Australia's National Science Agency

Process of Biological Control

Mariana Campos | October 2023

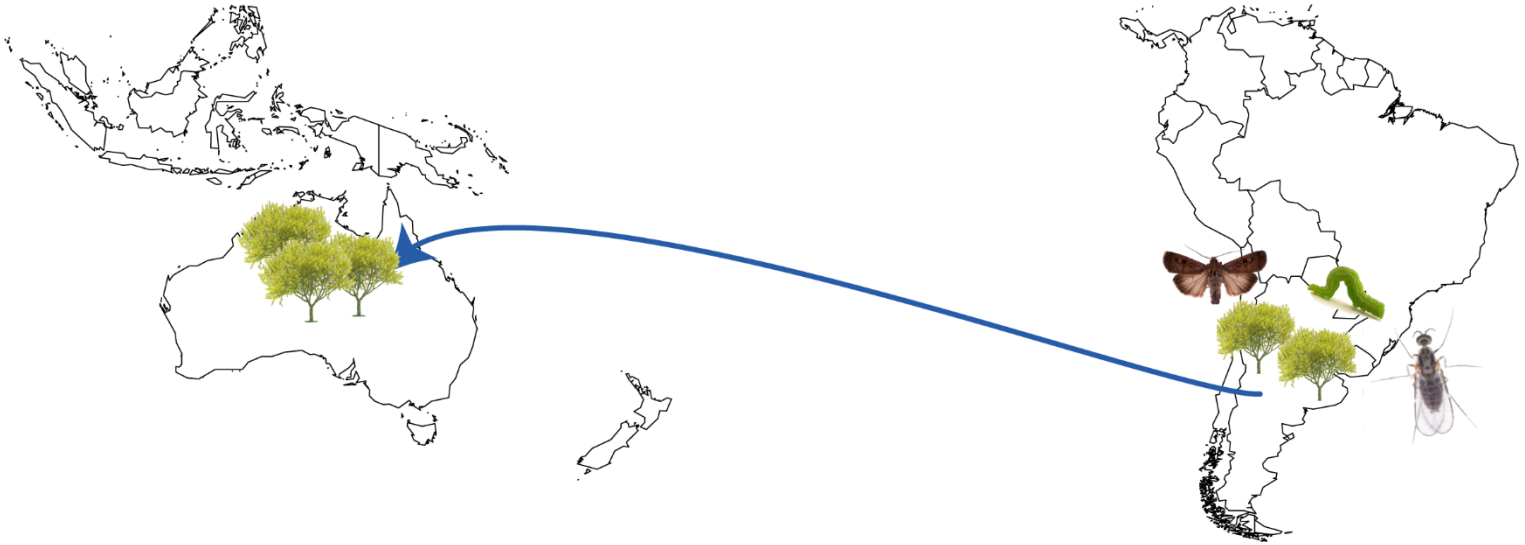
I would like to acknowledge
the Whadjuk people
as the Traditional Owners
of the Noongar country
where we meet today,
and pay my respect
to their Elders
past and present.

