SOUTH AUSTRALIA
BUFFEL GRASS
STRATEGIC PLAN 2012–2017

A plan to reduce the weed threat of buffel grass in South Australia

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Cover photo: Infestation of buffel grass along Brachina Gorge Road, Flinders Ranges (Heysen Range in the distance) M. Robertson, DEWNR, 2010

Pictured right: Buffel grass (top right) invading native grassland, APY Lands. Photo: J. Stelmann, DEWNR, 2011.

Buffel Grass (left and bottom) infestation in road reserve, South Eastern Freeway. Photo: T. Reynolds, Biosecurity SA, 2014.

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Buffel grass (Cenchrus ciliaris) has been listed among species of “extensive continental distribution” that are “capable of destroying” Australian ecosystems (Humphries et al. 1991). Buffel grass is arguably the single greatest invasive species threat to biodiversity across the entire Australian arid zone, and without active management it will continue to invade a wide range of native habitats to the extent that it would replace many native species in those habitats.

Buffel grass is a perennial tussock grass native to Africa, India and Asia. Since its introduction into central Australia last century for dust control and livestock production, buffel grass has spread widely across many landscapes including those for which it was not intended, causing significant problems. Globally, arid or semi-arid ecosystems are relatively resistant to alien invasions however buffel grass is an exception to this generalisation, including within Australia. In South Australia buffel grass is now widely distributed across northern regions as scattered populations, with extensive infestations in the far north-west. A formal weed risk assessment of buffel grass demonstrates a high to very high risk for both arid rangelands and native vegetation land-uses in South Australia.

Buffel grass forms dense monocultures, changes fire regimes, and displaces native plants. It imposes economic costs through the need to manage fire risk and to protect biodiversity and cultural assets, and infrastructure. Although it has been planted for pasture development in other States, productivity of buffel grass dominated pastures can decline in the longer term.

Buffel grass has several qualities that enables it to survive and persist in harsh arid conditions: in addition to prolific seed production and opportunistic germination, buffel grass has a deep root system that enables it to access water supplies faster and for longer than most native herbs and forbs. Individual tussocks have a long lifespan and can readily re-sprout following fire.

Once established, there is no single control method available for the successful management of buffel grass over extensive areas. The potential success of management is greater if buffel grass is controlled during the early stages of invasion. A range of control options may be considered, however it is important to implement these in a coordinated and sustained manner on a large scale.

Unlike other Australian States with extensive arid and semi-arid rangelands, South Australia has an opportunity in the next decade to prevent buffel grass from becoming permanently established across a significant portion of this important biome.

As eradication of buffel grass from the State is not feasible, this strategic plan aims to contain the spread and minimise the adverse impacts of buffel grass in South Australia. Management of buffel grass may include the destruction of localised infestations where feasible and strategically important. Cooperation, commitment and funding are sought from private and government stakeholders at the local, regional and State levels to manage this weed.

The strategic approach to the management of Buffel grass across the State is based on three broad management zones: the far north-west (Zone 1); the far north, north-east and upper mid-north (Zone 2); and the far-west, lower mid-north and south (Zone 3). The aim, State-wide, is to contain buffel grass and reduce its impact. This will be achieved through the Plan’s four Goals:

- **Goal 1** – Exclude the entry of buffel grass into SA and prevent its movement within the State (all zones)
- **Goal 2** – Manage impacts of buffel grass in Zone 1
- **Goal 3** – Contain spread of buffel grass in Zone 2, and destroy infestations in Zone 3
- **Goal 4** – Build capacity to manage buffel grass (all zones).

Significant partnerships and resourcing will be required to work towards achieving the four Goals of this Strategic Plan.
Buffel grass (*Cenchrus ciliaris*) is a perennial tussock grass native to Africa, India and Asia. Since its introduction into central and northern Australia for pasture improvement and for dust control, buffel grass has spread widely across many landscapes.

Many forms of buffel grass have been imported to Australia from across its native range – programs of pasture introduction have brought in approximately 580 accessions, with many informal and formal releases in central, tropical and sub-tropical Australia (Hall 2000). The species has highly varied morphological and physiological characteristics. There are at least three other exotic *Cenchrus* species that have naturalised in South Australia and could expand their distribution, including Cloncurry grass (*C. pennisetiformis*).

Buffel grass is widely distributed across northern arid South Australia as scattered infestations varying in size and density. Most infestations occur in the far north west of the state. The actual distribution of buffel grass however is likely to be larger than is currently known, and natural spread is occurring.

Environmentally, buffel grass is considered one of Australia’s worst weeds (Humphries et al. 1991). The success of buffel grass as a pasture species and an environmental weed is due to its ease of establishment, rapid growth rate, fast maturation, prolonged flowering periods, prolific seed production and high seed dispersal ability, coupled with relatively long seed dormancy (Franks 2002). Buffel grass is tolerant of drought, fire and grazing. The species can generate positive fire invasion feedbacks in central Australian woodlands (Miller et al. 2010) and has been shown to affect fire regimes in native plant communities (Butler and Fairfax 2003). It easily naturalises in most climates and on a range of soil types and quickly forms self-sustaining populations under a range of disturbance regimes (Franks 2002).

The potential value of buffel grass for livestock production is offset by its serious conservation and social impacts. It has been identified as a ‘transformer weed’ of the Australian rangelands (Bastin et al. 2008) due to its ability to transform the basic attributes of habitats. Modelling suggests buffel grass could establish in over 60% of mainland Australia (Lawson et al. 1994).

Buffel grass is recognised as a major threat to Country – the term commonly used to explain the land or waters with which an Aboriginal person, persons, community or homeland family has a traditional or contemporary association – particularly within the Alinytjara Wilurara Natural Resources Management Region (Alinytjara Wilurara NRM Board 2011).

Of the states and territories with extensive arid and semi-arid rangelands, South Australia clearly has the best opportunity to prevent buffel grass from becoming permanently established across a major portion of this important biome. Extensive areas of the State, such as the Great Victoria Desert bioregion, are still largely free of buffel grass. To prevent buffel grass from becoming a dominant and permanent feature of our arid landscapes significant intervention will be required within the next five to ten years. This will be achieved through implementation of this strategic plan, which will require the securing of new partnerships and additional resourcing. This plan will inform the development of a state-level policy and regional weed management plans. The latter will identify regional priorities including key assets requiring protection.

### 2.1 STRATEGIC PLAN DEVELOPMENT

This strategic plan is based on a draft State Operational Plan that was prepared by Rural Solutions SA, following a workshop held in Port Augusta in September 2010. The aim of the workshop was to initiate and guide the development of a state-wide strategic approach to minimising the impacts of buffel grass in South Australia. The workshop was instigated by Biosecurity SA with support funding from the 2010/11 State NRM Program, and involved representatives of state agencies (PIRSA, DEWNR, DPTI), regional NRM boards, and research organisations (CSIRO, University of Adelaide). Key areas of discussion were management objectives and strategies including a State buffel grass containment line, and best practice control. A draft of the operational plan was distributed for consultation and comment and the final draft plan took into account the feedback.

This strategic plan will be reviewed in five years (2017) or sooner if required.

### 2.2 PRINCIPLES UNDERPINNING THE STRATEGIC PLAN

The following four principles underpin this strategic plan:

1. Weed management is an essential and integral part of sustainable management of natural resources and the environment and requires an integrated, multi disciplinary approach.

2. Prevention and early intervention are the most cost effective techniques that can be deployed against weeds.

3. Successful weed management requires a coordinated approach which involves all levels of government in establishing appropriate legislative, educational and coordination frameworks in partnership with industry, landholders and the community.

4. The primary responsibility for weed management rests with landholders but collective action is necessary where the problem transcends the capacity of the individual landholder to address it adequately.
2.3 SCOPE OF STRATEGIC PLAN

Although the main focus of this Plan is the management of *Cenchrus ciliaris* in South Australia due to its current and potential impact, three other exotic *Cenchrus* species with weed potential and the ability to expand their current distribution in the State (below), are considered here. As they are less abundant and more restricted in distribution than *C. ciliaris*, their current management focus with respect to this Plan is prevention, i.e. the early detection of incipient populations and rapid response to prevent widespread establishment.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>DESCRIPTION</th>
<th>COMMENT</th>
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<tbody>
<tr>
<td><em>Cenchrus ciliaris</em> (buffel grass)</td>
<td>Perennial tussock grass</td>
<td>Primarily planted for pasture development and dust suppression. A highly invasive plant that has spread to many other environments.</td>
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<tr>
<td><em>C. pennisetiformis</em> (Cloncurry grass)</td>
<td>Perennial grass, easily confused with <em>C. ciliaris</em></td>
<td>Used for pasture in Australia. Appears to have similar invasive properties as <em>C. ciliaris</em>. Very few herbarium records for SA (&lt; 15: Flinders Rgs and Far North) – may greatly under-estimate its true prevalence.</td>
</tr>
<tr>
<td><em>C. setiger</em> (Birdwood grass)</td>
<td>Perennial grass, similar to smaller types of <em>C. ciliaris</em></td>
<td>Has been planted for pasture in Australia. Adapted to a wider range of soils and more drought tolerant than <em>C. ciliaris</em>. A serious weed of watercourses in WA. Only three records for SA (far NW).</td>
</tr>
<tr>
<td><em>C. echinatus</em> (Mossman River grass)</td>
<td>Annual grass, clump-forming, spiny attachable burrs</td>
<td>Not deliberately cultivated in Australia – a pest of pastures and some crops. Less than 20 records for SA (far NW incl. APY Lands).</td>
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2.4 LINKAGES TO OTHER PLANS

**National**

This strategic plan is consistent with the vision of the Australian Weeds Strategy: Australia’s economic, environmental and social assets are secure from the impacts of weeds, and in particular Goal 2: Reduce the impact of existing priority weed problems.

**State**

As a significant biological threat to South Australia, Goal 3 of the State NRM Plan is relevant to buffel grass: Improved condition and resilience of natural systems - in particular, Guiding Target 13: Limit the establishment of pests and diseases and reduce the impacts of existing pests.

The Pastoral Board has a policy relating to species not indigenous to South Australia: Policy No. 11: Introduced pasture species. This policy states:

“The (Pastoral) Board is not in favour of introducing non-indigenous species... The introduction of plants not locally indigenous for the purpose of improving pasture values will not be permitted without the written approval of the Board.”

Section 4(b) (ii), an Object of the Pastoral Land Management and Conservation Act 1989, is the legislative basis of the aforementioned policy. This Object provides for “the prevention of degradation of the land and its indigenous plant and animal life”.

**Regional**

Buffel grass is recognised in the pest management strategies for SAAL and AW NRM boards. The SAAL NRM Board has prepared a draft Buffel Grass Management Plan (Greenfield, 2007), the aim of which is to:

“To protect biodiversity and ecosystem functioning in the South Australian Arid Lands region and maintain sustainable productivity for existing and future land use options.”

The Plan’s Objectives are:

1. Take steps to prevent further deliberate introductions of buffel grass to the SAAL NRM region
2. Stakeholder awareness of buffel grass and its negative impacts improved
3. A measurable reduction in buffel grass distribution in key areas achieved
4. The impacts of buffel grass across the SAAL region strategically monitored
5. The Buffel Grass Management Plan is consistent with the objectives of the SAAL Buffel grass policy and is implemented.

