Department of Agriculture and Food

GOVERNMENT OF WESTERN AUSTRALIA

Situation Statement on Opuntioid Cacti (*Austrocylindropuntia* spp., *Cylindropuntia* spp.and *Opuntia* spp.) in Western Australia

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Cover photo: *Cylindropuntia fulgida* var. *mamillata* at Gwalia, by David Fitzgerald

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31 March 2014

Acknowledgements

The development of the opuntioid cacti situation statement has relied upon published information from a diverse group of stakeholders to provide up to date information on the distribution and abundance of cacti across Western Australia and the management actions currently in use.

The situation statement has also highlighted the large store of knowledge that has not been published, but is retained by individuals who are concerned about the management and control of invasive cacti.

The authors would like to acknowledge the skills and expertise of the many individuals who have contributed to the situation statement; in particular, we would like to thank Mike Chuk and Dr Bob Chinnock for their advice and support.

Jane Bradley from the Rangelands NRM, and Kay Bailey, Jon Dodd and Viv Read from the Department of Agriculture and Food Western Australia made valuable comments on report drafts. Jon Dodd also performed extensive editing of the statement.

We also wish to acknowledge: Dan Coleman, Main Roads Western Australia;

Department of Parks and Wildlife for permission to use FloraBase maps;

Horticulture Australia Limited for permission to use the map reproduced as Figure 8;

Glen Coupar, Kate Detchon, Rebecca Dray, Mac Jensen, Mike Jones, Lara Martin, Simon Merewether and James Sheehan from the Department of Agriculture and Food WA;

Steve Csurhes, Department of Agriculture Forestry and Fisheries, Queensland;

Lorraine Edmunds (South Australia), David Fitzgerald and Jane Bradley (WA) and Desert Channels Queensland for permission to reproduce images;

Royce Holtkamp, Department of Primary Industries NSW;

Jennifer Jackson and Vanessa Jackson, Department of Parks and Wildlife;

Steve Januszkiewicz, APD Pest Control;

Matthew Kennewell, Southcoast NRM;

Andrew Mitchell, retired botanist formerly with the Northern Australia Quarantine Strategy (NAQS);

John Peirce, retired senior research officer formerly with the Department of Agriculture and Food Western Australia;

Henry Rutherford, former WoNS Opuntioid Cacti Coordinator with Biosecurity South Australia; and

Helmuth Zimmermann, retired South African expert on invasive cacti and their biological control.

Table of Contents

Figures

Tables

Acronyms

BAM Act, BAMA	Biosecurity and Agricultural Management Act, 2007
DAFWA	Department of Agriculture and Food, Western Australia
DPAW	Department of Parks and Wildlife (formerly Department of Environment and Conservation, DEC)
LGA	Local Government Authority
RBG	Recognised Biosecurity Group
WoNS	Weed (or Weeds) of National Significance

Executive Summary

The opuntioid cacti are Weeds of National Significance, recognised for their agricultural, environmental and social impacts and the associated economic costs.

The purpose of this situation statement is to provide a snapshot of the opuntioid cacti in Western Australia by describing their current distribution, impact and management in WA, and identifying the major stakeholders that can contribute to the active management of these species.

Opuntioid cacti already infest large areas of southern and eastern Australia. In WA the total area infested is relatively small; however, the scattered infestations are dispersed widely from the Pilbara to the south coast, and have the potential to significantly increase their abundance, particularly in the southern rangelands. Abandoned and unmanaged cactus gardens, unmanaged infestations and dumping of unwanted cacti are important sources of new infestations.

To date, infestations of 16 different species of opuntioid cacti have been recorded in WA. Their current collective impact is low, but they present potentially large impacts, especially on the agricultural activities, biodiversity and cultural values of the rangelands.

DAFWA is currently reviewing the declaration status of the opuntioid cacti. Six species of opuntioid cacti are already declared in parts of WA, but this is not sufficient to ensure the appropriate management of all opuntioid cacti in WA.

The collective knowledge of the opuntioid cacti in Australia is relatively poor, but improving, and is fragmented across State jurisdictions and between government agencies, NRM and community groups. Significant challenges exist to achieving a coordinated approach to the management of opuntioid cacti in WA. For example, the collection and identification of specimens of weedy cacti is difficult, accurate distribution maps are not available, and more work is needed on identifying suitable control techniques.

There is a need to have a nationally supported best practice management guide to bring together the management, biological and control information for this diverse group of cacti.

A large number of stakeholders with interests in and/or responsibilities for the management of naturalised opuntioid cacti are identified in WA. The diversity of stakeholders and their differing capacities to manage opuntioid cacti adds to the complexity of achieving coordinated management.

Since 2012 there has been increasing interest in the management of opuntioid cacti in WA. It is intended that this situation statement will contribute to the further development of state, regional and species-specific management and response plans for these significant weeds.

1. Introduction

The opuntioid cacti (*Austrocylindropuntia* spp., *Cylindropuntia* spp. and *Opuntia* spp. except *O. ficus-indica*) were named as Weeds of National Significance (WoNS) in April 2012 (weeds.org.au/WoNS/opuntioidcacti/). They will be referred to in this report collectively as the opuntioid cacti.

In this report, the cacti will generally be referred to by their scientific names, because of the large number of common names available for some species, and the lack of consistency in their use for individual species. Some species lack common names.

1.1 Purpose and scope

The purpose and scope of this situation statement is to document the distribution, impact and current knowledge (and knowledge gaps) of the opuntioid cacti in Western Australia (WA)[1]. It also identifies the major stakeholders for control of these weeds, which includes landholders associated with the pastoral industry, Recognised Biosecurity Groups (RBGs), the Rangelands NRM, Local Government Authorities, community groups, mining companies, the Department of Parks and Wildlife (DPaW) and the Department of Agriculture and Food (DAFWA).

1.2 Links to DAFWA invasive species strategies

Opuntioid cacti have the potential to cause agricultural, environmental and some social impacts, and for these reasons they can be considered as significant weeds for the Invasive Species program.

As a group, the opuntioid cacti in WA are at the lower end of the 'Generalised Invasion Curve', where the return on investment in control is greater than for widespread weeds (Figure 1). DAFWA's interest in this group of weeds is consistent with the *Invasive Species Strategy for DAFWA Support of Agricultural and Pastoral Industries in Western Australia* (2012-2017).

Cacti have also been identified as targets for containment in the Goldfields, Pilbara, Carnarvon and Meekatharra sub-regions in DAFWA's *Rangelands Invasive Species Regional Strategy*.

Because of their status as WoNS and the risks they pose to agriculture, the environment and social amenities, further declarations of opuntioid cacti within WA are being considered.

1.3 Ecological information

Cacti belong to the family Cactaceae and are native to the Americas. There are no native Australian cacti. They can withstand arid conditions and drought due to their ability to store water, and they can tolerate a wide range of temperatures. These characteristics, in combination with being armed with spines and being difficult and expensive to kill, make the opuntioid cacti especially hard to manage.

[1] It is planned to update this Situation Statement as further information becomes available.

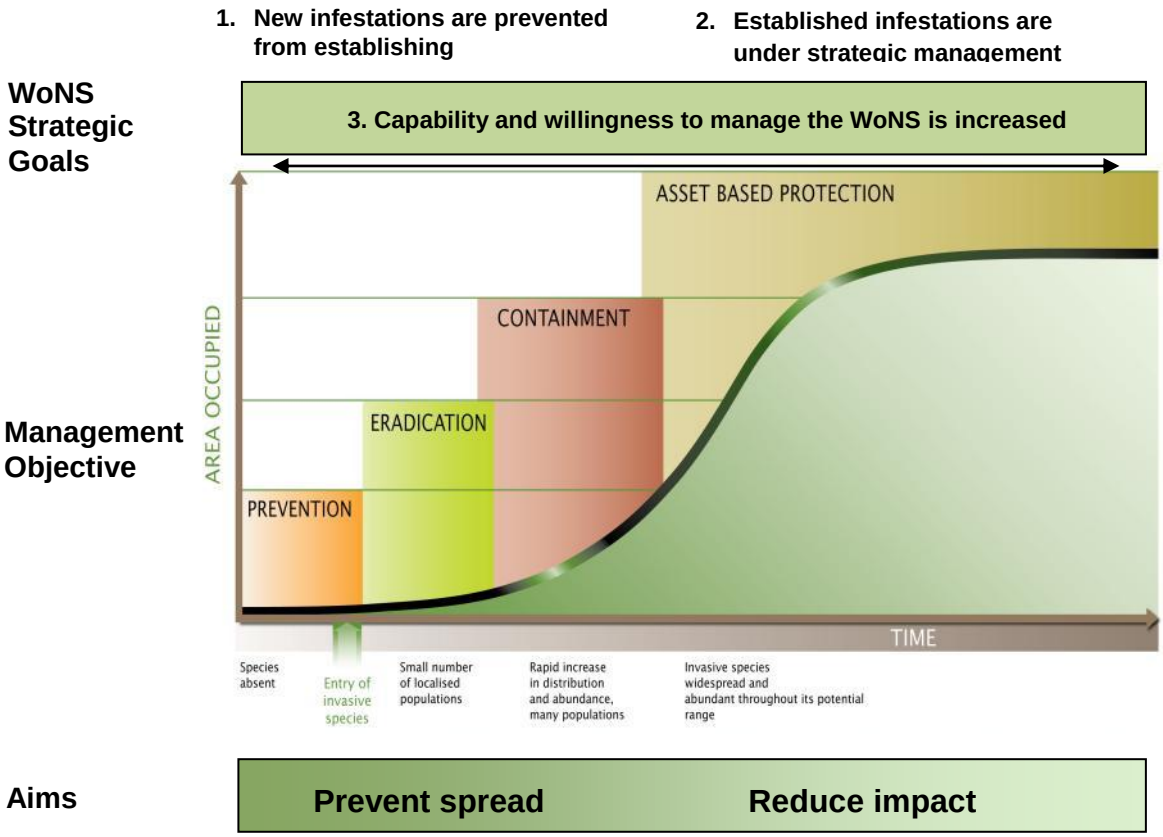

Figure 1. The Generalised Invasion Curve showing stages of weed invasion with corresponding goals, management objectives and actions at each stage, sourced from the Weeds of National Significance Opuntioid Cacti Strategic Plan (Australian Weeds Committee, 2012)

The opuntioid cacti are long-lived perennials with life spans measured in decades. For example, Bobich (2005) described *Cylindopuntia fulgida* with a life span of 30-40 years as “relatively short-lived”. They are distinguished from other cactus sub-families by having small detachable barbed bristles called glochids.