Biological control

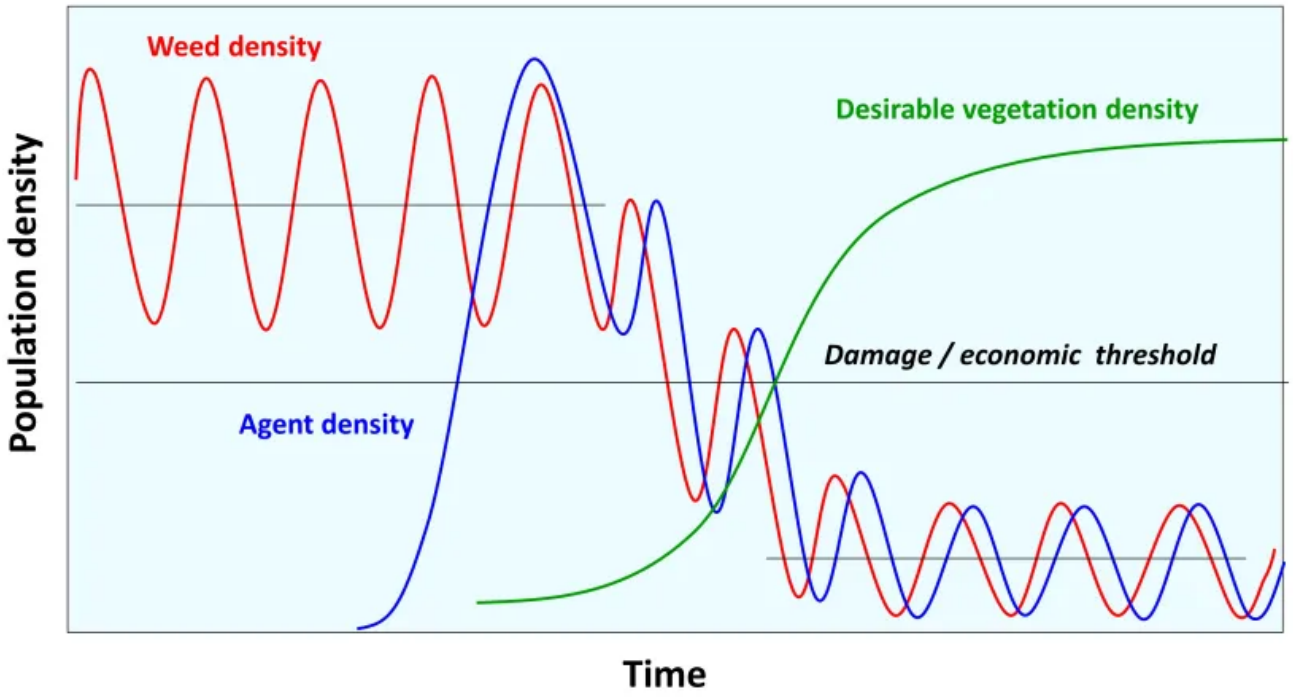
To introduce natural enemies of a target pest
that will reduce the density of that pest to an acceptable level
and maintain the pest at that acceptable level

Enemy release hypothesis

Exotic species are limited by their natural enemies in its native range. In the process of being moved from its native to introduced range enemies are left behind, leading to increased invasiveness.



Classical weed biological control

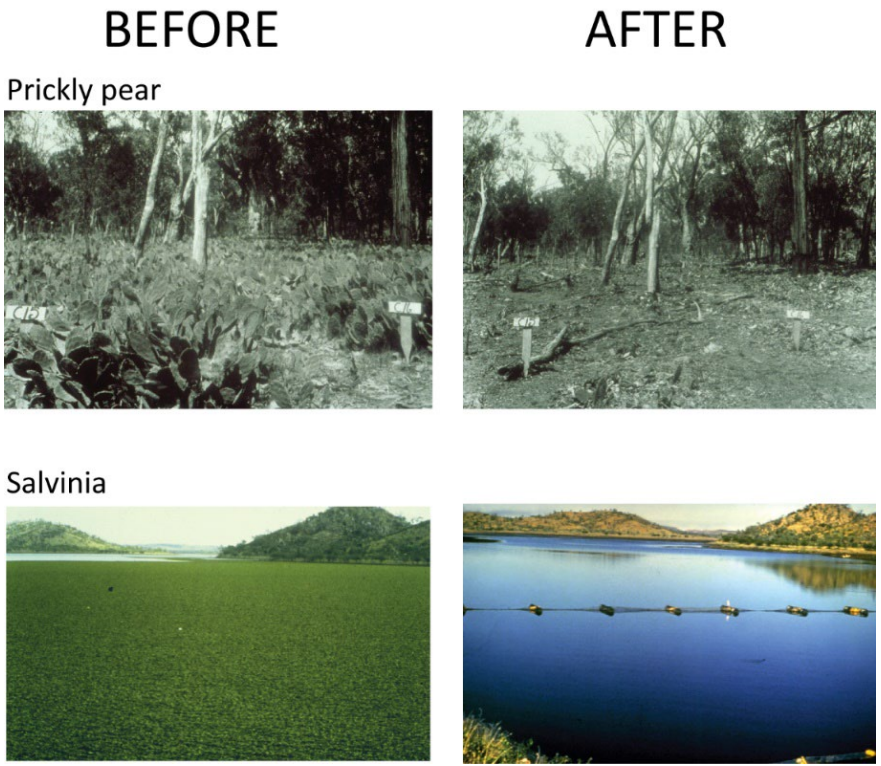


Briese et al. 2000. Classical biological control. *Australian weed managment sytems*, 161-192.

