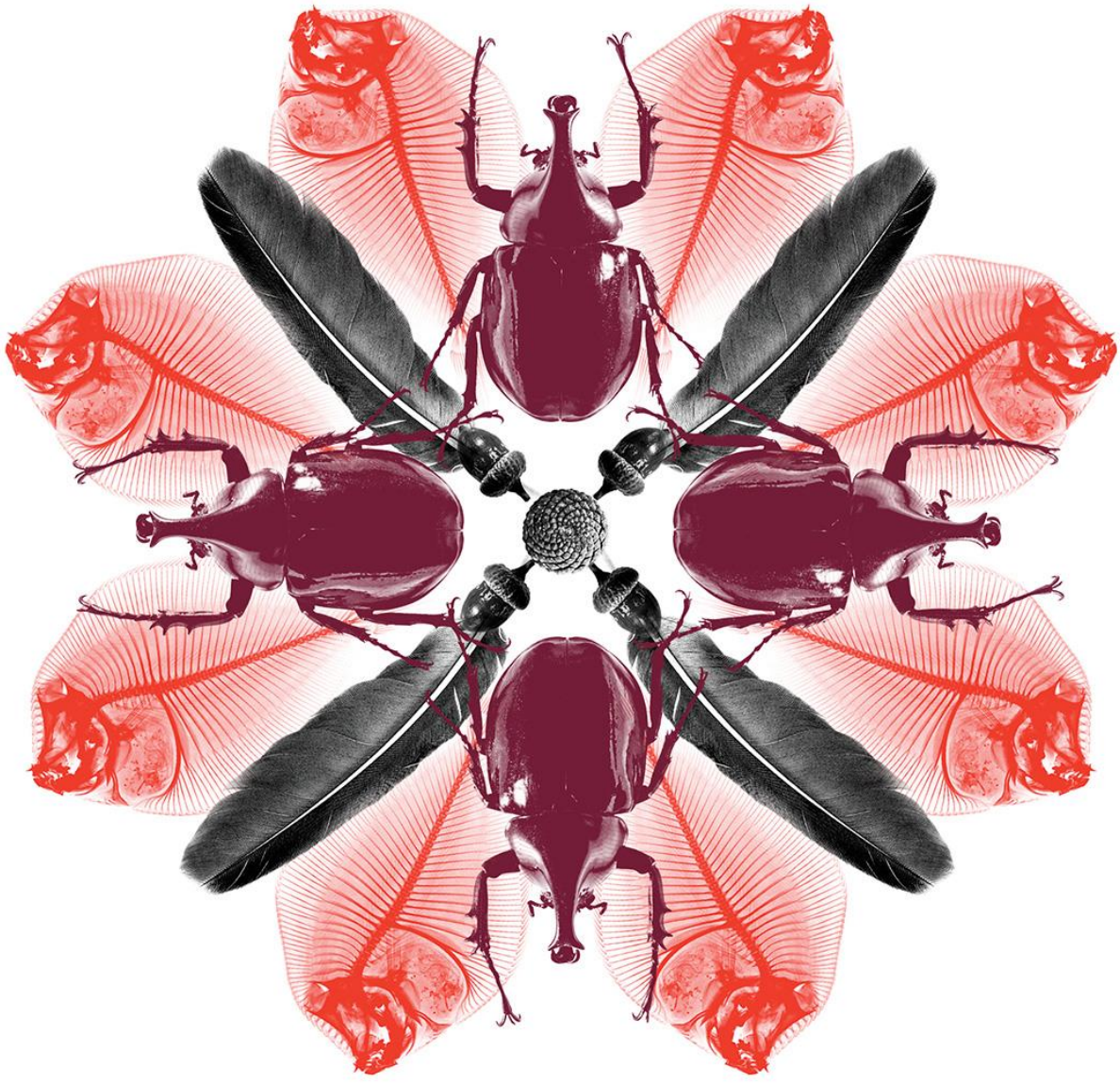
Australian Government
Department of Agriculture and Water Resources

Draft risk analysis report for the release of *Cecidochares connexa* for the biological control of *Chromolaena odorata*

July 2018



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Australian Government Department of Agriculture and Water Resources
GPO Box 858 Canberra ACT 2601

Switchboard: +61 2 6272 3933 or 1800 900 090

Facsimile: +61 2 6272 3307

Email: plant@agriculture.gov.au

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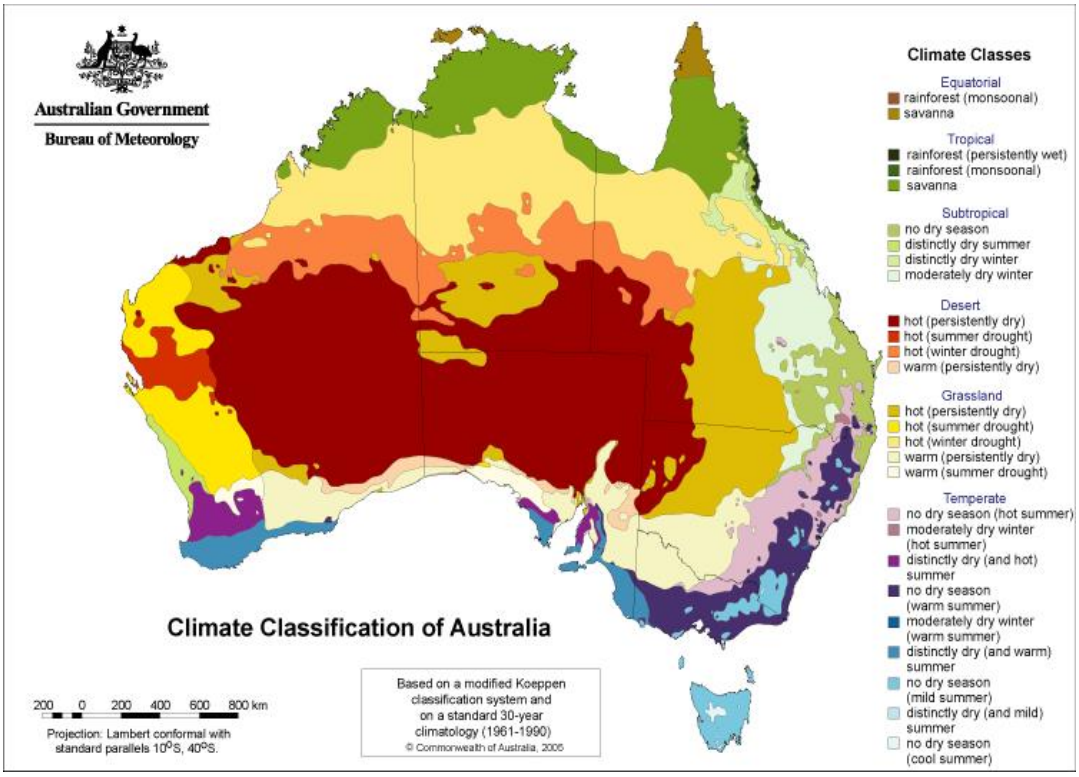