Some weedy cacti reproduce both by seed and vegetatively, while others are not known to produce fruits or seeds, and reproduce only vegetatively. Vegetative reproduction usually occurs from stem segments, technically known as cladodes but often referred to as pads. Vegetative reproduction can also occur if fleshy parts of flowers or immature fruits make contact with the ground. In some species, detached stem segments may remain dormant for long periods, although it is not known how long they can remain so, or what triggers them to take root. There is anecdotal evidence from other parts of Australia that large numbers of small segments will grow rapidly after successful control of parent plants, but the trigger for this is unknown.

Cacti have an important physiological adaptation that helps them to conserve water in arid environments; their photosynthesis demonstrates Crassulacean Acid Metabolism (CAM), which means that their stomata remain closed during the day to minimise evapotranspiration, then open at night to absorb carbon dioxide (Walters *et al.*, 2011).

2. Opuntioid cacti in Western Australia

The group of opuntioid cacti named as Weeds of National Significance currently consists of 27 known species in three genera: *Austrocylindropuntia*, *Cylindropuntia* and *Opuntia*[2]. It is likely that more species and/or hybrids will be discovered as further mapping and documentation of infestations occurs across Australia. At least two naturalised opuntioid cacti found recently in WA remain unidentified.

2.1 *Austrocylindropuntia*

Austrocylindropuntia species are distinguished by having non-segmented cylindrical branches that are of unlimited growth and which produce lateral branches. Their spines are not sheathed. The genus has 11 species, of which two are known to have naturalised in Australia.

FloraBase has one record of *A. cylindrica*, found at Kulin in 1999; the plants were destroyed by land clearing in 2012 (Lara Martin, DAFWA, pers. comm.). *A. subulata* has been found on a vacant house block in Mount Barker; however, these plants are regarded as survivors from an old planting rather than being naturalised.

2.2 *Cylindropuntia*

Cylindropuntia species have cylindrical or rope-like branches that are segmented. Their spines are sheathed.

Eight *Cylindropuntia* species have naturalised in Australia, with five known to have naturalised in Western Australia: *C. fulgida* (with two varieties, var. *fulgida* and var. *mamillata*), *C. imbricata*, *C. kleiniae*, *C. rosea* and *C. tunicata*.

Knowledge of the naturalised *Cylindropuntia* species continues to grow. The only known infestation of *C. kleiniae* was identified in January 2014 at Williamstown, in Kalgoorlie, although it had obviously been present for several years

Of the naturalised *Cylindropuntia* species in WA, *C. fulgida* var. *mamillata* (commonly known as coral cactus in WA) is by far the most widespread, and is known from the Pilbara, Gascoyne, Murchison and Goldfields. The largest known infestation of *C. fulgida* var. *mamillata* is on Tarmoola Station in the Shire of Leonora. This cactus is not known to be naturalised in the Kimberley, but is present in at least two gardens in that region, and may be more widely cultivated. A Media Statement released by DAFWA in September 2013 asking Kimberley residents to report cacti to DAFWA resulted in several reports of cacti in gardens, including *C. fulgida* var. *mamillata*.

[2] *Austrocylindropuntia*, *Cylindropuntia* and *Opuntia* were previously placed in the single genus *Opuntia*.

C. fulgida var. *mamillata* is considered to be the most rapidly spreading of the opuntioid cacti in Australia (Mike Chuk, pers., comm.)[3]. The earliest WA Herbarium specimen of *C. fulgida* var. *mamillata* was collected from Quobba Station (north of Carnarvon) in 2000; however, it has been naturalised there since at least the mid 1980s with DAFWA officers providing advice on its control in the mid to late 1980s (John Peirce[4] pers. comm.).

In the WA Goldfields and some other parts of Australia, *C. fulgida* var. *mamillata* is reverting to its original form, *C. fulgida* var. *fulgida* (Figure 2), which is far more spiny than var. *mamillata* (Mike Chuk and Bob Chinnock[5] pers. comm.).

Figure 2. *Cylindropuntia fulgida* var. *mamillata* reverting to *Cylindropuntia fulgida* var. *fulgida* at Gwalia (photo by Sandy Lloyd, DAFWA)

Some *Cylindropuntia* species, especially *C. fulgida* var. *mamillata*, have stem segments that detach easily (Figure 3). Some *Cylindropuntia* species produce fruits, although the seeds are not always viable. It is reported that *C. fulgida* var. *mamillata* does not produce flowers or fruits in Australia, apart from the population at

[3] Mike Chuk is Chair of the Australian Invasive Cacti Network and a Consultant with of the Desert Channels Queensland NRM group.

[4] John Peirce is a retired DAFWA weeds Research Officer.

[5] Dr RJ (Bob) Chinnock is a retired taxonomist, based in South Australia, who specialises in documenting and identifying the naturalised cacti of Australia.

Tarmoola (Australian Weeds Committee, 2012; Potter and Rutherford, 2013; Rutherford[6], pers. comm.); however, a plant of *C. fulgida* var. *mamillata* was observed in flower in a garden at Burakin, south east of Dalwallinu (Kate Detchon, DAFWA, pers comm.) and fruiting plants have been observed at Gwalia (Mike Chuk, pers. comm.).

Figure 3. *Cylindropuntia fulgida* var. *mamillata* surrounded by detached segments, Tarmoola Station (photo by Jane Bradley, Rangelands NRM).

C. imbricata currently occurs in the Pilbara, wheatbelt and Goldfields, although most infestations are small. At least one infestation, on the outskirts of Buntine in the Shire of Dalwallinu, is spreading into bushland (Kate Detchon, DAFWA, pers. comm.). *C. imbricata* produces viable seeds, which must be taken into account when managing this species, although the fruits do not seem to be attractive to birds. Similarly, *C. tunicata* produces viable seeds, but the fruits are not attractive to birds or other animals (Johnson *et al.*, 2009).

C. tunicata and *C. rosea* are similar-looking species that could be confused; in NSW both share the common name of Hudson pear. They have long sharp spines that are strong enough to pierce heavy work boots and car tyres. Both species have great potential for further spread in WA. The largest known infestation of *C. tunicata*

[6] Henry Rutherford is the former WoNS Opuntioid Cacti Coordinator with Biosecurity SA

in WA is within Coolgardie town site. The largest known *C. rosea* infestation in WA is at an old tip in the Shire of Menzies.

Infestations of *C. tunicata* and *C. rosea* in other states provide an indication of the potential impact of these species in WA; for example, *C. rosea* infests 60 000 hectares around Lightning Ridge, NSW, and a total of about 100 000 ha in north-western NSW. The Castlereagh-Macquarie County Council has spent some $500 000 on controlling *C. rosea*; and the Lightning Ridge Miners Association and Grawin, Glengarry, Sheepyard Miners Association have spent a similar amount between them to control *C. rosea* (Royce Holtkamp, NSW Department of Primary Industries, pers. comm.).

2.3 *Opuntia*

The *Opuntia* species are probably the most easily recognised of the opuntioid cacti, with their large round or oval flattened segments, usually known as pads. They are often referred to collectively as prickly pears or prickly pear cacti. Several *Opuntia* species are naturalised in WA, in parts of the Pilbara, Gascoyne, Murchison, Goldfields, the south-west and south coast. None is known to be naturalised in the Kimberley, although at least two species are in cultivation there. *O. ficus-indica* and *O. stricta* are considered to be the most widespread of the naturalised *Opuntia* species in WA.

Opuntia species have been cultivated in Australia for many years, and at least one, probably *O. monacantha*, the smooth pear or drooping tree pear, was brought to Australia by the first fleet in 1788 with the aim of establishing a cochineal industry to produce red dye. Some *Opuntia* plants reach two metres or more in height. They have yellow or orange flowers and some produce edible fleshy fruits.

Seven WoNS *Opuntia* species are known to have naturalised in WA: *O. elata*, O*. elatior*, *O. engelmannii*[7], *O. monacantha*, *O. puberula*, *O. stricta* and *O. tomentosa*. In addition, two unidentified *Opuntia* species, possibly hybrids, have been found on the Goldfields (Bob Chinnock, pers. comm.). There are several large *Opuntia* infestations in WA. For example, *O. elatior* infests about 200 hectares on Wydgee Station in the Shire of Mount Magnet (Reeves, 2013). An infestation of *O. stricta* at Scaddan, near Esperance, is estimated to be 2.5-3km long and about 1km wide at its widest point (Matthew Kennewell, Southcoast NRM, pers. comm.). *O. monacantha* is scattered along 6km of the Oldfield River in Ravensthorpe after being spread by floodwaters in the summer of 2006-7 (Dan Coleman, Main Roads WA, pers. comm.).

O. ficus-indica is common in cultivation in the southwest of WA, mainly for fruit production. No specimens of *O. ficus-indica* are held by the WA Herbarium (Table 2), yet there are several naturalised populations on the Goldfields and at least one near Carnarvon (Chinnock, pers. comm.), and DAFWA biosecurity officers have identified several small naturalised populations in the wheatbelt. *O. ficus-indica* is both cultivated and naturalised in the Perth Hills where numerous large naturalised

[7] Although FloraBase lists *O. engelmannii*, the single specimen in the WA Herbarium's collection is named as *O.* ? *engelmannii* because its identity has not been confirmed.

plants can be found along creek lines, particularly around Pickering Brook (Glen Coupar, DAFWA, pers. comm.). Orchardists report that the naturalised *O. ficus-indica* plants are a source of Mediterranean fruit fly which spreads to commercial fruit trees (Simon Merewether, DAFWA, pers. comm.).

As with the *Cylindropuntia* species, *Opuntia* infestations in other states provide an indication of the potential impact of these species in WA. For example, *O. aurantiaca*, which is not known to be naturalised in WA, infests large areas in eastern Australia, including 200 000 hectares in NSW (Australian Weeds Committee, 2012; Potter, 2011). *O. robusta* produces fleshy fruits with numerous viable seeds and is spread by fruit-eating birds. In SA it currently infests 35 000 hectares across the Flinders Ranges (Australian Weeds Committee, 2012). *O. robusta* has high potential as a weed in WA due to large areas of the south west of WA having moderately or highly suitable climates for this species (see Figure 6). It is not known to be naturalised in WA and has been reported only once in WA, in cultivation at Wongan Hills.

2.4 Distribution of opuntioid cacti in Western Australia

2.4.1 Opuntioid cacti in WA

Specimens of nine species of opuntioid cacti are held by the WA Herbarium and recorded on FloraBase (see Table 1 and Figure 4).