Australian weed biocontrol legacy

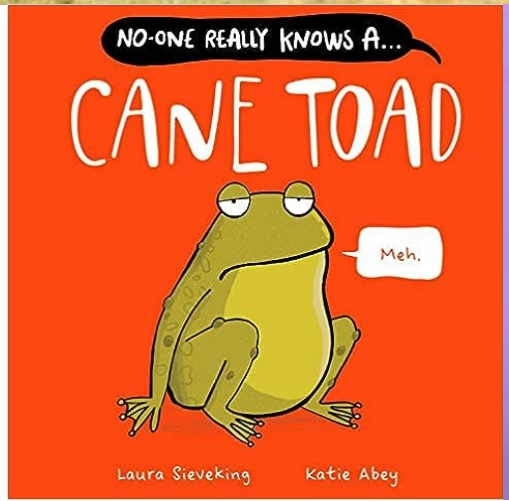
- 1920's prickly pear
- ~77 weed systems

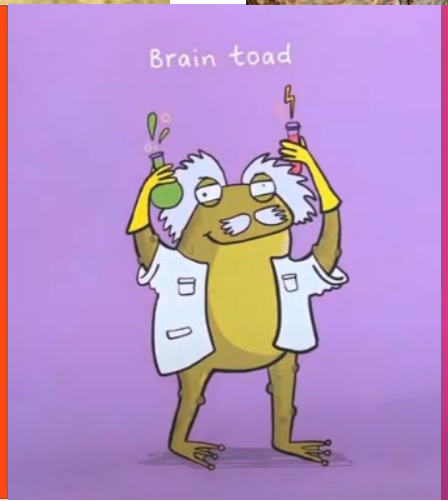
- ROI for 13 weeds (2017$)
  - Costs ~$6 M/y
  - Benefits $78-154 M/y
  - ↓ control costs
  - ↑ agricultural production

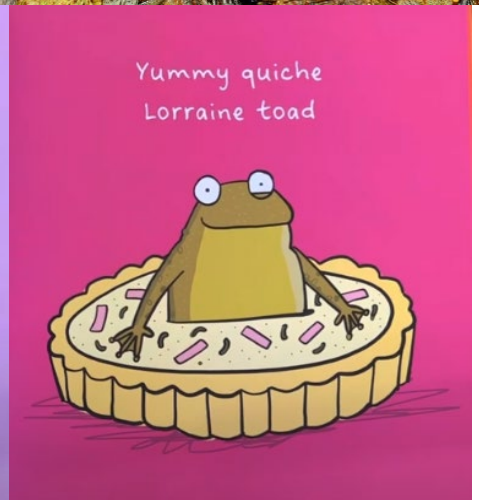


CSIRO (2017) *Research impact evaluation: Biological control of invasive plants*, Commonwealth Scientific Industry Research Organisation, Australian Government.

Page AR and Lacey KL (2006) 'Economic Impact Assessment of Australian Weed Biological Control', *Technical Series No. 10*, CRC for Australian Weed Management, Australian Government.