Buffel grass is noted for its impact on threatened species in the APY Threatened Species Recovery Plan, and in the Rare and Threatened Flora Management Plan for the APY Lands (AW NRM Board, DEWNR). Buffel grass is rated as “Very high” on the weed control list for rangelands in the Weed Management Plan for the Northern and Western Region of the Department for Planning, Transport and Infrastructure (DPTI).

2.5 LEGISLATIVE REQUIREMENTS

Buffel grass is currently not declared for control under the Natural Resources Management Act 2004 (NRM Act). Management of this weed presents a considerable challenge and requires long-term commitment to a coordinated control program. This would therefore require adoption of a State policy and development of management plans by the appropriate regional NRM boards. Consequently, buffel grass is currently being considered as part of a broader review of plant declarations.
Figure 2. Records of buffel grass in South Australia and Buffel Grass Management Zones. (Source: Rural Solutions SA, April 2012)
3 STRATEGIC GOALS AND ACTIONS

3.1 VISION

BUFFEL GRASS IS CONTAINED AND ITS IMPACT REDUCED TO A MINIMUM IN SOUTH AUSTRALIA

3.2 MANAGEMENT ZONES

A key component of reducing the impacts of buffel grass in South Australia is a management strategy based on a broad zonal system reflecting the gradient of invasion and establishment of buffel grass from the far north-west to the southern regions of the State. Management zoning is a tool that can be used to guide planning and management at a broad scale. It does not prescribe what must occur at a local scale, which should be determined on the basis of local issues. The use of a management zone approach recognises that while management of an invasive plant depends on local actions, these will be much more effective and efficient when they are part of a broader scale strategic approach (e.g. Grice et al. 2011).

A State buffel grass workshop in 2010 identified a State Containment Line that broadly corresponded with a containment line proposed in the draft SA Arid Lands NRM Board Buffel Grass Management Plan 2007–2012 (Greenfield, 2007), which divided the north of the State from the south at 29 degrees latitude (i.e. near township of Coober Pedy).

In this strategic plan, management zone boundaries are delineated broadly on the basis of current knowledge of the weed’s extent, having implications for the feasibility of eradication. These boundaries can be reviewed in the future after a more thorough investigation of the extent of buffel grass across the State. Although the State weed risk assessment determined a “Destroy Infestations” management action for the Arid Rangelands land-use, the destruction of all infestations (particularly in the heavily invaded far north-west of the State) was considered to be difficult to achieve without substantial resources over the long-term. Implementation of this management action in South Australia however is more feasible outside the Arid Rangelands.
The State management zones proposed below (see also Figure 2) may also be incorporated in Regional Weed Management Plans of individual NRM boards:

**Zone 1 – Manage Buffel grass**

**NRM boards:** Alinytjara Wilurara – Anangu Pitjantjatjara Yankunytjatjara (APY) Lands; SA Arid Lands – Marla-Oodnadatta NRM District.

**Status:** Numerous, extensive, widespread infestations, particularly in the far north-west.

**Management aim:** To reduce the overall impacts of the buffel grass through targeted management including protection of key sites/assets.

**Zone 2 – Contain spread**

**NRM boards:** SA Arid Lands (SAAL) excluding Marla-Oodnadatta NRM Group; Northern and Yorke – Upper North sub-region

**Status:** Mostly relatively small, widely scattered, localised infestations, but some larger infestations requiring greater effort to control, for example:
- townships along major roads, in particular Port Augusta, Pimba, Copley, Glendambo, Kingoonya, Tarcoola
- National Highway 1 road reserve and adjoining land between Port Augusta and Port Pirie
- the rail corridor (Interstate Main Line) between Port Augusta and Wynbrinb (SAAL and AW NRM)
- the North Flinders District (SAAL)
- parts of Innamincka Regional Reserve (SAAL)

**Management aim:** To prevent the ongoing spread of buffel grass into clean or priority areas within or beyond Zone 2, aiming for a significant reduction in all infestations.

**Zone 3 – Destroy infestations**

**NRM boards:** Alinytjara Wilurara – Maralinga Tjarutja (MT) Lands south of the northern boundaries of Mamungari and Tullarinda Conservation Parks; Eyre Peninsula; Northern and Yorke – Lower North sub-region and Yorke sub-region; SA Murray-Darling Basin; Kangaroo Island; South East.

**Status:** Predominantly small, widely scattered localised infestations, currently known to occur in EP, NY, AMLR, SAMDB and the MT Lands of the AW NRM Board. Not yet recorded in SE or KI.

**Management aim:** To significantly reduce the extent of buffel grass in Zone 3, locating and destroying all infestations aiming for local eradication at feasible sites.
3.3 GOALS AND ACTIONS

GOAL 1 – PREVENT

EXCLUDE THE ENTRY OF BUFFEL GRASS INTO SA AND PREVENT ITS MOVEMENT WITHIN THE STATE
(all Zones)

Background
Vast areas of South Australia are at risk from buffel grass. A key means of minimising the impacts of buffel grass across the State is the early detection of plants in areas where it is absent or sparse, and preventing the establishment of new populations. Priority should be given to areas where there is a significant risk of incursion and for important natural assets or social infrastructure that would be threatened by an abundance of buffel grass. Effort should focus on the routes by which buffel grass is likely to spread, principally transport corridors.

Assistance is needed from industries and communities, particularly in the northern parts of the State, to prevent spread and to detect new infestations. The mining industry presents particular challenges, given the recent growth in exploration and production activity. Earthworks such as roadside grading can spread seed, starting new infestations or expanding existing infestations. Road managers need to be aware of the risks of spreading the weed in this way and adopt appropriate hygiene practices. A range of education and awareness activities will be required. These include protocols to reduce seed spread, and more effective awareness campaigns. Resources need to be available when new infestations are detected to enable timely responses.

Increasing public and community awareness of what buffel grass looks like, its impacts and the benefits of control, is essential to build a community’s willingness and capacity to prevent, monitor for, and control new buffel grass occurrences (Pitt 2004). Landholders should be discouraged from planting buffel grass. The risk of spreading buffel grass by the transport of stock from infested properties, either interstate or within South Australia, should be addressed through appropriate hygiene measures.

Providing clean-down facilities at key locations (e.g. control lines) could reduce inadvertent spread of buffel grass by machinery (e.g. graders, livestock carriers, bulldozers, and trucks). An evaluation of wash-down facilities for the SAAL NRM Board by Rural Solutions SA in 2009 recognised that the cost-benefit of wash-down facilities is difficult to determine. Although clean-down facilities provide a visual reminder promoting biosecurity, and facilitate safe, convenient and secure locations for vehicle hygiene, their effectiveness is limited unless frequently used.

Preventing the introduction or movement of buffel grass in South Australia will help minimise further range expansion within the State. Strategic management of buffel grass will require an appropriate legislative framework, supported by non-legislative measures including community education. Buffel grass is not declared for control under the Natural Resources Management Act 2004 (NRM Act), but is being considered as part of a broader review of pest plant declarations. A declaration of buffel grass would involve endorsement of a State policy and management plan by Regional NRM boards prior to Ministerial approval.

A State-wide declaration to prevent entry, movement or sale would refer to the following sections of the NRM Act:

175(1)(2) Prohibiting movement on public roads and entry into SA.
177(1)(2) Prohibiting sale of the plants or their seeds, or contaminated material.

Individual NRM boards, where local eradication is a feasible management response, may propose declaration under either of the following sections:

182(1) Requiring landowners to destroy the plants on their properties.
182(2) Requiring landowners to control – as far as reasonably achievable – the plants on their land.

Declaration could also include Section 185(1) to allow the recovery of costs incurred by NRM authorities in undertaking control on road reserves.
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| 1.1 Minimise inadvertent spread of buffel grass by human activity | • Identify containment lines for road and rail maintenance and construction operators.  
• Develop Codes of Practice with reference to containment lines for road and rail infrastructure managers  
• Conduct community extension activities to promote awareness of impacts, mode of spread, hygiene and control options  
• Determine usage of public signage at strategic locations to promote awareness of the risk of inadvertent spread  
• Develop hygiene protocols for transport of stock to prevent movements from infested parts of Australia to parts of SA where eradication has been declared the principal management objective  
• Seek a cross-jurisdictional approach to preventing the further spread of buffel grass into SA from other states and territories (i.e. WA, NT, Qld, NSW) | NRMBs, DPTI, councils, industry |
| 1.2 Regulate the use and movement of buffel grass across all land tenures in SA | Seek to declare buffel grass to:  
• prohibit importation, trade, distribution, cultivation and sale in SA  
• make available enforcement as a management tool where necessary to ensure control aimed at prevention and local eradication is achieved | Biosec SA |
| 1.3 Develop and maintain early detection and eradication mechanisms | • Identify new entry pathways for buffel grass seed in SA  
• Intercept known pathways for buffel grass entry into SA (such as livestock or fodder movements) at the State border.  
• Undertake systematic surveys to ascertain the distribution status of buffel grass in SA and across State borders, particularly along high risk spread pathways | Biosec SA, NRMBs |

Single buffel grass plant adjacent to a track, in otherwise pristine native grassland, north of Umawa, APY Lands. Photo: R. J-P Davies, 2003
3.3 GOALS AND ACTIONS

GOAL 2 – MANAGE BUFFEL GRASS IN ZONE 1

REDUCE THE OVERALL IMPACTS OF BUFFEL GRASS IN ZONE 1 THROUGH TARGETED MANAGEMENT
(NRM boards: AW – APY Lands; SAAL – Marla-Oodnadatta NRM District)

Background
Control within Zone 1 should focus first on limiting further spread. The conventional approach is to concentrate on the small, outlying patches at the edges of an infestation, working back towards the core. However, a combined approach of destroying outliers and limiting seed production in large patches may be more effective in the longer term.

This zone includes areas where only limited management activities are currently economically and technically feasible. These sites include dense, inaccessible or lower priority infestations a long distance from infrastructure, key ecological assets, or organised management groups.

Mapping is important to determine where infestations are located, the area infested within a region, which infestations are eradicable, and where buffer/control zones should be located. Identifying priority areas for control should therefore consider:

- Size and density of infestations
- Distribution of infestations (isolated/scattered/widespread)
- Proximity to natural and cultural assets at risk
- Pathways of spread (roads, drainage lines, towns, etc.)
- Accessibility

Where resources are constrained, the need to delimit more accurately known infestations may need to be reconciled with a more urgent need to control infestations threatening Priority Assets1.