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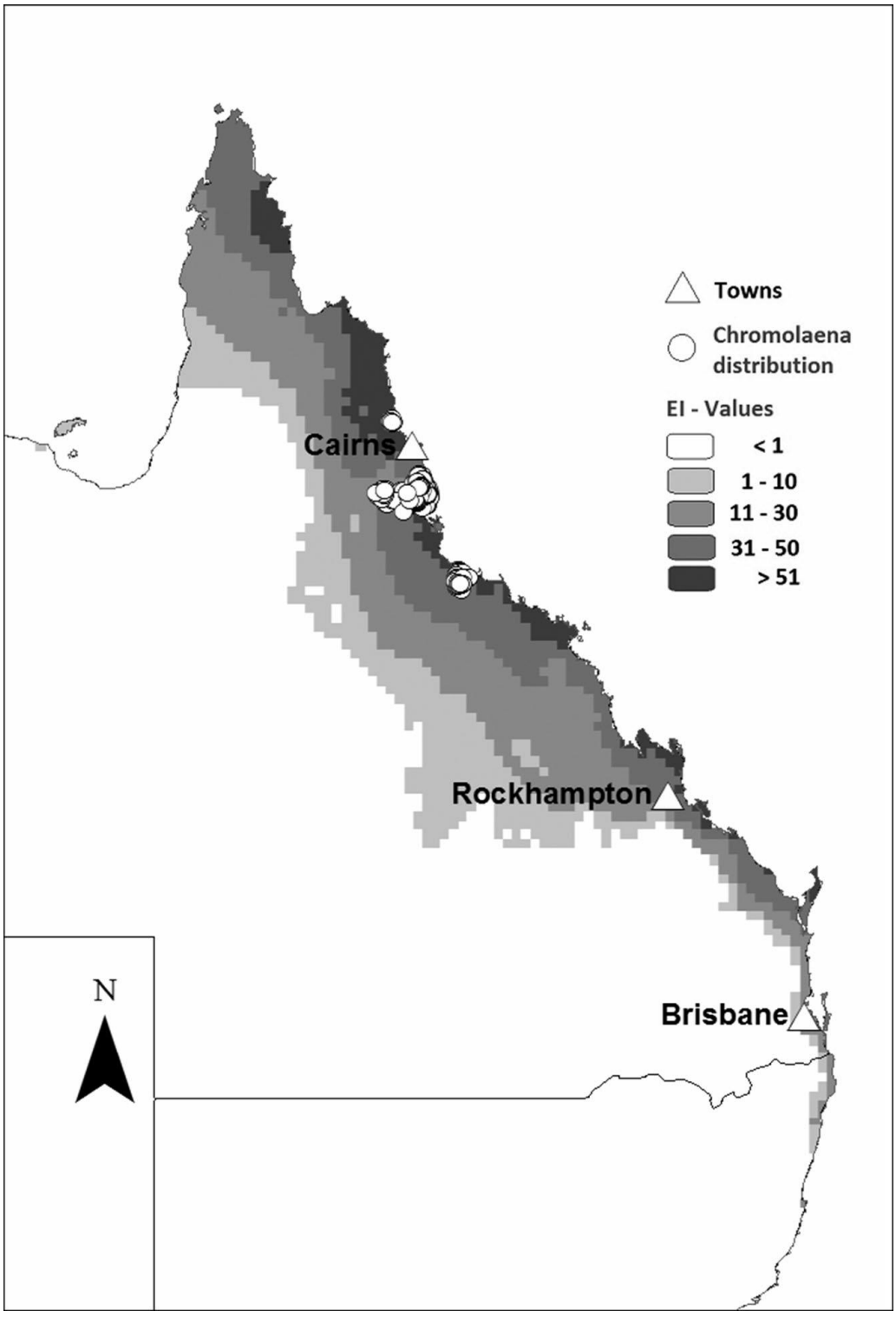

Map showing the the current distribution of *Chromolaena odorata*, as well as the eco-climatically suitable regions in Australia for *Cecidochares connexa*. The greater the EI value in the model, the more suitable the area is for *C. connexa*. Source: Day et al. 2016

Acronyms and abbreviations

Term or abbreviation	Definition
ALOP	Appropriate level of protection
BICON	Australia's Biosecurity Import Conditions System
BIRA	Biosecurity Import Risk Analysis
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	The Australian Government Department of Agriculture and Water Resources
FAO	Food and Agriculture Organization of the United Nations
FSM	The Federated States of Micronesia
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NPPO	National Plant Protection Organisation
PHC	Plant Health Committee
PRA	Pest risk analysis
QDAF	Queensland Government Department of Agriculture and Fisheries
SPS Agreement	WTO agreement on the Application of Sanitary and Phytosanitary Measures
WTO	World Trade Organization

Summary

The Australian Government Department of Agriculture and Water Resources (DAWR) has prepared this draft report to assess the proposal by the Queensland Government Department of Agriculture and Fisheries (QDAF) to release the gall fly *Cecidochares connexa* for the biological control of *Chromolaena odorata* in Australia.

This draft report proposes that the release of *C. connexa* should be permitted, subject to standard quarantine conditions associated with the import and release of biological control agents.

This draft report has determined the overall likelihood of off-target effects and potential consequences associated with the release of *C. connexa* to be Negligible. A risk estimate of Negligible meets Australia's appropriate level of protection (ALOP).

The assessment of risk to off-target plants included consideration of the testing methodology used and the plant species test list, including non-target species tested in described experiments and previous host specificity testing conducted overseas. The biology and state of knowledge of the biology of the proposed biological control agent, and departmental (NAQS) observations of target and off-target effects in areas overseas where *C. connexa* has been released for the biological control of *C. odorata* were also considered.

The Department of the Environment and Energy also has an approval process for the import and release of biological control agents under the *Environment Protection and Biodiversity Conservation Act 1999*.

This draft report contains details of the risk assessment for potential off-target effects associated with the proposed release of *Cecidochares connexa*. The application and supporting documents from QDAF that were provided to DAWR have been included with this draft report (Attachment 1).

The draft report has been published on the Department of Agriculture and Water Resources website to allow interested parties to provide comments and submissions within the consultation period.

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The risk analysis process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the level of biosecurity risk that may be associated with proposals to import goods or biological materials into Australia. If the biosecurity risks do not achieve the appropriate level of protection (ALOP) for Australia, risk management measures are proposed to reduce the risks to an acceptable level. If the risks cannot be reduced to an acceptable level, the goods or biological materials will not be imported into Australia until suitable measures are identified.

Successive Australian Governments have maintained a stringent, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of the ALOP for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's risk analyses are undertaken by the Australian Government Department of Agriculture and Water Resources using technical and scientific experts in relevant fields, and involve consultation with stakeholders at various stages during the process.

Risk analyses may take the form of a biosecurity import risk analysis (BIRA) or a non-regulated risk analysis (such as scientific review of existing policy and import conditions, pest-specific assessments, weed risk assessments, biological control agent assessments or scientific advice).

Further information about Australia's biosecurity framework is provided in the *Biosecurity Import Risk Analysis Guidelines 2016* located on the Australian Government Department of Agriculture and Water Resources website.

1.2 This risk analysis

1.2.1 Background

An application has been submitted by the Queensland Government Department of Agriculture and Fisheries (QDAF) to release a biological control agent (Attachment 1). The biological control agent *Cecidochares connexa* (Diptera: Tephritidae) is a gall fly proposed for the biological control of *Chromolaena odorata* (Asteraceae). The applicant has followed the steps outlined in the Biosecurity Guidelines for the Introduction of Exotic Biological Control Agents for the Control of Weeds and Plant Pests.