NO-ONE REALLY KNOWS A...
CANE TOAD
Meh.
Laura Sieveking
Katie Abey


Brain toad


Yummy quiche
Lorraine toad

Legislation around biological control

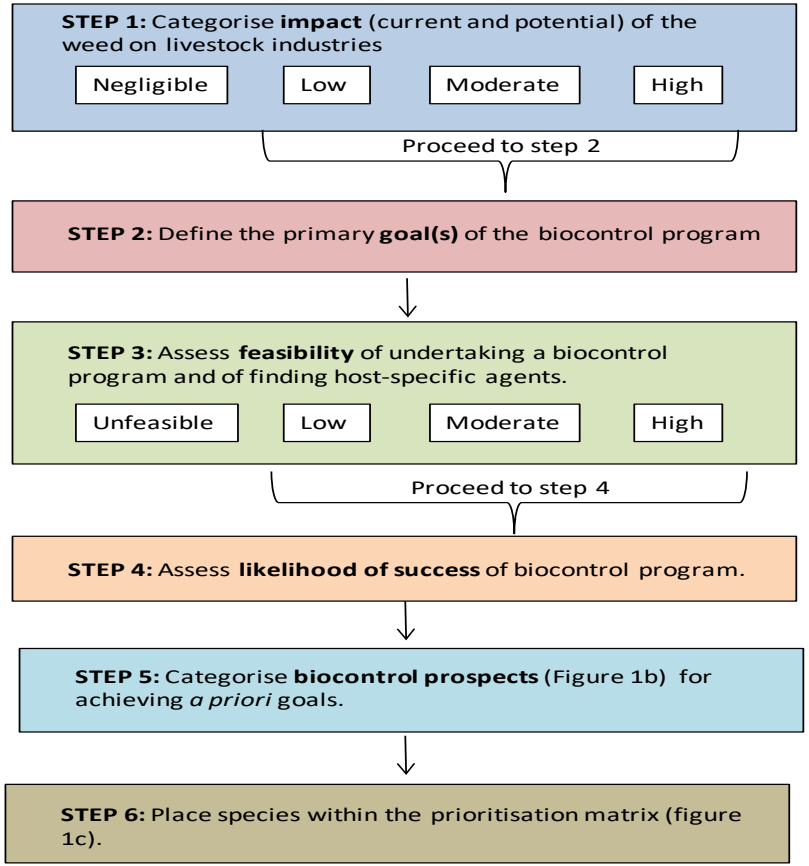
- Laws governing biological control in Australia
  - Quarantine Act 1908
  - Environment Protection and Biodiversity Conservation Act 1999
  - Biological Control Act 1984
- Commonwealth oversight
  - Department of Agriculture, Fisheries and Forestry (DAFF)
  - Department of Climate Change, Energy, the Environment and Water (DCCEEW)

- International Laws
  - Laws of the countries in native range
  - International Treaties
    - Nagoya Protocol (United Nations – Convention on Biological Diversity)

Regulatory process

Step 1	• Approval of target species as a candidate for biological control
Step 2	• Host-specificity test list
Step 3	• Import and export permitting
Step 4	• Quarantine testing permits
Step 5	• Application to release a biocontrol agent
Step 6	• Assessment of release package – Risk analysis
Step 7	• Final public consultation period
Step 8	• Release conditions/requirements
Step 9	• Live import list amended to include approved biocontrol agent

Prioritisation process: selection of target



b) Biocontrol prospects

Feasibility \ Likelihood of success	NA	Low	Mod	High
Negligible	Unf	Unf	Unf	Unf
Low	Unf	L	L	M
Moderate	Unf	L	M	H
High	Unf	L	H	H

c) Prioritisation matrix

Biocontrol prospects \ Weed impact	Negligible	Low	Mod	High
Unfeasible				
Low				
Moderate				
High				

Prioritisation process: selection of target

Biocontrol feasibility

Biocontrol likelihood of success	Low	Mod	High
Low	*Bromus diandrus* [1] *Bromus rigidus* [1] *Bromus rubens* [1] *Chloris virgata* *Citrullus lanatus* [2] *Cucumis myriocarpus* [2] *Cyperus rotundus* *Echinocloa crus-galli* *Lactuca serriola* *Moorochloa eruciformis* *Panicum hillmanii* [3] *Panicum capillare* [3]	*Brassica tournefortii* [5] *Diplotaxis tenuifolia* *Malva parviflora* *Polygonum arenastrum* [6] *Polygonum aviculare* [6] *Rapistrum rugosum* [5] *Salvia reflexa* *Sinapsis arvensis* [7] *Sisymbrium officinale* [7] *Sisymbrium thellungii* [5]	*Carthamus lanatus*
Mod	*Amsinckia calycina* [4] *Amsinckia intermedia* [4] *Amsinckia lycopsoides* [4] *Arctotheca calendula* *Heliotropium amplexicaule*	*Conyza canadensis* *Cirsium* spp. [8] *Silybum marianum* [8]	*Conyza bonariensis* [9] *Conyza sumatrensis* [9]
High	*Tribulus terrestris*		

