tested on a group of noxious weeds in California and compared to assessments by experts. Results showed that priority lists based only on species-level characteristics are less effective compared to lists based on species attributes and individual population and site parameters. The authors note that WHIPPET was time consuming to build and test, and accuracy of the tool relies on complete spatial datasets of information about weed location, area infested and treatment history.

Another key framework is that of Blackburn et al. (2014) who extended the previously reported GISS (Nentwig et al., 2016) to include additional environmental impact categories. The framework was named the Environmental Impact Classification for Alien Taxa (EICAT) by Hawkins et al. (2015), who also provide comprehensive details about the framework and guidelines for implementation. In 2020 the EICAT was officially adopted as the IUCN (International Union for Conservation of Nature) standard for classifying alien species in terms of their environmental impact (Volery et al., 2020). The 12 EICAT impact mechanisms are: competition; predation; hybridisation; transmission of diseases to native species; parasitism; poisoning/toxicity; biofouling; grazing/herbivory/browsing; chemical, physical of structural impact on ecosystems; and interaction with other species. Species are classified based on their most severe documented impacts in regions where they have been introduced, via five sequential categories of impact: minimal, minor, moderate, major, and massive. Classification is based on the best available evidence, and the scheme can be applied across taxa and at a range of spatial scales.

Environmental impact is also the sole focus of the Norwegian Generic Ecological Impact Assessment of Alien Species (GEIAAS), developed by Sandvik et al. (2013, 2019). While the scheme underlies the classification of all 2,241 alien species known to occur in Norway, it may also be used to assess potential future introductions. Six criteria capture the ecological impact of the species (interactions with threatened/keystone or other native species, changes in threatened/rare or other ecosystems, and the potential to transmit genes or parasites) and each is assigned a score from 1 to 4. These are plotted against four measures of invasion potential giving 16 possible categories of 'final' impact. Uncertainty is considered in the assessment process by estimating prediction intervals, and by selecting the highest category encompassed by the intervals.

D'hondt et al. (2015) develop two frameworks — *Harmonia*$^{+}$ and *Pandora* — for rapid screening, ranking and risk analysis based on 25-30 questions relating to environmental impact and impact on human health. Several questions in each tool relate to environmental impact and human health impact, and guidance is provided for answering each question. Scores for each different 'impact module' may be aggregated into a general impact score, either by taking the maximum value of each module or the arithmetic mean if the user considers risks to be additive. Modules may be weighted depending on the importance of impact. Each tool considers uncertainty by requiring the assessor to provide a level of confidence with each answer (low/medium/high). The protocol is run 10,000 times, each time randomly drawing from the distribution.

A final semi-quantitative scoring system of note was developed by Davidson et al. (2017) — the Great Lakes Aquatic Nonindigenous Species Risk Assessment (GLANSRA) framework. A range of environmental and socio-economic impacts are considered via a question-driven assessment of a nonindigenous species from diverse spatial origins and taxonomic classifications, in novel environments. Several questions also consider the beneficial impacts of species. Scores for each question are summed for each species' potential impact category and converted to a categorical impact ranking using a scoring table. The assessment score is mitigated by the number of unknowns to produce a categorical descriptor (unknown, low, medium and high). This framework uses some expert judgement and also incorporates the precautionary principle.

3.2.4 Expert opinion-driven frameworks

Several frameworks identified rely solely on the use of stakeholders and experts in the assessment of invasive species risks. Cook and Proctor (2007) use a Deliberative Multi-criteria Evaluation (DMCE) process to rank and prioritise a set of plant pests and diseases in an Australian jurisdiction. The DMCE process contains elements of facilitation, interaction and consensus-building features of the citizen's science jury process with the structuring and integration features of multi-criteria evaluation (see Proctor and Dreschler 2006 for more details).

The prioritisation process developed by Kumschick et al. (2012) focuses on the use of stakeholders in the five-step process of prioritising invasive species for management. Stakeholder selection is important with 'stakeholder weights' applied according to the importance of the stakeholder in relation to the issue under evaluation. Input from scientists is sought when defining all changes that an invasive species may cause in the introduced range. The impacts are scored by stakeholders and when weights are applied a final impact score emerges. Species may then be ranked according to their overall scores and/or by the certainty of the scores.

A reasonably simple expert-opinion based scoring system is developed by Gallardo et al. (2016) for horizon-scanning. It is a four-step procedure where existing knowledge about high-risk invasive non-native species is combined with expert ranking of existing ‘Black List’ species. Ecological impact is one of the four categories of impact that is scored by experts.

4. Assessment of frameworks

4.1 Assessment criteria

Understanding which of the selected frameworks would be suitable for application, with or without modification, involves assessing each against a range of criteria. Criteria were developed, based on specific requirements for application by departmental staff and criteria considered best-practice in the literature.

The authors determined that for an existing framework to be appropriate for application by departmental staff it should be:

- Operable when information about pest behaviour in non-native ranges is minimal;
- Cost-effective in terms of resource requirements (time taken) for the department to undertake a species assessment in a timely manner, ideally within a couple of days of detection at the border;
- Minimise the use of expert knowledge and
- able to effectively categorise and detail a range of potential non-industry impacts of pests.

In addition, any chosen framework would ideally incorporate a number of key principles and ideal methodological properties which have emerged from the literature (Pheloung et al. 1999; Sandvik et al. 2013; Heikkilä 2011; Srėbalienė et al. 2019; Bartz and Kowarik 2019) and from international guidelines (European Union, 2018), notably:

- *Scientific robustness*. Risk assessments should be based on the best available information, where that information is collected and analysed using scientific methods. Components should have a scientific basis that is mathematically simple but logical. Any questions posed should be understandable and generic enough to allow application to a range of circumstances and easily adjustable to novel evidence of environmental change. There should be as few questions as possible, but the comparison should be robust. It should also be possible to use all available data in the framework.
- *Transparency and consistency.* Transparent methods are those that may be applied consistently by different users thus allowing the comparability of assessment scores and a greater likelihood of acceptance by stakeholders. Transparency requires that terminology is clear and that subjectivity via 'expert opinion' is minimised in favour of published data. Further, even when information is scant or absent, the evidence on which the decision is based should be clearly documented and open to scrutiny.
- *Uncertainty is considered; validation is possible.* Uncertainty is inherent in risk assessments, and stems from knowledge gaps, systemic and random measurement error, and variability (Dahlstrom et al., 2012). Uncertainty may be related to data inputs (the information needed for evaluation) or data outputs (the reliability of the outcome). There are several ways to account for uncertainty (Heikkilä, 2011), including the provision of scores for reliability of information or the inclusion of 'unknown' as a

potential assessment category to cope with input uncertainty; and the use of validation and testing to address output uncertainty.

Using knowledge of the department's existing risk assessment methodology and information identified in the literature, the authors determined a set of criteria to select frameworks for further analysis (Table 2, along with a detailed explanation for how to apply each criterion). Criteria 1–4 — data, time, use of expert knowledge, and the ability of the framework to capture environmental impacts — are seen as essential. Criteria 4–8 and 13 — environmental and biodiversity impacts, and transparency — are taken from Bartz and Kowarik (2017) with minor or no modification. Impacts on human health, infrastructure and amenity are listed as criteria 9–11.

The authors of this report also acknowledge that invasive species can impact on culture, for example certain species and places are culturally important to first nation peoples, and some species that are a key part of Australia's national identity however, we do not yet have the ability to measure these impacts.

Three or four 'codes' were assigned to each criterion. These were used to describe whether/how each framework met each criterion:

- ● = fully / directly applies: the criterion is met by the framework;
- ○ = partly/indirectly applies: the framework partially meets the criterion and is still workable;
- X = operationalisation not possible: the criterion is not met and thus the framework is not useful in the current context; and
- – = does not apply/parameter is not considered in the study: the parameter does not feature in the framework.

Table 2. Assessment criteria used to judge and select frameworks and examples of their application. Symbols are as follows: ● = fully / directly applies, ○ = partly / indirectly applies; X = operationalisation not possible; – = does not apply / parameter is not considered in the study.

Criterion	Explanation
1. Data*	This criterion describes whether data used by the tool currently exists in the scientific literature as raw data or as a secondary source, or whether it exists in some form that would likely need minor/quick manipulation. If raw data is required, the criterion is split into the following types of data: i) taxonomic; ii) biological; and iii) distributional. ● = operationalisation would be possible with existing data. ○ = operationalisation would be possible either using a straightforward and quick manipulation (e.g. substituting information for a closely related species or species with similar behaviours) or despite an incomplete dataset (e.g using a higher taxonomic level — genus or family). X = operationalisation not possible with existing data. – = Data not required by tool.
2. Time*	This criterion describes the time required to apply the tool to one species. Given the time critical nature of decisions required at the border, an ideal maxiumum time requirement was thought to be 2 days per species following the initial detection. ● = operationalisation would be possible in ≤ 24 hours. ○ = operationalisation would be possible in 2-5 days. x = operationalisation not possible within in 5 days or unclear.
3. Minimal use of expert knowledge*	This criterion describes the use and importance of expert knowledge in operationalising the tool, where ‘expert knowledge’ is defined as substantive information on a particular topic that is not widely known by others (Martin et al., 2012). ● = operationalisation is possible without the use of expert knowledge. ○ = operationalisation of tool involves the use of expert knowledge. x = operationalisation is not possible without the use of experts
4. Environmental impacts*+	Invasive species can induce impacts on the environment. This criterion describes whether environmental impacts are considered within the framework, and to what extent they are considered. ● = Impacts on environmental resources such as biodiversity are directly included through explicit criteria or questions. ○ = Environmental impacts are included indirectly by considering relevant effect-related species characteristics, for instance, the ability of a species to form large and dense monocultures. — = Parameter is not considered.
5. Genetic diversity+	The diversity of genetic characteristics within a species may be impacted by invasive species. Both direct and indirect effects of an invasive on genetic diversity should be considered here. These are listed in EFSA (2011) as gene flow disruption, introgression, hybridization (new genotypes, sterile hybrids, genetic pollution, outbreeding depression and extinction of native taxa). ● = Impacts on genetic diversity, e.g. by hybridisation, are directly included through explicit criteria or questions (e.g. ‘Impacts are through hybridization with native species, usually closely related to the alien taxon, leading to a reduced or lost opportunity for reproduction, sterile or fertile hybrid offspring, gradual loss of the genetic identity of a species, and/or disappearance of a native species (Nentwig et al., 2016). — = Parameter is not considered.

6. Species diversity+	This criterion describes the impact of an invasive on species diversity — the number and relative abundance of species found in a given population or region. ● = Impacts on species diversity are directly included through explicit criteria or questions, for instance regarding 'competition resulting in replacement or local extinction of one or several native species' (Blackburn et al., 2014), transmission of diseases or organisms to native species' (Nentwig et al., 2016) or 'predation' (Kumschick et al., 2012). ○ = Impacts on species diversity are included indirectly by considering relevant effect-related species characteristics, for instance, a species' ability to form large and dense monocultures (e.g). — = Parameter is not considered.
7. Ecosystem diversity+	Invasive species may impact ecosystem diversity — the variety of different habitats, communities and ecological processes in a particular region. ● = Impacts on ecosystem diversity are directly included through explicit criteria or questions concerning changes to processes, structures, abiotic factors etc. (e.g. 'taxon documented to alter composition, structure, or normal processes or function of a natural ecosystem', Pheloung et al. 1999). ○ = Impacts on ecosystem diversity are included indirectly by considering relevant effect-related species characteristics, for example, a species' ability to 'fix nitrogen' (Parker et al. 2007). — = Parameter is not considered.
8. Magnitude of overall environmental impact+	This criterion describes the overall magnitude of impacts in assessing the significance of impacts. Relevant parameters may be: a) magnitude of overall impact, b) size / intensity of individual effects, c) spatial extent of species spread, d) abundance of alien species, e) cumulativeness of impacts, f) irreversibility of impacts. ● = Approaches that explicitly present the magnitude of overall impact, mainly by merging individual impact scores into a final impact score (e.g. Randall et al. 2008) or by combining effect size with relevant impact attributes such as abundance and spatial extent (e.g. Olenin et al. 2007). ○ = The magnitude of overall impact is not explicitly presented but to some extent it can be derived by a closer look at individual assessment categories. For instance, some scoring systems consider different types of impacts but do not provide for generating a final impact score (e.g. Ou et al. 2010). — = Parameter is not considered.
9. Human health	Invasive species can induce impacts on human health, for example some species are vectors of human diseases and many species of insect pests have the ability to sting humans. ● = Impacts are directly included through explicit criteria or questions. – = impacts not considered.
10 Human infrastructure	Invasive species can induce impacts on human infrastructure, for example wood eating termites and beetle larvae can destroy building structures. ● = Impacts are directly included through explicit criteria or questions. – = impacts not considered.
11. Social amenity	Invasive species can induce impacts on social amenity, for example the presence of invasive species in public spaces and urban environments can reduce the use and enjoyment of these spaces. ● = Impacts are directly included through explicit criteria or questions. – = impacts not considered.
12. Scientific robustness	It is important that frameworks are scientifically robust; that data is collected and analysed using scientific methods. ● = Methods should be based on the best available information, where that information is collected and analysed using scientific methods. Components should have a scientific basis that is mathematically simple but logical. Any questions posed should be understandable and generic enough to allow application to a range of circumstances and easily adjustable to novel

	evidence of environmental change. It should also be possible to use all available data in the framework. ○ = Methods may have some attributes of scientific robustness, but in general there are flaws in application that would lead to some doubt about the result.
13. Transparency and consistency+	Transparent and consistent methods are those that will result in the same outcome even when they are applied by different users. Transparency requires that terminology is clear and that subjectivity minimised in favour of published data. The evidence on which the decision is based should be clearly documented and open to scrutiny. ● = The operationalisation of (≥90%) criteria is highly replicable, not matter by whom they are applied. This could be guaranteed, e.g. by quantification of thresholds or by providing distinct rules of application. Terms such as 'significant, low, middle, high etc' without further explanation are avoided. ○ = The operationalisation of provided criteria is partly replicable. For example, Ou et al. (2008) provide some quantified criteria (e.g. 'proportion of current range where the species caused negative impact'), but use rather imprecise phrases to differentiate between different levels of impact: 'little or without impact / weak impact / significant impact'. Without further explanation, it remains unclear how impact levels should be assigned. – = Very few criteria (<10%) are operationalised in a traceable and replicable manner.
14. Uncertainty	Uncertainty is considered. ● = Uncertainty explicitly features in the framework, perhaps by featuring directly in the scoring system (e.g Cowie et al. 2009), sampling from particular distributions (e.g. Dick et al., 2017), or by allocating a level of confidence to each answer (e.g. D'Hondt et al. 2015). ○ = Uncertainty is acknowledged but it is unclear how it is incorporated into the framework (e.g. Skurka Darin et al. 2011). – = uncertainty is not considered.