1 Priority Assets may be considered in the following broad categories:
- Social (e.g. dwellings, settlements at risk of buffel grass-fuelled fire)
- Environmental (e.g. species or ecological communities of conservation significance; specific habitats)
- Economic (e.g. native pastures and pastoral or mining infrastructure at risk of buffel grass-fuelled fire).
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| 2.1 Improve knowledge of buffel grass distribution in Zone 1 | • Survey and map areas where buffel grass presence is unknown  
• Undertake surveillance and mapping of key priority areas, in particular high risk pathways (e.g. roads, rail, towns)  
• Map sources and the invasion fronts of priority infestations and determine the ongoing control requirements | AW, SAAL |
| 2.2 Identify and prioritise areas for different management regimes | • Liaise with Traditional Owners and pastoral lessees  
• Identify and prioritise infestations according to proximity to Zone 2. Determine localised containment lines for larger infestations  
• Develop criteria for prioritising other areas, including the establishment of clean areas within the core areas of infestation, and the protection of Priority Assets. Identify roadside and non-roadside destruction targets based on isolation and feasibility of control. Plan actions according to risk of spread.  
• Develop and implement management plans for buffel grass for public lands  
• Ensure buffel grass management is included in regional, industry and property planning  
• Monitor and evaluate all management programs | AW, SAAL |
| 2.3 Contain or reduce established infestations in Zone 1 to prevent their spread into Zone 2 or 3 | • Treat infestations using appropriate control techniques  
• Involve landholders and community in the control of priority infestations  
• Regularly inspect treated areas for regrowth after significant rainfall events  
• Provide assistance and resources for effective follow-up  
• Record infestations treated | AW, SAAL, land managers |
| 2.4 Destroy and monitor outliers, new incursions and infestations threatening Priority Assets in Zone 1 where feasible | • Treat infestations using appropriate control techniques  
• Involve landholders and community in the control of priority infestations  
• Regularly inspect treated areas for regrowth after significant rainfall events  
• Provide assistance and resources for effective follow-up  
• Record infestations treated  
• Monitor control sites to confirm eradication | AW, SAAL, land managers |
3.3 GOALS AND ACTIONS

GOAL 3 – CONTAIN SPREAD (ZONE 2)\(^1\) OR DESTROY (ZONE 3)\(^2\)

\(^1\)CONTAIN SPREAD: PREVENT THE ONGOING SPREAD OF BUFFEL GRASS IN ZONE 2 AIMING FOR A SIGNIFICANT REDUCTION IN ALL INFESTATIONS
(NRM boards: SAAL excluding Marla-Oodnadatta NRM Group; Northern & Yorke’s Upper North sub-region)

\(^2\)DESTROY: SIGNIFICANTLY REDUCE THE EXTENT OF BUFFEL GRASS IN ZONE 3, LOCATING AND DESTROYING ALL INFESTATIONS AIMING FOR LOCAL ERADICATION WHERE FEASIBLE
(NRM boards: EP, NY – Mid North and Yorke sub-regions, SAMDB, AMLR, SE, Ki; AW – MT Lands south of northern boundaries of Mamungari and Tullaringa Cons. Parks)

Background

There are large areas of South Australia that are free of buffel grass or have sparse populations. With committed and sustained action, these areas can be protected from the establishment or further spread of the plant.

Mapping is an important first step in planning an eradication program. New infestations of buffel grass are often associated with roads and watercourses. Buffel grass establishes readily in these disturbed environments and human activity (e.g. roadworks) spread seeds further along these pathways from which natural dispersal into the surrounding landscape can occur. Roadside surveys may be undertaken to indicate infested and un-infested areas on a regional scale. GPS should be used for accurate mapping and sharing of data. Data collected by various sources should be collated prior to new surveys. Focusing on high-risk sites for buffel grass is one basis for planning surveys. Where resources are constrained the need to delimit more accurately known infestations may need to be reconciled with a more urgent need to control infestations threatening Priority Assets\(^1\).

The best opportunities to control buffel grass are in areas where it is confined to transport corridors and verge areas in townships (e.g. Appendix 2) – once it disperses from these areas into the surrounding landscape the ability to control becomes significantly more difficult and costly.

Although many buffel grass infestations in Zone 2 are relatively small and isolated, there are some locations where control is likely to be more difficult. This may be due to the density and size of the infestation, and the economic incentive to control, for example:

- townships along major roads, in particular Port Augusta, Pimba, Copley, Glendambo, Kingoonya, Tarcoola
- the rail corridor (Interstate Main Line) between Port Augusta and Wynbring (SAAL and AW NRMBs)
- North Flinders District (SAAL NRMB)
- Innamincka Regional Reserve (DEWNR)

In Zone 3 where destruction of infestations is the principal management aim, enforcement of control should be considered as a last resort, with primary emphasis on encouraging landholders through involvement in weed management to provide ownership of the issues and consequent outcomes or problems.
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| 3.1 Improve knowledge of buffel grass distribution in Zones 2 and 3 | • Survey and map areas where buffel grass presence is unknown  
• Undertake surveys of high risk pathways (e.g. roads, rail, towns) where there are current knowledge gaps  
• Undertake delimiting surveys of each infestation | Biosec SA, NRMBs, DEWNR |
| 3.2 Prioritise infestations for treatment | • Determine the feasibility of eradication of known infestations  
• Prioritise activities based on:  
  - assets at risk ("Priority Assets")  
  - high risk source infestations (e.g. townships)  
  - invasion pathways, and  
  - isolated occurrences (e.g. Appendix 2) | NRMBs, DEWNR |
| 3.3 Develop and maintain early detection and eradication capability | • Establish state-level procedures for receiving and responding to reports of new infestations, including specimens in State Herbarium  
• Improve communication and reporting networks between agencies  
• Increase the capacity of stakeholders to recognise, detect and report new incursions – develop community surveillance networks  
• Monitor high risk invasion pathways (e.g. roads, towns) during the growing season/undertake surveys of high risk areas following significant rainfall events | Biosec SA, NRMBs, DEWNR |
| 3.4 In Zone 2, contain and prevent the ongoing spread of buffel grass aiming for a significant reduction in all infestations | • Treat infestations using appropriate control techniques  
• Involve landholders and community in the control of priority infestations  
• Regularly inspect treated areas for regrowth after significant rainfall events  
• Provide assistance and resources for effective follow-up  
• Record infestations treated | SAAL, NY, land managers |
| 3.5 In Zone 3, destroy infestations where feasible | • Treat infestations using appropriate control techniques  
• Involve landholders and community in the control of priority infestations  
• Regularly inspect treated areas for regrowth after significant rainfall events  
• Provide assistance and resources for effective follow-up  
• Record infestations treated | All stakeholders |

Controlled burn of buffel grass, Umawa, APY Lands. Photo: J. Stelmann, DEWNR, 2011
GOAL 4 – BUILD CAPACITY

ENSURE SA HAS THE CAPABILITY AND COMMITMENT TO MANAGE BUFFEL GRASS (all Zones)

Background
The current and potential buffel grass infested area of South Australia is large; the resources required to prevent the spread of buffel grass and minimise the impacts are therefore large, and effective management of the weed requires a co-ordinated approach involving all key stakeholders. Management on government land, as well as on privately managed land, is required as this species occurs in protected areas and other Crown lands. Control programs are expensive and will require on-going landholder commitment to follow-up. Education activities to promote community awareness of the buffel grass threat will need to be ongoing.

Some research has been conducted interstate on the ecological impacts and control of buffel grass, however comparatively little research has been undertaken in South Australia. There is a need to undertake research that will contribute towards improved buffel grass management in this State.

The capacity of the State to manage buffel grass effectively will require the commitment and cooperation of key stakeholders in particular public land managers (DEWNR), road managers (e.g. councils, DPTI), Aboriginal landowners, the mining, pastoral, transport and tourism industries and the Australian Government.

As one of the greatest single threats to biodiversity by an invasive species within the Australian arid zone, buffel grass has been nominated as a Key Threatening Process under the terms of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The recent nomination – “Ecosystem degradation, habitat loss and species decline in arid and semi-arid Australia due to the invasion of buffel grass” – was not included on the Finalised Priority Assessment List for 2012, but could be reconsidered in the future.

Regional authorities and landowners should incorporate strategic buffel grass management in regional and local planning in accordance with this Strategic Plan. Regional planning may require the development of plans specific to buffel grass, particularly where the threat is recognised as a high regional priority.
<table>
<thead>
<tr>
<th>ACTION</th>
<th>ACTIVITIES</th>
<th>RESPONSIBILITY</th>
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| 4.1 Coordinate and maintain buffel grass management at a State level | • Establish and maintain a State Buffel Grass Taskforce  
• Facilitate the inclusion of strategic buffel grass management in pest management planning by regional authorities | Biosec SA, NRMBs |
| 4.2 Promote awareness of buffel grass to land managers and the community | • Conduct extension activities to promote awareness of impacts, mode of spread, hygiene and control options  
• Disseminate regular updates to weed managers on the progress of buffel grass management across the state  
• Produce best practice management information and provide in a variety of media formats | NRMBs, Biosec SA |
| 4.3 Consolidate and centralise existing distribution and control data across SA | • Establish a State database of buffel grass distribution and control  
• Make data available to NRM boards and regional weed managers to aid in priority setting | Biosec SA |
| 4.4 Guide and support research on buffel grass biology and control | Key research areas (refer Appendix 1 for further details):  
- ecology  
- impacts  
- taxonomy  
- management / control  
- distribution – current & potential | Biosec SA, research organisations |
| 4.5 Develop and promote integrated weed management to maximise benefits of buffel grass control | • Establish best practice demonstration sites and conduct training in management techniques  
• Publish best practice options for buffel management | NRMBs, Biosec SA, Universities |
| 4.6 Actively involve land managers and the community in buffel grass management | • Seek support and engagement for the management of buffel grass from community, industry and government.  
• Establish and maintain networks with relevant agencies, groups and individuals  
• Encourage the reporting of new infestations  
• Investigate funding opportunities for landholder incentives | NRMBs |
| 4.7 Seek Government support in reducing the buffel grass threat to SA | • Support the protection of Matters of National Environmental Significance (EPBC Act) in SA that are threatened by buffel, through national and state programs  
• Seek nomination of buffel as a Key Threatening Process under the EPBC Act | Biosec SA, AG |
3.4 STAKEHOLDER ROLES

THE FOLLOWING STAKEHOLDERS HAVE KEY ROLES IN THE EFFECTIVE MANAGEMENT OF BUFFEL GRASS IN SOUTH AUSTRALIA:

**Australian Government**
- Undertake strategic buffel grass control on Australian government managed lands in South Australia
- Support the protection of Matters of National Environmental Significance threatened by buffel grass within South Australia through national funding programs
- Consider the South Australian nomination of “Ecosystem degradation, habitat loss and species decline in arid and semi-arid Australia due to the invasion of buffel grass” as a Key Threatening Process under the EPBC Act

**Biosecurity SA (SA Dept. Primary Industries and Regions)**
Biosecurity SA provides technical, policy and scientific expertise for the control of declared plants under the NRM Act. It develops State policies, provides legislative recommendations to the Minister for Sustainability, Environment and Conservation, and works closely with NRM boards and other stakeholders to implement policies for management of weeds in SA.

- Develop a State policy and provide legislative recommendations to the Minister to achieve state level objectives for managing buffel grass
- Contribute to buffel grass control and coordination at the State level through representation on the proposed State Taskforce to complement the management and delivery of the Strategic Plan.
- Identify strategic management areas and associated objectives
- Promote consistency with this Strategic Plan in NRM Board regional weed management plans
- Provide advice on the inclusion of strategic buffel grass management in pest management planning by secondary stakeholders
- Contribute to priority research initiatives
- Source funding for strategic management programs and research
- Develop and implement communication and extension plans where appropriate
- Facilitate state level mapping

**State Buffel Grass Taskforce**
The establishment of a State taskforce can provide guidance, direction and policy advice for the management of buffel grass across the State through the delivery of the Strategic Plan.
- Ensure a diversity of community and agency views are represented for effective implementation of the strategic plan
- Facilitate the inclusion of strategic buffel grass management in pest management planning by secondary stakeholders
- Implement monitoring and reporting protocols for strategy implementation
- Assist in the development and implementation of programs and initiatives that support strategic actions
- Coordinate and facilitate the exchange of information on control initiatives around the State
- Maintain and build partnerships with key stakeholders to improve strategic buffel grass management
- Develop and implement communication and extension plans where appropriate
- Promote nationally and inter-state a greater recognition and understanding of the threat posed by buffel grass to natural, economic and social systems
- Identify funding sources and provide independent advice for prospective applicants for projects consistent with the needs of the Strategic Plan

**Regional Natural Resources Management Boards**
Eight regional NRM boards provide strategic oversight for local and regional control programs for weeds. The role of NRM boards is to lead regional natural resources management through developing regional NRM plans, advising government and connecting government to communities on relevant issues.

