CENTRE FOR
INVASIVE SPECIES SOLUTIONS

BEST PRACTICE MANAGEMENT FOR THE CONTROL OF opuntioid cacti (*Austrocylindropuntia, Cylindropuntia* and *Opuntia* spp.)

ADDENDUM TO THE WEEDS OF NATIONAL SIGNIFICANCE
OPUNTIOID CACTI BEST PRACTICE CONTROL MANUAL

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Cover images

Front — Cylindropuntia fulgida. Image by Wild Matters.

Back — Cylindropuntia tunicata penetrating 4WD tyre. Image by Wild Matters.

How to use this addendum

The opuntioid cacti best practice control manual **(PDF, 22.2 MB) was published in 2017 and provides information on the weed and best practice management options. The manual has since been reviewed to ensure currency of best practice management advice and information. Any updates to the information contained within the manual are included in this addendum and should be taken as the most current source of information.**

Note: the addendum is not a standalone document and should be read in conjunction with the 2017 manual.

The addendum focuses on updates to control options, including mechanical, chemical and biological control methods. It also includes updates on available herbicides and where to go to find additional information on cacti and their management.

When new or additional information is provided in the addendum, page numbers reference the related text in the original manual.

Chapter 4 Managing cacti

Page 75

Manual removal (hand-pulling)

Page 81 – Cacti flowers and fruit dislodge easily and may roll away from the parent plant and result in new plants. This vegetative spread can be reduced in new and small infestations (before full treatment of the entire plant) by pulling the fruits and flowers by hand.

Remove carefully using appropriate protective equipment (e.g. gloves and tongs) to reduce your risk of getting spiked. Ensure that the flowers and fruit are disposed of in an approved deep-burial facility (see **page 86**).

Mechanical removal (machinery)

Page 82 (and page 122 for case study 3) – The 2017 manual reported on mechanical removal of *Opuntia robusta* (wheel cactus) near Kellerberrin, WA, in 2016.

The treatment involved the use of a grapple arm on a tractor to 'pluck' wheel cactus from the ground (**page 84**) and dispose of it via deep burial in a purpose-dug pit (see **page 86**).

Six years later, the shire of Kellerberrin has reported the control effort a success. The cactus "hasn't come back" and "nothing has grown from the pit". Monitoring has continued at the pit site and at the site of the original infestation.

The large-scale mechanical removal of a number of opuntioid cacti species from a residential leasehold area in Williamstown on the Kalgoorlie Goldfields, WA, has also proved successful.

The CEO of the Kalgoorlie-Boulder Urban Landcare Group and project coordinator of the 2016 cactus removal program, Kim Eckert, commented in late 2022 that monitoring of the site has continued in conjunction with the WA Parks and Wildlife Service.

"Anything that does come up has been hand pulled. There has been a minimum [small] amount each year. A few outlying plants that were missed in the original control work were sprayed or hand dug. The key lessons were to **scrape the area well and deep-bury all the material (including the scraped soil)**. Monitoring will continue for 10 years," Kim said.

The Williamstown site six years after cactus removal. Source: Kim Eckert.

Chemical control

Page 88

Herbicide labels and legislation

Page 88 – The Australian Pesticides and Veterinary Medicines Authority (APVMA) regulates the availability of all pesticides, which includes herbicides. Herbicides are registered with the APVMA for specific applications as stated on the label. State governments regulate the use of pesticides after sale. A herbicide label is a legal document that defines where, when and how a herbicide can be used on which weed species and at what rate.

Note: not all registered herbicides are commercially available. Often, companies improve herbicide formulations and only market the new formulation. For example, many herbicides are being marketed in higher concentrations. This reduces transport, storage and container-disposal costs.

In addition to herbicides being registered and described 'on-label' for specific weeds and situations, herbicides can sometimes be used through permits or 'off-label' use. These situations are described below.

Minor use and emergency use permits

APVMA may issue minor use and emergency use permits for herbicide applications that are not otherwise registered for that particular use. Minor use permits are sometimes referred to as 'off-label' permits. Minor use and emergency permits are valid ('in force') for a limited time. See the APVMA website to find current permits.

Some states also have permits for the control of 'declared' weeds and may not specifically list the weed species to be controlled. These permits will often list a range of herbicides that can be used for the control of declared or environmental weeds. To find these permits for your state:

- go to the APVMA permits database search
- enter 'declared weeds' or 'environmental weeds' in the SEARCH box
- click the search term 'Pest/purpose'
- click 'Search'.

It is also recommended that if you are unsure which herbicides can legally be used on a particular weed in your state, contact the relevant biosecurity section of your state department of agriculture. When using herbicides in aquatic situations, only use those that are registered or permitted for use in and around aquatic areas.

Any minor use permits relevant to willows at time of publication are listed in Table 6 below.

Off-label use

Off-label use is the use of a registered chemical to address a specific issue that is not covered by the APVMA-approved label. Off-label use is to:

- control a different weed (or pest)
- apply at a different rate (only lower)
- apply in a different manner (not allowed in ACT, NSW and Tasmania).