Table 1. Species of opuntioid cacti listed on FloraBase[8] (March 2014)

Scientific Name	Common Name	Location(s)
Austrocylindropuntia cylindrica	cane cactus	Kulin
Cylindropuntia fulgida* var. *mamillata	coral cactus	Pilbara, Gascoyne, Goldfields
Cylindropuntia imbricata	devil's rope cactus	Goldfields
Cylindropuntia rosea	Hudson pear	Goldfields
Opuntia elata		Goldfields, Pilbara
Opuntia elatior		Goldfields
Opuntia engelmannii		Goldfields
Opuntia monacantha	smooth tree pear	Perth, Wheatbelt, Goldfields
Opuntia stricta	prickly pear	South coast, Abrolhos, Pilbara

Herbarium records do not give the full picture of the presence or distribution of the opuntioid cacti in WA, because they are difficult to collect and preserve, and many infestations are in remote locations and are not represented by specimens.

[8] FloraBase is the Department of Parks and Wildlife database of the flora of Western Australia.

Collecting and preparing cactus specimens is very difficult, especially for species with glochids or long spines. Unlike most plants, cactus specimens cannot be simply put in a plant press and dried (some cactus specimens continue to grow while in plant presses in a drying oven: Bob Chinnock, pers. comm.).

To be prepared as herbarium specimens, cactus segments must be split and the excess flesh removed before freezing, then drying. Glochids continue to be shed even from well-prepared herbarium specimens, making handling them difficult and unpleasant (Andrew Mitchell, pers. comm.).

Naturalised opuntioid cacti currently have a wide distribution in Western Australia from the Pilbara, Gascoyne and Murchison, through the Goldfields, to the south coast. Populations range from small isolated colonies (outlier populations) to large well-established infestations.

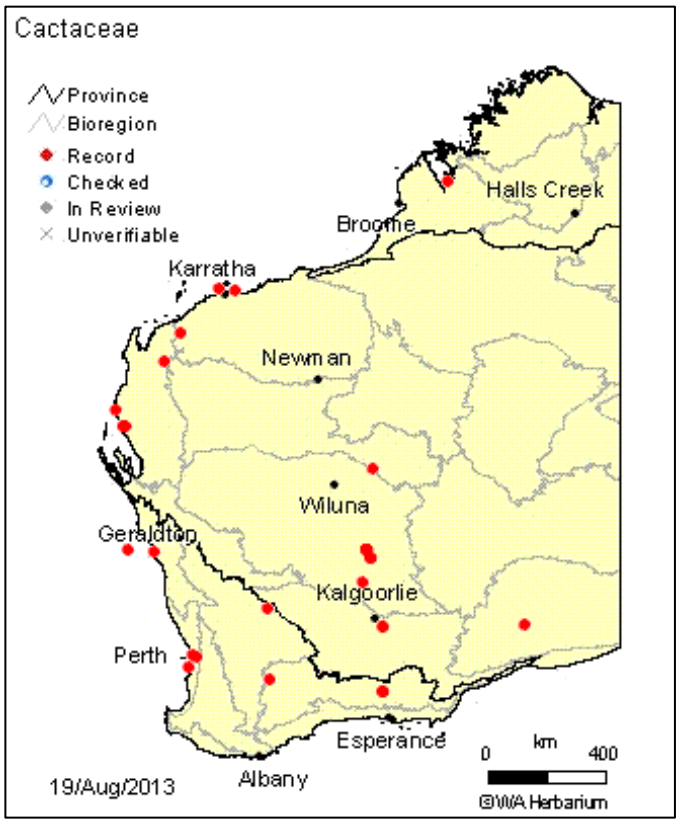

Figure 4. General distribution of Cactaceae in WA (listed in Table 1), illustrating the small number of sites from which specimens have been collected. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (florabase.dpaw.wa.gov.au/help/copyright). Accessed on 19 August 2013).

The non-WoNS species *Opuntia ficus-indica* is also naturalised in the Goldfields and the south west, with smaller populations in the Gascoyne. However, the opuntioid cacti have not been comprehensively documented or mapped in WA.

2.4.2 FloraBase and the WA Herbarium

Figures 4 and 5 are examples of outputs from FloraBase. They show the distribution of sites from which cacti (all genera and species) have been collected in WA (Figure

4) and the collection sites for specimens of the most widespread species, *C. fulgida* var. *mamillata* (Figure 5).

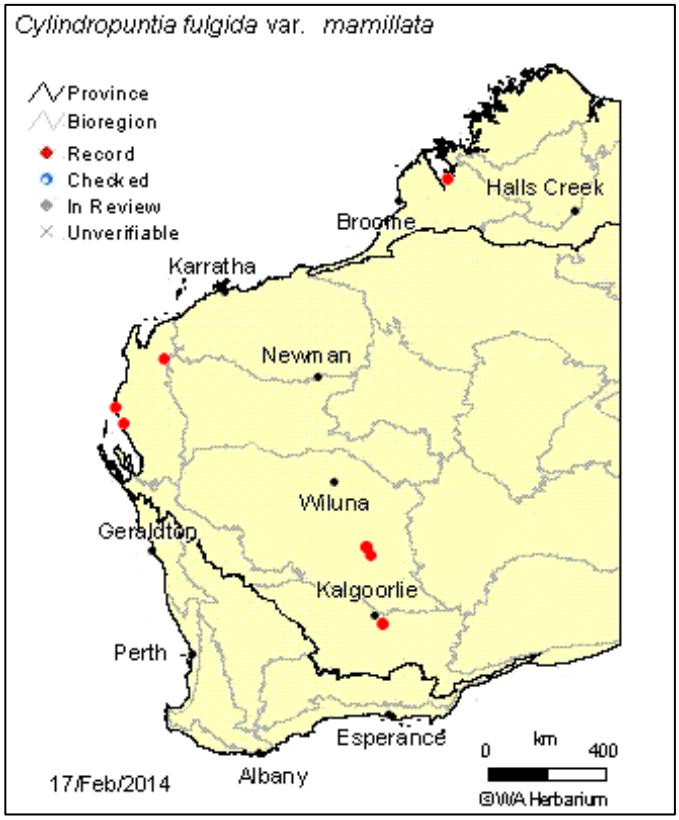

Figure 5. Collection sites of the most widespread species in WA, *Cylindropuntia fulgida* var. *mamillata*, which is known to occur from the Pilbara to the Goldfields, sometimes in quite large infestations. The plant in Derby is not naturalised. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (florabase.dpaw.wa.gov.au/help/copyright). Accessed on Thursday, 17 February 2014.

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Table 2. *Opuntia* species infestations recorded in Western Australia from 1 January 2000 to 31 January 2013

Region	IQC data entries
Central Agricultural	3
Northern Agricultural	3
Northern Rangelands	28
South West Agricultural	4
Southern Agricultural	1
Southern Rangelands	1

2.4.3 DAFWA Import Quarantine Compliance records

Only a limited number of records of opuntioid cacti exist in DAFWA's Import Quarantine Compliance (IQC) database, because only a few species of *Opuntia* are currently declared, and then only in the north of the State. This is illustrated by the relatively large number of entries for the northern rangelands (Table 2).

2.4.4 Current knowledge of the distribution of naturalised opuntioid cacti in WA

Reliable information on the current distribution of naturalised opuntioid cacti was collated from a range of sources to provide an overview of the current extent and status of these weeds in WA. The information presented in Table 3 is not comprehensive, but is a reasonable summary of current information.

Sources included WA Herbarium data, published and unpublished sources, and reliable verbal reports and anecdotal information. A particularly important source of information in recent years has been Bob Chinnock who has collected and identified opuntioid cacti from many parts of the state.

Sixteen species of opuntioid cacti are reported as being naturalised in WA. One species, *Cylindropuntia fulgida*, has two varieties (var. *fulgida* and var. *mamillata*). The identity of two naturalised *Opuntia* species is not yet known, they are probably hybrids (Table 3).

The size of many infestations is either currently unknown or has not been reported; however, some infestations are 200 ha or more in size. The two largest infestations in Table 3 are of *C. fulgida* var. *mamillata*, which covers about 1 000 ha (10 km^2) with a 100 ha (1 km^2) core at Gwalia town site, and about 6 600 ha (6.6 km^2) with a dense 3 ha core at Tarmoola Station.

Table 3. Examples of available information on opuntioid cactus infestations in Western Australia. (Note this is not a comprehensive account of WA opuntioid cactus infestations)

Scientific name (common name)	WoNS	Flora Base	Naturalised in WA	Reference to 26th parallel	Locations	Details
Austrocylindropuntia cylindrica (cane cactus)	Yes	Yes	Yes	Below	Kulin	Only one known infestation; destroyed during land clearing in 2012.
Cylindropuntia fulgida var. *mamillata* (coral cactus)	Yes	Yes	Yes	Both	Pilbara, Gascoyne, Goldfields	• Wooroora Station - infestation was described as covering 10-15 ha in a letter to the Australian Weeds Committee in September 2012 • Quobba Station - 15 ha • Infestation on Tarmoola Station, Leonora, covers about 66 km^2, or 6 600 ha. The rubbish tip is the core of the infestation and is about 3 ha in size (Jane Bradley, Rangelands NRM, pers. comm., February 2013). • Mardathuna Station – area not confirmed • Marilla Station – area not confirmed • The Gwalia infestation covers about 1 km2 at high density, and the whole infestation spreads over some 10 km2 or 1 000 ha (Mike Chuk, pers. comm., February 2013)
Cylindropuntia fulgida var. *fulgida*	Yes		Yes	Below	Goldfields	See Fig. 2

Table 3. (continued)

Scientific name (common name)	WoNS	Flora Base	Naturalised in WA	Reference to 26th parallel	Locations	Details
Cylindropuntia imbricata (devil's rope cactus)	Yes	Yes	Yes	Both	Goldfields, wheatbelt, Pilbara	Outskirts of Buntine, Shire of Dalwallinu, abandoned houses and rubbish tips. Lallah Rookh, an outstation of Strelley Station, West Pilbara
Cylindropuntia rosea (Hudson pear)	Yes	Yes	Yes	Below		The Menzies infestation of *C. rosea* is about 1.5 km x 1.5 km (~2.25 km^2 or 225 ha) (Mac Jensen, DAFWA, pers. comm., March 2013)
Cylindropuntia tunicata	Yes		Yes	Below	Goldfields	Coolgardie
Opuntia elata	Yes	Yes	Yes	Both		Indee Station infestation subject to eradication
Opuntia elatior	Yes	Yes	Yes	Below	Murchison	The Wydgee Station infestation of *O. elatior* originated from a planting near the tennis court about 80 years ago. It has spread into a creek line and now covers about 200 ha.
Opuntia engelmannii	Yes	Yes	Yes	Both		
Opuntia ficus-indica	No		Yes	Below		Naturalised in Carnarvon, Goldfields, Wheatbelt, Perth Hills; common in cultivation

Table 3. (continued)

Scientific name (common name)	WoNS	Flora Base	Naturalised in WA	Reference to 26th parallel	Locations	Details
Opuntia monacantha (smooth tree pear)	Yes	Yes	Yes	Below	Goldfields and wheatbelt	Goldfields; Oldfield River in Ravensthorpe
Opuntia polyacantha	Yes		Yes	Below	Wheatbelt locations	
Opuntia puberula	Yes			Below	Goldfields and wheatbelt	Zanthus
Opuntia stricta (prickly pear)	Yes	Yes	Yes	Both	Pilbara, Goldfields, south coast	Largest known infestation, at Scaddan, is estimated at being 2.5-3 km long and about 1 km wide at its widest point (~300 ha)
Opuntia tomentosa	Yes		Yes	Below	Goldfields	Coolgardie area (Steve Januszkiewicz, pers. comm.)
Opuntia 'sp. WA' unknown	Yes		Yes	Below	Goldfields	Tarmoola Station Gwalia town site (possibly an *O. microdasys* hybrid, Bob Chinnock, pers. comm.)
Opuntia sp. unknown	Yes		Yes	Below	Goldfields	Found by Megan Muir, DPaW, as part of Great Western Woodland weed survey.