* Denotes essential criteria.

+ From Bartz and Kowarik (2019) with some or no modification.

4.2 Review of frameworks against criteria

The authorship team initially reviewed each of the 23 frameworks against the four essential criteria (1–4) — without these characteristics, either fully or partially met, the frameworks would not be considered 'fit for purpose'. Frameworks that were categorised as 'expert–opinion driven' were removed because these typically required weeks to organise workshops and stakeholders, and so didn't meet the 'time required' criteria. All frameworks categorised as 'quantitative' were removed due to data requirements, the requirement for new skills to be acquired by the user in order to implement the method, or the use of experts was required to confirm data. Many of the 'scoring' and 'semi–quantitative' frameworks were also removed because they involved some expert judgement or because environmental impacts were not categorised into sub–types.

Four frameworks remained after this 'first-pass' review (Table 3): GISS (Nentwig et al. 2016); EICAT (Blackburn et al. 2014); Harmonia+ (D'Hondt et al. 2015) and GEIAA (Sandvik et al. (2013; 2019). These were the frameworks that relied on only/mostly on published data, a ready–to–use tool that had been developed to implement the framework, and environmental impacts were broken down into informative sub–categories. Unfortunately, following further

Table 3. Assessment of frameworks against criteria, adapted from Bartz and Kowarik (2019)

Criterion	**GISS** Nentwig et al. (2010;2016	**EICAT** Blackburn et al. (2014);	**Harmonia+** D'hondt et al. (2015)	**GEIAA** Sandvik et al. (2013; 2019)
1. Data (existing)	●	●	●	●
2. Time required	●	●	●	●
3. Minimal use of experts	●	●	○	○
4. Environmental impacts	●	●	●	●
5. Genetic diversity	●	●	●	●
6. Species diversity	●	●	●	●
7. Ecosystem diversity	●	●	●	●
8. Magnitude of overall environmental impacts	●	●	●	●
9. Human health	●	–	●	–
10. Human infrastructure	●	–	–	–
11. Social amenity	●	–	–	–
12. Scientific robustness	●	●	●	●
13. Transparency and consistency	●	●	●	●
14. Uncertainty and validation	●	●	●	●

Note: 1-4 are essential criteria; 4-8 and 13 are from Bartz and Kowarik (2019) with some/no modification.

investigation the template for the GEIAA was not readily available (while the test version was online, it was not accessible from a 'safe' website), and so this framework was deleted from further review.

Three *tools* were ultimately reviewed against the whole set of criteria; a summary of results is shown in Table 3 and detailed reasoning given in Appendix B.

5. Selection of tool

Preliminary testing was undertaken in order to make a final selection between the remaining tools.

5.1 Preliminary testing of remaining tools

The authors undertook preliminary testing of the three remaining tools — GISS, EICAT and Harmonia$^+$ — in order to select one tool and to understand whether any modifications would be required before that tool could be classified as fit for purpose. Each tool was initially tested with two species: i) *Caracollina lenticula*, a snail species with limited information on invasive history*;* and i) *Euglandina rosea*, a known predatory snail with detailed invasive history. These species are typical of the pests that are the focus of this project: neither was recorded as having impacts on industry but their non-industry impacts remained unclear. Both species had previously been intercepted at the Australian border. Two of the tools, GISS and EICAT were also tested with an invasive ant, *Nylanderia fulva.*

A summary of results from the preliminary testing are given in Table 4, in terms of the time required to apply each tool, the pros and cons of each approach, and required modifications. Detailed output is given in Appendix B for GISS and EICAT. All tools were implementable well–within the 24–hour timeframe. The templates provided with each tool were easy to use, however the EICAT tool appeared somewhat repetitive — impacts were required to be recorded in two worksheets. GISS and EICAT were only implementable where there was published evidence of invasive behaviour; Harmonia used expert opinion where no published evidence was available. Each tool included uncertainty through confidence rating based on data quality and robustness.

The GISS tool considered 6 environmental consequences, with detailed description of what each involves. EICAT proposes 12 environmental consequences — it expands the six impacts listed in GISS, with descriptions of each found in the associated journal article rather than in the tool itself. Harmonia$^+$ also includes six types of environmental impacts and includes impacts on agricultural production, human health and environmental services. The EICAT tool is relatively less user friendly to complete, compared to GISS and Harmonia, however modifications of the spreadsheet could improve this. Some relatively straightforward changes to the GISS spreadsheet would also be possible — these include adding guidance about the use of confidence levels and citation of references when evidence of impact is being reported. Unfortunately, modification of Harmonia features would not be possible — this tool is hosted by a third party, and therefore the department would have no control over modifications or even its discontinuation. As a result, Harmonia was no longer considered in tool selection.

Table 4. Summary of tool testing

	GISS	EICAT	Harmonia
Time	<24 hours	<24 hours	<24 hours
Pros	• Template is downloadable for use and modification. • Template allows for the assessment to be reviewed by others. • Includes uncertainty through confidence rating. • Avoids the use of expert opinion • Not a lot of data required • Good range of 'environmental' consequences considered. • GISS has been widely applied and adapted (see Nentwig et al. 2016 for list)	• Template is downloadable for use and modification. • Template allows for the assessment to be reviewed by others. • Includes uncertainty through confidence rating. • Avoids the use of expert opinion. • EICAT has been modified to align with IUCN scheme, the Global Invasive Species Database (GISD)	• The digital template is easy to use, with detailed guidance provided in an associated manual. • Template allows for the assessment to be reviewed by others. • Well established and developed tool with code behind the program. • Includes uncertainty through confidence rating • Adopted in Europe for use. • Considers establishment and spread which is not necessary for our purposes but could be a nice extra to have.
Cons	• Only works where there is existing invasion evidence in published data. • Need to establish what final score means in terms of wider application by DAWE.	• Only works where there is existing invasion evidence in published data. • Excludes social and economic impacts. • Assessor only needs to cite websites/links rather than setting out the information in these links. • Tool is not stand alone –it requires the assessor to refer to several other publications/supplementary materials. • Appears to be quite repetitive - several sections are duplicated for no obvious reason. • Habitat codes could be problematic to achieve consistency between assessors and obtaining info from the literature, particularly for lesser known species. • No clear outcome — following the assessment the data is submitted to a committee for final action/decision	• Digital tool is only available for online use via the Harmonia website, so no ability to download tool for use and modification. Also no control over future changes or discontinuation of the tool • Unclear how to imply 'no impact' in a category. • Uses expert opinion where no other information is available. • Some repetition throughout the tool. • Need to establish what final score means in terms of wider application by DAWE.

Required modifications	• Change 'Europe' to 'Australia' in row 27. • Interpreting the outcome of the assessment will need to be defined. • Additional guidance material should contain instructions to: – provide evidence of impact in comment boxes; – explain confidence ratings • Determine whether all consequence ratings should be equal (policy decision) • Determine which scores reflect non/actionable pests under ALOP (policy decision) • Develop user guidelines to assist in achieving consistency in the use of the tool	• Additional guidance material should contain instructions about providing evidence of impact and confidence ratings. • Provide details of impact within the tool itself. • Need to define interpretation of assessment outcome.	Modifications not possible due to online-only nature of platform and 'ownership' of the online platform

5.2 Selection of tool

The final choice was between GISS and EICAT. The authors chose GISS (Nentwig et al. 2016) as the preferred tool, based on what were assumed to be relatively minor modifications, if any, that would be required to the existing user-friendly spreadsheet-based tool for it to be adopted by the department.

The tool also offers i) scope for weightings of impacts to be changed, and ii) for the scoring system to be understood in terms of Australia's ALOP. Both items are out of scope for this project, but could be considered by the department in the future.

6. User testing of GISS

6.1 The user testing process

User testing involved five departmental staff from the risk assessment team (including two of the authors), classed as competent assessors, applying the GISS tool to four species (Table 5). The species were chosen to cover the range of invertebrate pests that are typically intercepted at the border (e.g. spiders, beetles, ants, millipedes), and to reflect the typical information-poor environment in which assessors must often make decisions. Further, each species had been intercepted in the past, and decisions had been made about whether to 'action' them or not — this would potentially allow assessments to be checked against past decisions.

Table 5. Species selected for testing against GISS

Scientific name	Common name	Notes on pest
Corticaria serrata	minute brown scavenger beetle	*C. serrata* feeds on fungi and is commonly associated with stored products including mouldy plant debris and grains. Some biological information available.
Erigone aletris	dwarf spider	The genus *Erigone* is commonly found in agricultural systems and disturbed sites. It is predator attacking small arthropods. Limited biological information available.
Nylanderia fulva	tawny crazy ant	Invasive in the USA where it is a nuisance pest in and around infrastructure due to its ability to attain extremely high abundance levels. Preys on arthropods and displaces the aggressive *Solenopsis invicta* (red imported fire ant). Good amount of information on biology and impacts available.
Trigoniulus corallinus	rusty millipede	Introduced to central and south America, the USA, the Caribbean and Pacific Islands. Decomposer of organic matter. Under certain conditions, millipedes can reach high densities aggregating on pavement and buildings and entering homes. Limited biological information available.

Assessors attended pre-and post-assessment meetings. During the pre-assessment meeting the user testing was explained to assessors — apply the GISS to each pest and make a conclusion about impact. Assessors were also required to record the following information:

- the time required to complete each assessment;
- observations about the tool itself, including likes, dislikes and difficulties with the tool;
- any recommended modifications; and
- general comments.

Staff were given a set of literature for each species, and were asked to draw conclusions about impacts using only this literature. Having a consistent set of literature across assessors and pests would allow comparison of time required to implement the tool, an assessment of consistency of interpretation of literature and of impact between assessors, and any problems with tool use that might require tool modification.

6.2 Outcomes from user testing

Assessors provided positive observations about their experiences using the tool and its ability to assess a range of non-industry impacts, with some finding the information provided in the tool describing impacts to be particularly useful. Overall it was felt the tool filled a gap in the environmental impact space, and that the tool provided an efficient way to record and justify decision-making at the border and under time pressure.

Four of the assessors had similar assessments for the time taken to assess each species — on average, assessments took from 2.1 hours (*E. aletris)* to 4.8 hours (*N. fulva)*. A fifth assessor took between 3 and 4.5 times these timeframes across the pests. All assessors, were therefore able to undertake pest assessments in timeframes that were well below maximum time requirement of two days. In reality assessors will take additional time to collect and review literature, although this appears unlikely to push the assessment period beyond two days.

Consistency across assessors, by pest, impact scores, and confidence level was mixed (data not shown). Assessors largely noted the same impacts and gave the same scores for those impacts where the number of impacts detected were relatively few — *C. serrata* (2-4 impacts) and *E. aletris* (1-3 impacts) — and impacts were rated '1' in all but one case. Assessors detected between one and four impacts for *T. corrallinus*, again all impacts were rated '1'. For *N. fulva*, an invasive ant with impacts on ecosystems, industry and human health and infrastructure, assessors were reasonably consistent in selecting the range of impacts — between 9 and 11 impacts were noted, however scores were reasonably inconsistent. For impacts that had been selected by all assessors (9), scores ranged from 1-3 for 5 of them. Interestingly, all assessors identified the serious impact of this ant on ecosystems, each scoring it with '3'.

For each pest a large number of different confidence levels were attributed to impact scores by the 5 assessors, and in general most impacts were scored with confidence levels of 2 (*Medium confidence*) or 3 (*high confidence)* regardless of impact score. There was some indication that the amount of biological information about a pest influences the level of confidence. Limited information was available for *E. aletris* and *T. corrallinus,* and for these pests 12% and 5% of impacts respectively were given with low confidence, compared to only 2% for *N. fulva* where there was a much larger amount of biological information available. For that pest half of all impacts were given with high confidence.

In relation to non-zero impacts, the way confidence was assigned to scores varied between assessor, impact and pest. For those pests with few and low-scoring impacts (*C. serrata* and *E. aletris*), the twelve identified impacts were split evenly between the three confidence levels. Some assessors appeared to be consistently more confident in their scores relative to other assessors, regardless of the impact score or pest.

Issues with applying confidence levels to assessments, particularly where there was ‘no data available’ was a concern raised by assessors. In particular they requested clarity around applying confidence levels when absence of impacts *is* and *isn’t* due to the absence of literature.

Assessors indicated they had difficulties in assessing indirect impacts — this may be responsible for some of the inconsistency between assessors.

6.3 Modifications to the GISS tool

In response to the difficulties reported by assessors and their suggested modifications the following modifications to the GISS tool were made:

- The question: ‘Is the species present in Australia?’ has been added to ‘Species Description’ in the tool. There are three possible ‘yes’ answers: i) ‘yes – under official control (National)’; ii) ‘yes – under official control (Regional)’; and ‘yes’. If the third option is selected, a message displays indicating the assessment is not required.
- The guidance document (Appendix D) and GISS tool were updated with additional examples and information on applying confidence levels to avoid confusion around their application. For example, a ‘low confidence level’ would be given where potential direct impacts weren’t identified from the literature, but where reasoning would suggest there could be impacts. Compare this to another pest where *no* impact was selected with a ‘high confidence level’ because there was evidence from the literature of *no* impacts.
- Further guidance included around the use of impact scale and confidence.
- Add ‘human movement and trade’ as a pathway of introduction
- Add guidance to impact level 2: Minor impacts, not only locally or on abundant species.