* Weeds associated with the same number were assessed together.
Green = Low biocontrol prospects; Blue = Moderate biocontrol prospects; Red = High biocontrol prospects

Weed impact

Biocontrol prospects	Low (< $5M)	Mod ($5 to 10M)	High ($10 to 50M)	Very High (> 50M)
Unfeasible	*Echium plantagineum* *Emex australis* *Hordeum glaucum* [10] *Hordeum leporinum* [10] *Hordeum marinum* [10] *Juncus bufonius* *Onopordum* spp. *Vicia sativa* ssp. *nigra* [11] *Vicia sativa* ssp. *sativa* [11] *Vicia villosa* [11]	*Chloris truncata*	*Avena fatua* [12] *Avena sterilis* ssp. *ludoviciana* [12] *Panicum effusum* *Sonchus oleraceus*	*Heliotropium europaeum* *Lolium rigidum* *Raphanus raphanistrum*
Low	*Amsinckia calycina* [4] *Amsinckia intermedia* [4] *Amsinckia lycopsoides* [4] *Arctotheca calendula* *Lactuca serriola* *Malva parviflora* *Salvia reflexa*	*Cyperus rotundus* *Diplotaxis tenuifolia* *Polygonum arenastrum* [6] *Polygonum aviculare* [6] *Sinapsis arvensis* [7] *Sisymbrium officinale* [7]	*Brassica tournefortii* [5] *Bromus diandrus* [1] *Bromus rigidus* [1] *Bromus rubens* [1] *Chloris virgata* *Echinocloa crus-galli* *Moorochloa eruciformis* *Panicum hillmanii* [3] *Panicum capillare* [3] *Rapistrum rugosum* [5] *Sisymbrium thellungii* [5]	*Citrullus lanatus* [2] *Cucumis myriocarpus* [2] *Heliotropium amplexicaule*
Mod	*Carthamus lanatus* *Cirsium* spp. [8] *Silybum marianum* [8]		*Conyza canadensis* *Tribulus terrestris*	
High			*Conyza bonariensis* *Conyza sumatrensis*	

* Weeds associated with the same number were assessed together.

Morin, L. and Raghu, S. (2020) Prioritisation of weeds of the grains industry in Australia as targets for biological control. CSIRO, Australia, pp. 133.