Off-label use is permitted in all states and territories; however, conditions vary in each jurisdiction (Table 1).

Table 1. Where to find specific rules relating to herbicide use, including off-label use, in each state and territory

STATE/ TERRITORY	WEBSITE AND FURTHER INFORMATION
ACT	Agvet chemical use https://www.accesscanberra.act.gov.au/s/article/pest-and-weed-control-tab-Agvet-chemical-use
NSW	Pesticides https://www.epa.nsw.gov.au/your-environment/pesticides/pesticides-nsw-overview
	Weed control and identification https://www.dpi.nsw.gov.au/biosecurity/weeds/weed-control
NT	Chemical use https://nt.gov.au/industry/agriculture/farm-management/using-chemicals-responsibly
Qld	Chemical use https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/aquaculture/chemicals/registered
SA	Rural chemicals https://pir.sa.gov.au/biosecurity/rural_chemicals
	Weed control handbook https://www.pir.sa.gov.au/__data/assets/pdf_file/0020/232382/WEB_8867_PIRSA_Weed_Control_Handbook_2018.pdf (PDF, 4.2 MB)
Tas	Agricultural and veterinary chemicals https://nre.tas.gov.au/agriculture/agvet-chemicals
	Weeds https://nre.tas.gov.au/invasive-species/weeds
Vic	Off-label chemical use https://agriculture.vic.gov.au/farm-management/chemicals/offlabel-chemical-use
WA	Using pesticides safely https://ww2.health.wa.gov.au/Articles/U_Z/Using-pesticides-safely

Safety and training

Page 89 – Personal protective equipment (such as protective clothing, eye or face shields, and respiratory protection) must be used in accordance with the recommendations stated on the herbicide label or permit. Chemical-use training is required for people using herbicides as part of their job or business. Training is recommended for community groups and may be required if working on public land. Training courses are run by ChemCert, AusChem and TAFE in each state. Other training courses may be available through state agencies (e.g. AgTrain in Victoria, SMARTtrain in NSW), local councils or non-government organisations.

By law, you must read the label (or have it read to you) before using any herbicide product. Always follow the label or permit.

Chemical user certification

Commercial weed-control operators need to be licenced in most states (Table 2). It should also be noted that there is now shared responsibility between landholders and their contractors for any breaches of laws and regulations (such as herbicide drift).

Table 2. Chemical-user certification by state and territory

STATE/ TERRITORY	WEBSITE
ACT	www.accesscanberra.act.gov.au/s/article/pest-and-weed-control-tab-Agvet-chemical-use
NSW	www.epa.nsw.gov.au/your-environment/pesticides/licences-and-advice-for-occupational-pesticide-users
NT	nt.gov.au/industry/agriculture/farm-management/using-chemicals-responsibly/spray-applicator-licences
Qld	www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/chemical-controls/commercial-operators
SA	www.sa.gov.au/topics/business-and-trade/licensing/building-and-trades/pest-control-licence
Tas	nre.tas.gov.au/agriculture/agvet-chemicals/licences-and-certificates/ground-spraying-and-pest-management-licences
Vic	agriculture.vic.gov.au/farm-management/chemicals/licences-and-permits/commercial-operator-licence-for-contractors
WA	https://www.health.wa.gov.au/articles/n_r/pest-industry-licensing-and-registration

Effective use of herbicides

Page 95 – Successful herbicide control is dependent on the right herbicide for the target species, growth stage of the target species, weather conditions during and after spraying, how thoroughly the herbicide is applied, and the herbicide mix and application rate.

For spraying, wind speeds should be low (< 15 km/h) with no rain expected in the following six hours.

Do not apply herbicide to plants that are under any sort of stress, as herbicide will not be absorbed and translocated effectively, resulting in a reduced level of control. Plants may be stressed due to:

- dry soil
- low humidity
- air temperatures above 30 °C
- frost.

Effectiveness of herbicides can be maximised further by:

- mixing dye with the herbicide to help minimise missed areas and prevent overspraying (double≈spraying)
- using an adjuvant – an additive that improves herbicide uptake (always read the adjuvant's product labels to ensure that they are compatible with the particular herbicide and there are no restrictions on their use; e.g. most adjuvants should not be used near waterways)
- ensuring spray equipment is correctly calibrated and maintained, including being thoroughly cleaned between uses.

Spraying in sensitive areas

Herbicide users have a legal obligation to avoid spray drift damage and to ensure that the chemicals applied stay within the target area. Target-weed infestations are often located in areas of native vegetation, so great care should be taken to avoid spraying surrounding foliage and soil. Do not use high pump/sprayer pressures that create small droplets which float in the air. Adjust the nozzle settings to produce coarser droplet sizes.

Using herbicides near water

Never spray herbicides over bodies of water or plants standing in water. Some herbicides are formulated to be a lower risk when used near water (e.g. Roundup® Biactive). NEVER add unregistered adjuvants to herbicides that will be used near water. Some states have publications explaining the safe use of herbicides near water (Table 3).