6.3.1 Potential future modifications

In undertaking this project, the department required a tool to improve their consequence assessment of ‘non-industry’ pests and the GISS tool is able to meet that requirement. It is worth noting, however, that the GISS tool contains the capacity to be used in additional ways, and these are largely related to use of scores that are calculated for each assessment, but which were not used under the current project’s remit. These are listed below for the purpose of flagging the potential of the tool:

- Determine whether the entire set of impacts needs to be assessed once there is clear evidence of one likely impact.
- Rather than level of impact from 0 to 5, it might be preferable to use either ‘yes’, ‘no’ or ‘unknown’.
- Each of the 12 impacts of the GISS tool are currently weighted equally. There is scope to give relatively higher weights to particular impacts such as environmental impacts compared to industry impacts as the latter would be captured by a plant pest assessment (separate assessment), or alternatively, those impacts could be removed from the tool.
- The scores that result from assessments could be collated and analysed to make inferences about which scores are suggestive of risks that are higher, lower or equivalent to ALOP. A good starting point would be to apply the GISS to pests that are known to breach ALOP and note their scores.

7. Key finding and recommendations

7.1 Key finding

The GISS tool is suitable for use to assess the potential impacts of non-industry pests detected at the Australian border.

The Generic Impact Scoring System (GISS) developed by Nentwig et al. (2010; 2016) for alien plants and animals was selected as the most suitable framework to identify potential non-industry impacts of pest species detected at the Australian border. An existing spreadsheet-based tool allows assessment of nine categories of non-industry impact — environmental (6); human infrastructure and administration (1); human health (1); and human social life (1) — and three categories of industry impact. The tool relies on published evidence of impact and can be completed within time frames that typically apply to these assessments at the border. Some limited modifications of the tool have occurred to ensure it is fit-for purpose, but others have been suggested for the future. There is also scope to extend the use of the tool, including through the use of the scoring function that allows prioritisation of threats.

The GISS tool was tested by several departmental staff for four typical pests detected at the border and found to be suitable with minor modifications. Guidelines have been developed to assist departmental assessors apply the GISS tool and the tool itself contains detailed descriptions of what should be included in assessing each impact category. The use of the GISS tool is expected to improve the rigour and transparency of risk assessments for non-industry pests whose impacts are on the environment, social amenity, human health and infrastructure.

7.2 Recommendations

Given suitability of the GISS to assess non-industry impacts of pests detected at the Australian border, it is also recommended that:

1. Wider departmental consultation on the tool and its planned use take place.

While the GISS tool has been assessed as ‘fit for purpose’ by the Plant Sciences and Risk Assessment branch in Plant Division, its use may have implications for, and/or be of interest to, various other sections in DAWE, including: Animal Division and the office of the Chief Environmental Biosecurity Officer. These and other areas of the department should be given the opportunity to understand the tool and its planned use. Any feedback from these groups on the use of the tool should be considered and the tool further modified if required.

2. Validation testing of known ‘actionable’ pests.

It would be a worthwhile process to reassess the impacts of pests previously deemed ‘actionable’ using the GISS tool. This would allow checks on consistency, both of past decisions and in terms of results from using the GISS tool. Revisiting actionable pests could occur on an ‘as-needs’ basis, perhaps as more information becomes available.

3. Further modifications to the tool and its use be considered.

Several minor modifications were made to the GISS tool in order make it fit-for-purpose, but there are other modifications that could be made to the tool to enhance its application. These include i) weighting non-industry impacts relatively higher than industry impacts; and ii) determining whether the entire set of impacts needs to be assessed once clear evidence of one likely impact is detected. In addition, the GISS tool has scope for the scoring system to be understood in terms of Australia’s ALOP.

The department is currently developing a range of IT systems and solutions to modernise its work processes. There is an opportunity to incorporate the GISS tool as an assessment module in the Pest and Disease Repository to facilitate information sharing, assessment transparency and consistency.

4. Ongoing evaluation of the tool’s use occur.

Ongoing evaluation of the GISS tool should occur in the interests of maintaining a rigorous and transparent risk assessment process. Evaluation would include understanding the implementation process, metrics around the tool’s actual use (number of times used, time required to use tool), ongoing feedback from staff about using the tool. It would also be beneficial to understand whether the tool has actually improved risk assessment at the border — for example, whether its adoption has saved time, improved the quality of information provided to importers. Obtaining this information would involve identifying stakeholders at the border (importers, departmental staff) and obtaining this information from them, either by survey or interview.

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9. Appendix A: Summary of risk assessment tools and frameworks

Table 2. Summary of risk assessment tools and frameworks

Author/year	Tool, methodology, purpose	Non-industry impacts considered	Impact-scales and descriptors of impact	Uncertainty	Application (current; potential)
Quantitative					
Worner and Gevrey (2006)	Self-organised mapping combined with pest species assemblages	Data was drawn from CABI, a predominantly agricultural data set	Risk index from 0-0.99		**Insects** species that threaten NZ. **All taxa:** Prediction of risk based on pest distribution and climate/habitat
Bomford et al. (2008)	CLIMATE software (BRS 2006) used to predict invasiveness	n/a	n/a	Predictive ability of analysis is tempered by several caveats	**Reptiles** and **amphibians** Factors associated with success: genus and family; propagule pressure; high climate-match scores (relative to failed species).
Magee et al. (2010)	Invasiveness-Impact score and Index of Alien Impact	Ecosystem alteration (7 traits)	Percentage score of Invasiveness-Impact, the higher the % the greater the potential impact	No	Current application is for invasive plant species. Would need considerable adaptation to other uses
Miller et al. (2010)	Relative Risk Model adapted from Landis (2004)	Consequence of invasive species on environment and rare/endangered species	Value 0-450+	Used Monte Carlo simulation	Specific use of the RRM to consider risk to endangered species in Nebraska
Dick et al. (2017)	Relative impact potential (RIP) **metric**; an invader/native ratio, derived from the product of the 'consumer' Functional Response (FR) and 'consumer' ABundance (AB)	'Ecological impacts' ie. measurable changes in populations of affected species.	RIP < 1 invader predicted to have less impact than native equivalents; RIP=1 predicts no impact above that driven by native equivalents RIP > 1 indicates likely invader ecological impact will occur;	Assume the observed FR and AB measures are samples from underlying log-normal distributions.	

	$RIP = \left(\frac{FRinvader}{FRnative}\right) \times \left(\frac{ABinvader}{ABnative}\right)$		increasing values above 1 indicate increasing impact		
Dickey et al. (2020)	using various factors to represent the key of per capital effect	Can be calculated based on impacts to any environment	<1, =1, >1	Can account for uncertainty by replacing unknown element with known element	Currently used for established species but can be used to predict invasive species where data is available
Scoring systems					
Pheloung et al. (1999)	Australian Weed Risk Assessment (WRA) model. Scoring system based on 49 screening questions (mainly yes/no). Spreadsheet-based.	One question relates to environmental weediness	Uses risk scores to categorise species as: Accept; Evaluate; or Reject	Claim that WRA is much less variable than expert opinion and it enforces objectivity.	**Plants**: Predict potentially invasive plants for Australia. Gordon et al. (2010) provides guidance on answering each question. Tool has been widely applied across the globe.
Ou et al. (2008)	Alien plant risk assessment system. Based on several similar tools. Six primary and several secondary criteria; AHP[1] is used to weight indices.	Three questions relate to ecosystem impacts and impacts on native species	Uses risk scores: Accept; Requires further research, Unacceptable. Max. possible overall score is 100.	Not in a robust way —users instructed that "the consequences of missing data need to be considered".	**Plants:** Screening for major and emerging invaders in the Xiamen region of China.
Cowie et al. (2009)	Risk assessment model Scoring system based on 12 non-exclusive attributes.	Environmental impacts can be considered under two of the questions: i) 'major pest elsewhere' and ii) 'multi-pest'.	Score 0, 0.5, 1 or nil depending on whether literature suggests the attribute will enhance their pest potential (0=will not enhance; 1=will enhance; 0.5 if data insufficient). No explicit weighting, although some attributes are related, so implicitly (positively) weighting of fundamental attribute.	Uncertainty accounted for by dividing the score by the number of attributes answered	**Molluscs**: created a ranked list of 46 non-marine snail species in US, from 18 families. Model validated using data on species previously introduced to US.

EFSA (2011)	Pest risk assessment scheme based on 6 questions and a number of sub questions.	Focused on environmental risk assessment. Considers both biodiversity and ecosystem services	Impact on ecosystem services is in terms of relative (%) reduction in services: minimal, minor, moderate, major, massive	Evaluates level of risk and associated uncertainty for every sub question, and question	**Plant Pests**. Questions and guidance is detailed.
Koop et al. (2012)	Plant Protection and Quarantine (PPQ) model plus secondary screening tool. Logistic regression model; builds upon on Australian WRA model — adds 17 related to impact, 9 relate to non-industry impacts; Secondary screening tool is a short decision tree.	Ecosystem processes, community structure and composition, threatened and endangered species, globally outstanding eco regions, conservation areas, human infrastructure and health, recreation.	PPQ uses two risk scores — i) establishment and spread potential, ii) impact potential — to categorise species as Accept, Evaluate Further, Reject. Secondary tool reviews plants categorised as 'Evaluate further' category	Missing information appears not to be a problem in the application.	**Plants**: Tool is applied to screening of potentially invasive plants, for the entire USA.
Gilioli et al. (2014)	Environmental assessment of invasive plant pests that can be incorporated into PRA. A further development of EFSA (2011)	Methodology is designed to consider functional and structural components of the environment impacted by invasive species	Impact calculated as a percentage reduction of a range environmental services	Level of uncertainty determined for each category of environmental service	**Insect**. Full environmental risk assessment to be incorporated into a PRA consistent with IPPC guidelines **Mollusc**. Gilioli et al. (2017) et al. improves on method and demonstrates environmental impact of apple snails if established in Europe
Nentwig et al. (2016) Nentwig et al. (2010)	Generic Impact **Scoring System** (GISS); Questionnaire and Excel-based tool. Relies on published knowledge (rather than expert knowledge) on 12 impact categories — 6 for environmental impact and 6 for socio economic impact (includes industry impact)	Impacts on plants or vegetation other than competition; impacts on animals through Predation, parasitism or intoxication; impacts on species through competition; transmission of diseases or parasites to native species; hybridization; impacts on ecosystems.	Each impact is scored from 0 (*no data available*, *no impacts known*, *not detectable* or *na*) to 5 (major large-scale impact…). Two ways of finding overall impact: i) Scores are summed. Equal weight given to each impact; or ii) use max. impact score in any of the 12 categories	Confidence levels of assessors must be stated (low, medium and high); authors suggest this is based on data quality	**Plants** and **animals**. Applied to 349 alien plant and animal species in EU. **Aquarium species**. Many others incl: aquarium species (Orfinger and Douglas Goodding, 2018); Blackburn et al. (2014). **Spiders** (Nentwig 2015).

		Impacts on human infrastructure and administration; human health; human social life.	Precautionary principle applies for conflicting studies — take highest impact.		
Semi-quantitative					
Skurka Darin et al. (2011)	WHIPPET (Weed Heuristics: Invasive Population Prioritization for Eradication Tool); Analytical Hierarchy Process[1].	Impacts on wildlands, human health and regional site value. Considers proximity of invasive population to rare, threatened or endangered species; recreational areas and protected federal land with limited control options.	Each criteria is scored as very high (10points), high (6 points), medium (3 points), low (1 point), or very low (0 points). Final score is the sum of all scores weighted by their percent contribution to the overall decision to eradicate.	Uncertainty is acknowledged, but it is unclear how/whether it is incorporated.	**Plants:** Assess relative impact, spread, and feasibility of eradication of invasive plants. AHP used by Ou et al. (2008). WHIPPET was time consuming to build and test.
Brunel et al. (2010) EPPO (2012) Branquart et al (2016)	To decide on invasiveness considers i) species' spread potential and ii) potential negative impacts. **Decision tree** for screening: two questions related to non-industry impact	Native species, habitats and ecosystems, human health and infrastructure, recreational activities	Low, medium and high with detailed descriptors;	Summarised as low, medium and high for each impact	Prioritisation to determine which species are high priority for a PRA;
Blackburn et al. (2014) Hawkins et al. (2015)	EICAT (Environmental Impact Classification for Alien Taxa) Extend GISS (Nentwig et al. 2010, 2016) to include additional impact categories. Classify alien species according to magnitude of environmental impacts, based on IUCN mechanisms of impact.	Tool is focused solely on environmental impacts. 12 impact mechanisms. Species are classified based on their most severe documented impacts in regions where they have been introduced.	Five semi-quantitative scenarios describing impacts under each mechanism to assign species to different levels of impact— ranging from Minimal to Massive—with assignment corresponding to the highest level of deleterious impact associated with any of the mechanisms.		**All taxa**
D'hondt et al. (2015)	*Harmonia*$^+$ and *Pandora* Protocols for rapid screening, ranking and risk analysis based on 25-30 questions	*Harmonia (Pandora)*: 6 (2) questions relate to environmental impact; 3 (2) relate to human health impact. Other 'modules' for impact on plants and animals.	Ordinal basis: low<medium<high 3 or 5 alternative answers to each quesiton. Alternative answers are rescaled to a [0,1]-scale; arithmetic mean is then taken of all answers within each 'module'. Module	Assessors provide a level of confidence (low/med/high) for each answer. Protocol is run 10,000 times	**Plants** and **animals** ***(****Harmonia*$^+$); **Parasites** and **pathogens** (*Pandora)* Tested on 5 species emerging in Belgium.