Australian Biological Control

Salvation Jane
(*Echium plantagineum*)
& crown boring weevil

~ 77 weed species targeted

~ 343 agent introductions

97%
at least 1 agent
established self-sustaining
populations

3%
weed species
no established agents

59%
effective biocontrol
observed

35%
weed populations not below the
desired threshold

Seed weevil
Rhinocyllus conicus
- released 1998-90

Gall fly
Urophora solstitialis
- released 1991

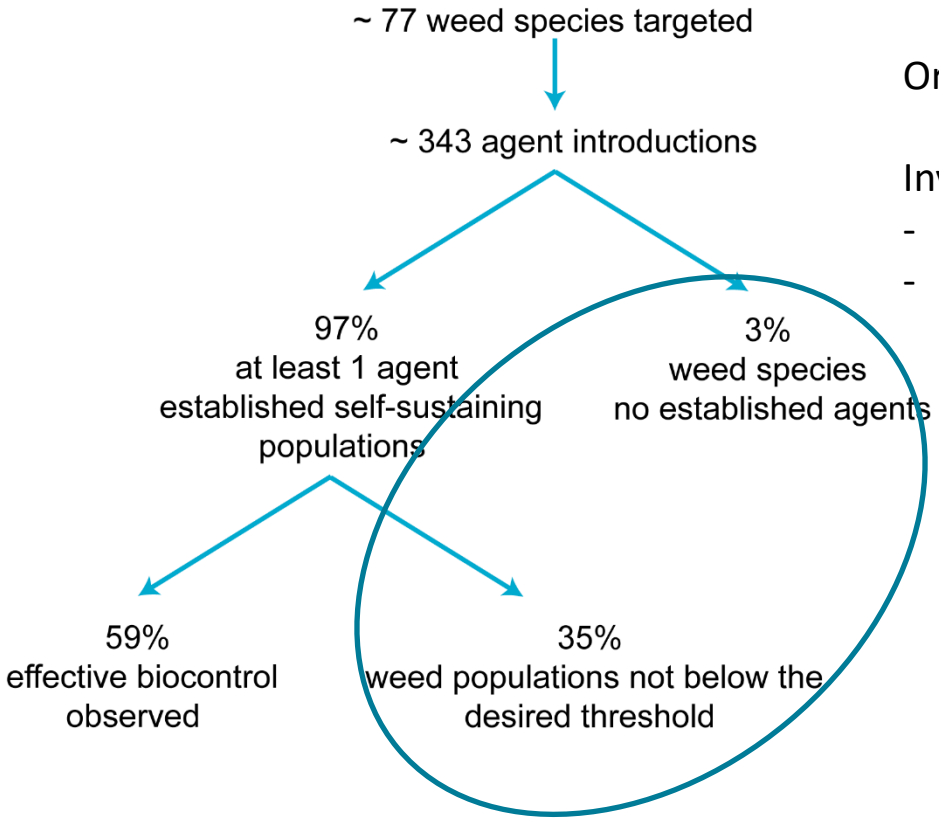
Rosette weevil
Trichosirocalus horridus
- released 1993

Nodding thistle (*Carduus nutans)*

Cullen, J. M., Sheppard, A. W., & Raghu, S. (2022). Effectiveness of classical weed biological control agents released in Australia. Biological Control, 166

Winston, R.L et al. Eds. 2023. Biological Control of Weeds: A World Catalogue of Agents and Their Target Weeds. https://www.ibiocontrol.org/catalog/

Australian biological control



Revisit:
- Climate modelling
- Weed population genetics

Or

Investigate genetic control:
- Weed/agent gene drives
- RNAi

Kumaran, N., et al. (2020). Gene technologies in weed management: a technical feasibility analysis. *Current Opinion in Insect Science, 38*, 6-14.

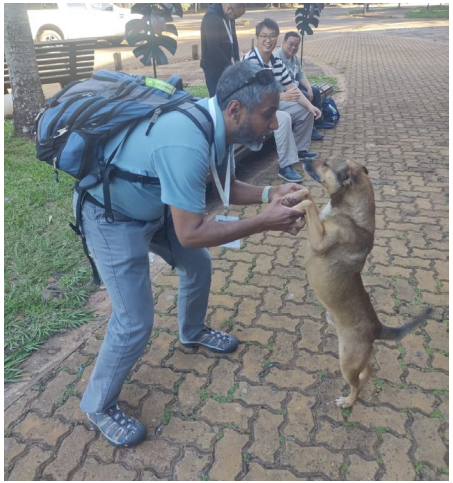
WA Weed biological control

Photo credit: M Davy

Active projects:
Passiflora and skeleton weed

Opportunities:
Sea spurge
African boxthorn
Onion weed *(Asphodelus)*

Photo credit: GNRBA



Thank you

Health & Biosecurity
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Steps in Classical Biological Control

1) Target Selection/Designation
   i. Understanding pest/weed issue
      - Is the target species of concern because of its ecology or because of some anthropogenic practice?
      - If the latter, would managing the anthropogenic practice mitigate the pest/weed problem?
      - Pest/Weed ecology and impact
   ii. Assessing relatedness of pest/weed to native fauna/flora