Table 3. Safe use of herbicides near water by state and territory

STATE/ TERRITORY	WEBSITE
South-eastern Australia	archive.dpi.nsw.gov.au/__data/assets/pdf_file/0011/319448/riparian-habitat-management-guide.pdf (PDF, 1.1 MB)
Qld	https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/sustainable/chemical/ground-distribution-herbicide/laws
SA	https://www.epa.sa.gov.au/files/477387_pesticide_water.pdf (PDF, 1.7 MB)
Tas	https://nre.tas.gov.au/Documents/herbicide_guidelinesFINAL2012.pdf (PDF, 689 kB)
WA	https://www.water.wa.gov.au/__data/assets/pdf_file/0016/3355/12149.pdf (PDF, 113 kB)

Regulations and permits for works in riparian zones

Areas on or near the bank of a river or other body of water (riparian zones) are sensitive habitats, and in some states a licence is required to conduct weed-control works (Table 4).

Table 4. Authorities who can advise about regulations and permits for works in riparian zones

STATE/ TERRITORY	DEPARTMENT	WEBSITE
NSW	NSW Department of Planning and Environment — Water	https://water.dpie.nsw.gov.au/
SA	Landscape SA, including 8 regional boards	https://www.landscape.sa.gov.au/
Vic	Catchment management authorities	https://viccatchments.com.au/about-us/our-cma-regions/
	Department of Energy, Environment and Climate Action — Forests and Reserves	Riparian management licences – www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0016/31426/Riparian-management-licences.pdf (PDF, 160 kB)

Herbicides for use on cacti

Page 91 – Table 5 and Table 6 list the herbicides registered for use on opuntioid cacti.

Table 5. Herbicides permitted for use on opuntioid cacti under registration

SPECIES SUITABILITY	SITUATION	ACTIVE INGREDIENT	COMMERCIAL PRODUCTS[1]	RATE	STATE/ TERRITORY[2]	COMMENTS
Common pest pear, Harrisia cactus, prickly pear, snake cactus, tiger pear, tree pear	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights of way	triclopyr + picloram[4,5] (240 + 120 g/L)	Access®	1 L:60 L diesel or Biosafe®	All states and territories	Apply as an overall spray, wetting all areas of the plant to ground level.
Prickly pear (common), smooth tree pear	Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights of way	triclopyr + picloram[3,4,5] (300 + 100 g/L)	Conqueror®	500 mL/100 L water	All	High-volume handgun. Actively growing phyllodes (leaf **stems**). Apply as an overall spray. Apply as a thorough foliage spray. Regrowth may occur, so a follow-up application may be necessary.
		triclopyr + picloram[4] + aminopyralid[5] (300 + 100 + 8 g/L)	Grazon® Xtra			
Prickly pear (common), *Opuntia* spp., tiger pear	Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights of way	triclopyr[3,5] (600 g/L)	Garlon® 600	3 L/100 L water	All	Apply as a thorough foliage spray.
Prickly pear (common), *Opuntia* spp., smooth tree pear, tiger pear				800 mL/60L diesel		Apply as a thorough foliage spray.
Common prickly pear, devil's rope, drooping prickly pear, Indian fig, wheel cactus	Treatment of prickly pear	MSMA[3] (800 g/L) **Note: this is a Schedule 7 (S7) poison; check its usage restrictions.**	Daconate®	1 L/40 L water	SA only	Apply during summer using a power sprayer when air temperature is above 30 °C. Thoroughly cover all pad surfaces. Respray any regrowth that occurs.
Tree pears (*Opuntia* spp.)	Non-crop areas around buildings, commercial and industrial areas, domestic and public service areas, and rights of way	amitrole + ammonium thiocyanate (250 + 220 g/L)	Amitrole® T Herbicide	1 mL/3 cm (inject) or 1 L/25 L foliar (small plants/ regrowth)	Qld only	Tree pears may take up to 12 months to die. Respraying may be needed in some cases (consult the label).
Prickly pear (common), smooth tree pear	Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights of way	picloram[4] (240 g/L)	Picoflex™ Herbicide	210 mL + 200 mL triclopyr[3] (750 g/L)	All	Apply as an overall spray, wetting all areas of the plant. Regrowth may occur.
Tree pear (*Opuntia tomentosa*) Prickly pear (*Opuntia* spp.)	Forestry, Pasture, Commercial & Industrial areas, Rights of Way, Around Agricultural Buildings & Public Service areas	aminopyralid + metsulfuron-methyl (93.7 g/kg + 75 g/kg)	Di-Bak™ AM	1 capsule every 10 cm of circumference	All	Use the InJecta applicator to drill a hole and deliver Di-Bak AM capsule in the sapwood layer beneath the bark. Space capsule insertions at 10 cm, centres around tree circumference below any branching, otherwise remove or treat all branches below the capsule insertion. On multiple trunk trees ensure each trunk is treated. ALL TREES: Apply the capsules to each tree at waist height or below.