Chromolaena odorata is a perennial shrub native to tropical America. The species is present in north Queensland, and was the target of a national cost-share eradication program until 2012, when it was decided by a nationally appointed Scientific Advisory Panel that eradication was no longer technically feasible (QDAF 2016). *Chromolaena odorata* has been declared a target for biological control in Australia, approved by the Australian Weeds Committee.

Stem galls formed by *Cecidochares connexa* result in reductions to stem growth, seed production and carbohydrate storage, often leading to reduced plant growth and even plant death (McFadyen et al. 2003). The species has previously been released as a biological control agent for *C. odorata* in 12 countries, including Indonesia, Thailand, the Philippines, Guam, The Federated States of Micronesia (FSM), the Northern Mariana Islands, India, Palau, Papua New Guinea, Timor Leste, Cote d'Ivoire and Tanzania (Winston et al. 2014). The gall fly is considered to be an effective biological control agent in these countries, with no report of any off-target effects (Attachment 1).

1.2.2 Scope

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the release of an exotic biological control agent into the Australian environment. The primary risk associated with a release of this nature is the possibility of unwanted off-target effects on other species already present in Australia. The Department of Agriculture and Water Resources assesses the risk under the *Biosecurity Act 2015*. The Department of the Environment and Energy also has an approval process under the *Environment Protection and Biodiversity Conservation Act 1999*. Under section 303EE(4) of the *Environment Protection and Biodiversity Conservation Act 1999*, risk analysis reports prepared by the Department of Agriculture and Water Resources may be used by the Minister for the Environment and Energy in making a determination to include the species on the *List of specimens taken to be suitable for live import*.

Plants that are considered weeds are sometimes also considered to have value, for example, for purposes such as ornamental display, traditional medicine, feed for stock, etc. Consideration of the benefits and therefore any associated concerns about eradication of the target weed species are out of the scope of this analysis.

The Department of Agriculture and Water Resources will not commence an assessment to release a biological control agent unless the target has been approved by an appropriate government body. *Chromolaena odorata* was approved as a target for biological control by the Australian Weeds Committee in August 2010.

1.2.3 Contaminating pests

There are other organisms that may arrive with imported exotic biological control agents. These organisms may include, for example, parasitoids, mites or fungi. The Department of Agriculture and Water Resources considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. Should an application to release a biological control agent be approved, these risks will be addressed by existing operational procedures that apply to the importation and final release of the agents. These procedures include detailed examination of imported material, confirmation of identity, and breeding under containment conditions before release. For this reason, contaminating pests are not further considered in this risk analysis.

1.2.4 Consultation

In January 2016, a preliminary draft of this report was distributed to state and territory departments of primary industry and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) through the Plant Health Committee (PHC), and also to the Department of the Environment and Energy.

There was no opposition to the release of *C. connexa*. However, CSIRO provided several comments on which the applicant was requested to provide clarification. In particular, CSIRO requested further specification on the number of replicates that were conducted for each plant species in the 'no-choice' tests. This information has been included in this report (Table 2.2). Additionally, CSIRO questioned the species test list and the decision to only include plant species in the tribe Eupatorieae without testing additional confamilial Australian plants of increasing phylogenetic distance in a 'no-choice' setting. The applicant has provided further information on the total number of plant species *C. connexa* has been tested against outside Australia (Appendix A).

1.2.5 Next Steps

This draft report gives stakeholders the opportunity to comment and draw attention to any scientific, technical or other gaps in the data, or any misinterpretation or errors.

The department will consider submissions received on the draft report and may consult informally with stakeholders. The department will revise the draft report as appropriate. The department will then prepare a final report, taking into account stakeholder comments.

The final report will be published on the department's website along with a notice advising stakeholders of the report's release. The department will also notify the proposer and the registered stakeholders about the release of the final report. Publication of the final report represents the end of the risk analysis process. Following the risk analysis process, if the department approves release of the biological control agent, a letter will be sent to the applicant providing conditions of release.

2 Assessment of off-target risks

This section sets out the assessment of off-target risks that could be associated with the release of the biological control agent. Where appropriate, the methods followed those used for pest risk analysis (PRA) by the Department of Agriculture and Water Resources in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2016), ISPM 3: *Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms* (FAO 2017a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2017c) that have been developed under the SPS Agreement (WTO 1995). The methodology for a commodity-based PRA is provided in Appendix B.

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in 1 marked 'very low risk' represents the upper boundar of the ALOP for Australia.

The risk associated with the release of a biological control agent is a combination of the likelihood of off-target effects and the potential magnitude of the consequences of any off-target effects. A risk estimation matrix (Table 2.1) is used to combine these estimates.

Table 2.1 Risk estimation matrix

Likelihood of off-target effects	Consequences of off-target effects					
	Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

2.1 Stage 1: Initiation

Initiation commences when an applicant provides a submission proposing the release of a biological control agent.

The risk analysis area is defined as all of Australia given that once released there will be no control of spread of the agent other than environmental constraints related to the biology of the organism.

2.2 Stage 2: Risk assessment

This assessment evaluates the likelihood of off-target effects and the potential economic and environmental consequences of any such effects.

The risk assessment is based primarily on consideration of the information provided by the applicant in the application package, including the results of host specificity testing, and current information in the scientific literature, where this is available. Given that the proposal is for deliberate release, the likelihood of entry, establishment and spread is assumed to be certain, and therefore the assessment relates to the host specificity of the proposed agent.

A likelihood is assigned to the estimate of occurrence of off-target effects. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible. Descriptive definitions for these descriptors and their indicative ranges are given in Appendix B, Table 1.

2.2.1 Host specificity testing methodology

The following summarised information regarding host specificity testing has been sourced from the application provided by QDAF (Attachment 1). For further details please refer to the application.

In order to predict whether any non-target species would be at risk from the candidate agent, a series of host specificity experiments were conducted with *C. connexa* under contained conditions in Australia. In previous studies overseas, *C. connexa* was tested against 122 plant species, representing 31 families, including 38 species in the family Asteraceae and six species in the tribe Eupatorieae (Appendix A), with no gall formation observed on any species other than *C. odorata*. The applicant conducted on-shore host specificity testing on 17 plant species found in Australia (Table 2.2), all from the tribe Eupatorieae, to which *C. odorata* belongs. The applicant considers this test list to be adequate, due to the agent already having been tested on a broad range of plant species overseas.

Host specificity testing for this application involved several experimental methods. 'Choice-minus-target' tests were used as the principal testing method; these involved providing *C. connexa* with simultaneous access to multiple plant species, none of which was the target species (*Chromolaena odorata*). 'No-choice' tests were conducted as a complementary methodology; these involved providing *C. connexa* with access to a single non-target species. Additional tests were also done with *Praxelis clematidea* due to observed gall formation on this species during 'choice-minus-target' and 'no-choice' tests. This additional testing consisted of *P. clematidea* 'choice' tests, paired 'no-choice' tests, continuation tests, and time-dependent trials; see Section 2.2.2 for details.

For all these host specificity tests healthy, fresh, clean, pest-free plants were used, each sourced in Australia. A different plant of the same species was used for each replicate test, with plants being obtained from the field, nurseries, or grown from seed. A weak honey solution was provided to the *C. connexa* flies, and extra moisture was provided by finely spraying water into the cages each day. Plants were watered as required. All plants were monitored for gall

development over the duration of the tests, and test plants that had no galls develop were discarded once all flies had emerged from the corresponding experimental control cage.

