

ALIEN INVASIVE PLANT SPECIES ASSESSMENT AND MANAGEMENT GUIDELINES

Prepared by:

Dr Sue Milton, SACNASP Professional Natural Scientist (Reg. No. 400047/08), RENU-KAROO Veld
Restoration cc.

Reviewed and edited by:

Dr Graham Harding
Director at Invader Plant Specialists (Pty) Ltd
SACNASP Professional Natural Scientist, Pest control operator Registration No 2012/036721/07

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I. Alien invasive plant species identified in the Karoo Central Astronomy Advantage Area

This section provides a high-level description of the alien invasive plant species present within the study area of the Strategic Environmental Assessment for the first phase of the Square Kilometre Array (SKA) project (further called "SEA study area") and the wider Karoo Central Astronomy Advantage Area, as well as proposed long term research and monitoring programmes for the control and management of these alien invasive plant species. The identification of the alien invasive plant species present within the study area is based on literature review, observations made by Dr Sue Milton during the ecology specialist study fieldwork in March 2016, and personal data collected by Dr Sue Milton-Dean during other research or consulting visits to the area. It is important to note that less than one percent of the Karoo Central Astronomy Advantage Area was ground-truthed and no density data were collected within that area.

This chapter incorporates information from the Department of Environmental Affairs (DEA) 2015 guidelines¹ for alien invasive plants monitoring, control and eradication plans. The chapter aims to provide information on alien invasive plants identified within the study area and highlight the need for further research and monitoring activities within the study area. Potential control methods and approach to reducing listed alien plant invasion risks on construction sites within Strategic Environmental Assessment study area, as recommended by Dr Sue Milton and Dr Harding have been included in the draft Environmental Management Programme (Chapter 4 of this IEMP).

During the Strategic Environmental Assessment process, SKA SA initiated a discussion with the Natural Resource Management Programme of the Department of Environmental Affairs (DEA) (contact person: Michael Braack, Deputy Director at the directorate: Operational Support and Planning) on a collaboration between the National Research Foundation and the Working for Water programme² for alien invasive plants clearing and control activities within the SKA core area. The Department of Environmental Affairs Natural Resource Management Programmes operational Support and Planning unit is currently working on a Management Unit Control Planning (MUCP) tool which aims to quantify the extent of the alien plants invasion problem, prioritise most important areas for clearing and calculate required investment for the implementation of the alien invasive clearing and control programme, depending on the time frame and availability of funds. Department of Environmental Affairs Natural Resource Management Programmes indicated that the MUCP tool could be used for the SKA core area once invasions maps with info on species and densities, landscape management units, and a detailed history of clearing efforts in the area are available. Further research and monitoring activities are required in order to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed alien invasive plant species Management Plan.

A list of alien invasive plant species was extracted from the South African Biodiversity Information Facility (SABIF) and the Plants of South Africa database on South African National Biodiversity Institute (SANBI) website (POSA) data for all degree squares in the Karoo Central Astronomy Advantage Area 1, and additional species were added from Dr Sue Milton's field record and by referring to maps in

¹ Department of Environmental Affairs 2015 Monitoring, Control and Eradication Plans: Guidelines for species listed as invasive in terms of Section 70 of National Environmental Management Biodiversity Act 2004 (Act No. 10 of 2004) and as required by Section 76 of this Act. Biosecurity Department of Environment Affairs Private Bag X4390, Cape Town, 8000

² <https://www.environment.gov.za/projectsprogrammes/wfw>

Henderson (2001)³, Bromilow (2010)⁴ and Walters et al. (2011)⁵. As indicated in Chapter 1, the Karoo Central Astronomy Advantage Area study area covers more than 12 million hectares and lies in the Central Karoo, and mainly in the Northern Cape Province (Figure 1). In total 93 invasive alien invasive plant species, mostly herbaceous annuals and grasses have been recorded in the Karoo Central Astronomy Advantage Area 1. Of these, only 23 plant species are listed as category 1, 2 or 3 invaders. These species are all illustrated and described in more detail below.



Figure 1: Karoo Central Astronomy Advantage Area 1 study area (green outline)

Alien invasive plant species grow among indigenous plants. It is important for any person working within the environment and especially those managing alien invasive plant species to be able to recognize alien invasive plant species amongst the indigenous ones. For example, in Figure 2, *Arundo donax* (giant cane), *Eucalyptus camaldulensis* (Red river gum), *Prosopis species* (mesquite) and *Tamarix ramossissima* (Pink tamarisk) are intermixed with indigenous *Acacia karroo* (Sweet thorn), *Atriplex vestita* (Vaalbrak), *Searsia lancea* (Rooi karee) and *Tamarix usneoides* (White tamarix).

³ Henderson, L. 2001. Alien weeds and invasive plants. Plant Protection Research Institute Handbook No. 12 ARC, Pretoria.

⁴ Bromilow, C. 2010. Problem plants and alien weeds of South Africa. Briza Publications, Pretoria.

⁵ Walters, M., Figueiredo, E., Crouch, N.R., Winter, P.J.D., Smith, G.F., Zimmermann, H.G. & Mashope, B.K. 2011. Naturalised and invasive succulents of southern Africa. ABC Taxa. The Belgian Development Co-operation, Belgium.

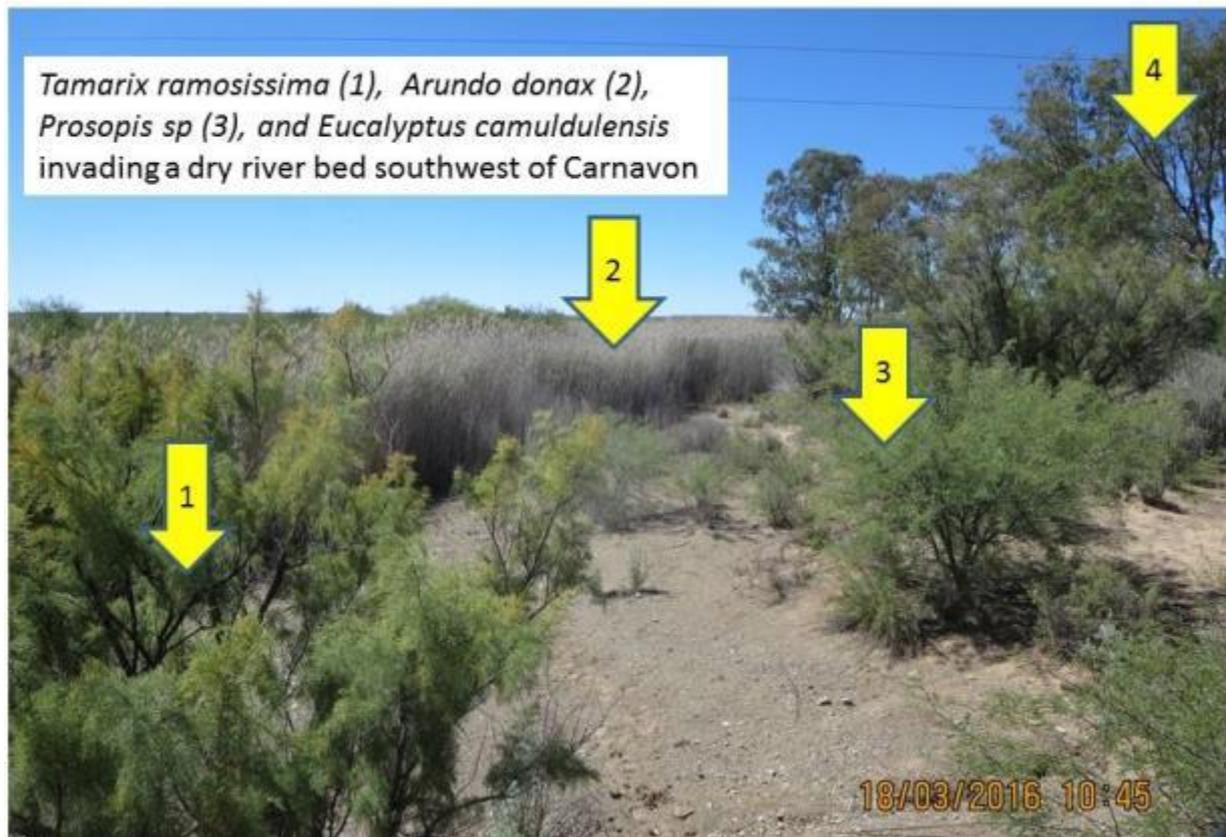


Figure 2: A mix of invasive alien plants in a river bed between Carnarvon and Fraserburg within the Karoo Central Astronomy Advantage Area

Alien invasive plant species are grouped as follows:

- Trees are woody plants that when fully grown at least 3 metre high. In this document we further distinguish between “re-seeding trees” that shed large quantities of hard seeds that accumulate in the soil and germinate months or years later, and “re-sprouting trees” that increase mainly by suckering from the roots;
- Shrubs are woody plants less than 3 metre high, usually with two or more stems at ground level. As for trees, a distinction is made between re-seeding and re-sprouting shrubs;
- Succulents are plants that have non-woody swollen stems or leaves that store water;
- Herbaceous broad-leaved weeds are annual or perennial plants that do not have hard woody stems and do not store water in their stems or leaves; and
- Reeds are plants with long, narrow leaves that are herbaceous or have hollow stems.

1. Alien invasive trees

There are six species of alien invasive trees naturalised within the study area:

1. Red River Gum (*Eucalyptus camaldulensis*) from Australia,
2. Narrow-leaved Ash (*Fraxinus angustifolia*) from Algeria,
3. Two species of Poplar, (*Populus canescens*, *P. deltoids*) from North American,
4. Weeping Willow (*Salix babylonica*) from Europe,
5. Mesquite hybrids (*Prosopis species*) from the Americas, and
6. Pink Tamarisk (*Tamarix ramossissima*) from Asia.

Of these six tree species, by far the most abundant and transforming invader is number 5: Mesquite.

Prosopis species (Mesquite)

Mesquite (*P. glandulosa* and hybrids between *P. glandulosa* and other *Prosopis*) was imported into South Africa in the early 1900s as a fodder, shade and firewood tree. All the *Prosopis* species that gave rise to the present hybrid population originate from semi-arid and arid savannas in the Americas. These may be large trees as well as multi stemmed shrubs. The shrubby form is often as a result of damage, either grazing or incomplete control operations. In the Karoo Central Astronomy Advantage Area, *Prosopis* is generally small (less than 2 metre high) and usually occurs in dense thickets. *Prosopis* bears a slight resemblance to *Acacia karroo* (sweet thorn). *Prosopis* species (Figure 3) is distinguished from the indigenous Sweet thorn by:

- Reddish young branches with hard thorns 10-15 millimetres in length (Sweet thorn has longer white thorns);
- Pale yellow "bottle-brush" flowers (Sweet thorn has globular dark yellow flowers);
- Yellow to straw-coloured pods containing sticky pith and brown seeds (Sweet thorn has narrow dark brown pods).