		Guidance provided	weights are equal. Obtain a general impact score	sampling from the distribution.	Modified version of Blackburn et al. (2011)
Sandvik et al. (2013; 2019)	Norwegian Generic Ecological Impact Assessments of Alien Species Generic, semiquantitative set of criteria (**classification scheme**) Two-dimensional approach to describing impact: 4 measures of ecological effect are plotted against 4 measures of invasion potential.	i) Interactions with native species; ii) changes in landscape types; iii) potential to transmit genes or iv) parasites.	Ecological impact is either no known, minor, medium or major effects. Invasion potential is either small, restricted, moderate or high, giving 16 categories of possible 'final' impact. Clear descriptors of impact provided.	Take uncertainty into account in the estimate — Estimate prediction intervals and select the highest category that is encompassed by the intervals	Method underlies classification of 2,241 alien species known to occur in Norway. Could be applied to future introductions. Application examples for: horse-chestnut leaf minor; Japanese knotweed; harlequin ladybird; common minnow; Eurasian collared dove
Davidson et al. (2017)	Great Lakes Aquatic Nonindigenous Species risk Assessment (GLANSRA) Semi-quantitative, **question**-driven assessment for a species' potential introduction (6 pairs of questions); establishment (18 questions); and impact (6 questions for 3 broad categories)	Environmental impact: hazard or threat to native species; out-competes native species; alters predator-prey relationships; potential to transmit genes or hybridize; effect on water quality; alters ecosystems. Socio-economic impact: human health; damages infrastructure; affects water quality; recreational activities, aesthetic or natural value. beneficial effect: 6 questions	Scoring system. Scores for each question are summed for each species' potential impact category and converted to a categorical impact ranking using scoring table.	Assessment score is mitigated by the number of unknowns to produce a categorical descriptor of *unknown, low, medium,* or *high.* Does include some expert judgement and a precautionary approach	**Aquatic species**
Expert opinion-driven					
Cook and Proctor (2007)	Multi Criteria Decision Analysis framework Uses citizen's jury and multi-criteria evaluation to rank quarantine threats.	Environmental and socio-economic damage may be considered — these criteria are agreed upon by the jury.	Linear summation of impacts; weights for criteria are determined in deliberation process.		**Plants**: establish priorities for biosecurity policies

Kumschick et al. (2012)	Resource allocation based on expert advice on impacts and stakeholder valuation Extends the impact classes of GISS (Nentwig et al. 2010, 2016)	Considers both positive and negative impacts on systems. Scoring system for 2 classes ecological and socio-economic, several categories including some environmental aspects.	Change impact scare range 0-5	Uncertainty ranked as low, medium, high	Resource allocation prioritization tool to support decision making on environmental asset protection; addresses potentially competing interests of stakeholders.
Gallardo et al. (2016)	Scoring system based on 4 questions based on expert response	One of the four questions was a score for ecological impact	Unknown, 1-4	Provides ability for responders to select unknown	**All taxa**.
Other					
Tana (2004)	OIE risk analysis methodology was applied to RIFA, a hitchhiker pest	The risk analysis focused on the import pathways and did not consider consequence	Very high, high, moderate, low, negligible		Full risk assessment framework

[1]The Analytic Hierarchy Process (AHP) is a multiple criteria decision-making tool (Saaty, 1987; Saaty, 2008).

10. Appendix B. Detailed reasons for assessment

Table 6. Generic Impact Scoring System (GISS); Nentwig et al. (2010; 2016)

Criterion	Reasoning
1. Data (existing)	Authors emphasise the need to systematically search the literature for relevant publications, and suggest ways of doing this, for example, by searching Google Scholar (http://scholar.google.com) or ISI Web of Knowledge for the Latin species name, relevant synonyms, and common names and considering journal articles, taxon-specific books, online databases on alien species, and references therein. Operationalisation would be possible with existing data (●)
2. Time required	An Excel spreadsheet has been developed and is freely available 1. Complete Excel spreadsheet: 1-2 days 2. Summarise the relative impact potential of a species (if required): 0.5 days Operationalisation would be possible in ≤ 24 hours (●).
3. Minimal use of experts	GISS relies on published evidence of the impacts caused, rather than on expert knowledge. Operationalisation is possible without the use of expert knowledge (●)
4. Environmental impacts	Considered via 6 categories of impact (●)
5. Genetic diversity	Considered via the 'Impact through hybridisation' category (●)
6. Species diversity	Considered via the 'Impacts on species through competition' and 'Impacts on plants or vegetation (through mechanisms other than competition)' categories (●).
7. Ecosystem diversity	Considered via the 'Impact on ecosystems' category (●).
8. Magnitude of overall environmental impacts	The aim of GISS is to score impacts and it does so via scoring impacts in each of the environmental impact category (●)
9. Human health	Considered via the 'Impacts on human health' category (●)
10. Human infrastructure	Considered via the 'Impacts on human infrastructure and administration' category (●).
11. Social amenity	Considered via the 'Impacts on human social life category' (●)
12. Scientific robustness	Methods are scientifically robust (●).
13. Transparency and consistency	Completed spreadsheet represents a comprehensive documentation of the scoring procedure, including geographical range for which the assessment is done, taxonomy of the considered species, ecosystems and areas affected, native and introduced ranges, reasons for introduction and pathways. For each of the 12 impact categories, a short concrete description of the given impact is required, including references. Assessors must declare their contact details and it is recomemnded that assessments undergo a review process in order to check for completeness and accuracy. The operationalisation of (≥90%) criteria is highly replicable, no matter by whom they are applied (●).
14. Uncertainty and validation	Confidence levels of assessors must be stated; authors suggest this should be related to data quality, as per Blackburn (2014) Uncertainty explicitly features in the framework (●).

Table 7. Blackburn et al. (2014); Hawkins et al. (2015) EICAT (Environmental Impact Classification for Alien Taxa)

Criterion	Reasoning
1. Data (existing)	Tool cannot be applied to species with no previous history of alien populations. EICAT relies on published evidence of impact Operationalisation would be possible with existing data (●)
2. Time required	An Excel spreadsheet has been developed and is freely available. It contains a data sheet for recording, details of a recommended search methodology. Guidelines for using EICAT are also available. 1. Complete Excel spreadsheet: 1-2 days Operationalisation would be possible in ≤ 24 hours (●).
3. Minimal use of experts	EICAT relies on published evidence of impact. Note that publication of assessments requires review of assessments by experts Operationalisation is possible without the use of expert knowledge (●)
4. Environmental impacts	EICAT is focused solely on environmental impacts. These are considered via 12 impact mechanisms Impacts on environmental resources are directly included through explicit criteria or questions. (●)
5. Genetic diversity	Considered via the 'hybridisation' category (●)
6. Species diversity	Considered via the 'competition', 'predation' and 'parasitism' categories (●).
7. Ecosystem diversity	Considered via several impact categories (●).
8. Magnitude of overall environmental impacts	EICAT explicitly presents the magnitude of overall impact, ranging from minimal to massive (●).
9. Human health	Impact is not considered (—).
10. Human infrastructure	Impact is not considered (—).
11. Social amenity	Impact is not considered (—).
12. Scientific robustness	Methods are scientifically robust (●).
13. Transparency and consistency	Completed spreadsheet represents documentation of the scoring procedure, including geographical range for which the assessment is done, taxonomy of the considered species, ecosystems and areas affected, native and introduced ranges. Assessors must declare their contact details The operationalisation of (≥90%) criteria is highly replicable, no matter by whom they are applied (●).
14. Uncertainty and validation	Uncertainty explicitly features in the framework (●).

Table 8. D'Hondt et al. (2015) *Harmonia*⁺ (for potentially invasive plants and animals)

Criterion	Reasoning
1. Data (existing)	Answers to each of 25 questions should be based on evidence, rather than on a purley hypothetical or speculative basis. Of the 25 questions, 7 relate to the probability of introduction, establishment and spread Operationalisation would be possible with existing data (●)
2. Time required	The full *Harmonia*⁺ platform can be applied and consulted online, with scores calculated via on online platform http://ias.biodiversity.be/protocols/form/show/83077cae-c6a7-4352-bf24-a27eb00b8424/default. Detailed guidance is also available. Apply *Harmonia*⁺: 1-2 days Operationalisation would be possible in ≤ 24 hours (●).
3. Minimal use of experts	For several questions related to impact on animals, humans and plants, if no appropriate data is available at all, a direct estimate is needed through expert opinion. Operationalisation of some aspects of the tool may require the use of expert knowledge (○)
4. Environmental impacts	Of the 25 questions in *Harmonia*⁺, 11 relate to environmental impacts Impacts on environmental resources are directly included through explicit criteria or questions. (●).
5. Genetic diversity	Considered in *Harmonia*⁺ via the 'interbreeding' question (●).
6. Species diversity	Considered in *Harmonia*⁺ via the 'competition', 'hosting pathogens and parasites' and 'predation, parasitism or herbivory' questions (●).
7. Ecosystem diversity	Considered in *Harmonia*⁺ via the 'abiotic' and 'biotic' questions (●).
8. Magnitude of overall environmental impacts	Alternative answers to each question within the environment module classify as ordinal data (low<medium<high), but converted to a [0,1] scale. The two possibilities for combining scores are to take the i) arithmentic mean or ii) to slect the macimum of the re-scaled weights. *Harmonia*⁺ explicitly presents the magnitude of overall environmental impact (●).
9. Human health	Considered in *Harmonia*⁺ via 3 questions (●).
10. Human infrastructure	Considered in *Harmonia*⁺ via question on 'damage to infrastructure' (●)
11. Social amenity	Not considered in *Harmonia*⁺ (—)
12. Scientific robustness	Methods are scientifically robust (●).
13. Transparency and consistency	Completed online tool represents documentation of the scoring procedure, including organism and area under assessment, domain of impact considered, purpose of assessment, name of assessor, choices re weights and aggregation. The operationalisation of (≥90%) criteria is highly replicable, no matter by whom they are applied (●).
14. Uncertainty and validation	For every relevant question, the assessor is asked to provide a level of confidence wrt answer ('low', 'medium', 'high'). Module and higher-level scores that summarise the overall level of uncertainty are calculated parallel to the base-level scores Uncertainty explicitly features in the framework (●).

Table 9. Sandvik et al. (2013; 2019) Generic Ecological Impact Assessment of Alien Species (GEIAA)

Criterion	Reasoning
1. Data (existing)	Where data for the region being assessed is unavailable, data should be sought from, in this order: other regions with comparable ecoclimatic conditions; other regions with different ecoclimatic conditions; and other, preferably closely related, species with comparable ecological and demographic characteristics. Precautionary principle is taken into account via 3 principles: *One out, all out; Future impact*, and *Incorporation of uncertainty.* GEIAA relies on published evidence of impact, from Scientific publications, reports as well as published data are accepted as documentation. Assessor's own observations or judgements and other unpublished data or analyses, can be included in the assessment, provided the latter are uploaded to the Alien Species Database. Operationalisation would be possible with existing data (●)
2. Time required	Supplementary material to Sandvik et al. (2019) states "Based on the experience in Norway, where 1532 taxa were assessed (Sandvik et al. 2020), the average work load was approximately 6 ±2 person-hours per assessment". Operationalisation would be possible in ≤ 24 hours (●).
3. Minimal use of experts	Assessments were carried out by expert panels, and the assessors' own observations or judgements and other unpublished data or analyses, can be included in the assessment. ○ = operationalisation of tool involves the use of expert knowledge
4. Environmental impacts	Alien species are classified according to their influence on native biota using 6 criteria. Impacts on environmental resources are directly included through explicit criteria or questions (●).
5. Genetic diversity	Considered via criterion H: 'Genetic introgression' (●).
6. Species diversity	Considered via criterion D: 'Interactions with threatened native species or keystone species', criterion E: 'Interactions with other native species' and criterion I: 'Vector for parasites' (●).
7. Ecosystem diversity	Considered via criterion C: 'Colonisation of ecosystems', F: 'State change in threatened or rare landscape types' and criterion G: 'State change in other landscape types' (●).
8. Magnitude of overall environmental impacts	GEIAA explicitly presents the magnitude of overall environmental impact (●).
9. Human health	Impact is not considered (—).
10. Human infrastructure	Impact is not considered (—).
11. Social amenity	Impact is not considered (—).
12. Scientific robustness	Methods are scientifically robust (●).
13. Transparency and consistency	It is a requirement to document that any criterion is met. Scientific publications, reports as well as published data are accepted as documentation, as long as the latter are made available to the assessors. Documentation also includes reporting the complete input values of models performed, not just their output. The operationalisation of (≥90%) criteria is highly replicable, no matter by whom they are applied (●).
14. Uncertainty and validation	The scores reported for each criterion represent the best estimate (mediam). Uncertainty is reported in terms of the quartile range. Uncertainty explicitly features in the framework (●).

11. Appendix C. Preliminary testing of tools

Three species were chosen as candidates for preliminary testing of the GISS and EICAT tools i) *Caracollina lenticula;* ii) *Euglandina rosea;* and iii) *Nylanderia fulva.* A description of each species is given in Table 10. Here we report the results for each tool for each pest. Note that results for the Harmonia analysis are not reported because the tool was removed from consideration.

11.1 GISS

Table 10. Descriptions of the three species selected for preliminary testing of GISS and EICAT.

Species name	*Caracollina lenticula* (Michaud, 1831)	*Euglandina rosea*	*Nylanderia fulva*
Higher taxonomy	Trissexodontidae; Stylommatophora; Gastropoda; Mollusca	Spiraxidae, Stylommatophora, Gastropoda	Formicidae; Hymenoptera; Insecta
Taxonomic comment	*Helix lenticula, H. subtilis*	*Achatina rosea Férussac, 1821; Glandina parallela Binney, 1878; Glandina truncata Say, 1831; Helix rosea Férussac, 1821; Polyphemus glans Say, 1818;*	*Prenolepis fulva (basionym); Paratrechina fulva (synonym)*
Taxonomic group	Invertebrate	Invertebrate	Invertebrate
Main ecosystem	Terrestrial	Terrestrial	Terrestrial
Area of origin	Mediterranean region	Southern United States (Tropical North America)	Brazil; Argentina; Uruguay and Paraguay
Invaded area	None reported	American Samoa, Bahamas, Bermuda, French Polynesia, Guam, Hong Kong, India, Indonesia, Japan, Kiribati, Madagascar, Mauritius, Mayotte, New Caledonia, Northern Mariana Islands, Palau, Papua New Guinea, Reunion, Seychelles, Solomon Islands, Sri Lanka, Taiwan, United States, Vanuatu, Wallis and Futuna	Anguilla; Bermuda; Columbia; Cuba; Guadeloupe; Martinique; Mexico; Panama; Puerto Rico; St. Vincent; Grenadines; US Virgin Islands, USA
Area assessed	Australia	Australia	Australia
Pathway	Stowaway with transport vector	Release	Unknown
Introduction time	September 2018; post-border detection currently under official control	N/A	N/A
Used as	Others	Biocontrol (for Giant African Snail)	unknown
Comments	Common name: lens snail	Common names: rosy predator snail, rosy wolf snail, and cannibal snail.	Common names: Tawny crazy ant; Caribbean crazy ant

Results from application of GISS to each pest are given in Table 11. No information about impacts of C. *lenticula* was available in the literature, but some conclusions about impact could be drawn based on impacts of other invasive snails. Substantially more information was available for the other two species, and this allowed scores to be ascribed with high levels of certainty (*E. rosea*) and low-high levels of certainty (*N. fulva*).