The total number of galls on each plant, the sex and total number of flies to emerge, and the time to emergence were recorded for each test. Once all flies had emerged, the diameter of the galls on each plant was measured.

'Choice-minus-target' tests

Five male-female pairs of randomly selected newly-emerged *C. connexa* flies were added to cages holding four to six test plant species. Each plant species (Table 2.2) was tested five times in such a way that no two plant species were tested together more than twice. Changing the combination of tested plant species was intended to limit the potential masking of one plant species by another if female flies preferred a particular species on which to oviposit. An experimental control was established for each test, being a single *C. odorata* plant and five male-female pairs of newly emerged *C. connexa* flies. Adult flies were left in testing cages until all had died, to ensure oviposition exhaustion/failure of females.

Single species 'no-choice' tests

Each test plant species was placed singly in a screened cage (400x400x900mm) with three male-female pairs of randomly selected newly-emerged *C. connexa* flies. An experimental control cage containing three male-female pairs of randomly selected newly-emerged *C. connexa* flies from the same pool of adults, and a single *C. odorata* plant, were set up concurrently with each test. Each plant species (Table 2.2) was tested at least once, depending on plant availability. Because *Praxelis clematidea* was the only test plant species on which *C. connexa* galls developed in 'choice-minus-target' tests, it was tested five times using a fresh plant for each replicate. Adult flies were left in the cages until they had died to ensure oviposition site exhaustion/failure of females.

Additional testing for *Praxelis clematidea*

***Praxelis clematidea* 'choice tests'**

One *P. clematidea* plant and one *C. odorata* plant were placed into a cage with three male-female pairs of randomly selected newly-emerged *C. connexa* flies that had emerged from *C. odorata*. The test was replicated five times. Adult flies were left in testing cages until all had died, to ensure oviposition exhaustion/failure of females. Once galls had begun to develop, plants were separated into individual cages to monitor adult emergence.

***Praxelis clematidea* paired 'no-choice' tests**

Two *P. clematidea* plants were placed into each of two cages and three male-female pairs of randomly selected newly-emerged *C. connexa* flies were added to each cage. A single cage containing one *P. clematidea* plant was also set up with three pairs of flies. Two cages each containing two *C. odorata* plants were set up as controls. The first control cage had five male-female pairs of randomly selected newly-emerged *C. connexa* flies added, while the second control cage had three pairs. Adult flies were left in testing cages until all had died, to ensure oviposition exhaustion/failure of females. Once galls had begun to develop, the plants were separated into individual cages to monitor adult emergence.

Because the numbers of plants and number of paired adult flies varied per cage, data was converted to galls/plant/female and adults emerged/female.

Continuation tests

These tests assessed the viability of flies emerging from galls on *P. clematidea*, and the ability of *P. clematidea* alone to maintain a population of *C. connexa*. Adult flies that emerged from choice-minus-target and no-choice tests were used. Three male-female pairs of newly-emerged adult flies that had been reared on *P. clematidea* were placed in a cage with one or two *P. clematidea* plants, depending on plant size, and kept in the cage for five days. After five days, the surviving adults from each cage were collected and placed into separate new cages, each containing one *C. odorata* plant. Adult flies were left in these cages until they all died. The test was repeated seven times.

Concurrently, three male-female pairs of newly-emerged adult flies that had been reared on *P. clematidea* were placed in a cage with one *C. odorata* plant. Adult flies were left in testing cages until all had died. This test was only replicated four times, due to the low availability of flies that emerged from galls on *P. clematidea*.

The experimental control consisted of three male-female pairs of newly-emerged adult flies reared on *C. odorata*, which were placed in a cage with one *C. odorata* plant, and left until all flies had died. The control test was repeated seven times.

Time-dependent tests

To determine the relative propensities of *C. connexa* females to oviposit on *C. odorata* and *P. clematidea*, three male-female pairs of randomly selected newly-emerged adult flies that had been reared on *C. odorata* were placed in a cage containing one *P. clematidea* plant. As a control, three male-female pairs of randomly selected newly-emerged adult flies that were reared on *C. odorata* were placed in a cage containing one *C. odorata* plant. All flies were removed from cages after five days, and placed in separate cages, each containing one *C. odorata* plant; flies were left in these cages until all adults had died. This test was replicated three times.

2.2.2 Results of host specificity testing

'Choice-minus-target' tests

Oviposition by *C. connexa* females was observed on both *P. clematidea* and *C. odorata* (in experimental controls), with galls developing on both plant species. Galls failed to develop on any other plant species. There were significantly more galls/plant formed on *C. odorata* (48±8.4, n=8) than on *P. clematidea* (2.4±1.5, n=5) ($t=5.38$, $p<0.001$).

Adults emerged only from *C. odorata* and *P. clematidea*. Significantly more adults emerged from *C. odorata* (128±38.5, n=8) than from *P. clematidea* (1.0±0.77, n=5) ($t=3.31$, $p=0.013$).

Single species 'no-choice' tests

Oviposition by *C. connexa* females was observed on both *P. clematidea* and *C. odorata* (in experimental controls), with galls developing on both plant species. Galls failed to develop on any other plant species. There were significantly more galls/plant formed on *C. odorata* (40.7±8.4, n=6) than on *P. clematidea* (9.2±2.6, n=5) ($t=3.57$, $p=0.012$).

Adults emerged only from *C. odorata* and *P. clematidea*. A greater number of adults emerged from *C. odorata* (168±70.4, n=6) than from *P. clematidea* (7.6±3.1, n=5), but this difference was not significant (t=2.29, p=0.071). The applicant suggests that the high variation in the number of adults emerging from *C. odorata* accounts for the statistical non-significance.

Additional testing for *Praxelis clematidea*

***Praxelis clematidea* 'choice' tests**

Oviposition by *C. connexa* females was observed on both *C. odorata* and *P. clematidea*, with galls developing on both plant species. A greater number of galls formed on *C. odorata* (29.6±8.7, n=5) than on *P. clematidea* (13.0±4.1, n=5), but this difference was not significant (t=1.72, p=0.123). The applicant attributes the statistical non-significance to the high variation in the number of galls forming on *C. odorata*.

Significantly more adult flies emerged from *C. odorata* (114.8±37.6, n=5) than from *P. clematidea* (5.2±3.0, n=5) (t=2.90, p=0.043).

***Praxelis clematidea* paired 'no-choice' tests**

There were significantly more galls/plant/female formed on *C. odorata* (17.5±3.6, n=4) than on *P. clematidea* (4.2±1.2, n=5) (t=3.82, p=0.007). There was no significant difference in the number of adults/female emerging from *C. odorata* (38.7±13.6, n=4) and *P. clematidea* (1.5±0.4, n=5) (t=2.73, p=0.072). The applicant attributes the statistical non-significance to the high variation in the number of adults emerging from *C. odorata*.

Continuation tests

Significantly more galls formed on control *C. odorata* plants using flies that had emerged from *C. odorata* (43.7±6.3, n=7) than formed on *P. clematidea* (12.0±2.9, n=7) or on *C. odorata* (5.3±3.4, n=4) each using flies that had been reared on *P. clematidea* ($F_{2,15}$=17.52, p<0.001).

A mean of 1.8±0.9 galls/plant (n=5) was formed on *C. odorata* by flies that were reared on *P. clematidea* and had been placed on *P. clematidea* plants for five days initially before being transferred to *C. odorata*. Five replicates were established; in two of these all adults died within three days of transfer. In the remaining three trials, adults lived for up to eight days, but females laid few eggs.