Prosopis seeds are dispersed primarily by animals in dung, but may also be spread by water and transported in mud or sand moved from site to site. Seeds normally germinate and establish after rainfall events during summer months. Seedlings establish deep roots (0.5 metres) within one year. Because many viable seeds are passed in dung, *Prosopis* trees often establish around livestock water points, stock kraals and along drainage lines where livestock and game shelter. This species commonly invades Central Karoo areas along dry river beds, old lands, around water points and in pans where the water table is shallow. As indicated in the map produced in 2007 by Working for Water (Figure 4), *Prosopis* is widespread in the Karoo Central Astronomy Advantage Area study area. Very dense stands occur around the pans and drainage systems of the Carnarvonsleegte and Sak drainage systems between Brandvlei Vanwyksvlei and Carnarvon. There are also dense *Prosopis* thickets in the core area. The optic fibre/power line infrastructure will pass through *Prosopis* invasions within the core as well as on all three spiral arms (Figure 4). Construction activities such as borrow pit excavation and channeling of water off roads or away from structures such as telescope mounts and buildings are vulnerable to mesquite invasion. Mesquite does not readily establish away from the deep alluvial soils of the drainage channels.



Figure 3: *Prosopis* species and mesquite thicket in the SKA Core area (Photo: L. Cape).

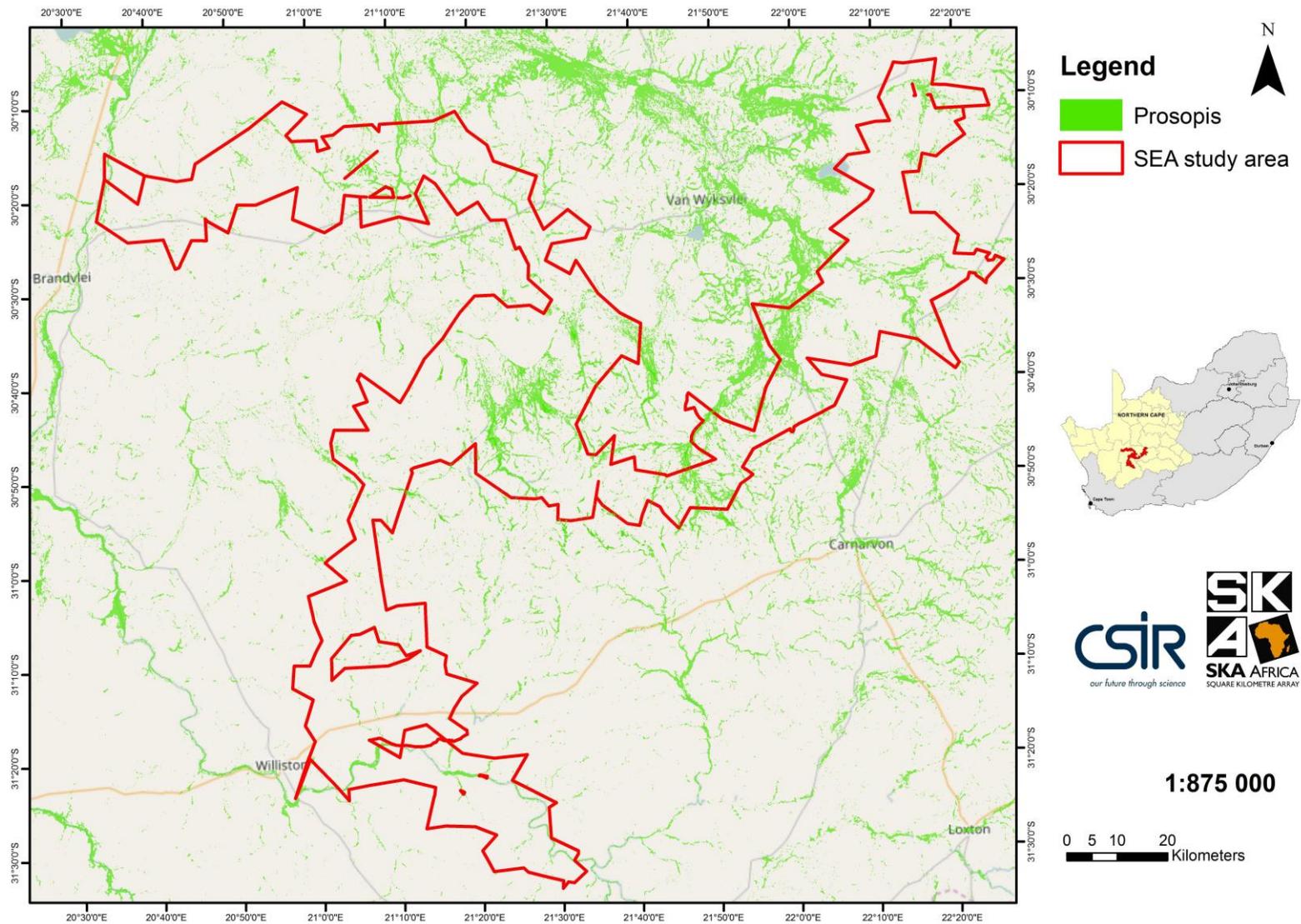


Figure 4: Distribution of *Prosopis* species in the SEA study area (Data Source: SANBI (2007) and SKA SA (2016))

Eucalyptus camaldulensis (Red river gum)

The Red River Gum is often planted around farm houses for shade and firewood production. It is a large, long-lived, evergreen tree that reproduces by seeding, and recovers from felling or fire by coppicing (Figure 5). Although drought tolerant once established it requires damp conditions for seed germination and seedling survival. For this reason it invades along rivers and around dams and natural wetlands.



Figure 5: *Eucalyptus camaldulensis* (Red River Gum). Note regeneration around felled tree. Inset shows frilling used to slow-kill re-sprouting trees without felling

Populus canescens (Grey poplar) and Populus deltoides (Cottonwood, Matchwood poplar)

The Grey Poplar and Matchwood Poplar grow in fresh water habitats such as along perennial rivers and in springs (Figure 6). They were often planted near farm houses to supply wood and shade, but unfortunately they sucker strongly from the roots, forming dense thickets in springs and along the river banks. Invasive clones of these species occur in the core area and in the southern and eastern parts of the Karoo Central Astronomy Advantage Area where there are fresh water springs and rivers.



Figure 6: Cottonwood (*Populus deltoides*) near a water point in the SKA Core (Photo L. Cape)

Tamarix ramosissima (pink tamarisk)

Pink Tamarix is a problem in rivers where water is saline or alkaline, and in dams that dry out. These large shrubs thrive on salty, alkaline (brak) soils in natural and modified habitats. They can easily be distinguished from indigenous *Tamarix usneoides* by small leaves that turn yellow in winter, feathery growth, supple red stems, and sprays of small bright pink flowers on the branch tips in spring (Figure 7). The flowers form feathery seeds that blow in the wind or drift on water. The seed is dispersed by wind and floodwater as well as being moved in building sand mined in dry riverbeds. When rivers, dams or borrow pits sites dry out the seeds rapidly germinate in the mud leaving behind thousands of seedlings that grow to metre-high shrubs within a year. Dense thickets of Pink Tamarix Clog Rivers causing flooding, and by excluding light, prevent re-establishment of indigenous plants.

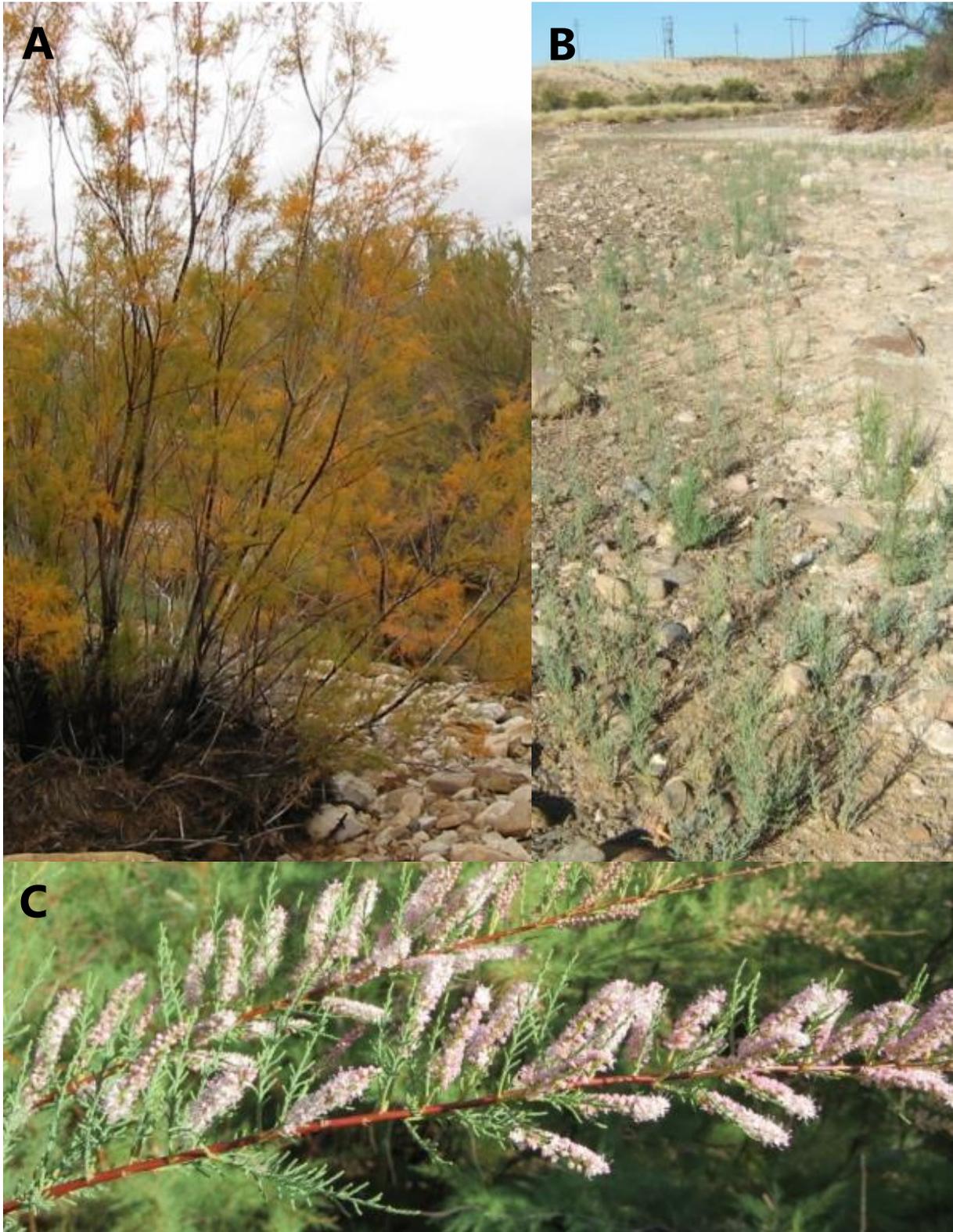


Figure 7: A) Pink Tamarix showing autumn and winter colours before the leaves are shed. B) numerous Pink Tamarix seedlings growing in a dry river bed downstream from a Tamarix invasion. C) flowers and feathery leaves

2. Alien invasive shrubs

There are three invasive alien shrubs in the Karoo Central Astronomy Advantage Area:

- *Nerium oleander* (Oleander, Selonsroos) is restricted to the western and southern edges of the area in freshwater rivers from mountainous watersheds;
- *Atriplex nummularia* (Oumnsoutbos) and *Nicotiana glauca* (Wild tobacco) are found throughout the area in dry river beds, on saline alluvium and floodplains.