2.4.5 Potential distribution

Apart from *Cylindropuntia fulgida* var. *mamillata*, the naturalised opuntioid cacti are more abundant and more widely distributed in eastern Australia than in WA. This discrepancy probably reflects their longer history as cultivated plants in eastern Australia, rather than any climatic or environmental unsuitability in WA.

The current distribution of the opuntioid cacti in eastern Australia indicates their potential distribution in WA; for example, the national WoNS map of potential distribution of *Opuntia robusta* (Australian Weeds Committee, 2012) (Figure 6) clearly shows that parts of the southern rangelands of WA and the southern agricultural region are climatically highly suitable for this particular species. *O. robusta* is not known to be naturalised in WA and is not common in cultivation.

Few other potential distribution maps of opuntioid cacti are currently available. South Australia was planning to prepare maps of potential distribution of several species and share them with the other jurisdictions; however, this is not progressed because funding for the WoNS Opuntioid Cacti program has ceased.

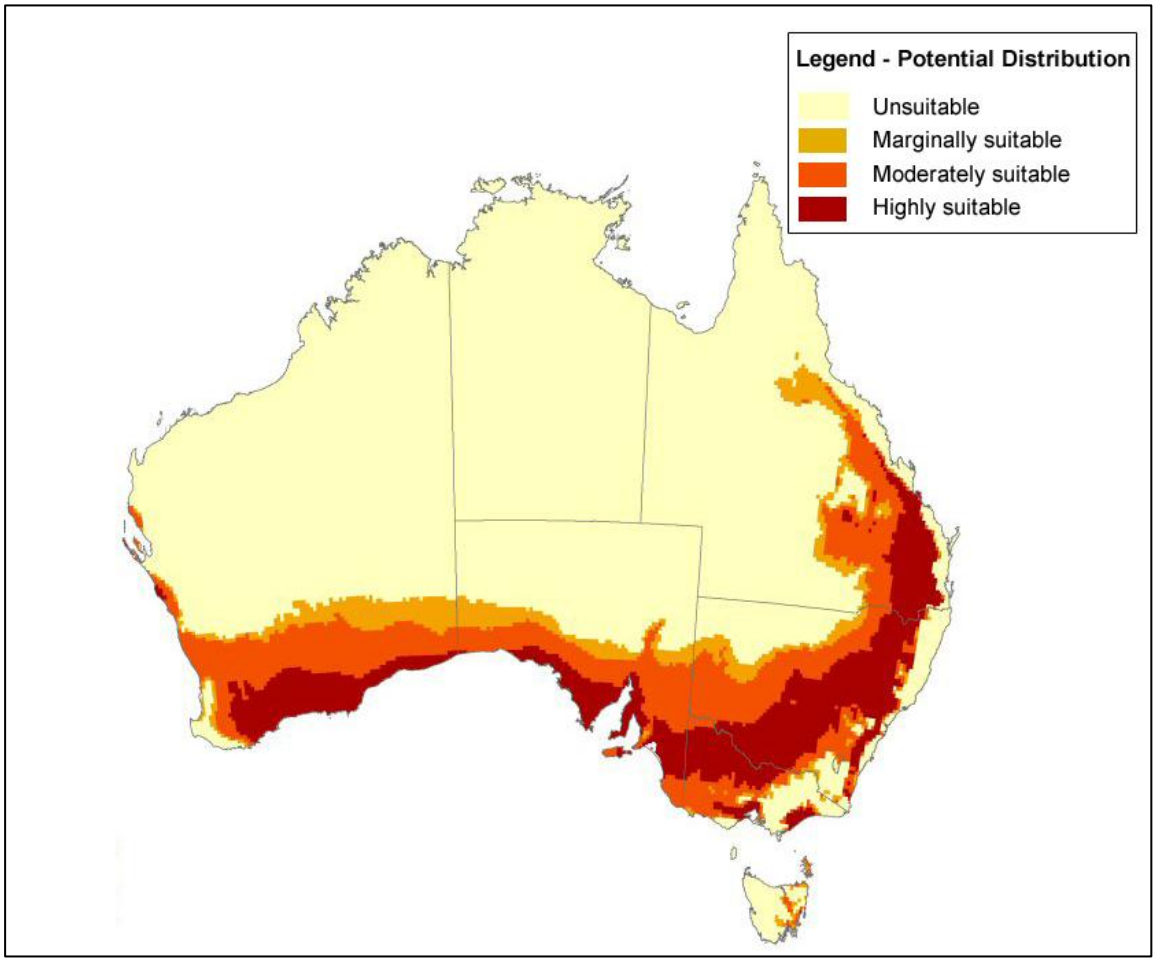

Figure 6. Potential distribution of *Opuntia robusta* in Australia (Australian Weeds Committee, 2012).

2.4.6 Dispersal of opuntioid cacti in Western Australia

The natural spread of opuntioid cacti occurs by several mechanisms. All species can spread vegetatively when stem segments become detached from the parent plant, or when the fleshy parts of flowers or immature fruits are broken off the main plant. Natural vegetative spread is slow and may proceed at only a few metres per year, except if segments are spread by floodwaters.

Large and small segments remain dormant for long periods, possibly several years when detached or on dead plant portions. Rapid, long distance spread of segments is caused by floodwaters, and by human-aided spread through the use of mechanical vectors such as earthmoving equipment and recreational 4WD vehicles in infested areas.

Spread by floodwaters can be very rapid; for example, after the 2010-11 flood of the Gascoyne River system, local community groups in Carnarvon reported that opuntioid cactus species had spread up to 5km beyond previously known infestations (Andrew Reeves, DAFWA, pers. comm.).

Birds and other animals also spread opuntioid cacti. *Cylindropuntia* species produce small segments that attach to animals (livestock, native animals and pest animals) and then disperse over significant distances. Some species produce fleshy fruits that are attractive to birds and, perhaps, other animals. If the fruits contain viable seeds, dispersal by birds causes rapid long-distance spread.

Dispersal also occurs as a result of the deliberate movement of cacti for horticultural purposes, such as for use as garden plants. This form of spread occurs through nurseries and informal outlets such as markets, fetes and garage sales. Labelling standards are often poor, even amongst commercial nurseries, with cacti and many different succulent plants from families including Agavaceae, Euphorbiaceae and Crassulaceae labelled simply - and inaccurately - as ‘cactus’.

Accidental human movement by mechanical vectors may disperse material along existing pathways such as roads and 4WD tracks. These movements can be effective in spreading cactus material over several kilometres, with segments dropping off vehicles and equipment at intervals, potentially spreading the infestation over a large area.

Deliberate human movement through the dumping of unwanted cactus plants is also an important means of dispersal and is known to be the source of several infestations in WA.

3. Impact of opuntioid cacti in Western Australia

The opuntioid cacti appear to be at an early stage in the invasion process in WA, but they have considerable potential to markedly increase their distribution and density (for example, see Figure 6 showing the potential distribution of *O. robusta*). Collectively, their current impact is low, but they have the potential to cause a significant impact across large areas of the State, especially in the rangelands from the Pilbara to the south coast.

3.1 Agricultural impacts

The major economic impacts of the opuntioid cacti are on the pastoral and grazing industries. The weeds' direct effects have not been quantified, but include:

- Reduced production of the grazing industry.
- Increased costs and reduced income due to lost production.
- Increased control and management costs (including cost of herbicides, spraying equipment and fencing).
- Increased veterinary and medical costs for the treatment of injuries due to cactus spines injuring livestock and humans.
- Interfering with mustering and reducing access to watering points.
- Damaging hides and contaminating fleeces, making shearing extremely difficult.
- Harbouring vertebrate pests such as foxes and rabbits.
- Some species have strong, sharp spines that allow segments to attach to heavy work boots and vehicle tyres, interfering with control operations.
- The glochids from various species cause serious skin irritation, which needs to be taken into account when carrying out control work.

Cacti also impact on horticulture through producing fruit that harbour fruit flies.

The cost of control exceeds the value of land in some areas. For example in Leander, Queensland, where land is worth about $250/ha, control costs are in the order of $750-1 000/ha (Mike Chuk, pers. comm.). Infestations are likely to require repeated visits after the initial treatment, because small segments not killed by the first spray often take root and grow.

In 2012-13, Biosecurity Queensland spent around $100 000 on cactus control, and a further $50 000 on extension, media and biological control research. This was in addition to costs incurred by a number of other groups, including NRM groups and local government authorities (Steve Csurhes, Queensland Dept of Agriculture Forestry and Fisheries, pers. comm.).

Opuntioid cacti also cause problems in other countries including South Africa, other African countries, and the Mediterranean region. For example, *C. rosea* is a problem in Spain, where small infestations cost about €2 600 (about AU $4 000) to remove, while the removal of an infestation of about ten hectares in rugged mountains in southern Valencia had a budget of €1 million (about AU $1.53 million) over four years (Deltoro *et al.*, 2012).

3.2 Environmental impacts

Environmental impacts of opuntioid cacti include:

- Loss of biodiversity and habitat change by competing with and replacing native vegetation (NOTE: opuntioid cacti are not currently regarded as a threat to any specific threatened ecological communities).
- Damage to environmentally sensitive areas, especially along water courses.
- Injuring or killing native animals (see Figure 7).
- Harbouring foxes and rabbits.