Time-dependent tests

There was a significant difference in the number of galls that developed on *C. odorata* using newly-emerged adult flies reared on *C. odorata* (44.0±1.0, n=3), *P. clematidea* using newly-emerged adult flies reared on *C. odorata* (11.0±7.0, n=3), *C. odorata* using adult flies previously exposed to *C. odorata* for five days (35.3±4.1, n=3) and *C. odorata* using adult flies previously exposed to *P. clematidea* for five days (24.5±0.5, n=2) ($F_{3,7}$=10.51, p=0.006). There was a significant difference in the number of galls that formed on *C. odorata* and *P. clematidea* over the first five days, but no significant difference for adults transferred from different species to *C. odorata* plants, nor in the number of galls formed on *P. clematidea* and then on *C. odorata* by the same females.

There was also a significant difference in the number of adults that emerged from galls on *C. odorata* using newly-emerged adult flies reared on *C. odorata* (109.0±25.7, n=3), *P. clematidea* using newly-emerged adult flies reared on *C. odorata* (2.3±0.9, n=3), *C. odorata* using adult flies

previously exposed to *C. odorata* for five days (41.7±11.9, n=3) and *C. odorata* using adult flies previously exposed to *P. clematidea* for five days (39.5±9.5, n=2) ($F_{3,7}$=8.26, p=0.011).

Table 2.2 The mean number of galls formed per plant for each species tested in 'choice-minus-target' tests and 'no-choice' tests.

Plant species	Choice-minus-target tests		No-choice tests	
	No. replicates	Mean galls/plant	No. replicates	Mean galls/plant
Chromolaena odorata (l.) R.M. King & H. Rob (experimental controls)	8	48	6	40.7
Praxelis clematidea (Griseb.) R.M. King & H. Rob	5	2.4	5	9.2
Adenostemma lavenia (L.) Kuntze *	7	0	2	0
Adenostemma macrophyllum (Blume) DC. *	5	0	4	0
Ageratina adenophora (Spreng.) R.M. King & H. Rob.	7	0	2	0
Ageratina altissima (L.) R.M. King & H. Rob.	5	0	2	0
Ageratina riparia (Regel) R.M. King & H. Rob.	7	0	2	0
Ageratum houstonianum Mill.	6	0	1	0
Bartlettina sordida (Less.) R.M. King & H. Rob.	14	0	6	0
Chromolaena squalida (DC.) R.M. King & H. Rob.	7	0	Not tested	Not tested
Conoclinium coelestinum (L.) DC.	8	0	1	0
Eupatorium lindleyanum DC.	6	0	5	0
Eupatorium purpureum (L.)	5	0	3	0
Gymnocoronis spilanthoides (D. Don ex Hook. & Arn.) DC.	7	0	2	0
Liatris spicata (L.) Willd.	5	0	1	0
Mikania micrantha Kunth	5	0	2	0
Stevia ovata Willd.	6	0	2	0
Stevia rebaudiana (Bertoni) Bertoni	6	0	2	0

* Australian native

2.2.3 Summary of host specificity testing of *C. connexa*

Cecidochares connexa gall formation and adult emergence were consistently observed in tests using *Chromolaena odorata*. *Cecidochares connexa* gall formation and adult emergence were also observed with *Praxelis clematidea* in a range of test procedures, as described above. No *C. connexa* galls were observed on any of the other 16 plant species tested, including the congeneric species *Chromolaena squalida*, which was tested in seven replicates of 'choice-minus-target' trials.

Studies reported here were, in some cases, based on relatively few replicates, and no Australian native species of Asteraceae were tested beyond the tribe Eupatorieae. It has been reported that there are more than 1,000 species of Asteraceae in Australia (Orchard & Thompson 1999). Conversely, the widely-accepted 'centrifugal testing' methodology (Wapshere 1974) indicates that substantial weight should be placed on results of tests on species most closely related to the target of control.

In overview, these results demonstrate a high degree of host specificity for *C. connexa*, but also indicate that some off-target effects may occur on *P. clematidea* in the Australian environment. The genus *Praxelis* is the most closely related genus to *Chromolaena*, with both genera belonging

to the subtribe Praxelinae. *Praxelis clematidea* is a minor introduced weed in Queensland, and its geographic distribution overlaps that of *C. odorata*. The species has no economic or environmental value, and is a listed non-native weed on the National Environmental Alert List (DEE 2011).

As reported, tests with *C. odorata* and *P. clematidea* indicated that *P. clematidea* is a substantially inferior host to *C. odorata*. In all studies reported the numbers of galls formed, and numbers of adults emerged from those galls, were notably higher for *C. odorata* than for *P. clematidea*. In many but not all instances there were statistically significant differences in the reported results; cases where statistically significant differences were not recorded were generally associated with large variabilities in observations between *C. odorata* test plants. It was noted that *C. connexa* did not form galls on *P. clematidea* during host specificity testing in Thailand, in contrast to the observed effects in on-shore tests described here. Possibly the host specificity for *P. clematidea* is not strong and can be influenced by other factors, such as differences in plant quality, as suggested by the applicant.

There have been multiple studies of *C. connexa* in tests outside Australia. For example, tests in Thailand showed that *C. connexa* did not lay eggs or form galls on 20 non-target species (Kernasa et al. 2013), and results of testing in the Philippines were similar, with no oviposition or gall formation observed on the eight non-target species tested (Aterrado & Bachiller 2002). Tests in India on a substantial number of plant species (75 species in 29 families; Bhumannavar et al. 2004) likewise found *C. connexa* to be capable of reproducing only on *C. odorata*.

In testing in Indonesia, no oviposition or gall formation was observed on 55 species tested. Oviposition was observed on two species, *Ageratum conyzoides* and *Austroeupatorium inulaefolium* (both genera being members of the tribe Eupatorieae, and the former species widely distributed in northern and eastern Australia), however there was no gall formation and no adults emerged from the eggs (McFadyen et al. 2003).

The applicant reports that *Cecidochares connexa* has been released and established in 10 countries as a biological control agent for *C. odorata*. The applicant further reports that in Palau there have been no reports of gall formation on *P. clematidea* or any other off-target plant species. Furthermore, no off-target effects have been reported from any of the other countries in which the agent has been released (Attachment 1).

Cecidochares connexa was released for control of *C. odorata* in Papua New Guinea and Timor Leste in 2001 and 2005 respectively. Plant health surveys undertaken over the last decade by the department's Northern Australia Quarantine Strategy (NAQS) program have included periodic observations of *C. odorata*, with a focus on the establishment and effectiveness of the control agent. In the course of those activities the distribution, abundance and general condition of *C. odorata* and 54 other species of Asteraceae known to occur in Australia were observed, including seven species that are native to Australia. *Cecidochares connexa* galls were repeatedly observed on *C. odorata*, but galls were never observed on any other species (including *Ageratum conyzoides*) and others native to Australia (Waterhouse et al. 2018). These observations are consistent with results and reports of the current applicant and other authors, and provide support for an assessment that a low level of risk is likely to be associated with release of the agent in Australia.

2.2.4 Likelihood of off-target effects

The likelihood of the occurrence and consequences of off-target effects is determined on the basis of the host specificity testing and other relevant information presented in the application (Attachment 1), along with results of testing conducted outside Australia and plant health surveys.