Atriplex nummularia (Ouman soutbos)

This grey salt-tolerant shrub from Western Australia was introduced to the Karoo as a drought fodder crop and planted on deep alluvial soils where it has formed dense stands (Figure 8), often in areas that had become too saline for crops. The seeds are dispersed in floodwaters and in the dung of livestock and wild herbivores. It can be confused with indigenous *Atriplex vestita* (Vaalbrak), a metre-high shrub that occurs naturally in similar habitats. However, Oumansoutbos reaches a height of 2 metres, is woody, and palatable, whereas the indigenous species seldom exceeds 0.5 metres, has a spreading growth habit, and is unpalatable to herbivores.



Figure 8: *Atriplex nummularia* (Oumansoutbos) showing height and grey colour of this shrub that forms dense stands on river banks

Nerium oleander (Oleander, Slonsroos)

Oleander are evergreen, multi-stemmed shrub with pink flowers (Figure 9) that invades fresh water perennial and seasonal river beds on the inland mountain slopes. Oleander leaves, green stems, dry wood and wood smoke are poisonous to people, livestock and wildlife – so the stems and wood of this plant should never be used as firewood. There are dense invasions of this species in the Hantamsrivier within the Karoo Central Astronomy Advantage Area east of Calvinia but it is absent saline or alkaline rivers in the Karoo Central Astronomy Advantage Area. The seeds are attached to silky parachutes and drift on wind and water. However its deep roots and vigorous sprouting ability is what makes this invasive Asian plant difficult to control.



Figure 9: *Nerium oleander* (Oleander) showing growth habit in the Hantamsrivier area of the Karoo Central Astronomy Advantage Area east of Calvinia, multi-stemmed growth habit that captures silt in river beds. The multiple stems and mounded silt are revealed by clear felling

Nicotiana glauca (Wild Tobacco, Wildetabak)

This is a lanky shrub up to 2 metre high with blue-green leaves and tubular yellow flowers (Figure 10). It is poisonous to herbivores. It grows on disturbed soil subject to occasional flooding, particularly in dry river beds, on roadsides and in borrow pits. The masses of dust-like dry seeds are dispersed in wind, floodwater and sand moved to building sites.



Figure 10: *Nicotiana glauca* (wild Tobacco, Wildetabak). Note large leaves and tubular flowers

3. Alien invasive succulents

Succulents are plants that store water in their leaves and stems. The succulent plant species that invade in the Karoo belong to the leaf succulent Agave family (e.g. sisal/garingboom) or to the stem succulent Cactus family (e.g. kaktus/turksvy/queen of the night). Cactus may have cylindrical or flat stems, but all are covered in thorns. Most Cactus have two kinds of thorns – long thin thorns that are barbed, and glochids or fine hair-like thorns that blow in the wind when the cactus is damaged. The best current guide to invasive succulents in South Africa is Waters et al (2011)⁶ which should be read in conjunction with the South African Plant Invaders Atlas (SAPIA) newsletters⁷.

Agave americana (American Agave) and Agave sisalana (sisal)

Both these American aloe-like plants may be present in the Karoo Central Astronomy Advantage Area, however neither was recorded on the field trip nor present in the South African Biodiversity Information Facility (SABIF) records for the area. The *A. Americana* has spines on the leaf point as well as along the leaf margin. The leaves have a tendency to fold onto the ground. In contrast *A. Sisalana* has rigid leaves with a single spine on the tip. They were commonly planted as fences to limit the movement of livestock into ploughed areas, as drought fodder, or planted in erosion ditches (dongas)

⁶ Walters. M., Figueiredo, E., Crouch, N.R., Winter, P.J.D., Smith, G.F., Zimmermann, H.G. & Mashope, B.K. 2011. Naturalised and invasive succulents of southern Africa. ABC Taxa Vol. 11, Belgium

⁷ <http://www.arc.agric.za/arc-ppri/Pages/Newsletters.aspx>

to stop soil erosion. They produce tree-like, giant flowering stems (Figure 11). In *A. Sisalana* the seeds germinate on the flower stem and small plants fall to the ground and take root. Seedlings do not disperse far from parent plants. After flowering the old plant dies, but root suckers surrounding it give rise to two or three new plants. In this way clumps continue to increase in size over many decades or centuries. *A. Americana* produces flowers and seeds.

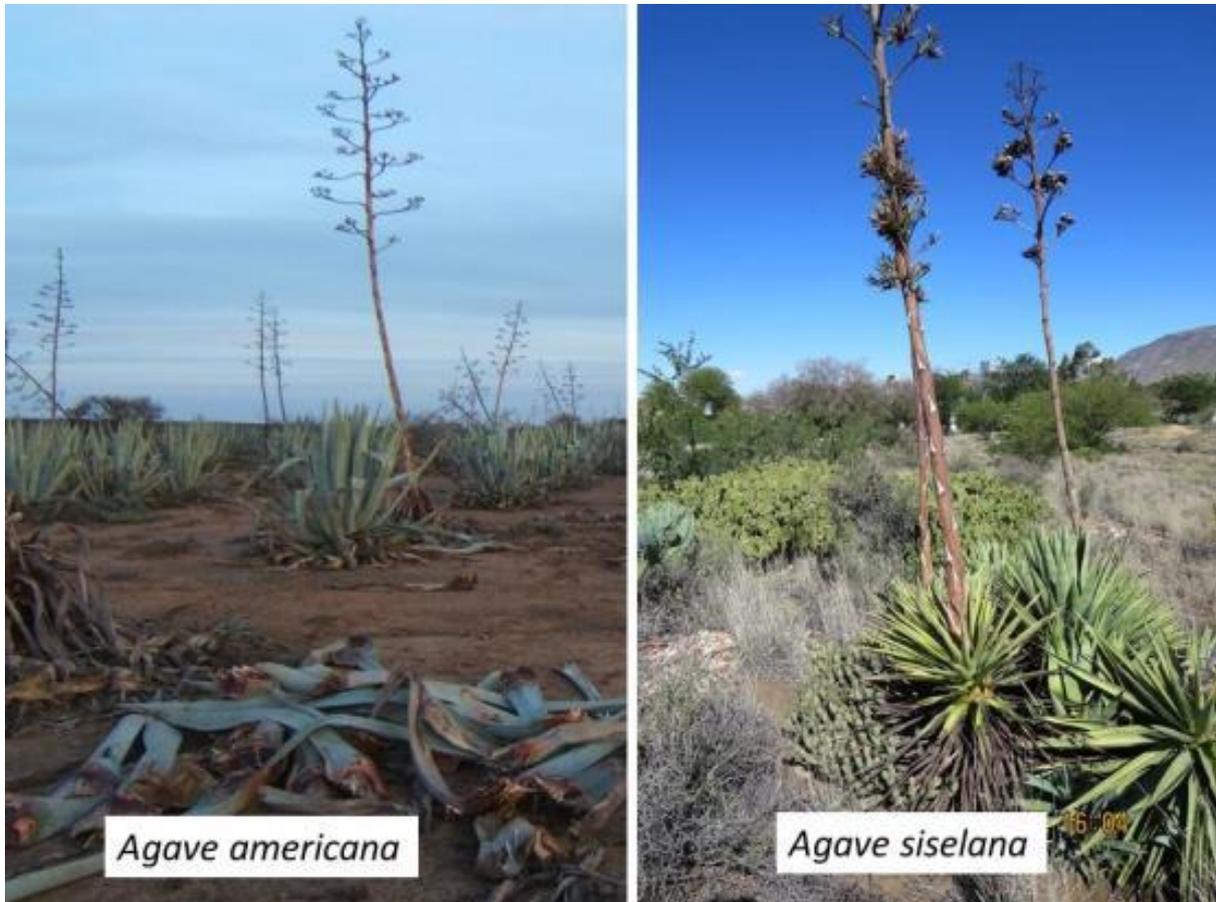


Figure 11: Agave and Sisal plants. Dead flower heads 3-4 metre high like trees

Cylindropuntia cactus species (*C. fulgida* var *mammilata*, *C. imbricata*, *C. pallida* and *C. spinosior*) Chain-fruit cactus, Kabel turksvy, Rosea cactus

This group of cactus species from the Americas has cylindrical stems that may be sparsely or densely covered in long white spines. They also have small fine spines (glochids) at the nodes where the longer spines are attached. Most have rose-coloured flowers and produce green to yellow fruits that hang in chains (Figure 12). The Boxing Glove Cactus (*C. fulgida* *mamillata*) has glove-shaped stems and shorter thorns. The Rosea Cactus (*C. pallida*) and some forms of *C. fulgida*, have very dense spines giving the plant a white appearance (Figure 12).