Add note: Notes to this table can be found at the bottom of Table 6.

Table 6. Herbicides permitted for use on opuntioid cacti under minor use permits

PERMIT NO.	EXPIRES	PERMIT HOLDER	ACTIVE INGREDIENT	COMMERCIAL PRODUCTS[1]	RATE	COMMENTS
NSW						
PER12363 Product for controlling various environmental weeds in natural ecosystems using helicopter and drone/unmanned aerial vehicle spot-spraying equipment	31 March 2026	National Parks and Wildlife Service	metsulfuron (600 g/kg)	Associate®	As per permit	Staff or contractors employed/contracted by the National Parks and Wildlife Service or agencies/organisations represented on NSW Local Land Services Regional Weeds Committees
Victoria						
PER14787 Chemical product for the control of Opuntia spp. in agricultural land, non-agricultural land and environmental areas	30 June 2025	Tarrangower Cactus Control Group	MSMA (800 g/L) **Note: this is a Schedule 7 (S7) poison; check its usage restrictions.**	Daconate®	4 mL/m of plant height Stem injection	Persons authorised to use specified agricultural chemical products in Victoria, under the Agricultural and Veterinary Chemicals (Control of Use) Act 1992
Tasmania						
PER84775 Herbicides for the control of environmental weeds in non-crop and bushland areas	30 September 2025	Department of Primary Industries, Parks, Water and Environment, Tasmania	glyphosate (360 g/L)	Roundup® Biactive	Undiluted Drill hole or cut-stump	Persons generally
South Australia						
PER13371 Chemical product for the control of environmental weeds in SA For non-crop areas, rights of way, roadsides and easements, forest and conservation areas	30 April 2027	Department of Primary Industries and Regions, South Australia	glyphosate (450 g/L)	Gladiator® CT	Undiluted Cut-stump or drill and inject See permit	Persons generally While actively growing, inject a measured dose of herbicide into the cladodes (stems that have become flat and produce energy from the sun for the plant; stem segments or pads) with a drenching needle.
			glyphosate (360 g/L) + metsulfuron (600 g/L)	Roundup® Biactive	1 L + 3 g/100 L High-volume spot spray	

PERMIT NO.	EXPIRES	PERMIT HOLDER	ACTIVE INGREDIENT	COMMERCIAL PRODUCTS[1]	RATE	COMMENTS
Queensland						
PER13812 Control coral cactus in pastures, rights of way, commercial and industrial areas	30 November 2027	Biosecurity Queensland	triclopyr + picloram[4] (240 + 120 g/L)	Access®	1:60 diesel	Persons who are trained and experienced in the use of agricultural chemicals Paint the stump immediately after cutting, or spray the basal bark.
PER90719 Chemical product for the control of introduced cacti in various situations Persons licensed to apply agricultural chemicals under the Queensland Agricultural Chemicals Distribution Control Act 1966. For pastures, non-crop areas, commercial and industrial areas, domestic and public service areas, and rights of way.	31 January 2024	Biosecurity Queensland	triclopyr + picloram[4] + aminopyralid (300 + 100 + 8 g/L)	Grazon® Extra	500 mL / 100 L	Pastures, non-crop areas, commercial and industrial areas, domestic and public service areas and rights of way. Thoroughly spray the plants. Further treatment may be necessary where cladodes fall and re-shoot following treatment.
			triclopyr + picloram[4] + aminopyralid (200 + 100 + 25 g/L)	Tordon® RegrowthMaster	2.5 L / 100 L water	For agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights of way. Thoroughly spray the plants. Further treatment may be necessary where cladodes fall and re-shoot following treatment.
			amitrole + ammonium thiocyanate (250 + 220 g/L)	Amitrole® T herbicide	4 L/100 L water	For non-crop areas around buildings, commercial and industrial areas, domestic and public service areas, and rights of way. Thoroughly spray the plants.
			MSMA (800 g/L) **Note: this is a Schedule 7 (S7) poison; check its usage restrictions.**	Daconate®	2.5 L / 100 L water	For non-crop areas, roadsides, fence lines and storage areas. Thoroughly spray the plants.
			glyphosate (360 g/L)	Roundup® Biactive	1 L / 100 L water	For pastures, roadsides, rights of way, bushland/native forests, agricultural non-crop areas, commercial and industrial areas, domestic and public service areas, vacant lots and wastelands. Treat all stems thoroughly. Avoid spraying nearby desirable vegetation as damage will result.

PERMIT NO.	EXPIRES	PERMIT HOLDER	ACTIVE INGREDIENT	COMMERCIAL PRODUCTS[1]	RATE	COMMENTS
Western Australia						
PER13333 Chemical product for the control of environmental weeds in various situations: For the purposes of this permit cacti are considered as 'Woody weeds' or 'woody weeds and trees' not 'broadleaf perennial' weeds.	31 March 2025	WA Forest Products Commission	glyphosate[3] (360 g/L)	Roundup® Biactive	As per permit 2 mL per hole or cut Undiluted to 1 L/5 L water for paint stump or basal bark	Persons generally
			MSMA (800 g/L) **Note: this is a Schedule 7 (S7) poison; check its usage restrictions.**	Daconate®	1 L/40 L water	Spot spray. Thoroughly cover all pad surfaces.