Testing in Australia indicates that off-target effects may occur on one species, *Praxelis clematidea*, a non-native minor weed species closely related to *C. odorata. Praxelis clematidea* has no economic or environmental value, and is listed on the National Environmental Alert List (DEE 2011). *Cecidochares connexa* did form galls and adults emerged from *P. clematidea*, indicating that off-target effects are possible for this species.

There are no indications that any other off-target species would be at risk. On the basis of the results of the host specificity testing reported in this application, together with published overseas host specificity testing and survey data, it is concluded that the likelihood of occurrence of off-target effects in Australia is **Low**.

2.2.5 Assessment of potential consequences of off-target effects

The potential consequences of any off-target effects that may be associated with *C. connexa* have been assessed using the same methodology (Appendix B) as used in the import risk analysis process for pests associated with imported fresh produce.

Criterion	Estimate and rationale
Direct	
Plant life or health	A—indiscernible With the exception of some minor off-target impacts that may be expected on *Praxelis clematidea*, host specificity testing has shown that *Cecidochares connexa* is host specific to *Chromolaena odorata*. *Praxelis clematidea* is an introduced weed with no economic or environmental value. It is listed on the Alert List for Environmental Weeds, a list of non-native plants that threaten biodiversity and cause environmental damage (DoE 2003). No galls developed on any other plant species tested, including Australian native species. No direct off-target effects on plant life or health of economic or environmental importance are expected to occur.
Other aspects of the environment	A—indiscernible There are no known negative impacts on other aspects of the environment within the native range of *Cecidochares connexa* or in countries where it has been released previously as a biological control agent. No direct effects on any other aspects of the environment are anticipated.
Indirect	
Eradication, control	A—indiscernible *Cecidochares connexa* is a biological control agent proposed for release for the biological control of *Chromolaena odorata*. As there are no predicted off-target impacts of economic or environmental significance it would be very unlikely to meet the criteria for eradication. Therefore, the need for eradication or control is not anticipated.
Domestic trade	A—indiscernible

	Cecidochares connexa is a biological control agent proposed for release for the biological control of *Chromolaena odorata*, a weed of economic importance. Host specificity testing indicates that this agent is host specific, although some minor off-target impacts may be anticipated on *Praxelis clematidea* where it grows in close proximity to *Chromolaena odorata. Praxelis clematidea* is also an introduced weed. *Cecidochares connexa* is unlikely to impact on any other plant species to the extent that domestic trade would be affected.
International trade	A—indiscernible *Cecidochares connexa* is a biological control agent proposed for release for the biological control of *Chromolaena odorata*, a weed of economic importance. No off-target impacts are expected to occur on any plants of significance to international trade. *Cecidochares connexa* is not anticipated to be associated with any traded commodity; the species is also readily distinguishable from other tephritid pest species.
Environmental and non-commercial	A—indiscernible *Chromolaena odorata* is an introduced weed, as is *Praxelis clematidea*, the only species that may sustain minor off-target impacts. The reduction of these species in the environment is not anticipated to have any negative indirect environmental or non-commercial effects.

Based on these considerations the potential consequences of off-target effects are assessed as **Negligible**.

2.2.6 Estimation of off-target risk of release

Unrestricted risk is the result of combining the likelihood of off-target effects with the outcome of overall consequences. Off-target consequences are combined using the risk estimation matrix shown in Table 2.1.

Risk estimate for *Cecidochares connexa*	
Likelihood of off-target effects	Low
Consequences	Negligible
Risk	Negligible

As indicated, the risk estimate for release of *Cecidochares connexa* has been assessed as 'Negligible', which achieves Australia's ALOP.

3 Recommendation on release

The potential for off-target effects and overall consequences for off-target plant species are assessed as Negligible, and the risk estimate for release of *C. connexa* achieves the ALOP for Australia. Therefore, it is recommended that this biological control agent be permitted to be released, subject to standard import and release conditions to ensure that the released material is free of other organisms. This recommendation is made on the basis of the high level of host specificity demonstrated by *Cecidochares connexa* on *Chromolaena odorata* and is based on currently available information.

4 Attachments

Attachment 1 – Application for the field-release of *Cecidochares connexa* (Macquart) (Diptera: Tephritidae) for the biological control of *Chromolaena odorata* (L.) King & Robinson (Asteraceae) in Australia.

Appendix A: Consolidated host test list for *Cecidochares connexa* in off-shore studies

Family	Genus/species	FSM[1]	Guam[2]	India[3]	Indonesia[4]	Palau[5]	Philippines[6]	Thailand[7]
Amaranthaceae	*Amaranthus tricolor* L.			✓	✓			
Amaryllidaceae	*Allium sativum* L.			✓	✓			
Anacardiaceae	*Anacardium occidentale* L.			✓				
Apiaceae	*Coriandrum sativum* L.			✓				
Araceae	*Colocasia esculenta* (L.) Schott					✓		
Asteraceae								
Eupatorieae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob.			✓				✓
	Ageratum conyzoides L.		✓	✓	✓			✓
	Austroeupatorium inulaefolium (L.)				✓			
	Mikania micrantha Kunth			✓				
	Mikania scandens (L.) Willd.		✓					
	Praxelis clematidea (Griseb.) R.M. King & H. Rob.							✓
Anthemideae	*Artemisia vulgaris* L.						✓	
	Chrysanthemum indicum L.			✓			✓	
	Chrysanthemum morifolium Ramat				✓			
Astereae	*Aster amellus* L.			✓				
	Aster sp.				✓			
	Solidago canadensis L.			✓				
Calenduleae	*Calendula officinalis* L.			✓				
Cichorieae	*Lactuca sativa* L.			✓				
	Sonchus arvensis L.			✓				
Coreopsideae	*Bidens pilosa* L.		✓	✓				
	Cosmos bipinnatus Cav.			✓				

Family	Genus/species	FSM[1]	Guam[2]	India[3]	Indonesia[4]	Palau[5]	Philippines[6]	Thailand[7]
	Cosmos caudatus H.B.K				✓			
	Cosmos sulfureus Cav.		✓					
Cynareae	*Carthamus tinctorius* L.			✓				
Heliantheae	*Clibadium surinamense* L.				✓			
	Dahlia pinnata Cav.			✓	✓			
	Eclipta alba (L.) L.			✓				
	Guizotia abyssinica (L. f.) Cass.			✓				
	Helianthus annuus L.		✓	✓	✓		✓	✓
	Lagascea mollis Cav.			✓				
	Spilanthes acmella (L.) Murray			✓				
	Tithonia diversifolia Gray.			✓	✓			
	Tridax procumbens L.			✓				
	Wollastonia biflora (L.) DC	✓						
	Xanthium strumarium L.			✓				
	Zinnia elegans Jacq.			✓	✓			
Inuleae	*Blumea aurita* L.							✓
	Blumea balsamifera (L.) DC						✓	
Mutisioideae	*Gerbera jamesonii* Bolus ex Hooker f.			✓	✓			
Plucheae	*Pluchea indica* (L.) Less.				✓			
Senecioneae	*Gynura aurantica* DC				✓			
Tageteae	*Tagetes erecta* L.			✓				✓
Balsaminaceae	*Impatiens balsamina* L.			✓				
Brassicaceae	*Brassica nigra* L.			✓				
	Brassica oleracea L.		✓					
	Raphanus sativus L.			✓				