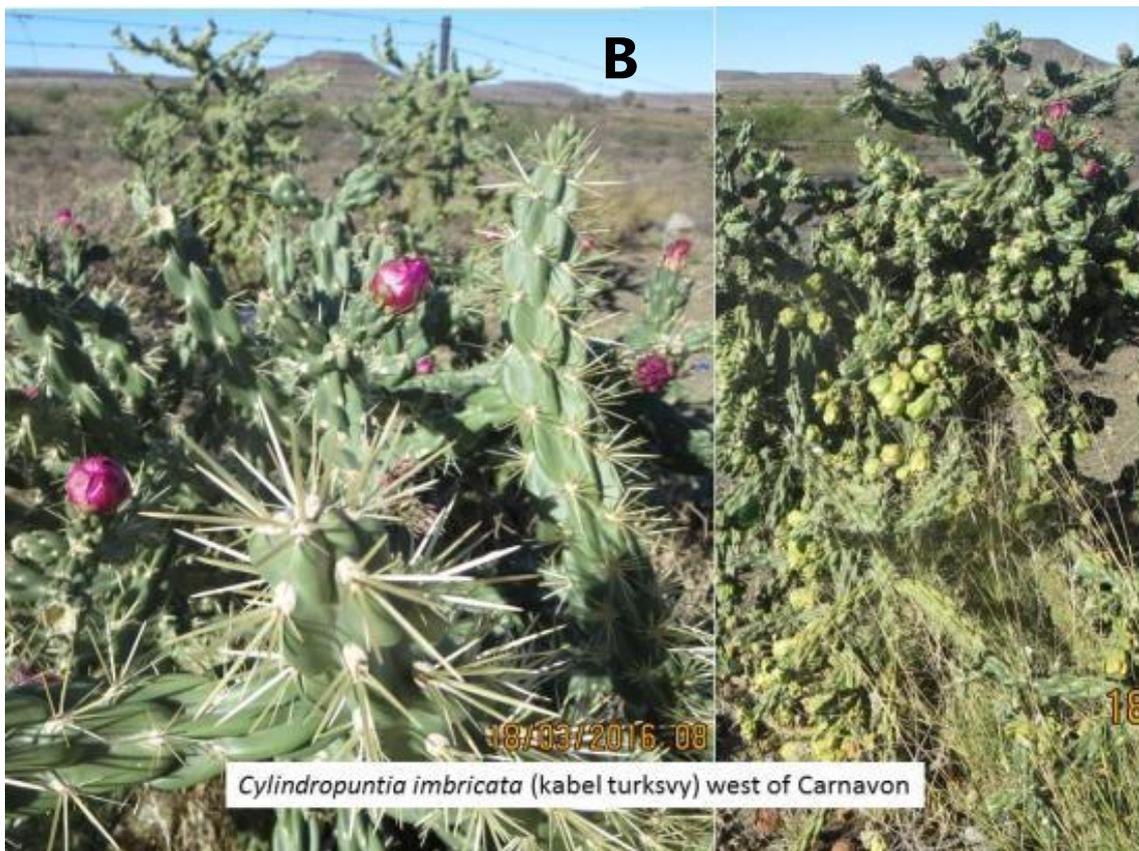
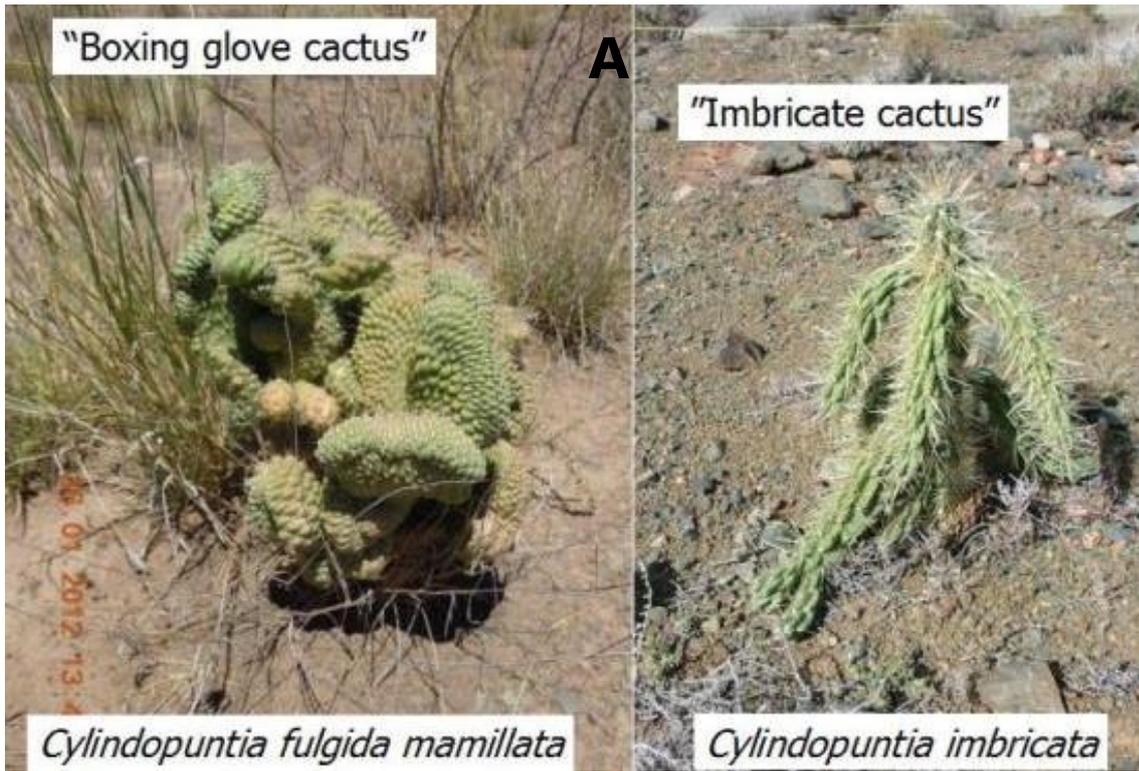


Figure 12: A) Boxing Glove Cactus and seedling Imbricate Cactus. B) Imbricate Cactus with rose-coloured flowers and chains of greenish-yellow fruits

All the *Cylindropuntia* Cactus species reproduce both by seeds and by shedding of stem sections that later take root. Seeds are dispersed in the fruits that are eaten by crows, monkeys and baboons, so the invasions are often associated with fences, powerlines, rock piles, koppies and other perch sites or refuges. Stem sections may be washed down rivers by floods. The very spiny forms of cylindrical cactus are also dispersed long distances when the barbed spines of small stem sections attach themselves to wildlife, shoes or vehicles (Figure 13). The only indigenous plant genus that could be mistaken for a cylindrical cactus is *Hoodia* (Figure 14). Plants in the genus *Hoodia* are all protected under national and provincial legislation and must not be removed. It is easy to tell *Hoodia* and Cactus apart – Cactus thorns are barbed and *Hoodia* thorns are short and never barbed.



Figure 13: *Cylindropuntia pallida* (Rosea Cactus) showing covering of white spines and a spiny cladode attached to a boot



Figure 14: *Hoodia gordonii* (Ghaap): protected indigenous plant

4. Alien invasive cactus

Pinecone Cactus (*Tephrocactus articulatus*) is probably one of the most widespread cactus invaders in the Central Karoo. It has escaped from farmhouse gardens via seeds dispersed by birds, and by stem sections that break off and are moved in garden refuse to dongas and dispersed further along small drainage lines during flash floods. This cactus is difficult to spot because it is grey-brown to olive green in colour and the same height as most indigenous Karoo shrubs (Figure 15). It occurs mainly along small washes or dry river beds and on over-grazed rangeland. It can easily be mistaken for *Hoodia* (see Figure 14).

Prickly Pear type Cactus (*Opuntia ficus-indica* and *Opuntia robusta*) are well known and widely planted on old lands as fodder banks and for edible fruits in the Karoo. Although Spineless Cactus is not a declared invader, the seeds dispersed by people, crows, monkey and baboons give rise to spiny plants. Plants are often seen along fence lines, under telephone poles and power pylons, and on rocky koppies where crows and baboons disperse the seeds (Figure 16). The plants disperse and multiply mainly by seed, but dumping of stem sections (cladodes) with other garden waste can give rise to new invasions. Torch cactus/Orrelkactus (*Echinopsis schickendantzii*, also known as *E. spachiana* and *Trichocereus spachianus*⁸) (Figure 17) is a tall, spiny, pole-like plant with large white flowers. It was frequently planted in gardens and as a barrier plant, but escapes into natural veld, especially among trees and rocks, via seeds dispersed by birds. It roots from cut pieces of stem and will invade wherever garden waste is dumped in the veld.

⁸ <http://www.arc.agric.za/arc-ppri/Newsletter%20Library/SAPIA%20NEWS%20No%2040,%20April%202016.pdf>



Figure 15: Pinecone cactus resembles indigenous Karoo shrubs in height and colour



Figure 16 Prickly pear (left) and Robusta Prickly Pear/Blou Turksvy

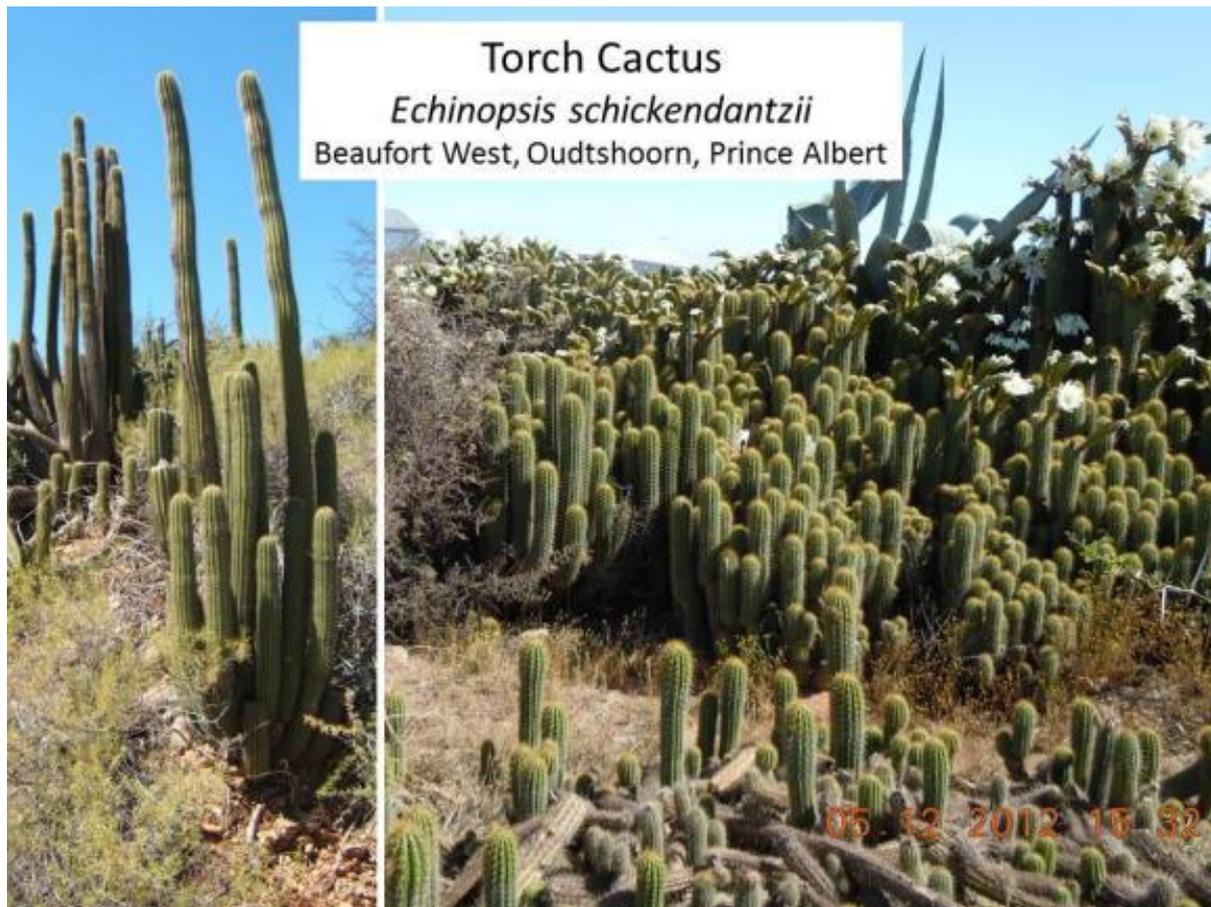


Figure 17 Left *Echinopsis* (orrelkactus)