1 Commercial products listed here are examples only, and many other products containing these active ingredients are registered for use on cacti. Visit www.apvma.gov.au to find registered products.

2 Products may be registered for use on cacti in all states and territories (shown as 'All') or only in the specific states and territories listed.

3 Products containing different concentrations of the active ingredients are registered for this use. For example, registered products containing the active triclopyr are available with 600, 750 and 755 g/L concentrations. Check the label for rates.

4 Higher doses of picloram such as by soil application can remain active in soil for extended periods and may leach into groundwater.

5 Users of the Victorian DPI Restricted use chemicals must be the holder of an Agricultural Chemical User Permit (ACUP) or be working under the direct and immediate supervision of an ACUP holder and must make and keep certain specified records of use for two years.

Note: not all currently registered herbicides are commercially available. Check the company website for a current label.

Note: herbicides are not to be used for any purpose or in any manner contrary to the label unless authorised under appropriate legislation. By law, you must read the label (or have it read to you) before using any herbicide product. The same applies for minor use permits. Always follow the label and permit directions.

Foliar spraying

Page 95 – Foliar spraying can be used in combination with other methods. If you are using both foliar spraying and biocontrol:

- spraying should be focused in a 10–15 m buffer along roads, paths and boundaries
- use of biocontrol should be focused on the core infestation.

Particular care should be taken to spray any loose cladodes and make sure you have thoroughly covered all parts of the plant. This will prevent spread.

Scattered or smaller plants can be sprayed using a backpack. For larger plants, use a spray unit to ensure thorough coverage.

In the Northern Slopes of NSW, for instance, evidence shows that it is effective to use a backpack for Hudson pear (*Cylindropuntia pallida*) plants less than 0.5 m high and not too wide. Use a spray unit for plants larger than this.

Stem injection (pad injection/drill and fill)

Page 96–99 (and page 118–121 for case study 2) – This section describes the effective use of the device called a 'Velpar® Spot Gun' to treat cacti with either glyphosate or MSMA **but not Velpar®** (hexazinone).

At the time of writing there are no registrations or permits for the use of hexazinone to control declared cacti.

An incorrect statement appears at the bottom of page 96: ~~"Glyphosate is registered for use for this application method throughout Australia".~~

Stem injection is not a registered application technique.

It is a permitted use only, with the following permits current at the time of writing:

- glyphosate – PER13371 – South Australia only
- MSMA – Permit PER14787 – Tarrangower Cactus Control Group, Victoria.

The herbicide MSMA is a a Schedule 7 (S7) poison; from a work, health and safety perspective it **should not be used in devices carried on the user's back**.

The Tarrangower Cactus Control Group have advised that they are still using hand digging and pad injection to treat wheel cactus (see page 118 for case study 2). No easier or more effective control methods have been found.

Because major infestations of wheel cactus remained, the group introduced cochineal, a biocontrol agent, on some properties in 2019 – particularly at inaccessible locations. However, it failed to establish and spread at most locations. It is thought that the wetter, cooler weather in the area over the last couple of years reduced the survival of the cochineal insect.

Case study: Successful pad injection at Pigeon Hill, Victoria

The landowners of a severely cacti-infested 185-acre property in the Pigeon Hill area (near Maldon) successfully treated wheel cactus using direct pad injection of glyphosate.

Using a contractor over 10 years they learned the following lessons:

- Ignoring a cactus infestation is not a viable strategy. It does not go away and can be more overwhelming for the property owner.
- Early intervention is the best strategy to manage cacti and keep control costs low.
- Each successive sweep of the property to treat cactus regrowth requires ever-decreasing effort.
- If you employ a contractor, build trust and together set realistic goals that will complete the task, aiming to reduce the infestation to a level that the landowner can maintain themselves.
- The time and money spent on reducing cactus infestations is an investment, resulting in increased value of the property.
- Preventing cacti from fruiting and producing seeds is responsible land management that benefits neighbours, the natural environment and the general community.

More details are online within the Tarrangower Cactus Control Group's case studies. Thank you to the property owners Denis and Jeff for sharing these lessons.

Stem injection with encapsulated herbicide

Stem injection of herbicide capsules can be used to control opuntioid cacti infestations. Di-Bak™ AM is a herbicide produced in capsule form, containing a combination of aminopyralid and metsulfuron-methyl.

Capsules can be inserted into the tree using a specially designed handheld applicator. The applicator, used in conjunction with a hand held drill, first drills a hole into the tree stem and then inserts the capsule. The capsule is sealed in place with a plug.

Alternatively, drill a 25-mm-deep hole in the tree stem using an 8 mm-diameter drill bit, approximately 10–30 cm above ground level. Insert one capsule and seal with a plug immediately.