Family	Genus/species	FSM[1]	Guam[2]	India[3]	Indonesia[4]	Palau[5]	Philippines[6]	Thailand[7]
Combretaceae	*Terminalia* sp.	✓						
Convolvulaceae	*Ipomoea aquatica* Forsk.				✓			
	Ipomoea batatas (L.) Lamk.			✓	✓	✓		
Cucurbitaceae	*Citrullus lanatus* (Thunb.)		✓		✓			
	Cucubita moschata Duch. ex Poir			✓	✓			
	Cucumis melo L.			✓	✓			
	Cucumis sativus L.			✓	✓			
Dioscoreaceae	*Dioscorea* sp.	✓						
Euphorbiaceae	*Hevea brasiliensis* (HBK)			✓	✓			
	Jatropha curcas L.							✓
	Manihot esculenta Crantz			✓	✓	✓		✓
	Phyllanthus sp.					✓		
	Ricinus communis L.			✓	✓			
Fabaceae	*Albizzia falcataria* (L.) Fosberg				✓			
	Albizzia lebbek (L.) Benth.			✓				
	Arachis hypogaea L.			✓	✓			
	Caesalpinia pulcherrima (L.) Swartz			✓	✓			
	Calliandra haematocephala Hassk.			✓	✓			
	Crotalaria juncea L.			✓	✓			
	Desmodium heterocarpon (L.) DC				✓			
	*Dolichos lablab (*L.) Sweet			✓	✓			
	Flemingia strobilifera R.Br.				✓			
	Gliricidia sepium Walp.			✓	✓			
	Glycine max (L.) Merr.			✓	✓			✓
	Leucaena glauca Merr				✓			

Family	Genus/species	FSM[1]	Guam[2]	India[3]	Indonesia[4]	Palau[5]	Philippines[6]	Thailand[7]
	Leucaena leucocephala (Lam.) de Wit			✓			✓	
	Pachyrhizus erosus (L.) Urb.				✓			
	Phaseolus sp.		✓					
	Pisum sativum L.			✓				
	Psophocarpus tetragonolobus DC				✓			
	Pterocarpus indicus Willd.						✓	
	Sesbania grandiflora Pers				✓			
	Vigna radiata (L.) Wilczek							✓
	Vigna unguiculata (L.) Walp.			✓	✓			
Lamiaceae	*Coleus blumei* Benth.					✓		
	Mentha arvensis L.			✓				
	Tectona grandis L.f.			✓				
	Vitex negundo L.						✓	
Lauraceae	*Cinnamomum zeylanicum* Blume			✓				
Lythraceae	*Punica granatum* L.			✓				
Malvaceae	*Abelmoschus esculentus* (L.) Moench		✓					
	Gossypium hirsutum L.			✓				
	Gossypium obtusifolium Roxb.				✓			
	Hibiscus rosa-sinensis L.			✓	✓			
	Theobroma cacao L.			✓	✓			
Meliaceae	*Swietenia macrophylla* King						✓	
Mimosaceae	*Mimosa* sp.					✓		
Moraceae	*Morus alba* L.			✓				
Myrtaceae	*Eugenia aquea* Burm.				✓			
	Eugenia caryophyllus Bull & Harris				✓			

Family	Genus/species	FSM[1]	Guam[2]	India[3]	Indonesia[4]	Palau[5]	Philippines[6]	Thailand[7]
	Eugenia jambolana Lam.			✓				
	Psidium guajava L.			✓	✓			
Oleaceae	*Jasminum sambac* (L.) Aiton			✓				
Piperaceae	*Piper methysticum* G. Forst	✓						
	Piper nigrum L.			✓				
Poaceae	*Oryza sativa* L.			✓	✓			✓
	Saccharum officinarum L.							✓
	Sorghum vulgare Persoon							✓
	Zea mays L.		✓	✓	✓			✓
Rubiaceae	*Coffea arabica* L.			✓				✓
	Coffea robusta Linden ex De Wild				✓			
Rutaceae	*Citrus aurantifolia* (Christm.) Swingle		✓					✓
	Citrus nobilis Lour				✓			
	Citrus reticulata Blanco			✓				✓
	Murraya koenigii (L.) Sprengel			✓				
Sapotaceae	*Achras zapota* L.			✓				
Solanaceae	*Capsicum annuum* L.		✓	✓	✓			✓
	Capsicum frutescens L.							✓
	Lycopersicum esculentum Mill.			✓	✓			✓
	Nicotiana tabacum L.			✓	✓			
	Physalis sp.					✓		
	Solanum melongena L.			✓	✓			
	Solanum tuberosum L.			✓	✓			
Theaceae	*Camellia sinensis* (L.) Kuntze			✓				
Verbenaceae	*Lantana camara* L.			✓	✓			

[1] Muniappan et al. 2007
[2] Muniappan & Bamba 2002
[3] Bhumannavar et al. 2004
[4] McFadyen et al. 2003
[5] Esguerra 2002
[6] Aterrado & Bachiller 2002
[7] Kernasa et al. 2013

Appendix B: Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture and Water Resources has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO, 2016) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO, 2017c) that have been developed under the SPS Agreement (WTO, 1995).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it' (FAO, 2017b). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO, 2017b). This definition is also applied in the *Biosecurity Act 2015*.

Biosecurity risk consists of two major components: the likelihood of a pest entering, establishing and spreading in Australia from imports; and the consequences should this happen. These two components are combined to give an overall estimate of the risk.

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, the department will verify that the consignment received is as described on the commercial documents and its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO, 2017b).

A glossary of the terms used in the risk analysis is provided at the end of this report.

The PRAs are conducted in the following three consecutive stages: initiation, pest risk assessment and pest risk management.

Stage 1 Initiation

Initiation identifies the pest(s) and pathway(s) that are of quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

For this risk analysis, the 'PRA area' is defined as Australia for pests that are absent, or of limited distribution and under official control. For areas with regional freedom from a pest, the 'PRA area' may be defined on the basis of a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

For pests that had been considered by the department in other risk assessments and for which import conditions already exist, this risk analysis considered the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration in this risk analysis.

Stage 2 Pest risk assessment

A pest risk assessment (for quarantine pests) is the 'evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences' (FAO, 2017b).

The following three, consecutive steps were used in pest risk assessment:

Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017b).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- identity of the pest
- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO, 2017c). The SPS Agreement (WTO 1995) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

A summary of this process is given here, followed by a description of the qualitative methodology used in this risk analysis.

Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The likelihood of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in the report. These practices are taken into consideration by the department when estimating the likelihood of entry.

For the purpose of considering the likelihood of entry, the department divides this step into two components:

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia when a given commodity is imported.
- **Likelihood of distribution**— the likelihood that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors to be considered in the likelihood of importation may include:

- distribution and incidence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with the commodity
- mode of trade (for example, bulk, packed)
- volume and frequency of movement of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (for example, refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors to be considered in the likelihood of distribution may include:

- commercial procedures (for example, refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to hosts
- time of year at which import takes place
- intended use of the commodity (for example, for planting, processing or consumption)
- risks from by-products and waste.

Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO, 2017b). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, survival) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the likelihood of establishment.

Factors to be considered in the likelihood of establishment in the PRA area may include:

- availability of hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Likelihood of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO, 2017b). The likelihood of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the likelihood of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the likelihood of spread.