Table 11. Summary of results from application of GISS to each pest.

	C. lenticula		***E. rosea***		***N. fulva***	
Impact	Score	Confidence	Score	Confidence	Score	Confidence
2.1.1 On plants or vegetation	0	1	0	3	1	3
2.1.2 On animals	0	3	3	3	1	2
2.1.3 Competition	0	1	0	3	3	3
2.1.4 Disease transmission	0	3	2	3	0	2
2.1.5 Hybridization	0	3	0	3	0	1
2.1.6 Ecosystems	0	1	0	3	3	3
2.2.1 Agricultural production	0	1	0	3	1	2
1.1.2 Animal production	0	3	0	3	2	2
2.2.3 Forestry production	0	3	0	3	0	1
2.2.4 Human infrastructure	0	1	0	3	3	3
2.2.5 Human health	0	3	4	3	2	3
2.2.6 Human social life	0	1	1	3	2	3
Conclusion	*C. lenticula* may consume a range of plant hosts, impacting plant health. It may also displace native snails resulting in biodiversity loss.		Overall, *E. rosea* will have a negative impact on the environment due to its predatory nature that poses a threat to endemic Australian snails. It will also have a negative economic impact (and human health risk) due to its ability to host the parasite *Angiostrongylus cantonensis* (rat lungworm disease) which can be fatal in humans.		*N. fulva* has a range of environmental and economic impacts including displacing native ant species, preying on arthropods and affecting arthropod diversity, indirect consequences for plant health through association with plan-feeding hemipterans. This species of ant is also known to impact human infrastructure short circuiting a range of electrical equipment, entering homes and buildings and affecting public amenity spaces	

11.2 EICAT

Table 10. Summary of results from application of EICAT to each pest.

	EICAT Criteria impact mechanism(s)	Maximum recorded impact	Justification	EICAT confidence rating
C. lenticula	(8) Grazing/ herbivory/browsing	DD — Data deficient	Could cause decline in population of native species, or damage to agricultural crops if no methods of containment/eradication are put in place. There is some direct observational evidence, but only from one source.	Medium
E. rosea	(2) Predation	MV — Massive	Evidence of extinction of native snail species as a result of *E. rosea* is documented in the literature	High
N. fulva	(1) Competition	MO — Moderate	*N. fulva* displaces native and introduced ant species outcompeting them through a range of mechanisms including sheer numbers, more efficient hunter, capable of detoxifying the venom of another major invasive ant, S. invicta (LeBrun, Abbott & Gilbert 2013; Monash University 2019; Wang et al 2016). In Colombia, 9 of 14 native ant species were displaced following the establishment of *N. fulva* (Wang et al. 2016). In areas where high densities of *N. fulva* are present, arthropod species abundance declined (LeBrun, Abbott & Gilbert 2013); herbivorous arthropods were most affected declining in abundance and species richness. These impacts should translate into reduced rates or patterns of herbivory, potentially altering relative abundances of plant species over time (LeBrun, Abbott & Gilbert 2013). *N. fulva* are reported to attack and kill chickens on farms in Colombia. They are also reported to attack cattle around the eyes, nose and hoots and can blind calves (Monash Uni 2019; Wang et al 2016). Indirect impact on plants through protecting and 'farming' plant-feeding hemipterans (Sharma, Oi & Buss 2013). In Colombia *N. fulva* is reported to cause desiccation of rangeland grasses through association with phytophagous hemiptera (Wang et al 2016). Losses from hemipteran pests associated with *N. fulva* in coconuts in the Caribbean and coffee in South America have been observed but not quantified (Wang et al 2016). *N. fulva* may also spread plant diseases (Monash University 2019). Effects on non-target organisms can occur as a result of the use of chemical for control (Wang et al 2016).	Medium

References:

LeBrun, E.G., J. Abbott, and L.E. Gilbert. (2013). Imported crazy any displaces imported fire ant, reduces and homogenizes grassland ant and arthropod assemblages. *Biological Invasions*, 15: 2429-2442.

Monash University (2019). *Invasive Insects: Risks and Pathways Project: Tawny crazy ant*, Monash University, available at: https://invasives.org.au/wp-content/uploads/2019/06/Invasion-Watch_Tawny-crazy-ant.pdf, accessed 14 March 2021.

Wang et al 2016. Review of the tawny crazy ant, *Nylanderia fulva*, an emergent ant invader in the southern United States: is biological control a feasible management option? *Insects,* 7(4): 77.

12. Appendix D. GISS guidelines for assessors

Purpose of Assessments: to apply the GISS tool (Nentwig et al. 2016) to non-industry pests, using published or publicly available evidence of potential impacts to identify possible impacts on the Australian environment, community and the economy.

Resources provided: Nentwig et al. (2016); GISS version 27.04.2016; and two examples of completed templates (Supplementary material).

Begin Assessment: Open the GISS tool. Save the spreadsheet under a new name, preferably related to the pest under assessment. Commence the assessment process by completing the **Species description** — rows 21-33 in Figure 1. Here, and in the remainder of the worksheet you should input information into blue cells. Information to assist with this is provided adjacent to each cell.

	A	B	C	D	E
1	**Generic Impact Scoring System GISS**				
2	Excel version of 27.04.2016				
3	**Supplementary Material**				
4	Nentwig W, Bacher S, Pyšek P, Vilà M, Kumschick S (2016) The Generic Impact Scoring System (GISS): a standardized tool				
5	to quantify the impacts of alien species. Environmental Monitoring and Assessment, DOI: 10.1007/s10661-016-5321-4				
6	contact mail wolfgang.nentwig@iee.unibe.ch				
7					
8					
9					
10					
11	BLUE fields are those where some input is expected from you.				
12					
13					
14					
15					
16					
17	**A Species description**				
18					
19					
20					
21	Species name		Genus, species, authority		
22	Higher taxonomy		Family and 1-2 further higher taxa		
23	Taxonomic comment		If appropriate, add relevant synonyms. Mention if this is a cryptic species		
24	Taxonomic group		Drop down menu		
25	Main ecosystem		Drop down menu		
26	Area of origin		Usually a continent, river system, ocean, or major biogeographic area. Has to be different from the invaded area, otherwise the species is not alien.		
27	Is the species present in Australia?		Drop down menu		
28	Invaded area		Has to be different from the area of origin, otherwise the species is not alien. You may list invaded areas within Australia and also outside of Australia.		
29	Area assessed		GISS can be applied to all areas, but the area assessed has to be different from the area of origin.		
30	Pathway		Drop down menu		
31	Introduction time		Year or whatever is known		
32	Used as		Drop down menu		
33	Comments		If appropriate, add comments.		

Figure 1. Screenshot of the Species description section of the GISS

Next, you will undertake the **Impact assessment.** There are twelve impacts listed in the GISS tool: 6 environmental impacts, 3 economic impacts, and 3 societal impacts. Detailed instructions are provided about what would constitute each particular type of impact. Figure 2 shows information relevant to describing **1.1 Impact on plants or vegetation (through mechanisms other than competition)**. In the blue box at row 55 you should detail potential impacts that have been described in the literature, and the source of that evidence. This impact may have occurred in Australia or overseas. See the Supplementary material for an example of the appropriate level of detail. If there was no evidence in the literature of a particular type of impact occurring, then '*no direct impacts identified'* should be entered.

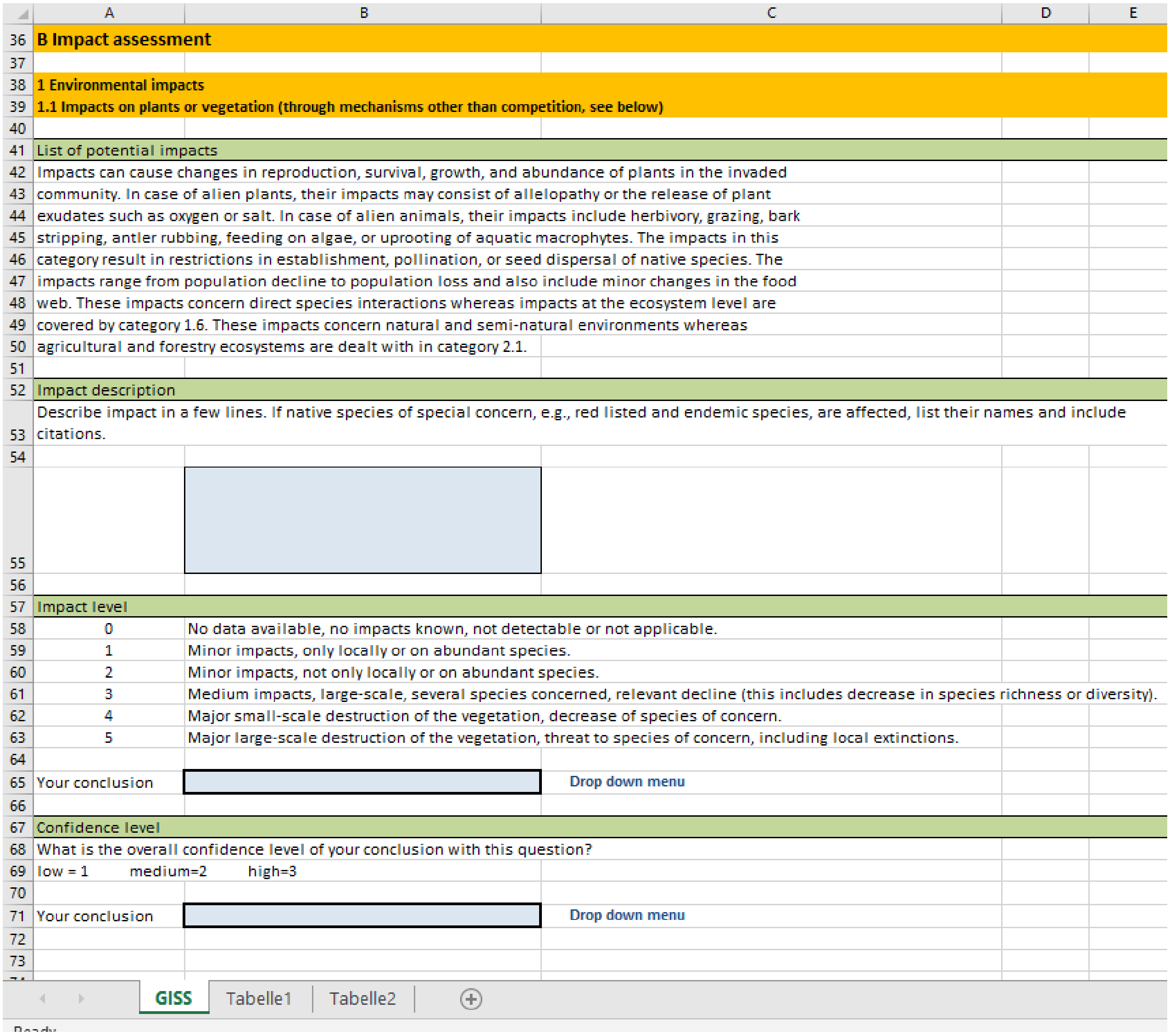


Figure 2. Screenshot of environmental impact 1.1

You will also be asked to provide an **Impact level**, where impact ranges from 0 (no data/no impacts known) to 5 (major large-scale destruction of the vegetation…) (rows 57-63 in Figure 2). In the current example, your answer would be provided in the blue box in row 65 and should be based on the earlier evidence provided. Your level of confidence with this answer is also relevant, and should be provided (row 71 in Figure 2 example). The **confidence level** refers only to uncertainty due to data quality — uncertainty related to variation in impacts in space or time is not considered. This is the approach is from Blackburn et al. (2014) who explain their definitions as follows (Blackburn et al. 2014, Text S1):

- *"High confidence* is assigned when there is **direct and relevant evidence** to support the assessment, the data are reliable and of good quality, and all evidence points in the same direction.
  Note, where the literature clearly provided evidence of *no* impact, '0' impact would be selected along with a *high confidence* level.
- *Medium confidence* is assigned when there is **some evidence** to support the assessment, but some of the data are indirect (estimated from another phylogenetically or functionally similar alien species with recorded impact, or deriving from a probabilistic risk assessment) and/or there is some degree of ambiguity in the direction or magnitude of the impact.
- *Low confidence* is defined as **no direct evidence** to support the assessment, for example only data from other species have been used as supporting evidence or data are of low quality or strongly ambiguous."
  For example, a *low confidence* level would be selected where potential direct impacts weren't identified from the literature, but where reasoning would suggest there could be impacts. Where logical reasoning would suggest no direct or indirect impact, but no literature is found that explicitly states this, '0' impact would be selected along with a *medium confidence* level.