Statutory measures may apply to the movement, sale, notification and control of a weed. NRM boards develop regional and local (NRM Group) pest management plans with priorities based on species risk assessments and assets at risk. Buffel grass will be amongst a group of plant species proposed for declaration under the NRM Act. If declared, NRM boards could require landholders in some parts of the State (e.g. southern agricultural districts) to control and manage buffel grass on their own lands in accordance with regional pest priorities.

Regional NRM boards are supported by DEWNR staff, with a regional manager who is responsible to both the Chief Executive DEWNR and the NRM board.
- Include buffel grass in the development, implementation and/or review of regional weed management plans in accordance with the Strategic Plan
- Facilitate the inclusion of strategic buffel grass management in pest management planning by secondary stakeholders
- Promote and support local and regional control programs in partnership with relevant stakeholders
- Initiate or sponsor buffel grass funding submissions in line with State priorities
- In partnership with DEWNR, guide local and regional mapping initiatives and contribute to state map production
- Promote awareness and best practice management through event coordination and product distribution.
• Include buffel grass in the development, implementation and/or review of regional weed management plans in accordance with the Strategic Plan

**Aboriginal land management authorities**

A number of authorities have been established across the state to assist traditional land owners to manage their land. These authorities include APY Land Management, Maralinga Tjaruţa, and Yalata Aboriginal Community Council (Alintja Wilurara NRM Region), and the Aboriginal Lands Trust. APY Land Management for example works with Traditional Owners on the Pitjantjatjara/ Yankunytjatjara lands in the northwest corner of South Australia – various activities are carried out to ensure that the ecological health of the lands is retained.

• Incorporate buffel grass management into property plans in accordance with strategic management objectives (e.g. regional weed management plans)
• Implement best practice management
• Practice good weed hygiene to minimise the spread of buffel grass
• Improve knowledge of the identification, impacts and best practice control of buffel grass

**State government landholders**

As the NRM Act binds the Crown, State government agencies with landholdings (e.g. DEWNR, DPTI, SA Water) would have the same duty of care as private landholders in the case of buffel grass being declared.

Department of Environment, Water and Natural Resources (DEWNR) DEWNR provides integrated environmental and natural resources services including management of the public land estate (parks, reserves and crown lands). DEWNR’s role in managing the State’s natural resources ranges from policy leadership to on-ground delivery with regional Natural Resources Management Boards, including issues relating to climate change, sustainable land management, and biodiversity conservation.

DEWNR has a supporting role to NRM boards to provide an integrated service delivery in each region on environment and NRM matters. Each region is led by a regional manager who is responsible to both the Chief Executive DEWNR and the regional NRM board.

**Private Landholders**

Buffel grass will be amongst a group of plant species proposed for declaration under the NRM Act. If declared, particular NRM boards could require landholders to control and manage buffel grass on their own lands in accordance with regional pest priorities.

• Incorporate buffel grass management into property plans in accordance with

• Support and/or develop buffel grass funding submissions in line with State priorities
• Participate in local and regional mapping initiatives and contribute to state map production
• Promote awareness and best practice management through event coordination and product distribution

**Department of Environment, Water and Natural Resources (DEWNR)**

DEWNR provides integrated environmental and natural resources services including management of the public land estate (parks, reserves and crown lands). DEWNR’s role in managing the State’s natural resources ranges from policy leadership to on-ground delivery with regional Natural Resources Management Boards, including issues relating to climate change, sustainable land management, and biodiversity conservation.

DEWNR has a supporting role to NRM boards to provide an integrated service delivery in each region on environment and NRM matters. Each region is led by a regional manager who is responsible to both the Chief Executive DEWNR and the regional NRM board.

• Include buffel grass in the development, implementation and/or review of management plans for the public land estate in accordance with the Strategic Plan
• Facilitate the inclusion of strategic buffel grass management in pest management planning by secondary stakeholders
• Promote and support local and regional control programs in partnership with relevant stakeholders

South Australia Buffel Grass Strategic Plan 2012 – 2017 | 17
• Promote awareness and best practice management through event coordination and product distribution

DEWNR Pastoral Program
The Pastoral Board has a key role in preventing the introduction of buffel grass as a pasture species under the provisions of the Pastoral Land Management and Conservation Act, 1989. The introduction of plants not locally indigenous for the purpose of improving pasture values is not permitted without the written approval of the Board.

• Uphold the current Board policy of not permitting the introduction of non-indigenous species on pastoral leases for the purpose of improving pasture values
• Encourage lease-holders to identify buffel grass and other weeds threatening the property
• Facilitate the inclusion of strategic buffel grass management in property planning in accordance with this Strategic Plan and regional weed management plans
• Encourage lease-holders to implement good weed hygiene and other control measures to minimise the spread of buffel grass

SA Department of Planning, Transport, and Infrastructure (DPTI)
DPTI carries out vegetation control on roadside verges primarily for road safety (e.g. to provide sight distance) and for the maintenance of road infrastructure along State arterial and many outback roads. Within local government districts, DPTI assumes maintenance responsibility for a portion of road reserve for state arterial roads (typically, the formation including batters and drains between the road shoulder or guide posts and the property boundary), with the remainder under care and control of the local council. In the case of outback roads (i.e. outside local government districts), DPTI has maintenance responsibility for the entire road reserve. Buffel grass is commonly introduced into new areas along transport corridors from which it can spread into the surrounding landscape. Buffel grass therefore need to be aware of this risk, including the potential for a rapid build-up of buffel grass fuel in road reserves and the threat to infrastructure and the wider landscape.

• Establish local management protocols that contribute to strategic management objectives
• Include weed hygiene and other prevention measures in work specifications
• Manage buffel grass on DPTI controlled land
• Contribute to strategic control programs
• Improve community and industry awareness of impacts and identification, and promote early detection

Local government
Within local government districts, councils are vested with care and control of most road reserves, with the exception of State arterial roads where DPTI typically assumes maintenance responsibility for a portion of the road reserve (see above). On State arterial roads the maintenance responsibility of councils is therefore reduced to the portion of road reserve between the road formation and the adjacent property boundary. Buffel grass is commonly introduced into new areas along transport corridors from which it can spread into the surrounding landscape. Local government authorities therefore need to be aware of this risk including the potential for a rapid build-up of buffel grass fuel in road reserves and other council-controlled land and the threat of fire to infrastructure and the wider landscape.

• Establish local management protocols (e.g. weed hygiene) that contribute to strategic management objectives
• Manage buffel grass on council controlled land

Railway and service easement managers
Buffel grass is commonly introduced into new areas along transport corridors, rights of way and service easements (e.g. pipelines, transmission lines, Dog Fence) from which it can spread into the surrounding landscape. Managers therefore need to be aware of this risk including the potential for a rapid build-up of buffel grass fuel within the easement and the fire threat to infrastructure and the wider landscape.

• Establish local management protocols (e.g. weed hygiene) that contribute to strategic management objectives
• Manage buffel grass on rights of way and service easements

SA Department for Manufacturing, Innovation, Trade, Resources & Energy (DMITRE) and the mining industry
As mineral exploration and extraction are major activities across the State (including regions where buffel grass is prevalent) the mining industry has a duty of care to prevent the spread of weeds, including buffel grass. DMITRE issues licences, leases and work approvals to the resource exploration and mining sector with conditions that ensure compliance with the control of weeds declared under the NRM Act 2004.

• Establish management policies to contribute to strategic management objectives
• Include buffel grass management (e.g. weed hygiene) in licences, leases and work approvals in accordance with the State Strategy and regional weed management plans
• Improve community and industry awareness of impacts and identification, and promote early detection

Inter-state government agencies
Cooperation is needed to reduce the ongoing invasion pressure of buffel grass into South Australia.

• Support efforts within South Australia to control or restrict the movement of contaminated goods, machinery livestock and materials from infested areas across the state border
• Cooperate with South Australian agencies in determining the distribution of buffel grass across common State borders
• Avoid the release of new cultivars
where there is a high risk of natural or inadvertent human spread into and establishment within South Australia

**Research institutions**
- Identify research gaps and seek innovative solutions for the management of buffel grass
- Seek new and on-going funding and support for research requirements

### 3.5 MONITORING AND EVALUATION

Monitoring and evaluation are important to the continued development of the strategy to improve the effectiveness of management actions. This strategic plan is subject to a five year review. The implementation of the plan will be monitored by a State Buffel Grass Taskforce.

Annual reports by the taskforce will include a review of actions implemented under the strategy and relevant actions under related strategies and plans including:
- NRM Board regional pest management plans
- local government pest management plans
- landholder property management plans
- management plans for conservation reserves

Evaluation should include assessing changes in distribution of buffel grass, determining the efficacy of control techniques, identifying new introduction pathways, and assessments of the costs and benefits of management actions.

The success of buffel grass control depends on an ongoing program of monitoring due to the opportunistic nature of its invasion and spread. Monitoring should be undertaken:
- periodically after control treatments (annually or biannually after rain)
- after a potential change in conditions, e.g. flood events, fire
- annually or biannually in areas located near known infestations and along creek lines to prevent new plants establishing, and
- at least every 5 years in clean areas

The national NRM Monitoring, Evaluation, Reporting and Improvement (MERI) Framework has been adopted by the South Australian government for monitoring natural resource management targets. Applied to this strategic plan, the MERI Framework should measure the effectiveness of specific management actions on achieving measurable outcomes.

Measurable outcomes could be based on the following performance indicators:
- Improved understanding of the environmental impacts of buffel grass by landholders, public land managers, and industry sectors (e.g. mining, pastoralism) and government authorities (local and State)
- Adoption of data collection standards and sharing of data between weed managers
- Improved knowledge of current and potential distribution of buffel grass in South Australia
- State-wide legal restrictions on cultivation, distribution and sale of buffel grass
- Reductions in the distribution, area and density of buffel grass infestations in eradication and containment zones
- Routine monitoring for and control of new buffel grass infestations in the eradication zone
- Increased resources for on-ground actions, including conservation areas and government lands
4 TECHNICAL BACKGROUND

4.1 DESCRIPTION

Buffel grass is an erect, deep-rooted, tussock forming, C4, summer-growing perennial grass. Seed heads are dense, white to purple in colour, growing in a spike-like raceme up to 15 cm long and are covered in clusters of bristles giving them a fluffy appearance; the flowering heads appear from November to May or sporadically following rain (Smith 2002). The bristly burrs are borne on a zigzag central axis (figure below).

Buffel grass is native to Africa, India and the Middle East (Whyte et al. 1959; Humphreys 1967).