Over time, the capsule dissolves, releasing the bioherbicide into the plant. This process can be performed at any time of year and is a cost-effective method suitable for low-to-high-density populations.

Further information on using this technique can be found at https://www.bioherbicides.com.au/about/videos-resources/

Biological control

Biological control of opuntioid cacti dates back to the early 1900s in Australia, with management efforts focused on species of *Opuntia* (the famous prickly pears) and several species of *Cylindropuntia.*

While scientists know some information on the natural enemies of *Austrocylindropuntia*, no biocontrol research on *Austrocylindropuntia* species has been attempted.

Since 1914, over 20 biological control agents have been introduced in Australia for *Opuntia* species, 14 of which have established. The most successful of these are:

- the cactus moth (*Cactoblastis cactorum*)
- cochineal insects (*Dactylopius* spp.) of several species and lineages (see Table 7).

Only one biological control agent has been released and is established in Australia for *Cylindropuntia* species:

- cochineal insect *Dactylopius tomentosus* (six lineages across the eight *Cylindropuntia* species present in Australia; see Table 7).

Understanding terms: lineage vs biotype

Page 104 – The original manual refers to 'biotypes' of *Dactylopius* species. 'Lineages' is now considered the more accurate term.

Lineages are populations of the same species (e.g. *Dactylopius tomentosus*) that can only be separated by their different abilities to feed, lay eggs and develop on a target species. Only molecular tools can distinguish between different lineages.

Different lineages target different *Opuntia* and *Cylindropuntia* species.

Biotypes are a group of organisms that have an identical genetic constitution. The organisms share a specified genotype.

Source: Harvey et al. 2021

Table 7. List of common Cylindropuntia *and* Opuntia *species and status of associated biological control agents*

SPECIES NAME	COMMON NAME/S	BIOLOGICAL CONTROL AGENT/S	EFFECTIVENESS OF AGENT
Species for which agents provide effective control			
Cylindropuntia fulgida var. mamillata	Boxing glove cactus, coral cactus	*Dactylopius tomentosus* 'cholla' lineage	Effective control provided.
Cylindropuntia imbricata	Rope pear, devil's rope pear	*Dactylopius tomentosus* 'cylindropuntia' lineage	Effective control provided. Released at several sites in north-western and western NSW, where field observations indicate this lineage is more damaging than 'imbricata'. Released at a small number of sites in Qld.
		Dactylopius tomentosus 'imbricata' lineage	Effective control provided. Prevalent in Qld and SA.
		Dactylopius tomentosus 'bigelovii' lineage	Research indicates good potential however further testing required.
Cylindropuntia kleiniae	Klein's cholla	*Dactylopius tomentosus* 'imbricata' lineage	Effective control provided.
		Dactylopius tomentosus 'bigelovii' lineage	Research indicates good potential however further testing required.
Cylindropuntia leptocaulis	Candle cholla	*Dactylopius tomentosus* 'imbricata' lineage	Effective control provided.
Cylindropuntia pallida	White spined Hudson pear	*Dactylopius tomentosus* 'californica var. parkerii' lineage	Effective control provided in some locations, but has not proven to be effective in SA as yet.
Cylindropuntia spinosior	Snake cactus	*Dactylopius tomentosus* 'bigelovii' lineage	Effective control provided. Released at a small number of sites in NSW where it is impactful once established (which can take time).
		Dactylopius tomentosus 'spinosior-safford' lineage	Research indicates good potential however further testing required.
Cylindropuntia prolifera	Jumping cholla	*Dactylopius tomentosus* 'californica var. parkerii' lineage	Effective control provided.
Cylindropuntia tunicata	Brown spined Hudson pear	*Dactylopius tomentosus* 'acanthocarpa var. echinocarpa' lineage	Effective control provided.
Opuntia aurantiaca	Tiger pear	*Dactylopius austrinus*	Effective control provided.
		Cactoblastis cactorum	Provide some control, though not as effective as *Dactylopius austrinus*.
		Tucumania tapiacola	