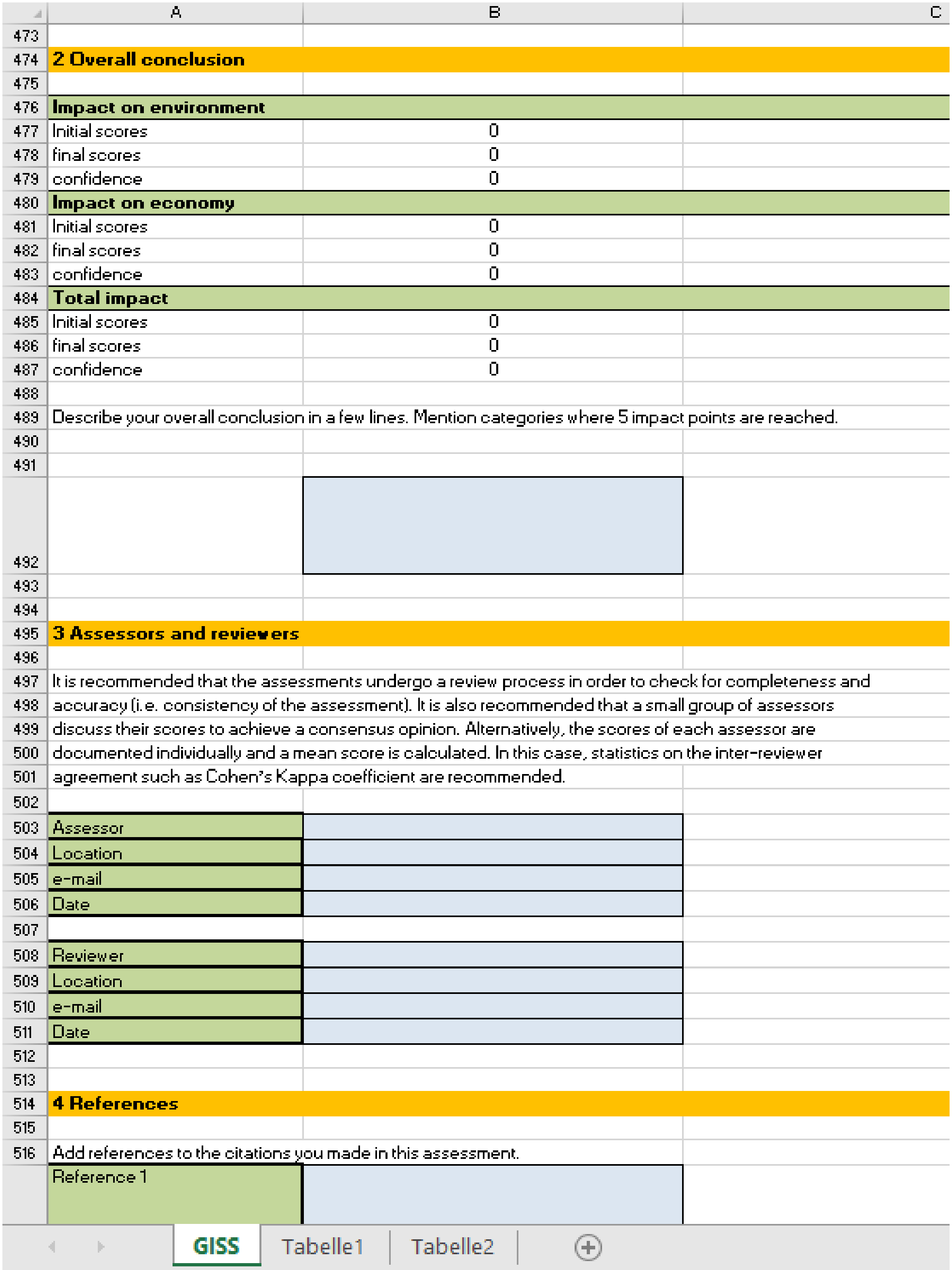
Once you have assessed each impact your scores will be automatically be collated in the **Conclusion** section (row 474) (Figure 3). This section also contains the relative weight of impacts (rows 460-471), which are automatically set to 1 (equal weighting). Any changes to impact weights will impact on final scores. At this stage, weights should remain at 1 for each impact. Note that the confidence level does not change the final score, but should still be reported.

An overall conclusion should be provided by the assessor in row 492 and will be based on impacts already reported in the worksheet. For example, an appropriate conclusion for *Nylanderia fulva* would be as follows:

> *N. fulva has a range of environmental and economic impacts including displacing native ant species, preying on arthropods and affecting arthropod diversity, indirect consequences for plant health through association with plan-feeding hemipterans. This species of ant is also known to impact human infrastructure short circuiting a range of electrical equipment, entering homes and buildings and affecting public amenity spaces.*

Additional examples are contained in the Supplementary material.

Assessor details should be given in rows 503-506, and full details of references should be provided in row 517 onwards.



	A	B	C
473			
474	**2 Overall conclusion**		
475			
476	**Impact on environment**		
477	Initial scores	0	
478	final scores	0	
479	confidence	0	
480	**Impact on economy**		
481	Initial scores	0	
482	final scores	0	
483	confidence	0	
484	**Total impact**		
485	Initial scores	0	
486	final scores	0	
487	confidence	0	
488			
489	Describe your overall conclusion in a few lines. Mention categories where 5 impact points are reached.		
490			
491			
492			
493			
494			
495	**3 Assessors and reviewers**		
496			
497	It is recommended that the assessments undergo a review process in order to check for completeness and		
498	accuracy (i.e. consistency of the assessment). It is also recommended that a small group of assessors		
499	discuss their scores to achieve a consensus opinion. Alternatively, the scores of each assessor are		
500	documented individually and a mean score is calculated. In this case, statistics on the inter-reviewer		
501	agreement such as Cohen's Kappa coefficient are recommended.		
502			
503	Assessor		
504	Location		
505	e-mail		
506	Date		
507			
508	Reviewer		
509	Location		
510	e-mail		
511	Date		
512			
513			
514	**4 References**		
515			
516	Add references to the citations you made in this assessment.		
	Reference 1		

GISS | Tabelle1 | Tabelle2

Figure 3. Screenshot of the Conclusion section of GISS

13. Supplementary material.

13.1 Completed GISS template for *Englandina rosea*

	A	B	C	D	E
1	**Generic Impact Scoring System GISS**				
2	Excel version of 27.04.2016				
3	**Supplementary Material**				
4	Nentwig W, Bacher S, Pyšek P, Vilà M, Kumschick S (2016) The Generic Impact Scoring System (GISS): a standardized tool				
5	to quantify the impacts of alien species. Environmental Monitoring and Assessment, DOI: 10.1007/s10661-016-5321-4				
6	contact mail wolfgang.nentwig@iee.unibe.ch				
11	BLUE fields are those where some input is expected from you.				
17	**A Species description**				
21	Species name	Euglandina rosea	Genus, species, authority		
22	Higher taxonomy	Spiraxidae, Stylommatophora, Gastropoda	Family and 1-2 further higher taxa		
23	Taxonomic comment		If appropriate, add relevant synonyms. Mention if this is a cryptic species		
24	Taxonomic group	Invertebrate	**Drop down menu**		
25	Main ecosystem	Terrestrial	**Drop down menu**		
26	Area of origin	United States (Tropical North America)	Usually a continent, river system, ocean, or major biogeographic area. Has to be different from the invaded area, otherwise the species is not alien.		
27	Invaded area	American Samoa, Bahamas, Bermuda, French Polynesia, Guam, Hong Kong, India, Indonesia, Japan, Kiribati, Madagascar, Mauritius, Mayotte, New Caledonia, Northern Mariana Islands, Palau, Papua New Guinea, Reunion, Seychelles, Solomon Islands, Sri Lanka, Taiwan, United States, Vanuatu, Wallis and Futuna	Has to be different from the area of origin, otherwise the species is not alien. You may list invaded areas within Europe and also outside of Europe.		
28	Area assessed	Australia	GISS can be applied to all areas, but the area assessed has to be different from the area of origin.		
29	Pathway	Release	**Drop down menu**		
30	Introduction time	1950	Year or whatever is known		
31	Used as	Biocontrol	**Drop down menu**		
32	Comments	Introduced as a Biological control agent for the Giant African Snail	If appropriate, add comments.		
36	**B Impact assessment**				
38	**1 Environmental impacts**				
39	**1.1 Impacts on plants or vegetation (through mechanisms other than competition, see below)**				
41	List of potential impacts				
42	Impacts can cause changes in reproduction, survival, growth, and abundance of plants in the invaded				
43	community. In case of alien plants, their impacts may consist of allelopathy or the release of plant				
44	exudates such as oxygen or salt. In case of alien animals, their impacts include herbivory, grazing, bark				
45	stripping, antler rubbing, feeding on algae, or uprooting of aquatic macrophytes. The impacts in this				
46	category result in restrictions in establishment, pollination, or seed dispersal of native species. The				
47	impacts range from population decline to population loss and also include minor changes in the food				
48	web. These impacts concern direct species interactions whereas impacts at the ecosystem level are				
49	covered by category 1.6. These impacts concern natural and semi-natural environments whereas				
50	agricultural and forestry ecosystems are dealt with in category 2.1.				
52	Impact description				
53	Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.				
55		No direct impacts identified.			
57	Impact level				
58	0	No data available, no impacts known, not detectable or not applicable.			
59	1	Minor impacts, only locally or on abundant species.			
60	2	Minor impacts, not only locally or on abundant species.			
61	3	Medium impacts, large-scale, several species concerned, relevant decline (this includes decrease in species richness or diversity).			
62	4	Major small-scale destruction of the vegetation, decrease of species of concern.			
63	5	Major large-scale destruction of the vegetation, threat to species of concern, including local extinctions.			
65	Your conclusion	0	**Drop down menu**		
67	Confidence level				

What is the overall confidence level of your conclusion with this question?
low = 1 medium=2 high=3

Your conclusion | 3 | **Drop down menu**

1.2 Impacts on animals through predation, parasitism, or intoxication

List of potential impacts

Impacts may concern single animal species or a guild, e.g. through predation, parasitism, or intoxication, measurable for example as reductions in reproduction, survival, growth, or abundance. When the alien species is a plant, the impact can be due to changes in food availability or palatability (e.g. fruits, forage or flowers affecting pollinators), and the uptake of secondary plant compounds or toxic compounds by animals. These impacts might act on different levels, ranging from population decline to population loss and they include also minor changes in the food web. These impacts concern direct species interactions whereas impacts on ecosystem level are covered by category 1.6. These impacts concern only free-living animals in the wild whereas animal production is covered by category 2.2.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

Negative impact on native fauna (snails) through predation, but will attack and consume small slugs in the absence of snail prey. Special concern to threatened species including: Achatinella mustelina Hawaii (IUCN red list: Critically endangered) Hadfield et al., 1993; Erinna newcombi Hawaii (Newcomb's snail) (IUCN red list: Vulnerable) US Fish and Wildlife Service, 2006; Eua zebrina American Samoa (Tutuila tree snail) (IUCN red list: Endangered) US Fish and Wildlife Service, 2014a; Newcombia cumingi Hawaii (Newcomb's tree snail) (IUCN red list: Endangered) US Fish and Wildlife Service, 2013; Ostodes strigatus American Samoa (sisi snail) USA ESA listing as endangered species US Fish and Wildlife Service, 2014b; Partulina semicarinata Hawaii (Lanai tree snail) (IUCN red list: Endangered) US Fish and Wildlife Service, 2013; Partulina variabilis Hawaii (Lanai tree snail) (IUCN red list: Endangered) US Fish and Wildlife Service, 2013.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally or on abundant species.
2	Minor impacts, not only locally or on abundant species.
3	Medium impacts, large-scale, several species concerned, relevant decline (this includes decrease in species richness or diversity).
4	Major small-scale impacts on target species, decrease of species of concern.
5	Major large-scale impacts on target species, threat to species of concern, including local extinctions.

Your conclusion | 3 | **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?
low = 1 medium=2 high=3

Your conclusion | 3 | **Drop down menu**

1.3 Impacts on other species through competition

List of potential impacts

Impacts concern at least one native species, e.g. by competition for nutrients, food, water, space or other resources, including competition for pollinators which might affect plant fecundity (i.e. fruit or seed set). Often, the alien species outcompetes native species due to higher reproduction, resistance, longevity or other mechanisms. In the beginning, these impacts might be inconspicuous and only recognizable as slow change in species abundance but might lead to the local/global disappearance of a native species. It includes behavioural changes in outcompeted species and ranges from population decline to population loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally or on abundant species.
2	Minor impacts, not only locally or on abundant species.
3	Medium impacts, large-scale, several species concerned, relevant decline, including decrease in species richness or diversity.
4	Major small-scale impacts on target species, decrease of species of concern.
5	Major large-scale impacts on target species, threat to species of concern, including local extinctions.

Your conclusion | 0 | **Drop down menu**

A	B	C	D	E

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion	3	Drop down menu

1.4 Impacts through transmission of diseases or parasites to native species

List of potential impacts

Host or alternate host for native or alien diseases (viruses, fungi, protozoans or other pathogens) or parasites, impacts by transmission of diseases or parasites to native species.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

E. rosea was found experimentally to be able to serve as both an intermediate and a paratenic host of Angiostrongylus cantonensis (rat lungworm disease- present in Australia) (Campbell B.G. and Little M.D. 1988)

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Occasional transmission to native species. No impacts on native species detectable.
2	Occasional transmission to native species. Only minor impacts on native species detectable.
3	Regular transmission to native species. Minor population decline in native species.
4	Transmission to native species and/or species of concern, decline of these species but no extinction.
5	Transmission to native species and/or species of concern, serious decline of these species and/or local extinction.

Your conclusion	2	Drop down menu

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion	3	Drop down menu

1.5 Impacts through hybridization

List of potential impacts

Impacts are through hybridization with native species, usually closely related to the alien taxon, leading to a reduced or lost opportunity for reproduction, sterile or fertile hybrid offspring, gradual loss of the genetic identity of a species, and/or disappearance of a native species, i.e. extinction.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Hybridization possible in ornamental breeding or captivity, but not or only rarely in the wild.
2	Hybridization common in the wild, no hybrid offspring, constraints to normal reproduction.
3	Hybridization common, with sterile offspring.
4	Hybridization common with fertile offspring, growing hybrid populations.
5	Hybridization common with fertile offspring, predominant hybrid populations, increasing loss of the genetic identity of a native species, local extinction of the native species.