Photo: Sainty and Associates Pty Ltd

4.2 TAXONOMY

Buffel grass (Cenchrus ciliaris L.) has highly varied morphological and physiological characteristics, reflecting its wide native range. Intra-species variation has arisen both naturally and from the development of new strains to improve productivity of pastoral land. Cultivars have been developed commercially with increased growth rates, disease resistance and tolerance to a range of environmental conditions. Marshall et al. (2012) suggest that knowledge about the suitability of various strains in different environments may be critical for effective control of infestations.

Caution should be taken to ensure that records of Cenchrus species are credible, as a number of grasses in this genus can be difficult to distinguish from one another, and from grasses in the closely related genus Pennisetum.

Three other Cenchrus species that are considered invasive weeds of natural rangelands in some parts of Australia but are much less common in this State than buffel grass, are also considered in this Plan:

- Cloncurry grass or slender buffel grass (C. penissetiformis Hochst. & Steud. ex Steud)
- Birdwood grass (C. setiger Vahl)
- Mossman River grass (C. echinatus L.)

Cloncurry grass, native to N Africa, Arabia and India, is difficult to distinguish morphologically from C. ciliaris, and until recently were considered to be the same species. It is also used for permanent pasture and has similar ecological requirements and invasive properties.

Birdwood grass C. setiger, native to Africa and India, is a perennial grass that is similar to smaller types of C. ciliaris. It has been planted as a fodder plant in pastoral areas in other States and is adapted to a wider range of soils and is more drought tolerant than C. ciliaris.

Mossman River grass C. echinatus, native to North and South America, is an annual grass forming loose tussocks and characterised by large spiny burrs. It has not been deliberately cultivated in Australia and is regarded as a pest of pastures and some crops.

4.3 REPRODUCTION

Buffel grass plants are bisexual and commonly reproduce by seed (produced with or without fertilisation) or vegetatively through rhizome or stolon production (Franks 2002). After ripening and shedding from the plant, seeds remain viable for 12 months or longer. Field experiments conducted near Alice Springs (Winkworth 1971) found that a small portion of the seeds can remain viable for up to 4 years in the soil, however only 10% were viable after 2 years. Generally at least 25 mm of rainfall is required for seed germination (Cavaye 1988). New germinants can grow and set seed in as little as 3 to 6 weeks with sufficient moisture and re-shooting mature plants can flower within 10 days after a rainfall event (Puckey and Albrecht 2004; Barrett and Dixon undated).

Wildfires may encourage germination as the ashes are reported to make good seedbeds (Paul and Lee 1978). Franks (2002) suggests that buffel grass seeds are triggered to germinate by even minor forms of soil disturbance, including breaking of the soil surface by stock movement.

4.4 PREFERRED HABITAT

Buffel grass currently predominates in areas where summer rainfall varies from 150-550 mm, winter rainfall is less than 400 mm, mean minimum winter temperatures rarely fall below 5oC, and soil texture is loamy (Cox et al. 1988). It favours creeks, alluvial plains, calcareous areas and rocky ranges (Albrecht and Pitts 1997), however, it has been successful in a broad range of soil types and landscapes. Buffel grass also readily establishes in road and track verges, parking bays, towns and other disturbed areas.
4.5 DISPERAL AND PERSISTENCE

Buffel grass spreads through dispersal of its fluffy burs by water, wind, accidental transportation (e.g. in hay) or, intentionally introduced by landholders seeking to establish an “improved” pasture (Puckey and Albrecht 2004). Seeds rarely survive ingestion and it is unlikely that herbivores are responsible for significant spread of buffel grass in this manner (Gardner et al. as cited in Griffin 1993).

Seeds are commonly introduced into new areas along roads and tracks. Spread along roads is assisted by vehicle draughts and movement of soil by graders and other machinery and vehicles. From the road or track verge buffel grass then spreads into the surrounding vegetation by wind or water, with drainage lines acting as conduits for more distant dispersal (Puckey and Albrecht 2004).

Buffel grass may be slow to establish initially, but under favourable seasonal conditions it may spread readily and aggressively invade arid riparian areas. Established buffel grass tussocks can remain dormant for long periods and plants can live for at least 20 years (Latz 1997). Leaves die off during dry or cold periods and new growth quickly emerges from the tussock with warm, moist conditions.

Buffel grass has a rapid growth rate, fast maturation, prolonged flowering/fruiting periods, prolific seed production, high seed dispersal ability, relatively long seed dormancy, and is tolerant to drought, fire and grazing (Franks 2002; Franks et al. 2000). In the arid zone, it has spread extensively during infrequent episodes when summer rainfall was well above average for several years.

Buffel grass is competitive as an established plant and less competitive as a seedling. To limit its dominance it is therefore important to maintain competition from existing vegetation, however, this is unlikely to prevent spread altogether (Mclvor 2003).

4.6 IMPACTS AND USES

Buffel grass forms dense monocultures, changes fire regimes, threatens refugia and displaces native and endemic plants (McIvor 2003; Humphries et al. 1991; Griffen 1993; Low 1997). Buffel grass has been identified as a ‘transformer’ species (Grice, 2006); Richardson et al. (2000) have defined these as ‘a subset of invasive plants which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem’. Bastin et al. (2008) identified it as a ‘transformer weed’ of the Australian rangelands.

In NSW, the “Invasion of native plant communities by exotic perennial grasses” is listed as a Key Threatening Process (KTP) under the Threatened Species Conservation Act 1995. Buffel grass is one of these grasses listed under this KTP.

Buffel grass aggressively and rapidly colonises preferred habitats where it forms dense monocultures, displacing native vegetation. In arid Australia, buffel grass often displays strongest growth along creek lines and embankments (Centre for Arid Zone Research, 2001).

Watercourses and other mesic areas are functionally critical in a landscape where water is limiting to growth. Mesic areas are also nutrient sinks and tend to support higher flora and fauna productivity, including endemic or rare species (Humphries et al. 1993).

Numerous studies have shown that the cover of buffel grass is negatively associated with species richness (e.g. Clarke et al. 2005). Where buffel grass density is high it is predicted that reductions in species richness will become more pronounced over time, because the seed banks of native forbs and grasses will gradually be depleted (Clarke et al. 2005).

Buffel grass threatens plant and animal communities that are not adapted to fire, by increasing the intensity and frequency of natural fire regimes (Adair and Groves 1998; NBIISSG 2005). Dry foliage can form a relatively continuous, flammable ground layer that can carry extensive and intense fires. Buffel grass produces approximately 2-3 times the combustible material of displaced native grasses, resulting in hotter, more intense fires (Humphries 1993) and is able to rapidly regenerate after fire and suppress regeneration of native species. An aspect of the ability of buffel grass to transform the fire regime at a landscape scale, particularly in dry environments, is its ability to infest creek-lines which would otherwise act as natural barriers to the spread of fire. In such environments, where creek-lines did not naturally support the growth of dense, fire-fuelling grasses, buffel grass can act as a “wick” for the transmission of a fire across the landscape.

Buffel grass threatens stands of long-unburnt vegetation, and the fauna that rely on these, for example mulga woodlands, hummock and spinifex grasslands. Research undertaken in central Queensland found counts of the native delicate mouse (Pseudomys delicatulus) declined as the cover of buffel grass increased (Ludwig et al. 2000).

Specialist seed eating birds, such as finches and some parrots, do not include buffel seed in their diet and become rare in buffel dominated landscapes (Franks et al. 2000). Rare and endangered fauna species in northern SA threatened by buffel grass include: Black-footed rock-wallabies; Great Desert Skink; Spinifex bird; Mallee fowl; and, a suite of ground / low shrub / grassland foraging birds such as Chestnut Quail Thrush, Dusk Grass wren, and Striated Grass wren (Paltridge et al. 2009). The Rare and Threatened Flora Management Plan for the APY Lands (Paltridge et al. 2009) identifies 12 plant species under threat from buffel grass. In Appendix 4 a listing is provided of indigenous flora and fauna species of conservation significance that are currently considered to be threatened by buffel grass in arid and semi-arid South Australia.

Buffel grass has been the subject of agricultural extension activity in northern Australia since the 1920s (Humphrys 1967); in the 1950s it became the prominent sown pasture grass for the more arid zones of northern Australia.
and was well researched for its potential to improve pastures across Queensland, Western Australia and the Northern Territory (Hall 2000). Most plantings have taken place since the late 1950s (Paul and Lee 1978).

Buffel grass is well regarded as a resource by many northern Australian cattle producers because of its palatability, responsiveness to limited rainfall, ability to colonise and its tolerance to drought and heavy grazing (Fairfax and Fensham 2000). It responds to out of season rain when native species remain dormant (Hall 2000) however it can displace a large range of short-lived native grasses and forbs important in fattening cattle (Puckey and Albrecht 2004). This is particularly concerning in far northern SA where these types of vegetation communities predominate (Greenfield 2007). Buffel grass invasion is facilitated by burning, producing positive feedback loop is an increased rate of degradation of the landscape as buffel grass increases in density and out-competes non-fire-dependent native species and further dominates the ground layer (Butler and Fairfax 2003; Miller et al. 2010)).

Buffel grass has a high demand for available soil nitrogen and phosphorus and as buffel assumes dominance, soil nitrogen is depleted and growth begins to decline in what has been described as a ‘run-down’ effect, with an associated decline in cattle live-weight gain (Puckey and Albrecht 2004). Buffel grass contains oxalates and can cause acute oxalate poisoning in ruminants, most often in young and hungry sheep (Thomas 2004). Under favourable conditions buffel grass can form monocultures or dense stands, displacing native plants including valuable forage species. Lack of diversity in pastures can limit the nutritive value available to stock during particular seasonal conditions (e.g. dry periods) or pasture “run-down”.

Buffel grass has also been used for soil stabilisation and erosion control (Albrecht and Pitts 1997).

Major threats to ‘Country’ in South Australia include invasions of existing or new weeds, in particular buffel grass, which is considered one of the greatest risks to biodiversity in the Alinytjara Wilurara Natural Resources Management Region (Alinytjara Wilurara Natural Resources Management Board, 2011). Biodiversity assets at risk within the region include culturally important or unique flora, fauna (e.g. the critically endangered Warru or black-footed rock-wallaby) and native habitats.

4.7 HISTORY OF SPREAD

Buffel grass is believed to have been accidentally introduced into the northwest coast of Western Australia in the 1870s in Afghan camel harnesses (Humphreys 1967). After the First World War, the WA Department of Agriculture was active in distributing Chenopodium varieties sent from Afghanistan. These were the source of the first buffel grass seeds being planted in Queensland at Cloncurry in 1926 (Humphreys 1967). Trials of buffel grass from Pretoria were recorded in the early 1920s in NSW and a buffel grass specimen was identified in Alice Springs in 1930 (Humphreys 1967). Since the late 1950s, buffel grass has been a major pasture grass sown in northern Australia (Loch 1999). Over 580 accessions of buffel grass have been brought into the Australia from 35 countries by various agencies (Hall 2000) with new varieties continuing to be introduced (Friedel et al. 2006).

Buffel grass has been accidently and intentionally introduced around northern South Australia. Small scale buffel grass trials have been carried out on many pastoral properties in South Australia since the 1950s (Greenfield 2007). Wind, water, animals and machinery dispersal vectors have spread it into other areas.

4.8 CURRENT DISTRIBUTION

Buffel grass is naturalised in Western Australia, the Northern Territory, Queensland, New South Wales and South Australia.