SPECIES NAME	COMMON NAME/S	BIOLOGICAL CONTROL AGENT/S	EFFECTIVENESS OF AGENT
Opuntia elata	Riverina pear	*Cactoblastis cactorum*	Effective control provided.
		Dactylopius opuntiae 'ficus' lineage *Dactylopius ceylonicus*	Further testing of *Dactylopius* in progress to determine effectiveness.
Opuntia englemannii	Engelmann's prickly pear	*Dactylopius opuntiae* 'ficus' lineage	Effective control provided.
Opuntia monacantha	Smooth tree pear	*Dactylopius ceylonicus*	Effective control provided. Takes several years to kill plants.
		Cactoblastis cactorum	Attacks plants and limits growth but does not control it.
Opuntia robusta	Wheel cactus	*Dactylopius opuntiae* 'ficus' lineage	Effective control provided.
Opuntia stricta	Common prickly pear	*Cactoblastis cactorum* *Dactylopius opuntiae* 'stricta' lineage	Effective control provided.
Opuntia tomentosa	Velvety tree pear	*Cactoblastis cactorum*	Effective control provided on young, small plants.
		Dactylopius opuntiae 'stricta' lineage	Effective control provided.
Further work required to identity an agent or to determine agent effectiveness			
Opuntia elatior	Red-flower prickly pear	Dactylopius opuntiae 'ficus' lineage	Effective control provided in NSW based on field observations. Released in SA in 2022, however field efficacy has not been evaluated.
Opuntia humifusa	-	Dactylopius opuntiae 'stricta' lineage	South African research indicates this lineage may be suitable, however there is a lack of data in Australia to confirm.
Opuntia puberula	-	None currently available.	Further testing of *Dactylopius* required
Opuntia schickendantzii	Chicken dance cactus	None currently available.	Further testing required to confirm efficacy
Opuntia streptacantha	Westwood pear	None currently available.	Further testing of *Dactylopius* required

The following text is sourced from:

Harvey KJ, McConnachie AJ, Sullivan P, Holtkamp R and Officer D (2021) *Biological control of weeds: a practitioner's guide for south-east Australia*, NSW Department of Primary Industries.

Approval from NSW Department of Primary Industries to use this information is gratefully acknowledged.

Effectiveness of agents

Cactus moths (cactoblastis)

Cactus moths feed on many opuntioid species, giving excellent control throughout Australia. Entire plants are often destroyed, but any uneaten cladodes can grow into new plants.

The biological control program for *Opuntia* spp. is regarded as one of the most successful examples of biological control in Australia. A benefit–cost ratio of 312:1 has resulted in productivity gains of over $3 billion between 1903 and 1987 (net present value; Page and Lacey 2006).

Cochineal insects

Some cochineal insect species (especially *Dactylopius tomentosus) have different lineages that target different Opuntia and Cylindropuntia species. These different lineages show great variation in their impact and are highly host specific.*

Cochineal-infested cladodes usually wither and die within three years. More rapid control is usually achieved in drier years.

Prickly pear bug

Chelinidea tabulata (prickly pear bug) has been reported in high numbers around South East Queensland in recent years. This plant-sucking bug was introduced from Texas in 1921.

It was effective against dense infestations of common prickly pear prior to the release of the cactus moth *Cactoblastis cactorum*. The prickly pear bug also attacks most other prickly pears, and has been reported on *Cylindropuntia imbricata*.

Current research

The Queensland Department of Agriculture and Fisheries (QDAF) is currently researching whether established *Dactylopius* spp. can be used to effectively control other *Opuntia* species not currently targeted. Work on *Dactylopius tomentosus* lineages is also ongoing.

Ongoing molecular work aims to identify both the cactus species and cochineal agents across Australia in an effort to better match biocontrol agents to weed species. Outcomes will contribute to a future database of verified distribution records for both the weeds and agents.

The NSW Department of Primary Industries currently has a project to mass rear, release and conduct a postrelease evaluation of *D. tomentosus* ('californica var. parkeri' lineage) in NSW.

Redistribution of agents

Different lineages of cochineal insects are highly host specific, so it is important to use the correct lineage for each target species. The correct cochineal species (or, in some cases, lineage) must be matched to its target cactus species, otherwise successful control will not be achieved. Discuss this with your local weed or biosecurity officer before redistributing agents directly from the field.

The current QDAF project aims to redistribute and establish all six lineages of *D. tomentosus* on numerous *Cylindropuntia* spp. infestations across Australia, especially outlying populations, to limit their spread. Multiple releases have been conducted in New South Wales, Queensland and Western Australia and mass-rearing facilities established (e.g. NSW Department of Primary Industries, Lightning Ridge) to expedite the release of some lineages.

Long-term monitoring programs have been established to determine the impact of several of cochineal lineages on their targets. For example, monitoring has indicated extremely effective control by *D. tomentosus* ('cholla' lineage), infesting over 99% of *C. fulgida* var. *mamillata* plants in two study areas, and killing 95% of plants within an 18-month period.

Mass-rearing facilities for Opuntia spp. biological control agents have also been established in a number of areas in Australia, including South Australia.

Read more about collecting, rearing and monitoring biological control agents on opuntioid cacti in the NSW DPI's biological control practitioner's guide.

Biocontrol Hub

Information sharing is vital to the success of biological control of weeds. Recording what weed species you are controlling, and the locations of agent release sites can also assist others obtaining access to the right agents for their infestation.

The Atlas of Living Australia (ALA) is a national online biodiversity database that helps information sharing. The Australian Biocontrol Hub is a portal within the ALA that acts as a one-stop shop for data and information sharing on weed biological control.

The Biocontrol Hub can:

- facilitate recording of biological control agent release and establishment data
- capture observations of biological control agent spread
- ensure biological control agent distribution data is readily accessible and
- provide access to biological control extension material.