Your conclusion	0	Drop down menu

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion	3	Drop down menu

1.6 Impacts on ecosystems

List of potential impacts

Impacts on characteristics of an ecosystem, its nutritional status (e.g. changes in nutrient pools and fluxes, which may be caused by nitrogen-fixating symbionts, increased water turbidity or faecal droppings), modification of soil or water body properties (e.g. soil moisture, pH, C/N ratio, salinity, eutrophication), and disturbance regimes (vegetation flammability, changes in hydrology, erosion or soil compacting), changes in ecosystem functions (e.g. pollination or decomposition rates), or other physical or structural changes. Impacts on ecosystems also include modification of successional processes. Such modifications may lead to reduced suitability (e.g. shelter) for native species, thus causing their disappearance. The application of pesticides to control impacts might have side effects on non-target organisms which count as ecosystem impacts here.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally.
2	Minor impacts, not only locally, e.g., impact on a particular ecosystem parameter.
3	Medium impacts, large-scale, damage of sites of conservation importance, relevant ecosystem modifications, impact on several ecosystem properties, pesticide applications needed, relevant changes in species composition.
4	Major small-scale effects, damage of sites of conservation importance, major changes in ecosystem services, decrease of species of concern.
5	Major large-scale effects, damage of sites of conservation importance, changes in disturbance regimes, threat to species of concern, including local extinctions.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

2 Economic impacts

2.1 Impacts on agricultural production

List of potential impacts

Impacts through damage to crops, pastures or plantations, but also to horticultural and stored products. Impacts include competition with crops by weeds, direct feeding damage (from feeding traces which reduce marketability to complete production loss) but also reduced accessibility, usability or marketability through contamination and cosmetic changes. Impacts include the need for applying pesticides which involve additional costs, also by reducing market quality. Impacts usually lead to an economic loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

2.2 Impacts on animal production

List of potential impacts

Impacts through competition with livestock, transmission of diseases or parasites to livestock and predation of livestock, or, more generally, affecting livestock health. 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. It also includes reduction of livestock accessibility to grazing land. 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. This category refers to livestock, poultry, game animals, fisheries and aquaculture.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No impact on livestock. The parasite Angiostrongylus cantonensis that E. rosea can host can only be found in these animals other than humans: dogs, flying foxes, marsupials and zoo primates. (Animal Diversity Web 2020)

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — Drop down menu

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — Drop down menu

2.3 Impacts on forestry production

List of potential impacts

Impacts on forests or forest products through plant competition, parasitism, diseases, herbivory, effects on tree or forest growth and on seed dispersal. Impacts might 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.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

Impact not known. No known pesticide or insecticide treatments are used for *E. rosea* .

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, effects on forest regeneration, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — Drop down menu

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — Drop down menu

2.4 Impacts on human infrastructure and administration

List of potential impacts

Impacts include damage to human infrastructure, such as roads and other traffic infrastructure, buildings, dams, 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 include the need for applying pesticides and performing management and eradication programmes, their development and further administration costs, as well as costs for research and control. Impacts usually lead to an economic loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.

A	B	C	D	E
5	Major impacts with complete destruction and economic loss.			
Your conclusion	0	Drop down menu		

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion	3	Drop down menu

2.5 Impacts on human health

List of potential impacts

Impacts comprise injuries (e.g. bites, stings, scratches, rashes, accidents), transmission of diseases and parasites to humans, bioaccumulation of noxious substances, health hazard due to contamination with pathogens or parasites (e.g. through contaminated water, soil, food, or by feces or droppings). It also includes human hazards to the ingestion or contact to plant secondary compounds which are toxic or poisonous, or to allergenic substances such as pollen. Impacts might affect human safety and cause traffic accidents. Impacts include the need for applying pesticides which due to their low selectivity and/or residues might have side-effects on humans. Via health costs, impacts usually lead to economic costs due to medication and treatments costs, as well as the consequences in productive losses from these impacts on workforce.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

E. rosea can serve as an immediate and paratenic host of Angiostrongylus cantonensis - a potentially fatal disease in humans and other mammals (eosinophilic meningitis- Rat lungworm- a rare disease already found in Australia). Humans contract the disease primarily through ingestion of infected gastropods, the intermediate hosts of Angiostrongylus cantonensis. (Kim J.R. et al, 2014) Very rarely, rat lung worm causes an infection (infestation) of the brain called eosinophilic meningo-encephalitis

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic costs.
2	Minor impacts, but more wide-spread, minor economic costs.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic costs.
4	Major impacts with high damage, often occurring or with high probability, but rarely fatal, major economic costs.
5	Major impacts, fatal issues, high economic costs.

Your conclusion	4	Drop down menu

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion	3	Drop down menu

2.6 Impacts on human social life

List of potential impacts

Noise disturbance, pollution of recreational areas (water bodies, rural parks, golf courses or city parks), fouling, eutrophication, damage by trampling and overgrazing, restrictions in accessibility (e.g. by thorns, other injuring structures, successional processes, or recent pesticide application) to habitats or landscapes of recreational value. Impact on human wellbeing. Restrictions or loss of recreational activities, aesthetic attraction, touristic value, or employment possibilities. Restrictions concern also aesthetic values and natural or cultural heritage.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

Some loss to human economic/livelihoods on the Huahine Island. This was due to the disappearance of the critically endangered Partula varia and the Partula rosea (due to predation by E. rosea), which had an economic and social impact on the local community. The snail shells were used for making shell jewelry (lei) and many women of the villages lost their livelihoods. (Coote 2000)

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.

A	B
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, recreational value of a location strongly affected, major economic loss.
5	Major impacts with complete destruction and loss of recreational value, major economic loss.

Your conclusion: 1 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

C Conclusions

1 Impact weight

Prior to scoring, it has to be decided if all impact categories are of equal value.
If deviations from default value = 1 are desired, this can be done here.
Provide here a justification of weights different from 1.

Impact category	weight	initial scores	final scores	confidence
2.1.1 On plants or vegetation	1	0	0	3
2.1.2 On animals	1	3	3	3
2.1.3 Competition	1	0	0	3
2.1.4 Disease transmission	1	2	2	3
2.1.5 Hybridization	1	0	0	3
2.1.6 Ecosystems	1	0	0	3
2.2.1 Agricultural production	1	0	0	3
1.1.2 Animal production	1	0	0	3
2.2.3 Forestry production	1	0	0	3
2.2.4 Human infrastructure	1	0	0	3
2.2.5 Human health	1	4	4	3
2.2.6 Human social life	1	1	1	3

2 Overall conclusion

Impact on environment	
Initial scores	5
final scores	5
confidence	3
Impact on economy	
Initial scores	5
final scores	5
confidence	3
Total impact	
Initial scores	10
final scores	10
confidence	3

Describe your overall conclusion in a few lines. Mention categories where 5 impact points are reached.

Overall, E. rosea will have a negative impact on the environment due to its predatory nature that poses a threat to endemic Australian snails. Overall, E. rosea will have a negative economic impact (and human health risk) due to its ability to host the parasite Angiostrongylus cantonensis (rat lungworm disease) which can be fatal in humans.

3 Assessors and reviewers

It is recommended that the assessments undergo a review process in order to check for completeness and accuracy (i.e. consistency of the assessment). It is also recommended that a small group of assessors discuss their scores to achieve a consensus opinion. Alternatively, the scores of each assessor are documented individually and a mean score is calculated. In this case, statistics on the inter-reviewer agreement such as Cohen's Kappa coefficient are recommended.

	A	B	C	D	E
502					
503	Assessor	Lydia Ayto			
504	Location	Canberra			
505	e-mail	lydia.ayto@agriculture.gov.au			
506	Date	16/02/2021			
507					
508	Reviewer				
509	Location				
510	e-mail				
511	Date				
512					
513					
514	**4 References**				
515					
516	Add references to the citations you made in this assessment.				
517	Reference 1	Hadfield MG, Miller SE, Carwile AH, 1993. The decimation of endemic Hawai'ian tree snails by alien predators. American Zoologist, 33:610-622.			
518	Reference 2	US Fish and Wildlife Service, 2006. In: Final Recovery Plan for the Newcomb's Snail (Erinna newcombi). US Fish and Wildlife Service, 61 pp.. http://ecos.fws.gov/docs/recovery_plan/060918b.pdf			
519	Reference 3	US Fish and Wildlife Service, 2013. In: Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui; Final Rule. 78(102) US Fish and Wildlife Service, 32014-32065. https://www.gpo.gov/fdsys/pkg/FR-2013-05-28/pdf/2013-12105.pdf			
520	Reference 4	US Fish and Wildlife Service, 2014. In: Species assessment and listing priority assignment form: Eua zebrina. US Fish and Wildlife Service, 20 pp.. http://ecos.fws.gov/docs/candidate/assessments/2014/r1/G0BJ_I01.pdf			
521	Reference 5	US Fish and Wildlife Service, 2014. In: U.S. Fish and Wildlife Service species assessment and listing priority assignment form: Ostodes strigatus. US Fish and Wildlife Service, 9 pp.. http://ecos.fws.gov/docs/candidate/assessments/2014/r1/G0A5_I01.pdfUS Fish and Wildlife Service, 2014. In: U.S. Fish and Wildlife Service species assessment and listing priority assignment form: Ostodes strigatus. US Fish and Wildlife Service, 9 pp.. http://ecos.fws.gov/docs/candidate/assessments/2014/r1/G0A5_I01.pdf			
522	Reference 6	Campbell, B.G. and Little, M.D. 1988. The finding of Angiostrongylus cantonensis in rats in New Orleans, Am J Trop Med Hyg. 38(3):			
523	Reference 7	Kim, J. R., Hayes, K. A., Yeung, N. W., & Cowie, R. H. (2014). Diverse gastropod hosts of Angiostrongylus cantonensis, the rat lungworm, globally and with a focus on the Hawaiian Islands. PloS one, 9(5), e94969. https://doi.org/10.1371/journal.pone.0094969			
524	Reference 8	Kim, J. R., Hayes, K. A., Yeung, N. W., & Cowie, R. H. (2014). Diverse gastropod hosts of Angiostrongylus cantonensis, the rat lungworm, globally and with a focus on the Hawaiian Islands. PloS one, 9(5), e94969. https://doi.org/10.1371/journal.pone.0094969			
525	Reference 9	Coote, Trevor, Zoological Society of London. Field Report 2000/2001 unpub.			
526	Reference 10	Global Invasive Species Database (GISD) 2021. Species profile Euglandina rosea. Available from: http://www.iucngisd.org/gisd/species.php?sc=92 [Accessed 15 February 2021]			
527	Reference 11	Animal Diversity Web 2020, Angiostrongylus cantonensis, Accessed February 16, 2021 at https://animaldiversity.org/accounts/Angiostrongylus_cantonensis/			

13.2 Completed GISS template for *Caracollina lenticula*

	A	B	C	D	E
1	**Generic Impact Scoring System GISS**				
2	Excel version of 27.04.2016				
3	**Supplementary Material**				
4	Nentwig W, Bacher S, Pyšek P, Vilà M, Kumschick S (2016) The Generic Impact Scoring System (GISS): a standardized tool				
5	to quantify the impacts of alien species. Environmental Monitoring and Assessment, DOI: 10.1007/s10661-016-5321-4				
6	contact mail wolfgang.nentwig@iee.unibe.ch				
7					
8					
9					
10					
11	BLUE fields are those where some input is expected from you.				
12					
13					
14					
15					
16					
17	**A Species description**				
18					
19					
20					
21	Species name	*Caracollina lenticula* (Michaud, 1831)	Genus, species, authority		
22	Higher taxonomy	Trissexodontidae; Stylommatophora; Gastropoda; Mollusca	Family and 1-2 further higher taxa		
23	Taxonomic comment	basionym *Helix lenticula*	If appropriate, add relevant synonyms. Mention if this is a cryptic species		
24	Taxonomic group	Invertebrate	**Drop down menu**		
25	Main ecosystem	Terrestrial	**Drop down menu**		
26	Area of origin	Mediterranean region	Usually a continent, river system, ocean, or major biogeographic area. Has to be different from the invaded area, otherwise the species is not alien.		
27	Invaded area		Has to be different from the area of origin, otherwise the species is not alien. You may list invaded areas within Europe and also outside of Europe.		
28	Area assessed	Australia	GISS can be applied to all areas, but the area assessed has to be different from the area of origin.		
29	Pathway	Stowaway with transport vector	**Drop down menu**		
30	Introduction time	Sep-18	Year or whatever is known		
31	Used as	Others	**Drop down menu**		
32	Comments		If appropriate, add comments.		
33					
34					
35					
36	**B Impact assessment**				
37					
38	**1 Environmental impacts**				
39	**1.1 Impacts on plants or vegetation (through mechanisms other than competition, see below)**				
40					
41	List of potential impacts				
42	Impacts can cause changes in reproduction, survival, growth, and abundance of plants in the invaded				
43	community. In case of alien plants, their impacts may consist of allelopathy or the release of plant				
44	exudates such as oxygen or salt. In case of alien animals, their impacts include herbivory, grazing, bark				
45	stripping, antler rubbing, feeding on algae, or uprooting of aquatic macrophytes. The impacts in this				
46	category result in restrictions in establishment, pollination, or seed dispersal of native species. The				
47	impacts range from population decline to population loss and also include minor changes in the food				
48	web. These impacts concern direct species interactions whereas impacts at the ecosystem level are				
49	covered by category 1.6. These impacts concern natural and semi-natural environments whereas				
50	agricultural and forestry ecosystems are dealt with in category 2.1.				
51					
52	Impact description				
53	Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.				
54					
55		Many terrestrial snails are polyphagous, feeding on a wide variety of host plants. Large populations of *C. lenticula* may impact plant health through feeding on plant species. *C. lenticula* is included on Australia's National Priority Plant Pest list along with several other species of exotic snail (DAWE 2019).			
56					
57	Impact level				
58	0	No data available, no impacts known, not detectable or not applicable.			
59	1	Minor impacts, only locally or on abundant species.			
60	2	Minor impacts, not only locally or on abundant species.			
61	3	Medium impacts, large-scale, several species concerned, relevant decline (this includes decrease in species richness or diversity).			
62	4	Major small-scale destruction of the vegetation, decrease of species of concern.			
63	5	Major large-scale destruction of the vegetation, threat to species of concern, including local extinctions.			
64					
65	Your conclusion	0	**Drop down menu**		
66					
67	Confidence level				

What is the overall confidence level of your conclusion with this question?
low = 1 medium=2 high=3

Your conclusion | 1 | **Drop down menu**

1.2 Impacts on animals through predation, parasitism, or intoxication

List of potential impacts

Impacts may concern single animal species or a guild, e.g. through predation, parasitism, or intoxication, measurable for example as reductions in reproduction, survival, growth, or abundance. When the alien species is a plant, the impact can be due to changes in food availability or palatability (e.g. fruits, forage or flowers affecting pollinators), and the uptake of secondary plant compounds or toxic compounds by animals. These impacts might act on different levels, ranging from population decline to population loss and they include also minor changes in the food web. These impacts concern direct species interactions whereas impacts on ecosystem level are covered by category 1.6. These impacts concern only free-living animals in the wild whereas animal production is covered by category 2.2.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

A search of the scientific literature failed to identify any reports that *C. lenticula* is predatory

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally or on abundant species.
2	Minor impacts, not only locally or on abundant species.
3	Medium impacts, large-scale, several species concerned, relevant decline (this includes decrease in species richness or diversity).
4	Major small-scale impacts on target species, decrease of species of concern.
5	Major large-scale impacts on target species, threat to species of concern, including local extinctions.