Steps in Classical Biological Control

2) Native Range Studies

i. Understanding pest/weed ecology and impact

ii. Understanding natural enemy complex

iii. Assessing role of natural enemies (natural control), relative to other factors, in target demography

iv. Evaluating host range of natural enemies

- Host-specificity experiments (lab, field, greenhouse, open-field)
- Published literature

iv. Understanding life-history requirements of specialist natural enemies (agents)

v. Shipping of natural enemies (agents) to exotic range

Steps in Classical Biological Control

3) Introduced Range Studies

i. Evaluating host range of natural enemies (agents)
   - Quarantine host-specificity studies (lab, greenhouse)
   - Limited field studies (isolated field plots)

ii. Evaluating agent impact
   - On target species AND
   - Non-target species

iii. Obtaining approval to release

Steps in Classical Biological Control

4) Rearing and Release

i. Develop optimal rearing strategies
   - 2-species issue vs. Artificial diet
   - Life-history strategies of agent (e.g. diapause)
   - Rearing protocols

ii. Develop optimal release strategies
   - S.L.O.S.S.
   - Timing and spatial location
   - Stage to be released
   - Release size
   - Strategy (e.g. use of pheromones)

Steps in Classical Biological Control

5) Evaluation

i. Establishment of agents

ii. Impact of agents

- Target
  - Quantitative (related to pre-release target ecology and impact studies)
  - Qualitative (Complete, Substantial, Partial/Negligible)

- Non-target (clues may be present from host-specificity studies)
  - Quantitative (must be measures of demographic impact)

Step 1

- Approval of target species as a candidate for biological control

- A pest/weed is nominated as a target for biological control to
  - Plant Health Committee (PHC; pests)
  - Weeds Working Group(WWG; weeds)
- Responsibility
  - Proposer
- Approval
  - WWG/PHC

Step 2

- Offshore research on possible agents

- Native range research
- Responsibility
  - Proposer
- Approval
  - none

Step 3

- Host-specificity test list

- Development of list of species to test in relation to candidate biocontrol agents
  - Developed consultatively
  - Published on DAFF website (voluntary)
- Responsibility
  - Proposer
- Approval
  - none

Step 4

- Permission to undertake specificity testing on contained use in Australia

- Specificity testing
- Responsibility
  - Proposer
    - Application to Import Plant Research Materials and Plant Pathogens
    - Approved Arrangements (AA, ex. Quarantine Approved Premises QAP) at the appropriate quarantine control level
- Approval
  - DAFF

Step 5

- Testing permit for proposed biological agents that are animals

- Permit to be obtained from the Department of the Environment to undertake the work in a AA
- Responsibility
  - Proposer
    - Permit application submitted to DCCEEW
      - Justification for doing the work in Australia
    - Lodgement of voucher material at recognized institution (e.g. ANIC)
- Approval
  - DCCEEW

Step 6

- Specificity testing

- Carry out specificity testing in Approved Arrangements
- Responsibility
  - Proposer
- Approval
  - None

Step 7

- Application to release a biological control agent

- Application to release agent
  - Comprehensive report on host-specificity testing to DAFF
    - “Information package”/”Release package”
- Responsibility
  - Proposer
- Approval
  - None

Step 8

• Assessment of release package

- Review of the release package and preparation of preliminary draft Import Risk Analysis report by DAFF
  - Consultation of PHC (State and Territory biosecurity officers)
  - Draft report published on DAFF website
    - Public comment period – 30 days
  - Final report to recommend whether the agent represents low-no risk
    - “Acceptable Level of Protection”
- Responsibility
  - DAFF (in consultation with DCCEEW, throughout)
- Approval
  - DAFF

Step 9

- Release conditions/requirements

- Letter notifying decision sent to Proposer
  - If release is approved, conditions of release are stipulated
  - Reminder of obligation to lodge voucher materials
- Responsibility
  - DAFF
- Approval
  - DAFF

Step 10

- Amending the live import list for biological control agents that are animals

- Recommendation will be made to the Minister for the Environment to amend the live import list to include the biological control species
  - Additional information from Proposer may be requested
  - Addition of the biological control agent to the “Live Import List”
- Responsibility
  - DCCEEW
- Approval
  - DCCEEW

Approval from DAFF AND DCCEEW is required prior to release