The impact of weedy cacti on native animals is not well documented. The dead euro in South Australia (Figure 7) had numerous segments of *C. prolifera* embedded in it and was assumed to have died from its wounds or infection. In WA, bats have been seen impaled on *C. fulgida* var. *mamillata* plants around Gwalia (Vanessa Jackson and Jennifer Jackson, DPaW, pers. comm.).

3.3 Social impacts

Opuntioid cacti have the potential to impact on culturally significant sites within a landscape, restricting access or completely degrading them. Tourism can also be adversely affected, with few people wanting to camp and recreate in areas dominated by infestations of opuntioid cacti.

Spines and glochids can cause injuries and serious skin irritation.

The following community perceptions and values of opuntioid cacti must be considered:

- Many cactus species are in cultivation, and there are cactus enthusiast groups in Australia, including the WA Cactus and Succulent Society.
- The fruits (“prickly pears”) of *Opuntia ficus-indica* are edible, and are produced commercially on a small scale, although most production is from home gardens.
- The problems caused by the extensive prickly pear (*O. stricta*) infestations in Queensland in the early 20th century are well known, and help identify opuntioid cacti as significant weeds, while the success of the *O. stricta* biological control program will drive community expectation that biological control programs for other opuntioid cacti will be equally successful.
- The recently-acquired WoNS status of the opuntioid cacti will help reinforce the community’s perception of their weed status.

3.4 Impact assessment for opuntioid cacti

An impact assessment was conducted on four opuntioid cacti species and the entire genus *Opuntia* as part of a process to undertake Benefit Cost Analysis for all declared plants and WoNS weeds present in WA (Petersen *et al.*, 2013). This assessment involved an expert panel approach, where weed specialists used their

knowledge of the benefits of control to score each plant on a scale of 1 to 5, using the key shown in Table 4. A total of 73 declared plant species were assessed.

Agricultural and environmental benefits were scored separately. Both private (landholder) and public (government and the wider community) benefits were considered. The agricultural and environmental benefit score given by all experts was averaged (that is, given equal weight in terms of benefits) to calculate an Impact Score as shown in Table 5.

Table 4. Scoring key for measuring benefits of plant control

Agricultural benefits	Environmental benefits
1 – Uncontrolled plant has very little impact on profit	1 – Uncontrolled plant has very little impact on environment
2	2
3 – Moderate	3 – Moderate
4	4
5 – Uncontrolled plant has significant impact on profit	5 – Uncontrolled plant has significant impact on environment

Table 5. Impact scores and rankings for opuntioid cacti

Common name(s)	Scientific name	Agric **impact** score	Ranking (out of 73)	**Enviro impact** score	Ranking (out of 73)
Cane or snake cactus	*Austrocylindropuntia cylindrica*	3.0	16=	3.5	28=
Coral cactus or boxing glove cactus	*Cylindropuntia fulgida* var. *mamillata*	3.6	9=	4.1	10=
Devil's rope cactus	*Cylindropuntia imbricata*	3.6	9=	4.1	10=
Hudson pear	*Cylindropuntia rosea*	3.6	9=	4.1	10=
Prickly pear	*Opuntia* spp.	3.6	9=	3.7	26=

The opuntioid cacti received high scores for both agricultural and environmental impacts (Table 5) and were among the highest ranked species. The scores placed the opuntioid cacti with other declared plants that are recognised as significant agricultural pests.

Overall, the agricultural impact scores for the opuntioid cacti were, on average, slightly lower than the environmental impact scores, whereas the agricultural rankings were slightly higher than environmental rankings.

The expert panel scores suggested that controlling opuntioid cacti species would lead to moderate to large agricultural and environmental benefits.

Figure 7. Dead euro in South Australia, with Cylindropuntia prolifera segments embedded in it (photo by Lorraine Edmunds).

4. Declaration status of opuntioid cacti in WA

4.1 Opuntioid cacti

Currently, the only opuntioid cacti declared in WA under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) are six *Opuntia* species. They are the WoNS species *O. elata*, *O. engelmannii*, *O. monacantha* and *O. stricta*, which are all Declared Pests (Section 22) in the C3 (Management) category for that portion of the State north of the 26th parallel of latitude. The fifth WoNS species, *O. microdasys*, is a prohibited Declared Pest (Section 12) in the C1 (Exclusion) category. *O. ficus-indica* is declared C3 north of the 26th parallel, but it is not a WoNS. See Table 6 for details of the declaration status of opuntioid cacti in WA.

Several other *Opuntia* species that are recognised as WoNS weeds are not categorised as Declared Pests in WA, and no *Austrocylindropuntia* or *Cylindropuntia* species are declared in WA.

Four opuntioid cacti (*Austrocylindropuntia cylindrica*, *Cylindropuntia californica*, C. *fulgida* and C. *tunicata*) are Permitted under Section 11 of the BAM Act. *C. californica* is not known to be naturalised (Table 6).

There are further deficiencies in the declaration status of the opuntioid cactus group, with none being declared in the areas where they are most abundant and problematic, and several that are not declared but are currently Permitted.

Overall, the declaration status of the opuntioid cacti in WA is not considered to be adequate to ensure appropriate management of these species.

DAFWA is currently reviewing the appropriate declaration status (in WA) of all the WoNS opuntioid cacti known to be naturalised in Australia.

4.2 Other cacti

Harrisia cactus (*Harrisia martinii*) is Declared (Section 22) in the C1 (Exclusion) category, but it is not one of the WoNS opuntioid cacti and is not known to be naturalised in WA, although it may be in cultivation.

Several species of cacti that are known to be invasive in other countries, for example *Cereus* species, are Permitted species and are cultivated in WA.

Table 6. Declaration status of opuntioid cacti known to be present in WA

Scientific name	Naturalised in WA	Cultivated or present in WA but not known to be naturalised	Current Declaration Status
Austrocylindropuntia cylindrica	✓		Permitted (Section 11)
Austrocylindropuntia subulata		✓	Unassessed
Cylindropuntia fulgida var. *mamillata*	✓		Permitted (Section 11)
Cylindropuntia fulgida var. *fulgida*	✓		Permitted (Section 11)
Cylindropuntia imbricata	✓		Unassessed
Cylindropuntia kleiniae	✓		Unassessed
Cylindropuntia rosea	✓		Unassessed
Cylindropuntia spinosior		✓	Unassessed
Cylindropuntia tunicata	✓		Permitted (Section 11)
Opuntia elata	✓		C3 above the 26th parallel (Section 22)
Opuntia elatior	✓		Unassessed
Opuntia engelmannii	✓		C3 above the 26th parallel (Section 22)
Opuntia ficus-indica	✓		C3 above the 26th parallel (Section 22)
Opuntia microdasys		✓	Prohibited; C1 Exclusion (Section 12)
Opuntia monacantha	✓		C3 above the 26th parallel (Section 22)

Table 6. (continued)

Scientific name	Naturalised in WA	Cultivated or present in WA but not known to be naturalised	Current Declaration Status
Opuntia polyacantha		✓	Unassessed
Opuntia puberula	✓		Unassessed
Opuntia robusta		✓	Unassessed
Opuntia stricta	✓		C3 above the 26th parallel (Section 22)
Opuntia tomentosa	✓		Unassessed
Opuntia 'sp. WA' unknown, (possibly *O. microdasys* hybrid, Bob Chinnock, pers. comm.)	✓		Unassessed
Opuntia sp. unknown, photographed by Megan Muir DPaW	✓		Unassessed

Note: Unassessed species cannot be assessed until the identity of the species is known.

5. Risk assessment

The present Situation Statement highlights the extent of the problem caused by the opuntioid cacti in WA, and aims to inform decision makers of the potential for these weeds to cause further significant agricultural and environmental impacts, and the associated risks.

DAFWA will produce a Response Plan related to the Situation Statement that encourages participation by key stakeholders, and outlines the resources needed for on-ground management.

The major risks associated with opuntioid cacti and the mitigation strategies that could be used to manage these risks are described below (Table 7).

Table 7. Risks and their mitigation

Risk 1–	**The extent of the infestations has not been determined fully, and the distribution of the various species has not been mapped. Specimens are difficult to collect and taxonomic expertise is limited.**

Mitigation strategy

- Support and partner with NRM, DPaW, local government and industry to encourage a statewide cactus coordinator to record all WA information.
- Support a working group or other coordinating body for cactus management.

Risk 2 –	**Action is not taken to eradicate infestations of opuntioid cacti that are at the early stage of invasion and are potentially eradicable.**

Mitigation strategy

- Support and partner with funding bodies to prepare funding applications that allow for the control of early stage infestations.

Risk 3 –	**The opuntioid cacti will invade much larger areas of the state than are currently occupied, especially in the southern rangelands.**

Mitigation strategy

- Support and partner with funding bodies to prepare funding applications to contain large infestations. If available, support the release of biocontrol agents to manage large or dense infestations.

Risk 4 –	**Biological control agents are not available for the main species.**

Mitigation strategy

- Partner with agencies searching for new biological control agents.
- Facilitate rearing and release of biological control agents when available.

Risk 5 –	**Most opuntioid cacti are not declared, making compliance and enforcement an issue for sale, supply and movement.**

Mitigation strategy

- Ensure appropriate declaration is in place under the BAM Act.

Table 7. (continued)

Risk 6 –	**Information on basic biology and ecology of opuntioid cacti is not adequate.**

Mitigation strategy

- Provide scientific expertise where staff and resources allow. Encourage universities and other organisations to carry out research on opuntioid cacti.

Risk 7 –	**Technical information for control such as types and rates of herbicides, timing of application, and use of additives and adjuvants is not adequate.**

Mitigation strategy

- Provide technical expertise where staff and resources allow.

6. Strengths and limitations of current knowledge of opuntioid cacti in WA

Opuntioid cacti have only recently been named as WoNS (in April 2012); they have not received the same level of attention as the original group of WoNS weeds that were named in 1999. There is relatively little awareness about the cactus problem in WA, and limited resources available to deal with them.