5. Herbaceous broadleaved weeds (opslag)

This group of plants are typical pioneer plants in that they thrive on disturbed lands. This makes them a potentially serious threat to the construction areas of the site. While their invasion into pristine veld is generally limited, they are classified as invasive and must be managed. The exception to this is *Solanum elaeagnifolium* that is perennial and persistent. There are 7 alien invasive non-woody broad-leaved herbaceous weeds commonly found in the Karoo Central Astronomy Advantage Area on disturbed soils of roadsides, old lands and in construction sites. Most of them are opportunistic, germinating after rain and vegetation removal from seeds stored in the soil or transported on vehicles. Many are poisonous to livestock species (e.g. *Datura* species, *Solanum* species.), have burr-like seeds that tangle wool (*Xanthium* species), or are thorny and unpalatable (*Argemone*, *Salsola kali*, *Xanthium* species). They are therefore unwelcome in rangelands. All of them have abundant, long-lived seed and thrive on bare and disturbed soil where there are no indigenous plants. They are briefly described and illustrated below, in alphabetical order.

Argemone ochroleuca (Mexican Poppy, Blou Dissel)

This is a poisonous, spiny weed in the poppy family that invades dry river beds and roadsides. Leaves are a characteristic blue-green and contain an unusual bright yellow sap that stains the skin. The flowers are large and yellow (Figure 18). The plant starts life as a rosette, growing flat on the soil surface, and making it difficult to hand pull. Seeds are often dispersed in flood water and building sand. It is common throughout the Central Karoo.



Mexican Poppy, Bloudissel
Argemone ochroleuca (LEFT)
Argemone mexicana (ABOVE)

Figure 18 Left: The Mexican Poppy with the pale yellow flower is very common in Central Karoo.
 Lower right: The plants start off as a rosette with leaves on the ground

Atriplex lindleyi subspecies inflata (Spongefruit saltbush, Klein blasie brak)

This saltbush imported from Western Australia a century ago has invaded saline, fine-textured soils throughout the Karoo, but particularly in areas receiving some winter rainfall. The plant is typically about 0.3 metre high, grey green, soft and spineless with characteristic sponge-filled fruits that float on water and roll along the ground in the wind (Figure 19). The whole plant is palatable to livestock and wild herbivores and seeds are dispersed in dung. It is particularly common in old lands, overgrazed veld and along roadsides. The plant does not re-sprout but germinates abundantly from seed stored in soil.



Figure 19 *Atriplex lindleyi* (Sponge Fruit Saltbush, Kleinblasiebrak) on the road verge near Carnarvon.
Inset shows spongy fruits that contain seed

Datura ferox and Datura stramonium

Thorn Apple/Stinkblaar/Olieboom are large-leaved, poisonous annual plants that thrive after flooding, especially in sites enriched by manure or vegetation clearing. The plants have a characteristic oily smell, purple to white flowers and spiny fruit capsules. They are commonly found around dams and pans, livestock and wildlife watering and shelter sites and along riverbanks and roadsides. The seeds are released from the spiny fruit when the capsules dry out (Figure 20) and can persist in the soil for some years. The plant does not re-sprout once cut.

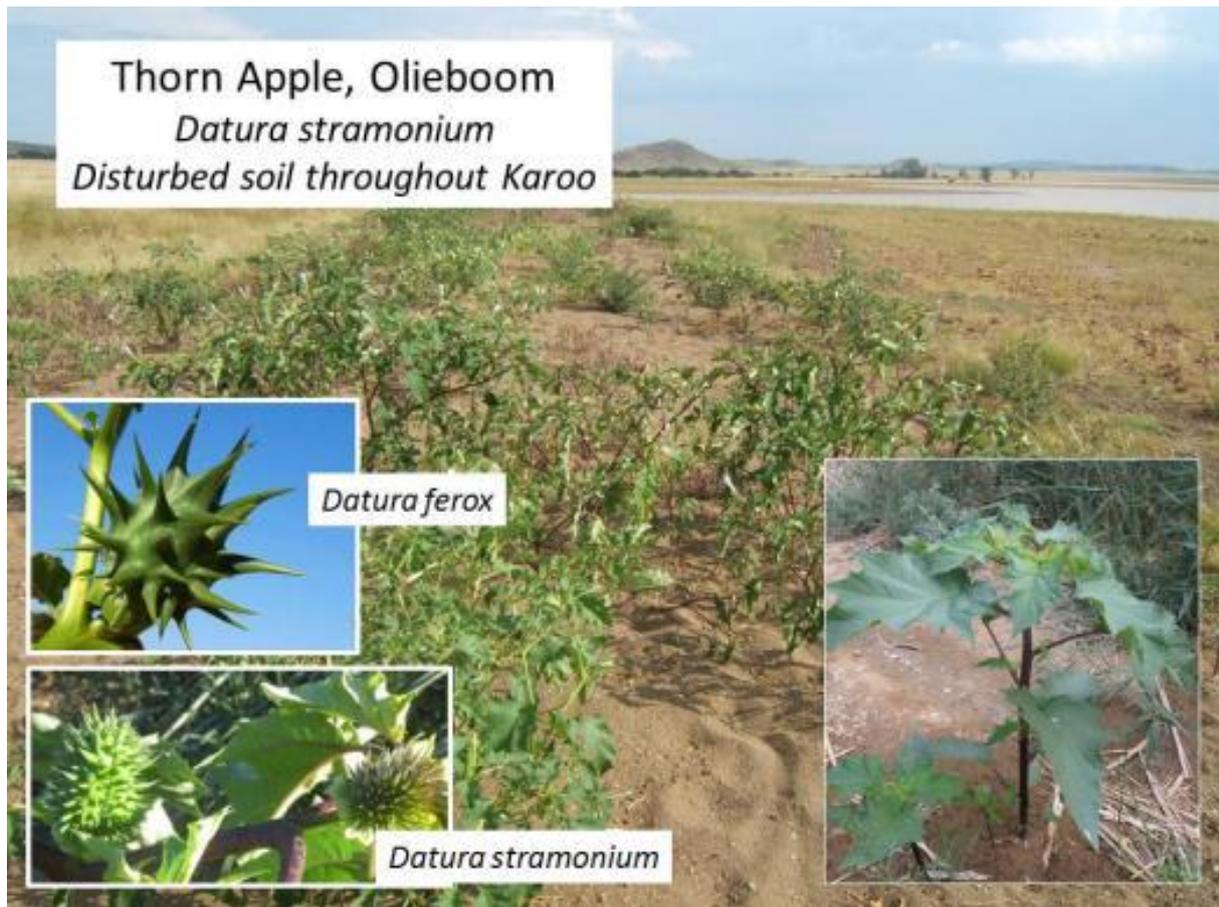


Figure 20 Thorn Apple/ Stinkblaar/Olieboom plants at the edge of a dam where soil is enriched by grazing antelope. Note spiny fruit capsules and large leaves (insets)

Salsola kali (Russian Tumbleweeds/Rolbos/Glasswort)

These annual plants from Asian desert areas have small leaves tipped with very sharp spines that break off in the skin. Young plants are soft and palatable to herbivores, but as the plants grow the stems and leaves harden and the plant structure thickens, eventually developing into a dry ball (Figure 21). When the plant dies the ball of leaves and seeds breaks loose from the roots and rolls along the ground shedding seeds – hence the common name “rolbos” and “tumbleweed”. Tumbleweed occurs throughout the Karoo Central Astronomy Advantage Area, especially on old lands and on roadsides. It does not re-sprout after clearing, but regenerates from seeds stored in the soil.

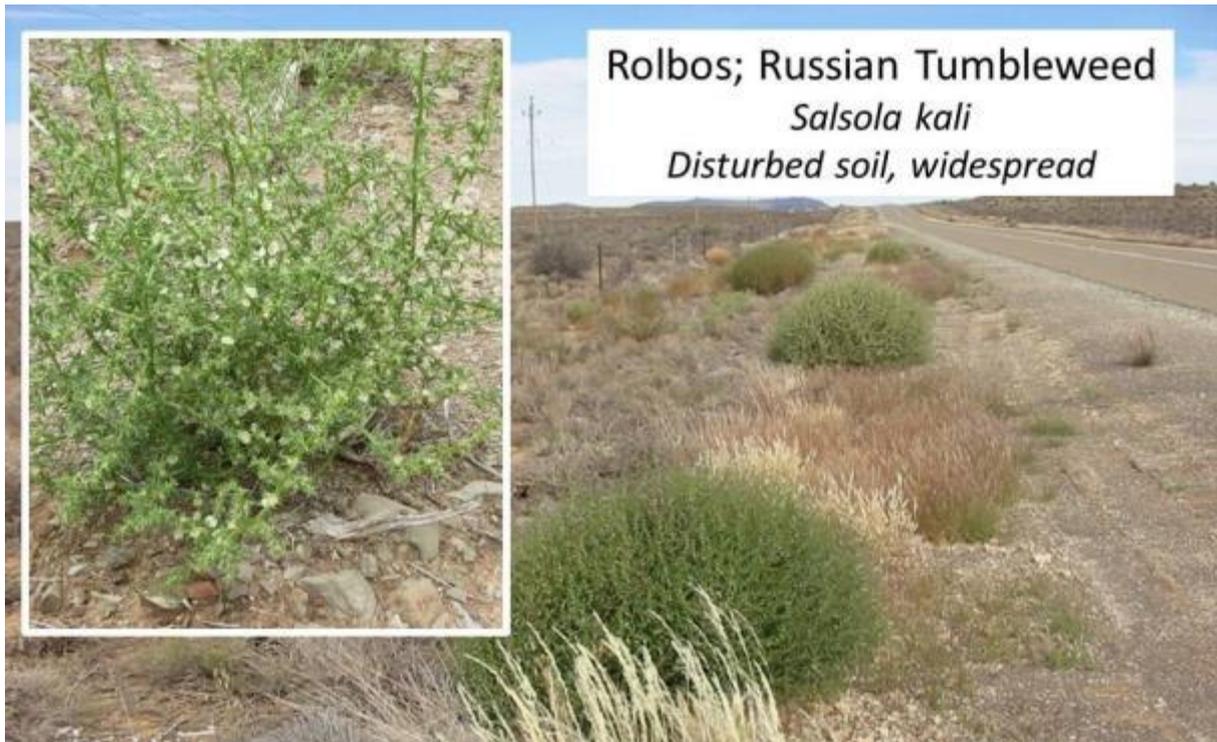


Figure 21 Russian Tumbleweed/Rolbos between Fraserburg and Williston

Solanum elaeagnifolium (Satan Weed)

This South American herbaceous plant with grey felty leaves and spiny stems is not annual but perennial (Figure 22). It has an extensive root system that enables it to re-sprout if damaged. The purple flowers develop into fruits that resemble small, yellow tomatoes and are eaten by birds and some other wildlife that disperse the seeds in their droppings. Within the Karoo Central Astronomy Advantage Area it is limited in distribution to abandoned erven in villages, and livestock kraals on farms. However, following significant rain and soil disturbance it can invade construction sites and road verges, being transported to such sites by birds perching on fences.