Your conclusion | 0 | **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?
low = 1 medium=2 high=3

Your conclusion | 3 | **Drop down menu**

1.3 Impacts on other species through competition

List of potential impacts

Impacts concern at least one native species, e.g. by competition for nutrients, food, water, space or other resources, including competition for pollinators which might affect plant fecundity (i.e. fruit or seed set). Often, the alien species outcompetes native species due to higher reproduction, resistance, longevity or other mechanisms. In the beginning, these impacts might be inconspicuous and only recognizable as slow change in species abundance but might lead to the local/global disappearance of a native species. It includes behavioural changes in outcompeted species and ranges from population decline to population loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

Similar to other invasive snails, it is possible that *C. lenticula* may compete with native snail species inhabiting the same or similar ecological niches resulting in displacement of native species.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally or on abundant species.
2	Minor impacts, not only locally or on abundant species.
3	Medium impacts, large-scale, several species concerned, relevant decline, including decrease in species richness or diversity.
4	Major small-scale impacts on target species, decrease of species of concern.
5	Major large-scale impacts on target species, threat to species of concern, including local extinctions.

Your conclusion | 0 | **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?
low = 1 medium=2 high=3

Your conclusion | 1 | **Drop down menu**

1.4 Impacts through transmission of diseases or parasites to native species

A	B	C	D	E

List of potential impacts

Host or alternate host for native or alien diseases (viruses, fungi, protozoans or other pathogens) or parasites, impacts by transmission of diseases or parasites to native species.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

> A search of the scientific literature failed to identify any reports that *C. lenticula* is a vector of plant or animal diseases.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Occasional transmission to native species. No impacts on native species detectable.
2	Occasional transmission to native species. Only minor impacts on native species detectable.
3	Regular transmission to native species. Minor population decline in native species.
4	Transmission to native species and/or species of concern, decline of these species but no extinction.
5	Transmission to native species and/or species of concern, serious decline of these species and/or local extinction.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

1.5 Impacts through hybridization

List of potential impacts

Impacts are through hybridization with native species, usually closely related to the alien taxon, leading to a reduced or lost opportunity for reproduction, sterile or fertile hybrid offspring, gradual loss of the genetic identity of a species, and/or disappearance of a native species, i.e. extinction.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

> There are 14 genus in the family Trissexodontidae (MolluscaBase 2021). None of genus occur in Australia (Stanisic 2021; AFD 2021). The lack of closely related genus indicates that hybridization with species in Australia is unlikely to be observed.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Hybridization possible in ornamental breeding or captivity, but not or only rarely in the wild.
2	Hybridization common in the wild, no hybrid offspring, constraints to normal reproduction.
3	Hybridization common, with sterile offspring.
4	Hybridization common with fertile offspring, growing hybrid populations.
5	Hybridization common with fertile offspring, predominant hybrid populations, increasing loss of the genetic identity of a native species, local extinction of the native species.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

1.6 Impacts on ecosystems

List of potential impacts

Impacts on characteristics of an ecosystem, its nutritional status (e.g. changes in nutrient pools and fluxes, which may be caused by nitrogen-fixating symbionts, increased water turbidity or faecal droppings), modification of soil or water body properties (e.g. soil moisture, pH, C/N ratio, salinity, eutrophication), and disturbance regimes (vegetation flammability, changes in hydrology, erosion or soil compacting), changes in ecosystem functions (e.g. pollination or decomposition rates), or other physical or structural changes. Impacts on ecosystems also include modification of successional processes. Such modifications may lead to reduced suitability (e.g. shelter) for native species, thus causing their disappearance. The application of pesticides to control impacts might have side effects on non-target organisms which count as ecosystem impacts here.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

Snails play an important role in ecosystems, many feed on plant material aiding breakdown of vegetation and unlocking nutrients (Smith and Kershaw 1979). Displacement of native snails may interupt these systems within environments.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally.
2	Minor impacts, not only locally, e.g., impact on a particular ecosystem parameter.
3	Medium impacts, large-scale, damage of sites of conservation importance, relevant ecosystem modifications, impact on several ecosystem properties, pesticide applications needed, relevant changes in species composition.
4	Major small-scale effects, damage of sites of conservation importance, major changes in ecosystem services, decrease of species of concern.
5	Major large-scale effects, damage of sites of conservation importance, changes in disturbance regimes, threat to species of concern, including local extinctions.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 1 — **Drop down menu**

2 Economic impacts

2.1 Impacts on agricultural production

List of potential impacts

Impacts through damage to crops, pastures or plantations, but also to horticultural and stored products. Impacts include competition with crops by weeds, direct feeding damage (from feeding traces which reduce marketability to complete production loss) but also reduced accessibility, usability or marketability through contamination and cosmetic changes. Impacts include the need for applying pesticides which involve additional costs, also by reducing market quality. Impacts usually lead to an economic loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

It has been proposed that *C. lenticula* may contaminate harvested grain (PIRSA 2020) however, there is no evidence in the literature to support this hypothesis.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 1 — **Drop down menu**

2.2 Impacts on animal production

List of potential impacts

Impacts through competition with livestock, transmission of diseases or parasites to livestock and predation of livestock, or, more generally, affecting livestock health. 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. It also includes reduction of livestock accessibility to grazing land. 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. This category refers to livestock, poultry, game animals, fisheries and aquaculture.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts on animal production identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

2.3 Impacts on forestry production

List of potential impacts

Impacts on forests or forest products through plant competition, parasitism, diseases, herbivory, effects on tree or forest growth and on seed dispersal. Impacts might 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.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No direct impacts on forestry production identified.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, effects on forest regeneration, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

2.4 Impacts on human infrastructure and administration

List of potential impacts

Impacts include damage to human infrastructure, such as roads and other traffic infrastructure, buildings, dams, 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 include the need for applying pesticides and performing management and eradication programmes, their development and further administration costs, as well as costs for research and control. Impacts usually lead to an economic loss.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

C. lenticula exhibits aggregation and climbing behaviour (PIRSA 2020). Some species of terrestrial snails can infest fencing and at high levels affect operation of harvesting machinery (McDonald et al 2018). However, there are no reports that *C. lenticula* demonstrates this impact in its native or introduced range.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, major economic loss.
5	Major impacts with complete destruction and economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 1 — **Drop down menu**

2.5 Impacts on human health

List of potential impacts

Impacts comprise injuries (e.g. bites, stings, scratches, rashes, accidents), transmission of diseases and parasites to humans, bioaccumulation of noxious substances, health hazard due to contamination with pathogens or parasites (e.g. through contaminated water, soil, food, or by feces or droppings). It also includes human hazards to the ingestion or contact to plant secondary compounds which are toxic or poisonous, or to allergenic substances such as pollen. Impacts might affect human safety and cause traffic accidents. Impacts include the need for applying pesticides which due to their low selectivity and/or residues might have side-effects on humans. Via health costs, impacts usually lead to economic costs due to medication and treatments costs, as well as the consequences in productive losses from these impacts on workforce.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

There are no reports that *C. lenticula* affects human health; a summary of snails known to vector important human diseases does not include *C. lenticula* (Lu et al. 2018).

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic costs.
2	Minor impacts, but more wide-spread, minor economic costs.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic costs.
4	Major impacts with high damage, often occurring or with high probability, but rarely fatal, major economic costs.
5	Major impacts, fatal issues, high economic costs.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

Your conclusion: 3 — **Drop down menu**

2.6 Impacts on human social life

List of potential impacts

Noise disturbance, pollution of recreational areas (water bodies, rural parks, golf courses or city parks), fouling, eutrophication, damage by trampling and overgrazing, restrictions in accessibility (e.g. by thorns, other injuring structures, successional processes, or recent pesticide application) to habitats or landscapes of recreational value. Impact on human wellbeing. Restrictions or loss of recreational activities, aesthetic attraction, touristic value, or employment possibilities. Restrictions concern also aesthetic values and natural or cultural heritage.

Impact description

Describe impact in a few lines. If native species of special concern, e.g., red listed and endemic species, are affected, list their names and include citations.

No identified impacts.

Impact level

0	No data available, no impacts known, not detectable or not applicable.
1	Minor impacts, only locally, negligible economic loss.
2	Minor impacts, but more wide-spread, minor economic loss.
3	Medium impacts, large-scale or frequently, pesticide application necessary, medium economic loss.
4	Major impacts with high damage, often occurring or with high probability, recreational value of a location strongly affected, major economic loss.
5	Major impacts with complete destruction and loss of recreational value, major economic loss.

Your conclusion: 0 — **Drop down menu**

Confidence level

What is the overall confidence level of your conclusion with this question?

low = 1 medium=2 high=3

A	B	C	D	E
Your conclusion	1	**Drop down menu**		

C Conclusions

1 Impact weight

Prior to scoring, it has to be decided if all impact categories are of equal value.
If deviations from default value = 1 are desired, this can be done here.
Provide here a justification of weights different from 1.

Impact category	weight	initial scores	final scores	confidence
2.1.1 On plants or vegetation	1	0	0	1
2.1.2 On animals	1	0	0	3
2.1.3 Competition	1	0	0	1
2.1.4 Disease transmission	1	0	0	3
2.1.5 Hybridization	1	0	0	3
2.1.6 Ecosystems	1	0	0	1
2.2.1 Agricultural production	1	0	0	1
1.1.2 Animal production	1	0	0	3
2.2.3 Forestry production	1	0	0	3
2.2.4 Human infrastructure	1	0	0	1
2.2.5 Human health	1	0	0	3
2.2.6 Human social life	1	0	0	1

2 Overall conclusion

Impact on environment	
Initial scores	0
final scores	0
confidence	2
Impact on economy	
Initial scores	0
final scores	0
confidence	2
Total impact	
Initial scores	0
final scores	0
confidence	2

Describe your overall conclusion in a few lines. Mention categories where 5 impact points are reached.

C. lenticula may consume a range of plant hosts, impacting plant health. It may also displace native snails resulting in biodiversity loss.

3 Assessors and reviewers

It is recommended that the assessments undergo a review process in order to check for completeness and accuracy (i.e. consistency of the assessment). It is also recommended that a small group of assessors discuss their scores to achieve a consensus opinion. Alternatively, the scores of each assessor are documented individually and a mean score is calculated. In this case, statistics on the inter-reviewer agreement such as Cohen's Kappa coefficient are recommended.

Assessor	Jana Mayo
Location	Canberra, Australia
e-mail	jana.mayo@agriculture.gov.au
Date	16/02/2021

Reviewer	
Location	
e-mail	
Date	

4 References

Add references to the citations you made in this assessment.

	A	B	C	D	E
517	Reference 1	ABRS 2021, 'Australian Faunal Directory', Australian Biological Resources Study (ABRS), Canberra, Australia, available at https://biodiversity.org.au/afd/home, accessed 2021.			
518	Reference 2	Department of Agriculture 2019, 'National priority plant pests 2019', Australian Government Department of Agriculture, Canberra, Australia, available at https://www.agriculture.gov.au/pests-diseases-weeds/plant/national-priority-plant-pests-2019.			
519	Reference 3	Lu, X-T, Gu, Q-Y, Limpanont, Y, Song, L-G, Wu, Z-D, Okanurak, K & Lv, Z-Y 2018, 'Snail-borne parasitic diseases: an update on global epidemiological distribution, transmission interruption and control methods', Infectious Diseases of Poverty, vol. 7, no. 28.			
520	Reference 4	McDonald, K, Micic, S & Butler, A 2018, 'Snail management guide for WA farmers', Department of Primary Insdustries and Regional Development, Perth WA, available at https://static1.squarespace.com/static/5c00a4b3620b859f65cfa797/t/5c74a6c38165f5cd85499726/1551148791867/SCF+Snail+Management+Guide+08+2018+web.pdf			
521	Reference 5	MolluscaBase eds. (2021). MolluscaBase. Caracollina H. Beck, 1837. Accessed at: https://www.molluscabase.org/aphia.php?p=taxdetails&id=934520 on 16 February 2021			
522	Reference 6	PIRSA 2020, 'Fact sheet - Lens snail, *Caracollina lenticula* ', Primary Industries and Regions SA, Adelaide, available at https://pir.sa.gov.au/__data/assets/pdf_file/0011/369794/Factsheet-Lentil-Snail-August-2020.pdf			
523	Reference 7	Smith,BJ & Kershaw, RC 1979, *Field guide to the non-marine molluscs of south eastern Australia* , ANU Press, Canberra.			
524	Reference 8	Stanisic J 2014, 'Native Australian land snails', available at https://factsaboutsnails.com/types-of-snails/native-australian-snails/ accessed 16 February 2021.			