For further information on how to contribute to or use information on the Australian Biocontrol Hub, visit the website: https://biocollect.ala.org.au/biocontrolhub

Chapter 5 Case studies

Case study 1 Cacti eradication: The Northern Territory approach

Page 114–117

UPDATE by Chris Brown

The 2016 Northern Territory declaration of the 27 species of opuntioid cacti (including numerous *Cylindropuntia* and *Opuntia* spp.) was in line with the national declaration of these species as Weeds of National Significance (WoNS).

A compliance program followed, with an extensive education and awareness campaign in the Alice Springs region undertaken by both by the Weed Management Branch (WMB) of the NT Department of Environment, Parks and Water Security and Alice Springs Landcare.

Since then, WMB staff have done approximately 6,500 roadside inspections, identifying 35 properties with declared cacti. Weed-control orders were issued to 10 landowners for noncompliance, which have since been successfully resolved.

All declared species of *Cylindropuntia* and *Opuntia* cacti are listed as priority weeds for eradication in the Alice Springs region in the Alice Springs Regional Weeds Strategy 2021–2026.

In late 2019 and early 2020, the WMB undertook a successful compliance program, targeting the removal of high-risk amenity (aesthetic) plantings of declared cacti located in urban and rural gardens in Alice Springs. The presence of declared cacti in these locations posed a significant, ongoing risk of reinvasion for landscapes in the Alice Springs region.

WMB officer assisting a landholder with the survey and control of common prickly pear (Opuntia stricta) on Aileron Station, north of Alice Springs, in 2018. Source: Chris Brown.

All 10 known infestations of declared cacti located in the pastoral estate in the Alice Springs region are under active management programs as landowners work towards eradication. The WMB undertakes compliance monitoring of these sites.

Community action involving Alice Springs Landcare; NT Parks and Wildlife; NT Department of Environment, Parks and Water Security; and local volunteers continues. Together, they control naturalised outbreaks of coral cactus (*Cylindropuntia fulgida* var. *mamillata*) in the rocky hill slopes north-east of Alice Springs (centred in and around the Telegraph Station Historical Reserve).

It is envisaged that – with the continuation of compliance programs, ongoing awareness and education programs, and community involvement – eradication of declared cacti from the Alice Springs region is achievable in the longer term.

Contacts

STATE/ TERRITORY	DEPARTMENT	PHONE	EMAIL	WEBSITE
National	Australian Pesticides and Veterinary Medicines Authority	02 6770 2300	enquiries@apvma.gov.au	www.apvma.gov.au
ACT	Parks and Conservation	13 22 81	ACTBiosecurity@act.gov.au	www.environment.act.gov.au/parks-conservation/plants-and-animals/Biosecurity/invasive-plants
NSW	Department of Primary Industries	1800 680 244	weeds@dpi.nsw.gov.au	www.dpi.nsw.gov.au/biosecurity/weeds
NT	Department of Environment, Parks and Water Security	08 8999 4567	weedinfo@nt.gov.au	www.nt.gov.au/environment/weeds
Qld	Department of Agriculture and Fisheries	13 25 23	info@daf.qld.gov.au	www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/plants-weeds
SA	Department of Primary Industries and Regions	1300 374 731	invasivespecies@sa.gov.au	www.pir.sa.gov.au/biosecurity/weeds
Tas	Department of Natural Resources and Environment	1300 368 550	biosecurity.tasmania@nre.tas.gov.au	www.nre.tas.gov.au/invasive-species/weeds
Vic	Agriculture Victoria	13 61 86	Refer to www.agriculture.vic.gov.au/about/contact-us for contact options	www.agriculture.vic.gov.au/biosecurity/weeds
WA	Department of Primary Industries and Regional Development	08 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au/pests-weeds-diseases/weeds

Further information

Case study of *The Successful Biological Control of Cylindropuntia Fulgida VAR. Mamillata (a. Schott Ex Engelm.) Backeb. (Cactaceae) (Coral or Boxing Glove Cactus) at Two Field Sites in Queensland, Australia*. Jones et al. (2022). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4200230

Page, A.R. and Lacey, K.L. (2006). Economic impact assessment of Australian weed biological control. Technical Series 10. CRC for Australian Weed Management, Adelaide.

Project report of *A Multi-pronged Strategy for Wheel Cactus Control*. Tarrangower Cactus Control Group Inc. (2019). https://cactuswarriors.org/newsite/wp-content/uploads/2020/02/Multi-pronged-Management-Project-Report.pdf (PDF, 2.2 MB)

Videos about cacti and controlling them. Northern Slopes Landcare (n.d.). https://www.northernslopeslandcare.com.au/cacti/cacti-news-media/cactus-news/85-hudson-pear-cylindropuntia-pallida

Compendium on the common prickly pear (*Opuntia stricta*). Olivia Mosse (2020). https://storymaps.arcgis.com/stories/bea70a04f4544e248c08e3b43d91ba26

Weeds Australia opuntiod cacti profile. Weeds Australia (2019). https://weeds.org.au/profiles/prickly-pears/

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