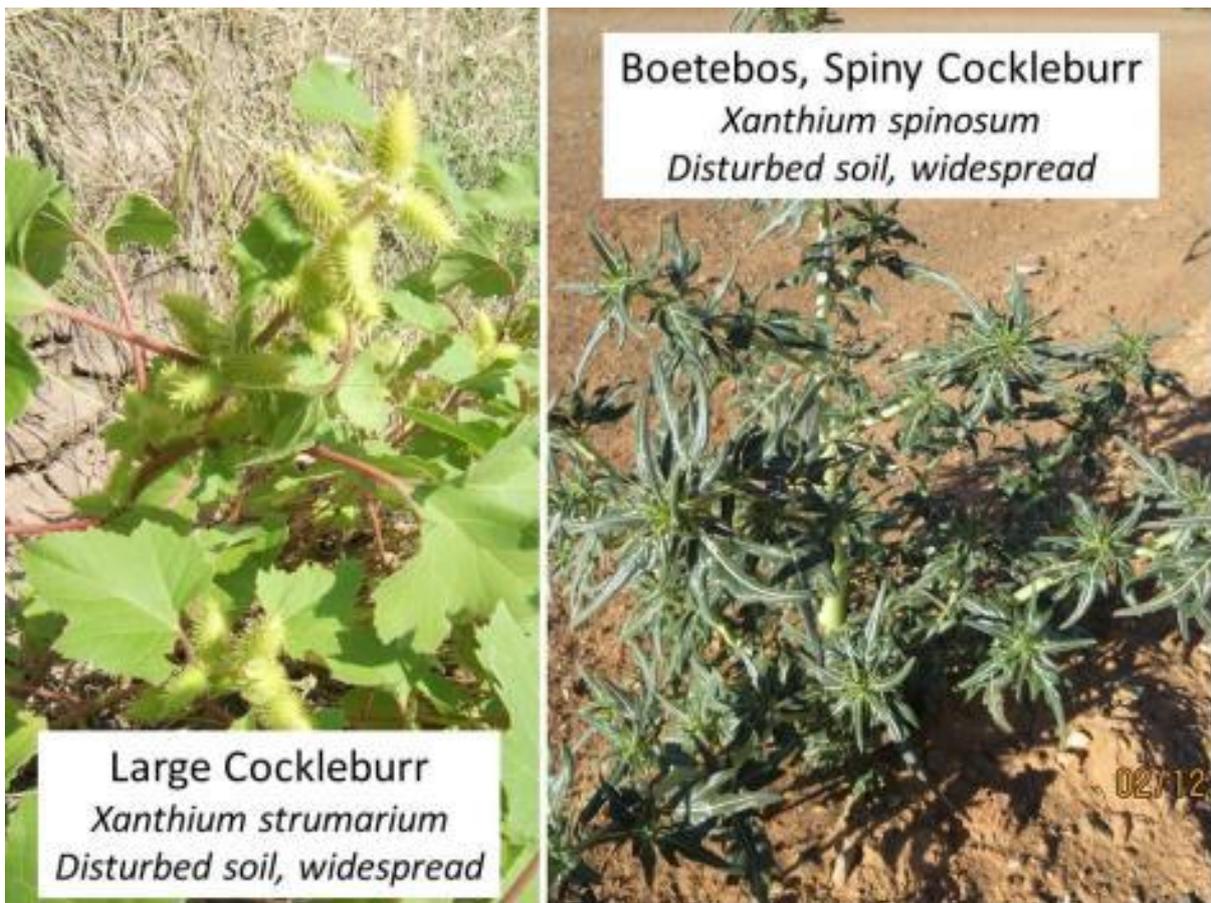
Xanthium spinosum (Cockleburr/Boetebos)

This burr-bearing plant is a serious threat to the wool industry and landowners who failed to eradicate it from their field and stock kraals were once fined (hence the common name "boetebos"). This large-leaved, poisonous weed with yellow sap, establishes in wet areas and on fertile soil – particularly around waterpoints, dams, rivers and roadsides. The seed case is a large burr covered in hooks (Figure 23) which attaches itself to the hair of animals and is dispersed in this way to places where livestock and wildlife congregate. Although the plant does not re-sprout, it regenerates from seed that can survive for years in the soil.



Solanum elaeagnifolium (satan weed) in Van Wyksvlei

Figure 22 Satan Weed showing LEFT numerous plants linked by underground suckers, and RIGHT felty grey leaves and purple flowers typical of the tomato family



Boetebos, Spiny Cockleburr
Xanthium spinosum
Disturbed soil, widespread

Large Cockleburr
Xanthium strumarium
Disturbed soil, widespread

Figure 23 Cockle Burr/Boetebos species. Note large cylindrical burrs

6. Alien invasive Grasses and Reeds

The only troublesome invasive alien plants in this group in the Karoo Central Astronomy Advantage Area are the Fountain Grass (*Pennisetum setaceum*) from North Africa, and European Spanish Reed (*Arundo donax*).

Pennisetum setaceum (Fountain grass/Pronkgras)

Fountain Grass more commonly invades roadsides and construction sites, particularly on rocky surface or fine-textured soil (Figure 24). Currently it is limited to the western and southern edges of the Karoo Central Astronomy Advantage Area, but has potential to invade on rocky ground and fine-textured soils under arid conditions with winter or summer rainfall⁹. It is a long-lived tussock grass with narrow leaves that have saw-toothed edges. As it is not eaten by livestock or wildlife (because of its high fibre content) the tussocks grow large and flammable because of many dead leaves. The fluffy plume-like pink flowers appear throughout the year, and the seeds are dispersed by the wind and water. It rapidly colonises bare rocky ground and small and large dry river beds. The deep-rooted tussocks are impossible to pull out by hand.



Figure 24 Fountain Grass as it is often seen along roadsides and in borrow pits in the Central Karoo. Note purple-pink feathery seed heads that are usually present

Arundo donax (Giant or Spanish Reed/Spaanse Riet)

This giant reed is about twice the height of the indigenous Fluitjies Riet, and colonises river banks rather than river beds (Figure 25). It does not set fertile seed but spreads mainly through plantings, and by movement of roots and rhizomes in flooding rivers. It re-sprouts vigorously after clearing or burning.

⁹ Rahlao, S.J., Milton, S.J., Esler, K.J. & Barnard, P. 2014. Performance of invasive alien fountain grass (*Pennisetum setaceum*) along a climatic gradient through three South African biomes. *South African Journal of Botany* 91:43-48

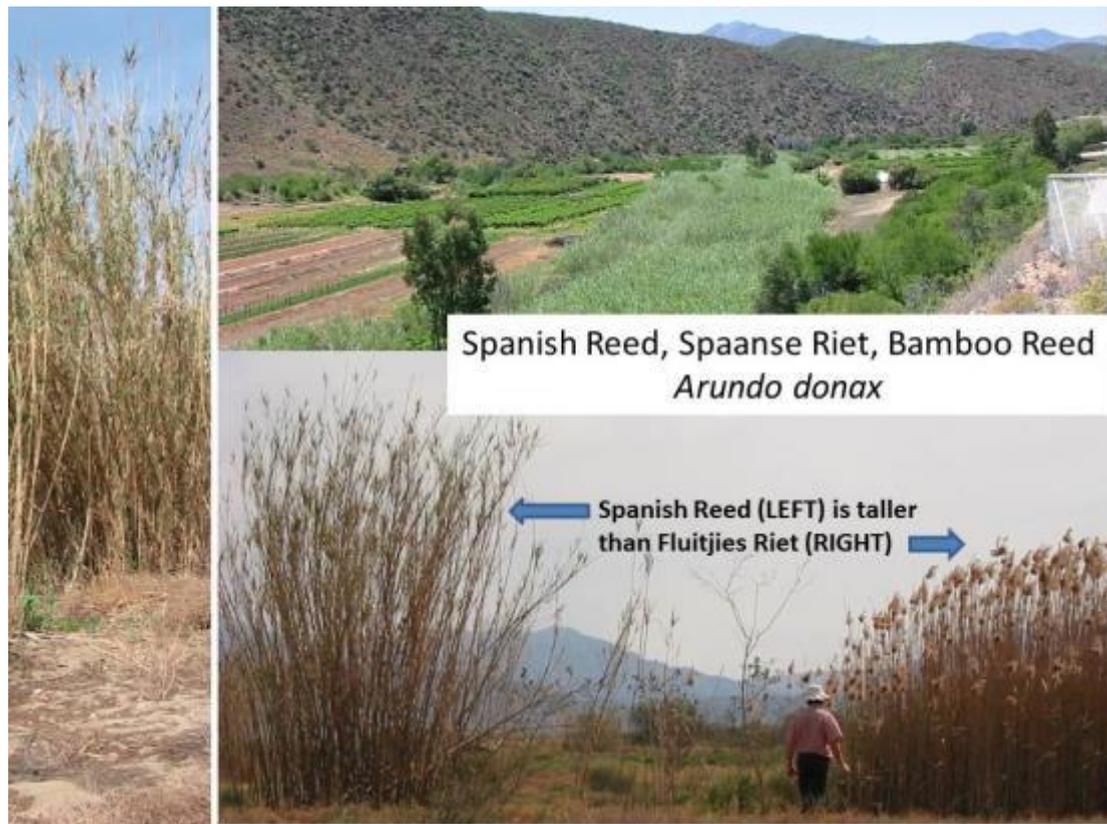


Figure 25: *Arundo donax* (Spanish reed) compared with the indigenous *Phragmites* (Fluitjiesriet)

7. Summary of the Invasive alien plant species recorded in Karoo Central Astronomy Advantage Area

Table 1 below includes the species listed as Invasive according to the National Environmental Management: Biodiversity Act (NEMBA, 2014) recorded in the Karoo Central Astronomy Advantage Area.