In South Australia, buffel grass is widely distributed across the northern regions with scattered populations varying in size and density. Extensive infestations occur in the State’s far north-west, in the northern part of the AW NRM Region (APY Lands). In the SAAL NRM Region buffel grass is widely distributed as scattered populations with most located in the north-west (Marla – Oodnadatta District). North of Marla, along the Stuart Highway verge and adjoining land, buffel grass densities are high, south of Marla the density and extent declines, particularly away from the highway.

With the exception of the far north-west, known non-roadside occurrences of buffel grass are widely scattered and sparse. Infestations are mostly small; however its distribution along some watercourses is likely to be more extensive, for example in the North Flinders District of SAAL NRM Region. Isolated infestations occur along the Oodnadatta Track, Cooper Pedy – William Creek Road, Borefield Track, Marree – Hawker Road, Birdsville and Strzelecki Tracks, and in townships including Marla, Oodnadatta, Cooper Pedy, Copley, Glendambo, Roxby Downs and Port Augusta.

There are small, isolated infestations in the EP NRM region, typically associated with roadsides and townships. In the NY NRM region there are small roadside populations along the Stirling North – Hawker road and an extensive infestation along the Port Augusta – Port Wakefield Road between Port Augusta and Port Pirie. There are relatively few infestations in the southern parts of the state. In early 2012 several small infestations were found within the SA Murray Darling Basin NRM region; prior to this, buffel had been recorded from only one location within the region (2004).

The distribution of buffel grass in South Australia is shown in Figure 1.

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1 Country is a term commonly used to describe the land or waters with which a person or community has a traditional, historical or contemporary association.
Using CLIMEX climatic and soil modelling it has been predicted that 25% of Australia is potentially highly suitable, and 43% is suitable for buffel grass spread, with the arid to semi-arid areas of the continent being potentially the most favoured for this species (Lawson et al. 2004). The CLIMEX model indicated buffel grass intolerance to cold and wet stress, and regions where there are insufficient days above the minimum threshold temperature necessary for the species to complete a generation.

More recent climatic modelling for South Australia using BIOCLIM2 (Marshall et al., 2010) predicted that no part of the State's land area is entirely unsuitable for establishment of buffel grass (See Table 1 and Figure 1). The model also showed that the degree of suitability for establishment is variable across the State: 30.5% is “moderately suitable”, a further 42% is “highly suitable”, and a further 27.5% is “very highly suitable”. A relatively small proportion of the State (0.03% or 33,000 ha, confined to the SA Arid Lands and Alinytjara Wilurlara NRM boards) was predicted as “extremely suitable”.

Buffel grass spreads through dispersal of seed by water, wind, or movement of soil or objects (e.g. vehicles, machinery, or animals). Seeds are commonly introduced into new areas along roads and tracks. Spread along roads is assisted by vehicle draughts and movement of soil by earthmoving equipment. Roadworks (e.g. patrol grading) can contribute significantly to dispersal of seed. From the road verge, seed can be spread into the surrounding vegetation, including drainage lines, by wind or water. Drainage lines then act as a pathway for more distant dispersal by water and wind. Another potential source is vehicles that have been off-road for a variety of purposes including mining exploration and tourism.

Climate change modelling recently undertaken by Macquarie University in conjunction with the NSW Office of Environment and Heritage suggests that suitable climatic habitat for this weed will shift from northern and central Australia towards south-eastern Australia, including large areas in South Australia and New South Wales (Wilson et al. 2011).

Figure 1. Current and potential distribution of buffel grass in South Australia. Potential distribution is based on BIOCLIM analysis. Current distribution is based on a range of sources including herbarium specimen records (AVH), Biological Survey of SA data (DEWNR), other survey data (NRM boards, University of Adelaide) and recent roadside surveys (RSSA, 2010).
Table 1: Climatic suitability for establishment of buffel grass in South Australia: Percentage of land area within each NRM Region in each suitability category. The analysis using BIOCLIM (Marshall and Hobbs, 2010) was based on existing distribution records sourced from Biological Survey SA, Australia's Virtual Herbarium, NRM regions, and local government groups, as well as new roadside survey data (Shepherd and Marshall, 2010).

<table>
<thead>
<tr>
<th>CLIMATIC SUITABILITY CATEGORY</th>
<th>NRM REGION</th>
<th>Percentage of land area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAAL</td>
<td>AW</td>
</tr>
<tr>
<td>Not suitable</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately suitable</td>
<td>29.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Highly suitable</td>
<td>47.6</td>
<td>38.2</td>
</tr>
<tr>
<td>Very highly suitable</td>
<td>22.8</td>
<td>51.3</td>
</tr>
<tr>
<td>Extremely suitable</td>
<td>0.1</td>
<td>0</td>
</tr>
</tbody>
</table>

4.10 RISK ASSESSMENT

A State-level weed risk assessment was carried out using the SA Weed Risk Management System (PIRSA – Biosecurity SA, 2011) for the following land-uses:

**Arid Rangelands:**
Arid and semi-arid parts of the State represented by AW and SAAL NRM boards. Land-uses including grazing on leases permitted under the Pastoral Management Act, conservation (public and private reserves) and aboriginal lands (including some grazing). It is assumed, on average across the State, weed management is sporadic and minimal in this land-use.

**Native Vegetation (southern regions):**
This land-use includes all forms of land tenure both public and private in the southern, higher rainfall parts of the State represented by the remaining six NRM boards (EP, NY, SAMDB, AMLR, SE and KI). It includes public and private protected areas and other land supporting native vegetation outside the State’s arid and semi-arid rangelands. It is assumed, on average across the State, there is no routine weed management in this land-use.

The results of the assessment are given in Table 2 below.

The assessed weed risk is high to very high for both land-uses due particularly to its invasiveness, especially its dispersability, high potential distribution and the impact on desired vegetation.

Key influencing factors for the relatively high assessed feasibility of control for both land-uses are:

- Maximum propagule longevity – seed may survive for up to an estimated 4 years in the soil (Anon. 2008)
- Effectiveness of targeted control treatments – plants are responsive to herbicides (when in active growth phase), e.g. glyphosate, fluopropanate

Feasibility of control is lower for Arid Rangelands – representing the remote arid and semi-arid regions of the State – than for Native Vegetation, principally due to the relative accessibility of known infestations. At a sub-regional level, though, feasibility of control would be significantly lower in the APY Lands (AW NRM board) in the far north-west of the State than in any other part of the State due to its remoteness, and the extent of land infested by the weed.

With regard to the Arid Rangelands land-use, the aim of a “Destroy Infestations” response is to significantly reduce the extent of the weed species in the management area. This management response may feasible or appropriate for AW and SAAL NRM boards but only with significant, long-term resources.

With regard to the Native Vegetation land-use, the aim of an “Eradicate” response is to remove the weed species from the management area. This management response may be feasible or appropriate for other NRM boards, i.e. EP, NY, SAMDB, AMLR, SE and KI.

Table 2. State-level risk assessment of buffel grass for two land-uses in South Australia using the SA Weed Risk Management System.

<table>
<thead>
<tr>
<th>LAND USE</th>
<th>WEED RISK (SCORE)</th>
<th>FEASIBILITY OF CONTAINMENT (SCORE)</th>
<th>STATE LEVEL MANAGEMENT RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arid Rangelands</td>
<td>Very High (192)</td>
<td>High (21)</td>
<td>Destroy Infestations</td>
</tr>
<tr>
<td>Native Vegetation</td>
<td>Very High (208)</td>
<td>Very High (2)</td>
<td>Eradicate</td>
</tr>
</tbody>
</table>
4.11 CONTROL OPTIONS

There are considerable challenges to the control of buffel grass in northern South Australia: its physiological and ecological characteristics; its widespread geographic distribution; the extensive area infested; the land use present; and the current level of community awareness regarding impacts of this species (Greenfield 2007). In addition, spread by wind and water can potentially move buffel seed many kilometres in a single event.

Information on the distribution of buffel grass, including where control works have been completed, is critical to support planning. The degree of detail required would vary with the scale and purpose of the planning, for example planning in eradication areas with scattered plants requires knowledge down to single plant level.

Once established there is no single control method available for the successful management of buffel grass over extensive areas (Tu 2002). Prevention is the most cost-effective means of weed control. It is important therefore to keep currently uninfested areas free of buffel grass, particularly near high value assets.

As the current extent of buffel grass in northern South Australia precludes absolute control, effort needs to be guided by decision making based on biodiversity values and other assets potentially at risk, logistics, and available resources.

Chemical and mechanical methods, and in some situations fire can be used in an integrated control program for buffel grass. All methods may be effective in particular situations depending on the infestation density and extent, terrain, resources, and the management objectives (e.g. eradication or containment). There is potential to improve the effectiveness of control methods for some sites and to then disseminate the knowledge to weed managers and landholders. Control methods should be complementary. Control programs require several years of follow-up that may increase the cost several-fold; in some situations the long-term costs can make control of large dense infestations uneconomic.

Buffel grass must be actively growing for effective uptake of herbicides. In arid or semi-arid regions of South Australia the period of active growth is unpredictable and may be short-lived, and timing is therefore very important for control. Foliar application of select herbicides to young plants or regrowth following rain provides the best opportunity for success. Simple physical removal of buffel grass may be considered for new, small infestations, particularly where the plants are bearing seed and the plants are not in an active growth phase. Fire or slashing and herbicides may be integrated to improve foliar uptake and to manage larger infestations.

The high cost of herbicides and associated labour is a hindrance to control. All control programs require several years of follow-up treatment and monitoring, which further increases the cost. Control and eradication of infestations must be carried out on all tenures including government and Aboriginal lands.

Biological control is considered the most cost effective management method for dense areas of many weeds. However, as buffel grass is recognised as a valuable forage species in some parts of Australia, the potential use of biological control agents is unlikely to gain acceptance.

Although there are no approved biocontrol agents in Australia for buffel grass, it is affected by several diseases, and an insect pest. The most important diseases are buffel blight, caused by fungal pathogen *Pyricularia grisea*, and ergot (*Claviceps* spp.) affecting seed production (Perrott 2000). A condition known as buffel grass dieback in areas of central Queensland has been described but the causal agent(s) are unknown (Makiela et al. 2008). The buffel grass seed caterpillar (*Mampava rhodoneura*) is the only major insect pest of buffel grass. It has been recorded in warmer, higher rainfall areas of Queensland.

The range of options that may be considered for the control of buffel grass in South Australia are presented in Appendix 3.

### Regional

Weed risk assessments for buffel grass using the SA Weed Risk Management System have been undertaken for NRM Regions where the risk of introduction and establishment is considered to be the greatest in South Australia. The following regional-level management responses have been determined:

<table>
<thead>
<tr>
<th>NRM REGION</th>
<th>MANAGEMENT RESPONSE AS DETERMINED BY WEED RISK ASSESSMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alintjara Wilurara</td>
<td>Manage weed to protect sites</td>
</tr>
<tr>
<td>SA Arid Lands</td>
<td>Manage weed to protect sites</td>
</tr>
<tr>
<td>Eyre Peninsula</td>
<td>Eradicate weed</td>
</tr>
<tr>
<td>Northern and Yorke</td>
<td>Contain spread in native vegetation, Monitor in non-arable grazing</td>
</tr>
<tr>
<td>SA Murray-Darling Basin</td>
<td>Not assessed (current practice is to destroy new incursions where possible)</td>
</tr>
<tr>
<td>Adelaide and Mt Lofty Ranges</td>
<td>Contain spread</td>
</tr>
<tr>
<td>South East</td>
<td>Not assessed (current practice is to destroy new incursions where possible)</td>
</tr>
<tr>
<td>Kangaroo Island</td>
<td>Not assessed (current practice is to destroy new incursions where possible)</td>
</tr>
</tbody>
</table>
CASE STUDY

Control of Buffel grass along the Stuart Highway

In the interest of road safety and infrastructure protection the Department for Planning, Transport and Infrastructure (DPTI) has recently invested resources in the control of buffel grass as the predominant weed infesting the Stuart Highway. Buffel grass is common along the highway with many stretches of verge covered by dense stands that were rapidly spreading.