6.1 Strengths in current knowledge

- A national strategy for opuntioid cacti has been developed (AWC 2012).
- A management guide has been produced (Potter 2011).
- A field identification guide for opuntioid cacti has been produced (Potter and Rutherford 2013).
- Eradication of small, isolated infestations of weedy cacti is in progress at some sites. This will provide strategic benefits and is economically justifiable.
- There has been increasing interest in the management of opuntioid cacti in Western Australia during 2012 and 2013, for example, from the Rangelands NRM and the Goldfields Nullarbor Regional Biosecurity Association investing in cactus management (see Table 8).
- Groups that are actively interested in cactus control have access to funding from a variety of sources such as State and Regional NRM bodies, Local Government and environmental management funds from the mining industry.
- Groups that are actively interested in cactus control often contain land managers who can undertake work, while community groups such as landcare and industry groups and individual landowners can undertake control.
- The groups (for example, RBGs) that are interested in cactus control have the potential to bring together a diverse range of views on weedy cacti. They will also contribute to developing approaches to the management of these weeds that reflect the prevailing attitudes within a region.
- Mining companies are significant landholders and land managers in areas where weedy cacti are present, with company-owned transport routes that might pass through infested areas, and port facilities and processing plants in near-coastal areas where some of the infestations occur.
- Mining/resource companies now own some of the stations that have significant infestations of weedy cacti. Some of these companies commit significant levels of long-term resources (especially financial) for weed management on these stations, and will not be dependent on agricultural factors such as cattle prices, mustering durations or seasonal conditions.
- Mining companies have strict environmental management policies that should facilitate management of these weeds, even though the weeds

themselves do not have a direct impact on the companies' primary business activity.

- Environmental consultants working for mining companies are, potentially, major partners in undertaking surveillance for opuntioid cacti: consultants visit remote places and are likely to a) recognise these weeds and b) record and report them.
- There is further scope for establishing constructive partnerships between key stakeholders for the ongoing management of the opuntioid cacti.
- Several agencies including the NSW Department of Primary Industry and the Queensland Department of Agriculture, Fisheries and Forestry are carrying out research into biological control agents for cacti, for example, a cochineal scale (*Dactylopius tomentosus*) that attacks *Cylindropuntia fulgida* var. *mamillata*. This agent was identified by biocontrol specialists in South Africa, where it is effective.
- The biological control of *O. stricta* in Queensland and northern New South Wales in the 1920s and 1930s is a well-known and successful example of biological control (Hosking, 2012, Raghu and Walton, 2007) that provides impetus for finding future biological control agents.
- In Queensland, the NRM group Desert Channels Queensland is about to carry out herbicide trials that will target several species of cacti (and other weed species).
- Aerial spraying is used in the USA for control of large cactus infestations and may be relevant to Australia.

6.2 Limitations in current knowledge

- Limited information is currently available on the biology and management of opuntioid cacti within Western Australia.
- The identity of the various species present in WA is not well documented.
- A concerted effort is required to collect material suitable for herbarium specimens from all infestations across the State.
- The WA Herbarium currently does not have the capacity to receive and process cactus samples for identification and curation as herbarium specimens.
- No comprehensive distribution mapping exists for cacti in WA.
- Because traditional methods of collecting plant specimens do not work well for cacti, new ways need to be found to document and report cacti, such web-based reporting and mobile phone apps.
- A detailed national or state-level Best Practice Management Guide for the opuntioid cacti does not exist.
- Most species of opuntioid cacti that are naturalised in WA are not declared, while existing declarations do not include regions in the south of the state that are climatically suitable and where some significant infestations already occur.

- At times, effective control is prevented by the large size and remoteness of many of the pastoral properties (and other units of land) on which infestations of weedy cacti occur. Also, seasonal conditions in parts of the rangelands may restrict access to many infestations.
- Cacti are common in the nursery industry, and are routinely traded by amateur gardeners and cactus enthusiasts. This trade includes opuntioid cacti.
- More work is needed on identifying herbicides that could be used to control cacti, and conducting trials on new herbicide formulations.
- The rates of some herbicides currently registered for cactus control are not considered adequate to achieve control.
- Further research is required on chemical additives, adjuvants and carriers for herbicides used in the control of opuntioid cacti; and on the timing of application.
- Weedy opuntioid cacti have been present in WA for many years with little or no intervention to reduce their abundance. This is probably a reflection of the weeds' vigour and capacity for long distance spread, the remote location of many infestations, and a history of inadequate or inconsistent control.
- Some members of the community might not fully appreciate the threat posed by weedy opuntioid cacti. The high cost of effective control measures inhibits active management, especially in the rangelands, as does the reduced workforce available to undertake control programs.
- Formal Weed Action Plans (WAPs) for opuntioid cacti, developed with Biosecurity Officer involvement, do not exist for many infested properties and localities in the rangelands.
- While some mining companies have effective weed management programs in place, other companies might place less emphasis on the agricultural, environmental and social impacts of weedy opuntioid cacti and, therefore, have a limited awareness of the significance and impacts of these weeds.
- Local and State government agencies are not consulted as a part of the approvals process for resource exploration or mine site development, and do not receive requests for declared pest information on proposed sites[9]. This means that opuntioid cacti (and other weeds) may not be 'on the radar' of resource companies completing exploration or construction projects. This significantly increases the likelihood of weeds spreading across the landscape via segments trapped on vehicles or heavy machinery.

[9] Resource developers currently ask the Department of Parks and Wildlife about environmental weeds associated with mine sites, etc., but DAFWA is not routinely approached about Declared Plants.

7. Stakeholders

There is a large number of stakeholders involved in managing and/or reporting the distribution of opuntioid cactus species, as follows:

- Department of Agriculture and Food Western Australia (DAFWA)
- Department of Parks and Wildlife (DPaW, including the WA Herbarium)
- Regional NRM Groups
- Recognised Biosecurity Groups
- Local Government Authorities
- Pastoralists and other primary producers
- The Pastoral Lands Board
- Agriculture industry associations (for example, Pastoralists and Graziers Association, and WA Farmers)
- Mining companies, through both mining leases and pastoral leases now owned by mining companies
- Community and Landcare groups
- Indigenous and other land managers throughout the WA rangelands
- Landholders other than primary producers
- Environmental consultants
- Department of Water
- Department of Regional Development and Lands
- Main Roads Western Australia

This large number and diversity of stakeholders could contribute to the complexity of achieving coordinated, consistent management of opuntioid cacti in WA; however, some groups are already working together to successfully manage cactus infestations. The key stakeholders for opuntioid cacti are detailed below.

7.1 Regional NRM Groups

There are six regional natural resource management (NRM) groups in Western Australia, operating within each of the State's six NRM regions. These regions are based on a combination of catchments or bioregions and local government boundaries.

Regional NRM groups work in partnership with all tiers of government, regional organisations, industry, landowners, researchers, environmental and community groups. They provide a community leadership role in their region, mobilise regional effort and ensure priority needs are addressed. They also build on government investment by leveraging private investment and volunteer activities and ensuring collaboration across established networks.

Each regional group has developed a regional strategy and investment plan that address significant NRM issues within their region. The plans incorporate

environmental, social, and economic factors. The regional NRM groups in WA are shown in Figure 8 and listed below:

- Rangelands NRM
- Northern Agricultural Catchments Council
- Wheatbelt NRM
- Perth NRM
- South West Catchments Council
- South Coast NRM.

Figure 8. Map of the regions covered by Natural Resource Management (NRM) Group regions in WA. Source: Horticulture Australia Ltd 2014 (horticulturefortomorrow.com.au)

7.1.1 Rangelands NRM

Rangelands NRM is a key stakeholder in opuntioid cactus management. This is largely due to the presence of many of the most significant opuntioid cactus infestations in the rangelands, and the high potential for further spread of opuntioid cacti within this region.

The Rangelands NRM region is the largest of the NRM regions in Australia. It covers around 85% (2,266,000 square kilometres) of the WA State's land mass,

and 75% of the coastline. Due to the vast size of the rangelands, community engagement is undertaken through seven recognised subregional areas: the Kimberley, Pilbara, Gascoyne, Murchison, Goldfields, Nullarbor and Western Desert.

Most of the Rangelands NRM's current projects are funded by grants from the Caring for Our Country program and the State NRM. Through some of its recent activities, the Rangelands NRM is a key stakeholder in several opuntioid cacti management activities in the rangelands. These are outlined in Table 8.

7.2 Recognised Biosecurity Groups

Five Recognised Biosecurity Groups (RBGs) are established in the Rangelands (Figure 9). The general objectives of the pastoral RBGs are to:

- initiate, promote and foster the control of declared pests in the sub-region;
- encourage landholders and other persons to adopt sound biosecurity practices throughout the sub-region;
- foster the sustainable development of the sub-region; and
- encourage the control of pests other than those declared in the sub-region.

The five pastoral RBGs are:

- Kimberley Rangeland Biosecurity Association
- Pilbara Regional Biosecurity Group
- Carnarvon Rangeland Biosecurity Association
- Goldfields Nullarbor Rangelands Biosecurity Association
- Meekatharra Rangeland Biosecurity Association.

Of these the Goldfields Nullarbor Rangelands Biosecurity Association (GNRBA) is currently involved with a number of opuntioid cactus control activities – see next section and Table 8.