Table 1: Species listed as Invasive according to the National Environmental Management: Biodiversity Act (NEMBA, 2014) and recorded in the Karoo Central Astronomy Advantage Area

Family	Species	NEMBA listing	Data source	Number of records	Grids
AGAVACEAE	Agave. Sialana	2	Fieldwork Dr Milton		
APOCYNACEAE	Nerium oleander L	1b	Fieldwork Dr Milton	1	3119
ARUNDINACEAE	Arundo donax L.	1b	Fieldwork Dr Milton		3121
ASTERACEAE	Xanthium spinosum	1b	Fieldwork Dr Milton		
BRASSICACEAE	Nasturtium officinale R.Br.	2	Plants of South Africa database on the South African National Biodiversity Institute (SANBI) website (POSA), South African Biodiversity Information Facility (SABIF)	1	3122
CACTACEAE	Cylindropuntia fulgida mammilaris	1b	Fieldwork Dr Milton	2	3121 3122
CACTACEAE	Opuntia ficus-indica	1b	POSA, SABIF	4	3122
CACTACEAE	Tephrocactus articulatus	1a	Fieldwork Dr Milton	1	3121
CHENOPODIACEAE	Atriplex lindleyi Moq. subsp. inflata (F.Muell.) Paul G.Wilson	1b	POSA and SABIF, Fieldwork Dr Milton	12	3020 3021 3022 3120
CHENOPODIACEAE	Atriplex nummularia Lindl. subsp. Nummularia	2	POSA, SABIF	3	3019 3021
CHENOPODIACEAE	Salsola kali L.	1b	POSA and SABIF, Fieldwork Dr Milton	12	2919 2920
FABACEAE	Prosopis glandulosa Torr. var. and hybrids	3	POSA and SABIF	9	2919 2921
FABACEAE	Prosopis velutina Wooton	3	POSA and SABIF	7	2919
MYRTACEAE	Eucalyptus camaldulensis	1b riparian	Fieldwork Dr Milton	1	3120B
PAPAVERACEAE	Argemone ochroleuca Sweet subsp. Ochroleuca	1b	POSA and SABIF, Fieldwork Dr Milton	3	3019 3021 3022
POACEAE	Pennisetum clandestinum	1b	POSA and SABIF	1	
POACEAE	Pennisetum setaceum (Forssk.) Chiov.	1b	Fieldwork Dr Milton	1b	3121
POACEAE	Sorghum halepense (L.) Pers.	2	POSA and SABIF	1	3022
SALICACEAE	Populus x canescens (Aiton)	2	POSA and SABIF	1	3019
SOLANACEAE	Datura ferox L.	1b	POSA and SABIF	2	2920
SOLANACEAE	Datura stramonium L.	1b	POSA and SABIF	1	3121
SOLANACEAE	Nicotiana glauca Graham	1b	POSA and SABIF	2	2921 3122
SOLANACEAE	Solanum elaeagnifolium Cav.	1b	Fieldwork Dr Milton	1	3021
TAMARICACEAE	Tamarix ramosissima Ledeb.	1b	POSA and SABIF	1	3023

II. Alien invasive plant species clearing and control guidelines

This section provides a description of control methods for woody plants, succulents, herbaceous plants, grasses and reeds. Information on methods and chemicals to be used for the control of alien invasive plant species is provided as guidelines only. Further research and monitoring activities are required in order to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed Alien Invasive Plant Species Management Plan. Additional information species-specific herbicide application rates should be obtained from labels of registered herbicides.

1. General guidelines for the control of woody plants

Cut stump

Fell trees according to label instructions using a suitable tool (lopper, hand saw or chain saw). Label recommendations suggest that trees should be felled between 10-20 centimetres above the ground. Field conditions may dictate that trees are felled outside these parameters but this should be the exception and not the norm. A suitable and registered herbicide should then be applied as per label recommendations. When treating the cut stump of a felled tree all cut branches and stems must be treated.

Foliar applications

Foliar applications are not recommended for the SKA core area (due to the fact that development areas must be cleared for construction activities; and it is not applicable for the climate and growth characteristics of the trees in the SKA core area) but can be used for follow-up operations, treatments of suckers and any seedlings that cannot be hand pulled.

Mechanical Control

Mechanical Control is also not recommended for the SKA core area as it is not suitable for the alien plant species present within this area.

Biological control

The only tree with biological control available is *Prosopis*. The beetle is wide spread and well established already so no further action is required.

Handling of trash

Trash from felled trees should be stacked in a suitable area (to be included in the detailed Invasive Alien Species Management plan for the SKA construction footprint area). Stacking will depend on the desired and recommended actions but there is no need to remove off site.

2. Specific guidelines for the control of *Prosopis* species

This group of plants is renowned to be hard to kill. Young trees (2 metre tall) of all species can be foliar sprayed but this is difficult and has limited success due to the tree and climate. Research has shown that the window for spraying is limited both on a daily basis and yearly. Trees cannot be sprayed during the heat of the day and should only be treated late summer to autumn. The best method to manage *Prosopis* trees is to use cut stump operations. Numerous herbicides are registered but experience has shown that not all are equally effective. Herbicides that may be used include:

- Triclopyr 480g EC with diesel;
- Triclopyr/clorpyralid (270/90) in water;
- Picloram/Triclopyr 50 50 Gel; and
- Triclopyr 360 SL in water.

Triclopyr 480 EC is not a widely used option due to the cost of the diesel but it is widely accepted as the product that is the most reliable. Follow-up treatments of felled trees will need to continue for at least 24 months. Coppice growth can be treated with one of the registered herbicides but Triclopyr/clorpyralid (270/90) is possibly the best. Use the herbicide according to the label and ensure thorough wetting of all leaves.

3. Specific guidelines for the control of Poplar species

Poplar is easy to kill but difficult to manage due to the fact that it produces root suckers. Any treatment programme must treat the parent plant and all juveniles in the area. This may involve a cut stump and foliar methods included at the same time.

Cut stump

Apply the herbicide of choice to the stems felled as discussed above. Herbicides registered for this tree include:

- Imazapyr 100;
- Picloram 240;
- Picloram/Triclopyr gel; and
- Triclopyr 360 SL.

Refer to Tables 5-3 and 5-4 below. Due to the ability of "Imazapyr 100" to translocate readily through the plant, this would be the herbicide of choice. Treatment for poplar is best conducted in late summer just before the onset of leaf fall.

Foliar treatments of suckers and seedlings

The only herbicide registered for this end use is metsulfurom-methyl (600 grams per kilogram).

4. Specific guidelines for the control of Tamarisk species

This is a problem species to manage as there are no registered herbicides currently available in South Africa. The only method of managing tamarisk legally is to use mechanical control. This however will require felling followed either by digging it out or by stump grinding.

5. Specific guidelines for the control of Sisal species

These plants are too large to remove manually. Both Sisal species can be controlled by the injection of 2 millilitres neat MSMA into pre-made holes in the stem. It may be necessary to remove some leaves to allow access to the bole to make the holes. These plants do not re-sprout once removed and cannot regenerate from the leaves. Leaves are useful mulch if chopped and spread on site to reduce soil erosion, and provide a seed bed and protection for regenerating indigenous plants (Figure 26).



Figure 26: Leaves of cleared agave spread over bare ground to facilitate regeneration of indigenous plant species after reseeding (Photo credits: Wilderness Foundation)

6. Specific guidelines for the control of Cactus species

Manual control

Manual control should be confined to single plants or very small groups of plants because felling large plants, digging out the roots and collecting up all the fruits and “cladodes” (pieces of stem) that break off while moving the cactus not only creates disturbance but increases risk of further invasions. Pieces of stem that are left on the soil surface will take root and lead to re-invasion of the site. Moreover, Cactus spines are barbed and painful to remove, and the smaller hair-like spines (glochids) on the nodes of cactus pads spines can cause long-lasting skin irritation and eye damage. Glochids blow in the wind and embed themselves in skin and clothing when a cactus plant is cut or moved. When removing Cactus, workers need additional safety equipment including goggles, masks, boots and thick overalls.

Chemical control

Inject MSMA 720 grammes per litre into pre-made holes in the stems of the cactus. This herbicide is yellow-labeled (see Table 2, Table 3). Not all cactus plants have a stem injection registration and a few have a foliar spray registration. As indicated above, further research and monitoring activities are required in order to understand the densities and distributions of the different cactus species and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan.

Table 2: Hazard ratings for commonly used herbicides available in South Africa¹⁰

South African hazard classification for herbicides	Hazard statement	Colour band
Class Ia – Extremely hazardous	Very toxic	Red
Class Ib- highly hazardous	Toxic	Red
Class II - moderately hazardous	Harmful	Yellow
Class III - slightly hazardous	Caution	Blue
Class IV - Acute hazard unlikely in normal use	-	Green

Table 3: Example of chemical control (herbicides) products and associated hazard ratings

Manufacturer	Active ingredient	Concentration	Hazard class
Dow Agroscience SA (Pty) Ltd	clopyralid/triclopyr (triethylamine salts)	90/270 g/l	Class II
Dow Agroscience SA (Pty) Ltd	Glyphosate	360 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	680 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	540 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	450 g/l	Class III
Arysta Life Science Pty (Ltd)	imazapyr	100 g/l	Class III
Arysta Life Science Pty (Ltd)	MSMA	720 g/l	Class II
Dow Agroscience SA (Pty) Ltd	triclopyr (butoxy ethyl ester)	480 g/l	Class II
Dow Agroscience SA (Pty) Ltd	triclopyr (Pyridyloxy Compound)	360 g/l	Class II

¹⁰ National Department of Agriculture (NDA) 2011.

http://www.nda.agric.za/doaDev/sideMenu/ActNo36_1947/AR/marketed_%20herbicides_%20active%20ingredients.pdf

Biocontrol

Biocontrol organisms are available for long-term control of some Cactus species (Figure 27). However the biological control agents appropriate for the particular cactus species must be used¹¹. Cactus species for which biocontrol is currently available are Boxing Glove and Imbricate Cactus (*Dactylopius tomentosus*, imbricata biotype, a cochineal insect), and Prickly Pear (*Cactoblastis cactorum* a stem boring caterpillar, and *Dactylopius opuntiae*, a sap sucker). Information on obtaining biocontrol agents can be obtained from the Agricultural Research Council¹².