Factors to be considered in the likelihood of spread may include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 1). Definitions for these descriptors and their indicative probability ranges are given in Table 1Table . The indicative probability ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative probability ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table 1 Nomenclature of likelihoods

Likelihood	Descriptive definition	Indicative range
High	The event would be very likely to occur	0.7 < to ≤ 1
Moderate	The event would occur with an even likelihood	0.3 < to ≤ 0.7
Low	The event would be unlikely to occur	0.05 < to ≤ 0.3
Very low	The event would be very unlikely to occur	0.001 < to ≤ 0.05
Extremely low	The event would be extremely unlikely to occur	0.000001 < to ≤ 0.001
Negligible	The event would almost certainly not occur	0 < to ≤ 0.000001

Combining likelihoods

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a

matrix of rules (Table 2). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

For example, if the likelihood of importation is assigned a descriptor of 'low' and the likelihood of distribution is assigned a descriptor of 'moderate', then they are combined to give a likelihood of 'low' for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of 'high' to give a likelihood for entry and establishment of 'low'. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of 'very low' to give the overall likelihood for entry, establishment and spread of 'very low'. This can be summarised as:

importation x distribution = entry [E]	**low x moderate = low**
entry x establishment = [EE]	**low x high = low**
[EE] x spread = [EES]	**low x very low = very low**

Table 2 Matrix of rules for combining likelihoods

	High	Moderate	Low	Very low	Extremely low	Negligible
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases.

The department normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account. The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may take many years.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on the department's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO, 1995), ISPM 5 (FAO, 2017b) and ISPM 11 (FAO, 2017c).

Direct pest effects are considered in the context of the effects on:

- plant life or health
- other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:

- eradication, control
- domestic trade
- international trade
- non-commercial and environmental.

For each of these six criteria, the consequences were estimated over four geographic levels, defined as:

Local—an aggregate of households or enterprises (a rural community, a town or a local government area).

District—a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').

Regional—a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).

National—Australia wide (Australian mainland states and territories and Tasmania).

For each criterion, the magnitude of the potential consequence at each of these levels was described using four categories, defined as:

Indiscernible—pest impact unlikely to be noticeable.

Minor significance—expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.

Significant—expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.

Major significance—expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A-G) using Table 3. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

Table 3 Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic scales

	Geographic scale			
Magnitude	Local	District	Region	Nation
Indiscernible	A	A	A	A
Minor significance	B	C	D	E
Significant	C	D	E	F
Major significance	D	E	F	G

Note: In earlier qualitative PRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A to F has been changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 4 were adjusted accordingly.

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

Table 4 Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of 'G'; or more than one criterion has an impact of 'F'; or a single criterion has an impact of 'F' and each remaining criterion an 'E'.	Extreme
2	A single criterion has an impact of 'F'; or all criteria have an impact of 'E'.	High
3	One or more criteria have an impact of 'E'; or all criteria have an impact of 'D'.	Moderate
4	One or more criteria have an impact of 'D'; or all criteria have an impact of 'C'.	Low
5	One or more criteria have an impact of 'C'; or all criteria have an impact of 'B'.	Very Low

6	One or more but not all criteria have an impact of 'B', and all remaining criteria have an impact of 'A'.	Negligible

Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread and for potential consequences are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 5) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the combination of likelihood and consequence.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (for example, low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a 'low' likelihood combined with 'high' consequences, is not the same as a 'high' likelihood combined with 'low' consequences—the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of 'moderate', whereas, the latter would be rated as a 'low' unrestricted risk.

Table 5 Risk estimation matrix

Likelihood of pest entry, establishment and spread	Consequences of pest entry, establishment and spread					
	Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

The appropriate level of protection (ALOP) for Australia

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 5 marked 'very low risk' represents the ALOP for Australia.

Stage 3 Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve the ALOP for Australia, while ensuring that any negative effects on trade are minimised.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate does not achieve the ALOP for Australia, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve the ALOP for Australia. The effectiveness of any proposed phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure the restricted risk for the relevant pest or pests achieves the ALOP for Australia.

ISPM 11 (FAO, 2017c) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the likelihood of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

options for consignments—for example, inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity

options preventing or reducing infestation in the crop—for example, treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme

options ensuring that the area, place or site of production or crop is free from the pest—for example, pest-free area, pest-free place of production or pest-free production site

options for other types of pathways—for example, consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery

options within the importing country—for example, surveillance and eradication programs

prohibition of commodities—if no satisfactory measure can be found.

Risk management measures are identified for each quarantine pest where the level of biosecurity risk does not achieve the ALOP for Australia.

Glossary

Term or abbreviation	Definition
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Appropriate level of protection (ALOP) for Australia	The *Biosecurity Act 2015* defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Australian territory	Australian territory as referenced in the *Biosecurity Act 2015* refers to Australia, Christmas Island and Cocos (Keeling) Islands.
Biological control agent	A natural enemy, antagonist or competitor, or other organism, used for pest control (FAO 2017b).
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity measures	The *Biosecurity Act 2015* defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity import risk analysis (BIRA)	The *Biosecurity Act 2015* defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation.
Biosecurity risk	The *Biosecurity Act 2015* refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2017b).
The department	The Australian Government Department of Agriculture and Water Resources.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2017b).
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2017b).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2017b).
Gall	An abnormal growth of plant tissues caused by various organisms which irritate the plant and possibly lead to the production of some type of growth hormone (Nichols 1989).
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.

Term or abbreviation	Definition
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2017b).
Host specificity	The degree of fidelity of a biological control agent to the target host plant.
Host specificity test	The testing of host specificity in a biological control agent.
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2017b).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or t6o determine compliance with phytosanitary regulations (FAO 2017b).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2017b).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on Phytosanitary Measures or the Commission on Phytosanitary Measures, established under the IPPC (FAO 2017b).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2017b).
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2017b).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Biosecurity import risk analysis guidelines 2016).
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
Off-target effect	Effect either of feeding or oviposition on a plant other than the species that is the target of control.
Oviposition	The act of depositing eggs (Nichols 1989).
Parasitoid	An internal or external parasite, e.g., many Hymenoptera and Tachinidae (Diptera), that slowly kills the host, this event occurring near the end of the parasite's larval development (Nichols 1989).
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2017b).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2017b).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2017b).
Pest free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2017b).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated,

Term or abbreviation	Definition
	and the strength of any phytosanitary measures to be taken against it (FAO 2017b).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2017b).
Pest risk assessment (for regulated non-quarantine pests)	Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact (FAO 2017b).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2017b).
Pest risk management (for regulated non-quarantine pests)	Evaluation and selection of options to reduce the risk that a pest in plants for planting causes an economically unacceptable impact on the intended use of those plants (FAO 2017b).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2017b).
Phytosanitary measure	Phytosanitary relates to the health of plants. Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2017b). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2017b).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2017b).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2017b).
Practically free	Of a consignment, field or place of production, without pests (or a specific pests) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (FAO 2017b).
Pupa	An inactive life stage that only occurs in insects that undergo complete metamorphosis, for example butterflies and moths (Lepidoptera), beetles (Coleoptera) and bees, wasps and ants (Hymenoptera).
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2017b).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2017b).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2017b).
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO 2017b).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2017b).
Restricted risk	Restricted risk is the risk estimate when risk management measures are applied.
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the

Term or abbreviation	Definition
	identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	Are conditions that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2017b).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Target	The plant species that is the subject of the biological control program.
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2017b).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

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