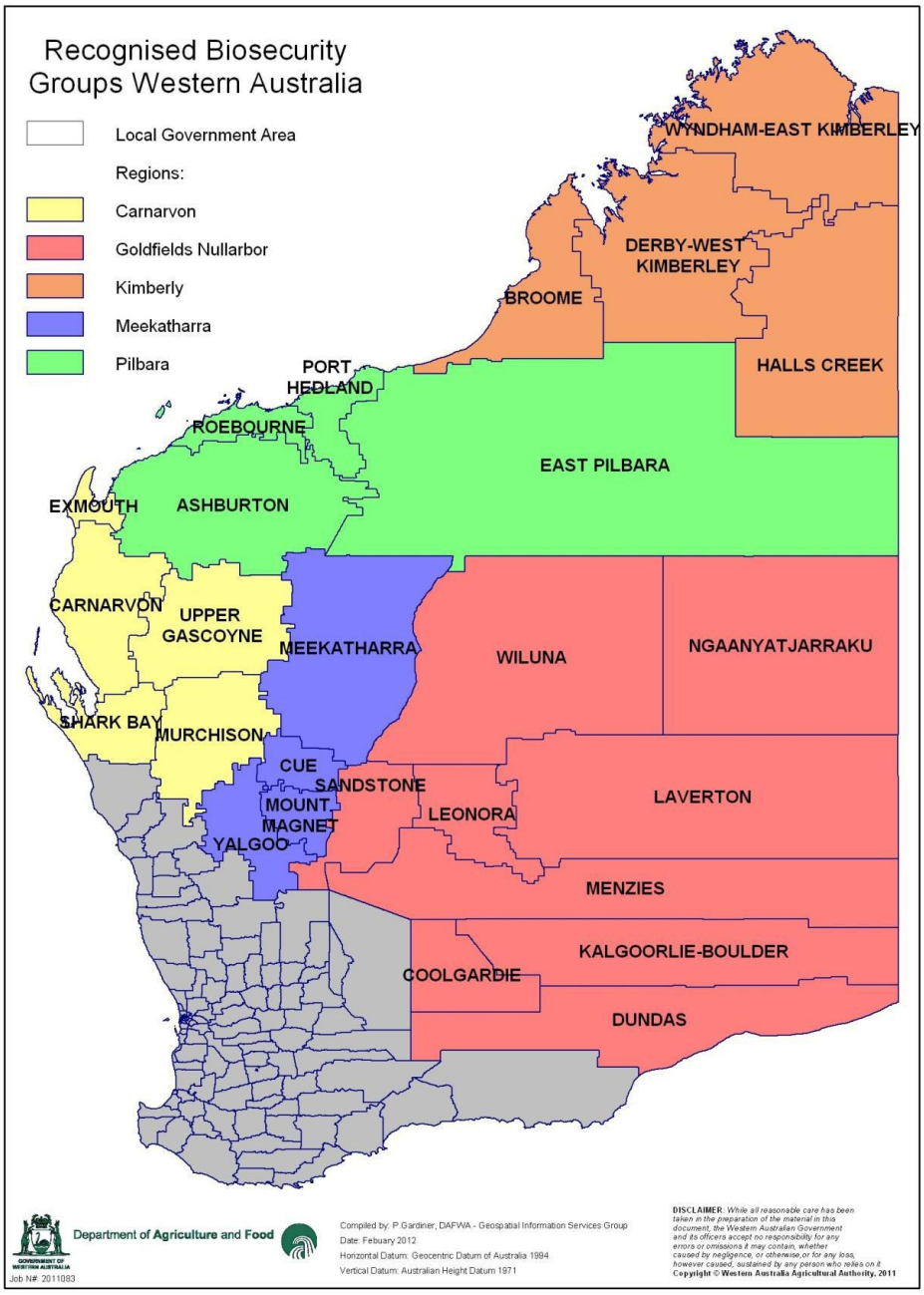

Figure 9. Sub-regions covered by the Rangelands Recognised Biosecurity Groups (RBGs). Source: Biosecurity in WA Website, (biosecurity.wa.gov.au)

7.3 Local Governments

Several Local Government Authorities (LGAs) in the rangelands are investing in the management of cactus infestations, often in partnership with bodies such as NRM groups, RBGs, mining companies and community groups. The LGAs in the Goldfields have been particularly active in partnering with other groups to facilitate control of weedy cacti, with several other projects still in the planning phase (see Table 8).

For example, the Shire of Leonora has made arrangements for a Kalgoorlie based

pest control company to spray the large infestation of *C. fulgida* var*. mamillata* at the old Gwalia townsite (see front cover). The Shire of Menzies is working with the Goldfields Nullarbor Regional Biosecurity Association (GNRBA), DAFWA and DPaW on a plan to eradicate the *C. rosea* infestation at the Menzies tip (Table 8).

The City of Kalgoorlie-Boulder is working with the GNRBA on a plan to control a large infestation of at least four cactus species (including the only known infestation of *C. kleiniae* in WA) at Williamstown (Table 8). Through the Goldfields Voluntary Regional Organisation of Councils (GVROC), ten Goldfields LGAs are collaborating on opuntioid cactus management.

7.4 Mining companies

Mining companies are significant landholders in the rangelands and have been actively seeking to partner with NRM groups, RBGs, local government and community groups. Mining companies are currently playing an active role in herbicide demonstration plots and working towards finding cost effective measures to manage large infestations (Table 8).

7.5 DAFWA's role as a stakeholder for opuntioid cacti

To date, DAFWA's involvement with regulatory and compliance activities for the opuntioid cacti has been directed towards infestations of the five *Opuntia* species that are declared north of the 26th parallel, in keeping with their declaration status. However, as described previously (for example in Section 1.3 and Table 6), many infestations occur outside the area covered by the current declarations.

DAFWA's role includes:

- Ensuring appropriate declaration is in place under the BAM Act (including reviewing the declaration status of the currently declared species), and evaluating the potential declaration status of the additional opuntioid cacti named as WoNS weeds.
- Carrying out surveillance for opuntioid cacti, and documenting the species present in WA and their distribution.
- Working to develop partnerships with government agencies, non-government organisations and landholders to facilitate surveillance for - and control of - opuntioid cacti, as funding and staff resources allow.
- Providing advice on control of opuntioid cacti, including herbicide recommendations.
- Undertaking research and development as funding and staff resources allow.
- Facilitating the release of existing biological control agents and new biological control agents as they become available.
- Enforcing audit and compliance activities under the BAM Act in regard to sale and supply.

7.6 Stakeholder involvement in Western Australia

Involvement by key stakeholders in opuntioid cactus management is detailed in Table 8. The full extent of some of the financial investments is not available.

Table 8. Examples of stakeholder involvement in opuntioid cacti in WA (2013-14)

Stakeholder	Management Action	Details
DAFWA	Ensuring appropriate declaration of opuntioid cacti.	Draft Briefing Note, March 2014, recommending declaration categories.
DPaW	Identification and control of cacti as part of activities including the Great Western Woodlands Project.	Spraying cacti at several sites including Lorna Glen Station, Kalgoorlie, Coolgardie, Kambalda, Southern Cross, Bullabulling, Boorabbin and Yellowdine. Documenting species present at these locations.
DAFWA (in partnership with Rangelands NRM, Pilbara Corridors program, and Pilbara Mesquite Management Committee)	Project: **Cactus Management in the Pilbara 2014.**	Manage current known infestations, survey for and record the occurrence of cacti in both towns and pastoral areas of the Pilbara, and to increase community awareness of the potential impact of invasive cacti. Project will commence in March 2014.
St Barbara Mines	Mapping the infestation, installing fence, spraying outlying patches, funding for Cactus Forum.	**Corralling the Coral Cactus project**, Tarmoola Station, Shire of Leonora.
St Barbara Mines	Management research.	Herbicide demonstration plots (MSMA) on Tarmoola Station.
Rangelands NRM (in partnership with Goldfields Nullarbor Regional Biosecurity Association)	$100K for various activities including fencing off infested area to prevent further spread (see below).	**Corralling the Coral Cactus project** on *Cylindropuntia fulgida* var. *mamillata*, Tarmoola Station, Shire of Leonora.
Rangelands NRM (in partnership with Goldfields Nullarbor Regional Biosecurity Association)	Funding for management research.	Herbicide demonstration plots for *C. fulgida* var. *mamillata*, *C. imbricata* and an unknown *Opuntia* sp. on Tarmoola Station and *C. rosea* on the Menzies tip in June and September 2013.

Table 8. (continued)

Stakeholder	Management Action	Details
Goldfields Nullarbor Regional Biosecurity Association (GNRBA)	Liaising with various stakeholders, sourcing funds, delivering projects.	Delivered projects including the fencing on Tarmoola Station, and herbicide demonstration plots on Tarmoola Station and at Menzies tip. More information will be available by the end of 2014.
Goldfields Nullarbor Regional Biosecurity Association (GNRBA)	Negotiating with local governments (directly and through GVROC) and other organisations on control of opuntioid cacti.	Some projects are expected to commence in 2014. More information will be available by the end of 2014.
St Barbara Mines (in partnership with Goldfields Nullarbor Regional Biosecurity Association)	Release site for biological control agent *Dactylopius tomentosa*.	The *C. fulgida* var. *mamillata* infestation at Tarmoola Station has been offered as a nursery site for rearing the biological control agent when it becomes available.
Goldfields Voluntary Regional Organisation of Councils (GVROC)	The City of Kalgoorlie-Boulder and Shires of Coolgardie, Dundas, Esperance, Laverton, Leonora, Menzies, Ngaanyatjarraku, Ravensthorpe and Wiluna.	Discussed opuntioid cacti at their November 2013 meeting. Interested in collaborating with each other, with GNRBA, DAFWA and DPaW. More information will be available later in 2014.
The Shires of Laverton, Leonora, Menzies and Wiluna in partnership with the Goldfields Nullarbor Regional Biosecurity Association and DAFWA Invasive Species staff	Allocated funding in the local government budget in 2013-14.	Spraying cactus infestations and other control work in Goldfields Shires. More information will be available later in 2014.
Shire of Menzies and Goldfields Nullarbor Regional Biosecurity Association (proposed project)	Control	Control of *C. rosea* infestation on the Menzies tip.
Lyndon LCDC, with State NRM funding (proposed project)	Cactus control on Mardathuna Station	$20,000 for cactus control (probably *C. fulgida* var. *mamillata*).

Table 8. (continued)

Stakeholder	Management Action	Details
Rangelands Fibre and Produce Association Inc., with State NRM funding (proposed project)	Control of significant outlier infestations of strategically important WoNs weeds.	$40,000 for *O. elatior* control.
Goldfields Nullarbor Rangelands Biosecurity Association, with State NRM funding (proposed project)	Mertondale/Menzies invasive cactus round-up.	$40,000 for general cactus control (mainly *C. fulgida* var. *mamillata*, also *C. rosea*), building on community momentum from the Tarmoola project

A significant recent example of stakeholder investment and involvement is the *Corralling the Coral Cactus* project on Tarmoola Station in the Shire of Leonora[10]. Based on advice from Helmuth Zimmermann[11], the Rangelands NRM provided $100 000 to the Goldfields Nullarbor Regional Biosecurity Association for various activities including building a fence around Tarmoola Station's rubbish tip.

The purpose of the fence is to prevent further spread of various cacti, particularly *C. fulgida* var. *mamillata*, from the tip to other parts of the station by preventing access by livestock, feral and native animals that have spread cactus segments from the tip over the past 10 years.

The Australian Government provided funding for the fence through the *Caring for Our Country* program. Construction was carried out in close cooperation with St Barbara Mines, the company that holds the Tarmoola mining lease.

[10] For more information see: rangelandswa.com.au/733/coralling-the-coral-cactus-at-leonora

[11] Helmuth Zimmermann is a South African expert on invasive plants, including cacti and mesquite, and their biological control.

8. Management

8.1 Management techniques

Cacti can be managed by a range of means including herbicides, fire, solarisation, deep burial, exclusion fencing and biological control – a brief outline of these is provided in Tables 9 and 10.