¹¹ https://www.environment.gov.za/sites/default/files/docs/aiptreatment_table_biocontrol.pdf

¹² Agricultural Research Council information on Biocontrol Agents Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website <http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx>



Weeds Biocontrol Leaflets series 2 ARC-Plant Protection Research Institute, Pretoria

Figure 27: Biocontrol of Cactus by insects

7. Control of herbaceous plants

Solanum elaeagnifolium (Satan Weed)

This herbaceous, perennial plant has a deep root system that re-sprouts after above-ground parts of the plant have been cleared. For this reason it should be controlled by foliar spraying with systemic herbicides (fluroxypyr). For chemical control to be effective the herbicide must be applied with a wetter to aid penetration and sticking on the hairy leaves. Ensure that all plants are treated and that regular follow-up treatments are made to kill any plants that were missed. Biocontrol is not a suitable method of management in construction areas but will have a role to play in large or widespread population of the plant. The leaf-feeding biocontrol Chrysomelid beetles *Leptinotarsa defecta* and *Leptinotarsa texana* are effective and can be obtained from the Agricultural Research Council (ARC)¹³. Sites cleared of this species must be monitored and receive follow-up treatment until it is obvious that the plant has been killed.

8. Weeds of construction and disturbed areas

Broadleaved herbaceous weeds such as Mexican Poppy, Blasiebrak and Tumbleweed, and the shrub Wild Tobacco (*Nicotiana glauca*) can all be controlled in the same way. The only exception is *Solanum elaeagnifolium* (see above section) which is a re-sprouter.

¹³ Biocontrol agents available from the Agricultural Research Council Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website <http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds-.aspx>

Broad-leaved herbaceous weeds

When broadleaved herbaceous weeds are immature (have not yet made seed), the most effective means of control is by manual removal using a hoe or spade. Immature plants without seed can be left on site. However, if the weeds have seed heads they must be gathered up, put in garbage bags or waste drums, transported and disposed of at a licensed waste disposal facility. Alternatively broadleaved weeds that are green and actively growing can be killed by foliar spraying with herbicides such as those used to maintain road verges. Re-invasion of broadleaved weeds after cessation of construction activities is best prevented by re-seeding the area with indigenous grasses and shrubs. Indigenous plants that can colonise bare soil and are suitable for the Central Karoo include the grasses *Fingerhuthia africana*, *Cenchrus ciliaris* and *Stipagrostis* species, and the shrubs *Pentzia incana* and *Erioccephalus* species. However, the appropriate species for re-seeding will vary with soil type, altitude and drainage.

Pennisetum setaceum (Fountain Grass)

There are no registered herbicides for the control of fountain grass. However it grows as a roadside weed so a suitable grass herbicide applied as a post-emergent herbicide will control the plants (Figure 28). Further research and monitoring activities are required in order to provide details on *Pennisetum setaceum* and other herbaceous plant control and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan. As is the case of other invaders of disturbed sites, re-invasion by Fountain Grass after construction site closure is best prevented by re-seeding the area with appropriate indigenous grasses and shrubs. Monitor construction sites from which Fountain Grass was removed after 12 months, and hand pull or spot spray any Fountain Grass seedlings that have established.



Figure 28: Control of Fountain Grass on roadsides. Grasses are cut, allowed to re-sprout and sprayed with a herbicide containing a marker dye

9. Control of *Arundo donax* (Spanish reed)

Spanish reed is difficult to control because of its extensive underground rhizomes. Options are to completely excavate the rhizomes (roots and underground stems) using a mechanical shovel. Alternatively cut or burn and after 6-8 weeks spray the 1 metre regrowth with a systemic herbicide (glyphosate), or spray standing (uncut) reeds in late summer, after flowering, but before the leaves turn brown in autumn¹⁴. Dead stems should not be left standing in rivers that are subject to flash flooding because they can block waterways and bridges. The dead reeds can be used as mulch on surrounding bare soil. Reed regrowth should be monitored within six months after clearing, and follow-up treatment applied as required.

¹⁴ Bell, G.P. 1997. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in southern California. Pp 103-113 in Brock J.J, Wade, M. Pysek, P & Green, D. (eds) Plant invasion: studies from North America and Europe. Backhuys Publishers, Leiden

III. Research and monitoring activities for the SKA alien invasive plants control strategy

The various SKA construction activities resulting in the reduction of vegetation cover, hydrology changes, and seeds introduction, create opportunities for invasion by alien plant species. The efficient and effective control and management of listed alien invasive plants species within the SKA construction footprint area will require a combination of invasion risk reduction on construction sites, and proactive containment of existing invasions by means of mapping, prioritization, biocontrol, systematic clearing, monitoring and follow up treatments on clearing projects¹⁵. It is recommended that specific alien invasive plants species management plans are developed for the various sections of the SKA construction footprint area with the services of an invader plant specialist.

Preliminary mitigation measures, control methods and management actions compiled by Dr Sue Milton and Dr Harding for this study have been included in the SKA Environmental Management Programme (Chapter 4 of this IEMP). Once compiled, the specific alien invasive plants species management plans should be added to the SKA Environmental Management Programme, prior to the construction phase of SKA1_MID, in order to ensure that the required mitigation measures, control methods and management actions are implemented, monitored and reported on at regular interval of time during the lifecycle of SKA. The implementation of these species-specific management plans will provide opportunities for capacity building, particularly in the fields of species identification, biocontrol, environmental management, data and human resource management, communication and law enforcement. It is recommended that interns from the Department of Environmental Affairs internship programme¹⁶ provide support to the SKA Environmental Manager and Environmental Control Officer responsible for administration and monitoring of the alien invasive plants species clearing and biocontrol programmes. Long-term research and monitoring programmes including systematic clearing and follow-up observations should be based in Van Wyksvlei and Carnarvon, and should focus on low density invasions at the edges of the main invasions that appear to follow the major drainage systems.

The following activities are proposed as part of further research and monitoring activities for the SKA alien invasive plants control strategy:

- Maintain an updated map of alien invasive plants extent and density within the SKA construction footprint area;
- Undertake surveys of alien invasive plants or potential alien invasive plants within the Karoo Central Astronomy Advantage Area (photograph, identify and record locations);
- Track-record and monitoring of the activities and successful eradication of alien plants in collaboration with the Expanded Public Works Programme (EPWP)¹⁷ and Working for Water (WfW) programme within the SKA construction footprint area;
- Maintain a track-record of successful clearing and control activities (e.g. percentage of new alien invasive plants-free site) with detailed information on the season during which the control measures was implemented as well as the herbicide used and the successful

¹⁵ Department of Environmental Affairs 2014. A National Strategy for dealing with biological invasions in South Africa <https://sites.google.com/site/wfwplanning/strategy>

¹⁶ Department of Environmental Affairs 2014 "A National Strategy for dealing with biological invasions in South Africa" <https://www.environment.gov.za/careers/internships>

¹⁷ The EPWP projects are funded by the Department of Environmental Affairs Natural Resource Management and Social Responsibility Programmes. The main focus of the EPWP is to provide income relief through temporary work for the unemployed to carry out socially useful activities.

application method. This can be done through the creation of a grid over the study area with each grid cell numbered for tracking and mapping of progress, methods, dates and follow-up work.

1. Prioritisation for clearing and biocontrol within Karoo Central Astronomy Advantage Area

According to existing models for the prioritization of alien invasive plants control operations by WfW in South Africa (Van Wilgen et al. 2012)¹⁸, areas where alien invasive plants can be a threat to surface water (particularly water resources stressed by human demand), soil stability, and regional poverty levels; as well as areas with existing high levels of alien invasive plants invasion (especially where the invader is *Prosopis* species) should be targeted for priority control activities. Existing Working for Water programmes are located outside the boundaries of the Karoo Central Astronomy Advantage Area, the nearest being at Beaufort West to the South and in Calvinia to the West. The involvement of the Working for Water operations contractors in the alien invasive clearing and control activities on the SKA core site requires that a proposal including the detailed alien invasive management plan informed by the Management Unit Control Planning (MUCP) information is submitted to Department of Environmental Affairs Natural Resource Management Programmes (NRMP) for consideration. The Karoo Central Astronomy Advantage Area includes stressed surface water resources, priority wetland for conservation, erodible soils and a high river length ratio as well as high level of poverty especially in small rural towns. Within the Karoo Central Astronomy Advantage Area, the “Carnarvonleegte” drainage line between Kenhardt, Van Wyksvlei and Carnarvon is an obvious focus for biocontrol and clearing because it is heavily invaded by *Prosopis* and lies between under-resourced towns. This area should be targeted for biocontrol (seed-feeding beetle) release.

2. Containing existing invasions within SKA core area

Within the Strategic Environmental Assessment study area, the *Prosopis* invasion is most concentrated within the SKA core characterised by lowland area receiving drainage from the mountains to the South. The degree of soil and vegetation and hydrological disturbance will also be greatest within the SKA core area. The major steps in achieving effective control of *Prosopis* (and other alien invasive plant species) in the SKA core area would be financial and project planning, mapping, prioritization, appointment of contractors, clearing and rehabilitation, monitoring and follow-up control. A systematic clearing programme which aims to prioritize the lower-density edges of the invasion, very small areas of high density invasion (less than 1 hectare), and areas subject to high levels of SKA-related activity for clearing should be developed and implemented within SKA core area.

¹⁸ Le Maitre, D.C., Forsyth, G.C & O’Farrell, P.J. 2012. Development of generic species- and area based prioritisation models for use by Working for Water in prioritising invasive alien plant control operations in South Africa. Report number CSIR/NRE/ECO/ER/2012/0028/B for the Working for Water Programme

3. Checklist for monitoring alien invasive plant species at control sites

Common name	Initial survey date	Density on site Zero, <10, 11-100, >1000	Control methods	Audit date	Density on site Zero, <10, 11-100, >1000	Follow-up treatment method
River red gum						
Grey poplar, Matchwood poplar						
Matchwood poplar						
Weeping Willow, Treurwilge						
Pink tamarisk						
American ash and Desert ash; Esseboom						
Mesquite, honey						
Oleander						
Old Man Saltbush						
Wild tobacco						
Century-plant, American aloe						
Boxing-glove cactus						
Imbricate cactus, kabelturksvy						
Torch cactus, orrelkaktus						
Rosea cactus, Rosea kaktus; and Spiny cholla						
Blue-leaf cactus, Robusta (E), Turksvy (A)						
Mission prickly pear (E), Turksvy (A)						
Pine cone cactus, Paper- spine						
Spiny cocklebur						
Sponge-fruit saltbush, klein blasiebrak						
Tumbleweed (E), Rolbos (A)						
Mexican thistle, Bloudissel						
Large thorn apple, grootsinkblaar						
Common thorn apple, olieboom						
Silver-leaf bitter apple, satan weed						
Spanish reed						
Fountain grass						