DPTI first targeted isolated occurrences of buffel grass along the Eyre Highway between Port Augusta and Whyalla, and after initial success decided to focus next on the Stuart Highway with the aim of removing it from the verge between Port Augusta to Coober Pedy, a distance of 530km.

In order to address the problem of recurring reinvasion, control normally undertaken in the close verge area was extended up to a further 50 metres on either side of the road. Parking bays were also included in the spray program.

North of Coober Pedy buffel grass is widely dispersed across the landscape, while south of Coober Pedy the Stuart Highway is its major stronghold and acts as the conduit of spread in an otherwise relatively buffel grass free landscape. Eradication of buffel grass from the Stuart highway and other roadside verges south of Coober Pedy is therefore an important step towards minimising further spread.

The program started in 2007 and, by the end of 2010, the Port Augusta to Pimba roadside had been sprayed three times, the Pimba to Glendambo stretch twice and the Glendambo to Coober Pedy stretch once. In a June 2010 roadside survey very few live buffel grass plants were found along the road verge from Port Augusta to Pimba, even after good rainfalls in the area, however after ongoing extensive rains late in 2010 and early 2011 regeneration of buffel grass was moderate both on the Stuart and Eyre highways demonstrating the need for ongoing management.

This successful 3-year control program used the following approach:

• Spraying only green, actively growing plants
• Spraying with a flupropanate – glyphosate formulation
• Applying 3-4 sprays, each 3-4 months apart (depending on rainfall)

Flexibility in the spray program to enable quick response to favourable growing conditions based on rainfall events and temperature (less than 28°C)

Spraying regrowth after burning was trialled and abandoned when flupropanate was found to be as effective in unburnt trials. Flupropanate was found to be very effective and although a residual herbicide, observations suggest that its long-term effects on native grass regeneration are negligible (see below).

Before and after photos showing good regeneration of native grasses following buffel grass control using flupropanate. Photos: D.Powell, DPTI
Controlled burn of buffel grass, Oak Valley, MT Lands. Photo: T. Gurney, DEWR, 2011

Weather station and water tank surrounded by cured, highly flammable buffel grass, APY Lands. Photo: J. Stelmann, DEWR, 2012
5 REFERENCES


Humphreys, L. R. (1967). Buffel grass Cenchrus ciliaris) in Australia. Tropical Grasslands 1, 123–34.


### 6 APPENDICES

#### APPENDIX 1: KNOWLEDGE GAPS AND DIRECTIONS FOR FUTURE INVESTIGATION AND RESEARCH ON BUFFEL GRASS IN SOUTH AUSTRALIA (REFER ACTION 4.4)

<table>
<thead>
<tr>
<th>KEY AREAS</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>• Identify habitat preferences – e.g. soil, invaded vegetation, disturbance regime – consider possible differences between buffel varieties</td>
</tr>
<tr>
<td></td>
<td>• Determine potential for establishment in different environments by natural or unassisted forms of dispersal</td>
</tr>
<tr>
<td></td>
<td>• Fire ecology: effect of buffel infestations on the fire-proneness of different plant communities – e.g. changes to fuel loads, burn severity and potential for buffel–initiated positive fire-invasion feedback</td>
</tr>
<tr>
<td></td>
<td>• Determine seed bank longevity - predict how long seeds will persist in different soils – consider potential varietal differences</td>
</tr>
<tr>
<td></td>
<td>• Determine germination requirements (consider potential varietal differences)</td>
</tr>
<tr>
<td>Impacts</td>
<td>• Identify adverse long term impacts on biodiversity (e.g. competition, effect of fire), pastoral production (e.g. change in fire risk, loss of native forage species) and infrastructure (e.g. change in fire risk)</td>
</tr>
<tr>
<td>Taxonomy</td>
<td>• Genetic analysis of buffel grass varieties in SA to determine whether there is any dominance in particular landscapes and to determine dispersal pathways – and to enable rapid identification where non-reproductive material or seedlings is collected.</td>
</tr>
<tr>
<td></td>
<td>• Evidence of hybridisation and adaptation</td>
</tr>
<tr>
<td>Management / control</td>
<td>• Investigate potential for fire as a component of integrated weed management for small and large infestations</td>
</tr>
<tr>
<td></td>
<td>• Apply new knowledge of functional differences between varieties, germination requirements and seed longevity to improved management</td>
</tr>
<tr>
<td></td>
<td>• Identify typical invasion pathways including vectors and pathways of spread</td>
</tr>
<tr>
<td></td>
<td>• Investigate cost-effective options for control of buffel grass on organic certified properties</td>
</tr>
<tr>
<td>Current distribution</td>
<td>• Develop a GIS layer of buffel grass distribution (including estimates of abundance /densities)</td>
</tr>
<tr>
<td></td>
<td>• Improve understanding of the distribution and habitat requirements of C. pennisetiformis</td>
</tr>
<tr>
<td></td>
<td>• Integrate data from different systems to enable uniform Statewide monitoring and reporting</td>
</tr>
<tr>
<td></td>
<td>• Potential use of satellite data (subject to sufficient spectral differentiation of buffel grass from other ground layer species)</td>
</tr>
<tr>
<td></td>
<td>• Undertake aerial surveys and ground validation for large and inaccessible areas</td>
</tr>
<tr>
<td></td>
<td>• Refine / apply survey methods able to detect low densities of buffel (hence early stages of invasion)</td>
</tr>
<tr>
<td>Potential distribution</td>
<td>• Predictive spatial and/or habitat modelling at a range of spatial scales (State, regional, local), refined to identify environments prone to buffel infestation</td>
</tr>
<tr>
<td></td>
<td>• Identify physical aspects such as climate and soil; biotic factors such as competition from other grasses, tree cover, effects of herbivores – to determine limitations on potential distribution as well as preferred habitats</td>
</tr>
<tr>
<td></td>
<td>• Identify areas of high biodiversity value (e.g. areas of high diversity, threatened species, endemism, or ecological integrity) at greatest risk of invasion based on environmental preferences of buffel grass</td>
</tr>
</tbody>
</table>
## Appendix 2: Isolated Roadsides and Townships Infestations of Buffel Grass Recommended for Priority Control Based on a Survey of Outback Roads Undertaken in 2010 (Shepherd, 2011)

<table>
<thead>
<tr>
<th>Priority Roadside Occurrence (Based on Isolation)</th>
<th>Description of Occurrences/Notes</th>
<th>Potential Buffel Grass Free Zone Being Protected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside at Kokatha and Lake Everard Stations (Gawler Ranges)</td>
<td>5 small populations and one single occurrence mainly confined to the roadside disturbance zone with 2 locations where the plants extend 1-10 metres into the natural zone</td>
<td>Prevent roadside spread into the Gawler Ranges (primarily by graders) from the Glendambo to Tarcoola Road populations. Maintain the Gawler Ranges buffel grass free.</td>
</tr>
<tr>
<td>Roadside at Corunna Station (Gawler Ranges)</td>
<td>A small population confined to the disturbance zone. Small sparse populations of buffel grass are likely to be present on the Pt Augusta to Iron Knob road.</td>
<td>Prevent spread into the Gawler Ranges from Lincoln Highway infestations. Maintain the Gawler Ranges buffel grass free.</td>
</tr>
<tr>
<td>Roadside at Mt Eba and Mt Vivian Stations (north of Glendambo)</td>
<td>3 small populations mainly confined to the roadside disturbance zone with 2 locations where the plants extend 1-10 metres into the natural zone</td>
<td>Prevent roadside spread from the Stuart Highway populations. Maintain all roads running east from the Stuart Highway buffel grass free.</td>
</tr>
<tr>
<td>Roadside on the William Creek to Coober Pedy Road, 63 km from Coober Pedy</td>
<td>A small clump of plants confined to the roadside disturbance zone.</td>
<td>Maintain all roads running east from the Stuart Highway buffel grass free.</td>
</tr>
<tr>
<td>All occurrences on the Oodnadatta Track from William Creek to Marree</td>
<td>5 known small occurrences.</td>
<td>Prevent roadside spread along the Oodnadatta Track. Maintain the Oodnadatta track, between Marree and William Creek buffel grass free.</td>
</tr>
<tr>
<td>All occurrences on the Borefield Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadside on the Strezelecki track, 17 km east of Lyndhurst.</td>
<td>A small population confined to a large culvert. Closest other existing records are 20km east along the Strezelecki track in a drainage line.</td>
<td>Prevent roadside spread along the Strezelecki Track from Frome (and nearby) creek populations.</td>
</tr>
<tr>
<td>Arkaroola visitor centre</td>
<td>6-10 plants around the Arkaroola visitor centre. Several other existing records close by.</td>
<td>Prevent spread by vehicles from high visitation areas. Promote awareness and control by the Arkaroola managers.</td>
</tr>
<tr>
<td>Roadside on the Quorn and Parachilna Road – excluding the area around the Brachina Creek and Brachina Gorge turn off</td>
<td>4 small populations confined to the disturbance zone. One population/clump 4.5 km north of Quorn the other 3 populations/clumps 2.5, 22 and 30 km north of Hawker. Larger populations of buffel grass were also mapped at the Brachina Gorge turn off, in the Brachina Creek and in Commodore Swamp. These populations are listed under the heading Locations where buffel grass was widespread in the natural zone. Other existing records are on the road between Hawker and Wilpena Pound.</td>
<td>Prevent spread into the Flinders Ranges.</td>
</tr>
<tr>
<td>Glendambo, Tarcoola, Barton, Ooldea</td>
<td></td>
<td>Prevent further spread from high visitation areas into AW NRM, Yellabinna Regional Reserve, Gawler Ranges.</td>
</tr>
</tbody>
</table>
### APPENDIX 3: SUMMARY OF MANAGEMENT OPTIONS FOR BUFFEL GRASS (SHEPHERD 2011)