Table 9. Management techniques for weedy cacti

Management technique	Notes
Herbicides	Herbicides registered in WA for control of cacti are triclopyr, picloram and Access^{TM}. Diesel is used as a carrier with the latter. MSMA is registered in South Australia. Spraying costs vary from a few hundred dollars to $8,000 or more per hectare (Vanessa Jackson, DPaW, pers. comm.) Research is needed into different herbicides, additives and adjuvants, and timing of application, to give more options and more effective means of control of cacti in WA. Herbicides are mainly applied by spraying, but injection is suitable for some large *Opuntia* species.
Fire	Fire has limited potential as a tool for controlling cacti because few sites, if any, carry a sufficient fuel load to produce a fire hot enough to kill large cactus plants. Fire can be used to clear sites of leaf litter and shielding plants, such as grasses, before spraying herbicides. Fire may kill small segments, but no research has been done on this.
Solarisation	Solarisation has been tried near Carnarvon, but it is not particularly effective. It is also expensive, because it is a labour intensive technique that requires large amounts of plastic sheeting.
Deep burial	Deep burial can be cheaper (sometimes considerably cheaper) than spraying (Mike Chuk, pers. comm., Australian Invasive Cactus Network, September 2013), see Figures 10 and 11. Deep burial is most useful where there is a monoculture of cacti, a suitable soil type for digging a burial pit, and the availability of equipment to uproot and bury the cactus plants. It can be a quick and effective means of control, particularly if there is ready access to heavy equipment.
Exclusion fencing	Can be expensive, but is useful to prevent spread by vectors such as vehicles and animals.
Biological control	Is potentially the most suitable management tool for widespread species, as discussed in detail below and in Table 10; however, it is not available for all species.

Figure 10. Dense *Cylindropuntia fulgida* infestation on a rubbish tip near Longreach, Queensland, prior to burial (photo from Desert Channels Queensland).

Figure 11. Burying *Cylindropuntia fulgida* near Longreach, Queensland, using a front end loader (photo from Desert Channels Queensland).

8.2 Biological control

Biological control is potentially an effective management tool for large or dense infestations of opuntioid cacti; however, biological control agents are currently not available for most species (Table 10). The best known example of biological control is the use of *Cactoblastis cactorum* against prickly pear (*Opuntia stricta*) in Queensland in the 1920s and '30s (Hosking, 2012). The success of the *O. stricta* program will drive community expectation that biological control programs for other opuntioid cacti will be equally successful; however, biological control should not be seen as a universal management tool.

Some agents are species-specific, while others feed on several cactus species. Some cacti require not just a particular species of agent, but a specific biotype of the agent to achieve biological control.

Climate, especially rainfall, plays a critical part in the establishment and success of biological control agents. Cochineal scale insects (*Dactylopius* species), for example, generally fail in high rainfall areas, because they are likely to be washed off the plants. *C. cactorum* feeds on a number of *Opuntia* species, but is only effective as a biological control agent for *O. stricta* (Figure 12). *C. cactorum* cannot control *O. stricta* in cooler areas where the moth is unable to complete two life cycles in a year, or in areas that are hot most of the time (Hosking, 2012).

Figure 12. *Cactoblastis cactorum* collected near Geraldton in September 2013 (Mike Jones, DAFWA)

Biological control agents for opuntioid cacti have been introduced into WA on several occasions. The cochineal scale insect *Dactylopius opuntiae* was released on *O. stricta* on West and East Lewis Islands in the Dampier Archipelago in 1984 and 1986. A combination of further releases and natural spread resulted in *D. opuntiae* establishing on all *O. stricta* infestations on the Lewis Islands. About

two years after the first release at the 0.5 ha site on West Lewis Island, it was estimated that about 90% of the plants there had been destroyed. *D. opuntiae* was also released on *O. stricta* on the Roebourne Common in 1985, but failed to establish (Coyle, 1990).

D. opuntiae and *C. cactorum* were released in May and September 1989, respectively, on a mixed infestation of *O. stricta* and another *Opuntia* sp. (possibly *O. elatior*) along the Chapman River in Geraldton. Coyle (1990) reported that by April 1990 there was no sign of the agents nor any damage that could be attributed to either species; however, in 2005 DAFWA officers collected *C. cactorum* from the Chapman River (James Sheehan, DAFWA, pers. comm.). *O. stricta* was found at four sites on the Chapman River in September 2013, but showed no evidence of attack by *C. cactorum*, although the agent was present at another site about 1.5 kilometres from the river (Mike Jones, DAFWA, pers. comm.; Figure 10).

C. cactorum was taken from the Chapman River to Wydgee Station in the Shire of Mount Magnet in 2005, where it survived for a period of time; however, it was not effective as a biocontrol agent and could not be found in June 2013. The reason for this became apparent when the cactus at Wydgee was identified from photographs as *Opuntia elatior* (Bob Chinnock, pers. comm.), which is not a suitable host for *C. cactorum*. The infestation at Wydgee has increased since 2005, and was estimated to cover about 200 hectares in 2013 (Reeves, 2013).

Table 10. **Biological control agents for opuntioid cacti in Australia Information from Hosking (2012) and Royce Holtkamp (pers. comm.)**

Biological control agent	Species controlled	Comments
Cactoblastis cactorum	*O. stricta*	Larvae also feed on other *Opuntia* species, including *O. aurantiaca*, *O. elata*, *O. ficus-indica*, *O. humifusa*, *O. monacantha*, *O. streptacantha* and *O. tomentosa*, but do not cause major damage
Dactylopius austrinus	*O. aurantiaca*	
Dactylopius ceylonicus	*O. monacantha*	Possibly suitable for controlling *O. elata* if combined with *C. cactorum*
Dactylopius opuntiae	*O. stricta*	Can also attack *O. streptacantha* and *O. tomentosa*, particularly if they are felled
Dactylopius tomentosus '*C. fulgida* biotype'	*C. fulgida*	In quarantine in Queensland
Dactylopius tomentosus '*C. rosea* biotype'	*C. rosea*	In quarantine in Queensland

A promising biocontrol agent for *C. fulgida* is currently in quarantine in Queensland. It is a cochineal scale insect, *D. tomentosa*, that may be the only effective and economically viable means of controlling this particular cactus in WA and the rest of Australia. This particular biotype of *D. tomentosa* was sourced from South Africa where it has proved to be highly effective on *C. fulgida* (Royce Holtkamp, NSW DPI and Helmuth Zimmermann pers. comm.). The application seeking approval to release this agent will be submitted to the Australian Government in 2014.

Research is also being carried out on another biotype of *D. tomentosa*, which is a biocontrol agent for *C. rosea*. Another *Dactylopius* sp., *D. opuntiae*, controls the unidentified species *Opuntia* 'sp. WA' referred to in Tables 3 and 6 and was supplied to St Barbara Mines for release at Tarmoola Station and Gwalia in December 2013. The agents appear not to have survived heavy rain in January 2014 and further releases are planned (Bob Chinnock, pers. comm.).

9. Conclusions

The opuntioid cacti have proved themselves to be intractable weeds: they are highly invasive and can tolerate a mix of harsh conditions including drought and a wide range of temperatures; they are armed with spines, and are difficult and expensive to kill.

At present it appears that some species of opuntioid cacti can still be eradicated, and there is increasing interest in the community to manage them.

The collective knowledge of cacti in Australia is fragmented across the various jurisdictions, government and non-government agencies and groups working on them. This is partly due to them being named as WoNS relatively recently, and not yet receiving the same level of attention as the original group of WoNS weeds which were named in 1999. It might also be partly due to complacency and a lack of awareness about the problem.

A national strategy, a management guide and an identification booklet have been produced recently. However, there is a need for research in several areas, including the basic biology and ecology of opuntioid cacti; herbicides and their application; and existing and new biological control agents. Knowledge gained could be used to produce a much-needed national best practice management guide.

Knowledge of the species present in WA and their distribution is improving almost on a weekly basis. Unlike other plants, cacti are difficult to collect and preserve which makes documenting them difficult. It is hoped that some of the problems with reporting and identification might be overcome with the use of new tools such as mobile phone apps and on-line mapping.

The WoNS opuntioid cacti have negative impacts on agriculture and the environment. The pastoral industry is WA's agriculture sector most likely to be impacted by cacti; impacts include hindering mustering and reducing access to water points, damage to hides and fleeces, and making shearing extremely difficult. Production is reduced and management costs (such as expenditure on herbicides, spraying equipment and fencing) are high. The horticulture sector is also being impacted through one species, *Opuntia ficus-indica*, being a source of Mediterranean fruit fly.

Environmental impacts are poorly documented, although there is evidence that native species are being killed through impalement on cactus spines. An impact assessment on opuntioid cacti placed them amongst other declared plants that are already recognised as significant agricultural pests, and suggested that controlling opuntioid cacti would lead to moderate to large agricultural and environmental benefits.

Currently only six *Opuntia* species are declared under the Biosecurity and Agriculture Management Act 2007 (BAM Act). There are obvious deficiencies in the declaration status of the opuntioid cactus group, with none being declared in the areas where they are most abundant and problematic, and several others that are not declared but are actually permitted. Overall, the declaration status of the opuntioid cacti in WA is not considered to be adequate to ensure their appropriate management and declaration of a number of species is currently being considered.

Seven major risks associated with opuntioid cacti have been identified:

1. The extent of infestations and identity of species present have not been fully determined;
2. Opportunities to eradicate infestations at an early stage of invasion may be missed;
3. Opuntioid cacti have the potential to invade much larger areas of WA;
4. Biological control agents are not available for most opuntioid cacti;
5. Most opuntioid cacti are not declared;
6. Information on basic biology and ecology of opuntioid cacti is inadequate; and
7. Technical information for control of opuntioid cacti is inadequate.

A large number of stakeholders with interests in and/or responsibilities for the management of naturalised opuntioid cacti in Western Australia have been identified. They include government departments, NRM groups, Recognised Biosecurity Groups, Local Government Authorities, pastoralists, and mining companies (see section 7.0 for a comprehensive list and discussion).

During 2012 and 2013 there has been increasing interest in the management of opuntioid cacti. For example, the Rangelands NRM and the Goldfields Nullarbor Regional Biosecurity Association have invested significantly in cactus management, and several local government authorities in the Goldfields have been actively partnering with others to manage opuntioid cacti. The need for research and collaboration presents many opportunities and several new projects on opuntioid cacti will commence in 2014. There are obvious benefits in managing infestations while they are small, while containing large infestations to prevent further spread.

Although the current level of infestation by opuntioid cacti in WA is relatively low, it has the potential to get much worse unless there is active, coordinated intervention. Potentially many hundreds of thousands of hectares of land, particularly in the rangelands, could become infested if appropriate, timely action is not taken.

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