<table>
<thead>
<tr>
<th>MANAGEMENT OPTION</th>
<th>DESCRIPTION</th>
<th>ADVANTAGE</th>
<th>DISADVANTAGE</th>
</tr>
</thead>
</table>
| Prevention – actively prevent deliberate introductions | Limit introduction and spread of buffel seed by preventing introduction of contaminated vehicles, produce, animals, soil, machinery, etc. Prohibit propagation under NRM Act | • Cost effective  
• No need to use herbicides | • Difficult to justify and implement when such practices are not generally employed for other pest plants  
• Requires vehicle washdown facilities – may be expensive to install and maintain  
• Voluntary use of washdown facilities by community likely to be low  
• Compliance activities are expensive |
| Mechanical | Grubbing or digging out | • Effective for small isolated patches.  
• Mowing can stimulate regrowth that is more effectively killed by spraying  
• Can be done any time of year (eg dry conditions when other methods unsuitable)  
• Can be done by unskilled persons  
• No chemicals required | • Labour intensive and costly  
• Unsuited as a single method for extensive areas, but combined with another method may improve efficacy (e.g. mow and spray regrowth)  
• Ongoing hand pulling and herbicide treatment of regrowth is required.  
• Soil disturbances can stimulate seed germination and enhance seedling establishment (though can also stimulate native spp.)  
• May need to destroy removed plants to avoid further spread |
| Fire | Burn and follow up treatment of regrowth with herbicide applications | • Herbicide spray regrowth gives good results  
• Burning stimulates regrowth  
• Reduces seed bank  
• Burning stimulates and provides uniform regrowth for follow up chemical control | • Fire is not an effective management tool on its own  
• Can stimulate buffel grass growth over native species  
• Herbicide treatment of regrowth is essential  
• Equipment and clean water needed for herbicide application.  
• Risk of fire escape |
| Herbicide – foliar spray (refer Table 5) | Foliar spray when actively growing  
Use of residual herbicides may be an option on roadsides or along fence lines where risk of off-target damage is low | • Minimal soil disturbance.  
• Can be very effective with follow up control  
• Can be cost effective on large and dense infestations  
• May be an effective follow up at sites cleared by mechanical removal  
• Some residual herbicides do not need a water carrier (i.e. apply as a “spot treatment”) | • Buffel must be actively growing for effective uptake of foliar spray  
• Brief opportunity for chemical application – timing is critical  
• 2 or 3 sprays may be required to control large plants  
• Residual herbicides may impact non-target and/ or competitive species  
• Efficacy is dependent on good quality water – may not be readily available in remote outback areas |
| Biological | There are no known biological controls of buffel grass | • Potential for ongoing reduction of the impact and spread of buffel grass  
• Highly target-specific and low cost once established | • Conflicts of interest as a pasture grass would prevent buffel grass being listed as an approved target for biological control research  
• Limited international track record on successful biocontrol of grass weeds  
• High cost of long-term research until an agent is approved for release (typically 10 years) |
| Ecological | Maintain ground cover and competition by existing veg | • Encouragement of good land management practices has triple-bottom line benefits | • Perceived conflict with grazing as a land use, particularly in arid areas  
• Insufficient alone to prevent invasion |
| Pulse grazing | Graze to prevent formation of seed heads | • Can reduce the soil seed bank | • Difficult to implement and impossible to achieve selective grazing  
• Disturbance by cattle can create favourable conditions for buffel grass establishment |
## Table 2: Herbicides registered and permitted for use on buffel grass.

<table>
<thead>
<tr>
<th>HERBICIDE</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIQUAT PRESENT AS DIQUAT DIBROMIDE / PARAQUAT PRESENT AS PARAQUAT DICHLORIDE</strong></td>
<td>• Fast action, may be useful in burning seed heads off (to control seed set) if sprayed late.</td>
<td>• Classed as moderately toxic (S7) to humans (LD50 by skin absorption is 260 mg/kg male rabbit). Not safe for general use. • Toxic to fish and wildlife also. • Only burns the top off the plants</td>
</tr>
<tr>
<td><strong>HALOXYPF-P PRESENT AS THE HALOXYPF-P-METHYL</strong></td>
<td>• 100% effective (Dixon et. al. 2002). • Not residual (degrades within 24 hours) therefore will not prevent regrowth of competitive native plants</td>
<td>• Classed as slightly hazardous to humans (S6)</td>
</tr>
<tr>
<td><strong>360, 450 or 540 g/L GLYPHOSATE PRESENT AS THE ISOPROPYLAMINE SALT as their only active constituent</strong></td>
<td>• Relatively safe (S5) for general use by a broad range of people. • Not residual therefore will not prevent regrowth of competitive native plants • A general use herbicide that can be used on a range of weeds • Roundup Biactive is registered for use in waterways • Can be mixed with flupropanate herbicides4</td>
<td>• 80% kill rate (Dixon et. al. 2002).</td>
</tr>
<tr>
<td><strong>FLUROPROPAenate PRESENT AS THE SODIUM SALT as their only active constituent.</strong></td>
<td>• Residual herbicide is good for areas such as roadsides and fence lines. • Good results achieved along the Stuart Highway (see case study). • Can be mixed with glyphosate herbicides.</td>
<td>• Classed as slightly hazardous to humans (S6). • Residual herbicides may prevent regrowth of competitive native plants.</td>
</tr>
<tr>
<td><strong>128 or 212g/L FLUAZIFOP-P PRESENT AS THE BUTYL ESTER as their only active constituent.</strong></td>
<td>• 100% effective (Dixon et. al. 2002) • Low persistence and mobility in soils (half life of 1 week) therefore will not prevent regrowth of competitive native plants • May only control seedlings (Pers. Comm., I. Honan, DEWR)</td>
<td>• Classed as slightly hazardous to humans (S6). • Ester formulations are relatively volatile with a greater change of off target damage. • Moderately toxic to fish.</td>
</tr>
</tbody>
</table>

4 A glyphosate – flupropanate mix (e.g. Roundup Power-Max® and Tussock®), in conjunction with burning, has provided the most effective long term control in most situations when applied in a timely manner on Eyre Peninsula (Pers. Comm., I. Honan, DEWR).
Herbicide control

Buffel grass must be actively growing for effective uptake of herbicides. Foliar application of select herbicides to young plants or regrowth following rain provides the best opportunity for success.

Timing is critical to successful chemical control. Re-sprouting plants can flower within a week after rain and new germinations can set seed within three to six weeks with sufficient moisture (Barrett and Dixon, undated). As a general rule, foliar herbicides should be applied after rainfall when the plant is actively growing and before seed set. Well developed rootstock may mean that two or three sprays are required to destroy large plants (Barrett and Dixon, undated) and seeds can remain viable for up to 4 years (Winkworth, 1971). Chemical control programs thus require flexibility and responsiveness around rainfall events and monitoring and follow up control is required for an extended period to ensure eradication.

There are 52 registered products and 1 minor use permit (PER9792) that are permitted for the control of buffel grass (PUBCRIS search, February 2011). The following table summarises the advantages and disadvantages of each herbicide.

When using herbicides, it is important to follow safe use instructions on herbicide labels. Refer to product label for full conditions of use and application instructions. Some of the herbicides are soil active residuals and must be used with care to minimise damage to native vegetation.

In remote locations where follow up control is less likely to occur, the use of granular applied residual herbicides for isolated small infestations or single plants can be an alternative to mechanical grubbing (Greenfield 2007). Off-target impacts to native vegetation that could effectively compete with buffel grass need to be considered with this method. More research into other potential herbicides for buffel grass control is required.

Friedel et al. (2009) provide an example of the costs involved in the chemical control of buffel grass for a project conducted at Alice Springs Desert Park, NT between 1997 and 2007, indicating the very high cost of control in arid regions. The cost of labour and materials for herbicide spraying varied from almost $10,000/ha in 2000 in the initial stages of the project, to $50/ha in 2006 for regular follow-up spraying of buffel grass after rain events once the buffel grass was largely under control. Over the 10 year period (1997-2007) the average cost was $5500/ha.
APPENDIX 4: INDIGENOUS FLORA AND FAUNA SPECIES OF CONSERVATION SIGNIFICANCE IN ARID AND SEMI-ARID SOUTH AUSTRALIA CONSIDERED TO BE THREATENED BY BUFFEL GRASS (MARCH 2012).

**Table 1.** Species of conservation significance not currently listed under the Environment Protection and Biodiversity Conservation Act 1999.

<table>
<thead>
<tr>
<th>SPECIES SCIENTIFIC NAME</th>
<th>COMMON NAME</th>
<th>DATA ON CURRENT STATUS</th>
<th>HOW BUFFEL GRASS POSES A THREAT</th>
<th>REFERENCE / INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melaleuca fulgens subsp. corrugata</td>
<td>Wrinkled Honey Myrtle</td>
<td>Endemic to Central Ranges IBRA region. All populations surveyed on the APY Lands contain very few individuals and are under threat from inappropriate fire regimes. Total Area of Occupancy in South Australia is less than 5 km². Total number of mature individuals is known to be less than 2500 individuals</td>
<td>Buffel grass promotes inappropriate fire regimes. The ongoing invasion of buffel grass across the Central Ranges IBRA ranges will not only outcompete this species but also increase the frequency and intensity of fires, posing a threat to small and isolated endemic plant species</td>
<td>APY Rare and Threatened Plant Management Plan (Paltridge et al. 2009)</td>
</tr>
<tr>
<td>Acacia tenuior</td>
<td>Central Ranges Wattle</td>
<td>Currently only two populations of A. tenuior known, the combination of small population size and disjunct population means that this species is at risk of extinction from catastrophic events posed from Buffel Grass</td>
<td>Buffel grass promotes inappropriate fire regimes. The ongoing invasion of buffel grass across the Central Ranges IBRA ranges will not only outcompete this species but also increase the frequency and intensity of fires, posing a threat to small and isolated endemic plant species</td>
<td>APY Rare and Threatened Plant Management Plan (Paltridge et al. 2009)</td>
</tr>
<tr>
<td>Eremophila willsii subsp. indeterminate</td>
<td>Musgrave Ranges Fuschia</td>
<td>Currently only one population known from Australia, in APY Lands</td>
<td>Buffel grass promotes inappropriate fire regimes. The ongoing invasion of buffel grass across the Central Ranges IBRA ranges will not only outcompete this species but also increase the frequency and intensity of fires, posing a threat to small and isolated endemic plant species</td>
<td>APY Rare and Threatened Plant Management Plan (Paltridge et al. 2009)</td>
</tr>
<tr>
<td>Acacia ammobia</td>
<td>Mount Connor Wattle</td>
<td>Relatively abundant but restricted to Mt Connor/Uluru district of the Central Ranges Region</td>
<td>Highly sensitive to fire – killed by the mildest of fires and populations would require a fire frequency of less than 25 years. Buffel grass promotes very hot fires. Ongoing invasion of buffel grass in Central Ranges, therefore, poses a threat to this species in the long-term</td>
<td>APY Rare and Threatened Plant Management Plan (Paltridge et al. 2009)</td>
</tr>
<tr>
<td>Goodenia brunnea</td>
<td>Central Ranges Goodenia</td>
<td>Limited distribution – endemic to Central Ranges region. Total extent of occurrence 27,523 km²</td>
<td>Goodenia brunnea is a primary successional plant following fire. If Buffel grass becomes the dominant successional species, it will outcompete Goodenia brunnea</td>
<td>APY Rare and Threatened Plant Management Plan (Paltridge et al. 2009)</td>
</tr>
<tr>
<td>Teucrium reidii</td>
<td>Showy Germander</td>
<td>Small population sizes and limited distribution to APY Lands in Central Ranges region. Total known population size probably &lt;5000 individuals nationally</td>
<td>Buffel Grass currently known to be significantly encroaching on two largest known remaining populations. Fire sensitive plant. Inappropriate fire regimes and competition from buffel grass will significantly affect this species status</td>
<td>National Recovery Plan for Olea macdonnellensis, Minuria tridens (Minnie Daisy) and Actinotus schwarzii (Desert Flannel-flower)</td>
</tr>
<tr>
<td>SPECIES SCIENTIFIC NAME</td>
<td>COMMON NAME</td>
<td>CURRENT LISTING CATEGORY</td>
<td>DATA ON CURRENT STATUS</td>
<td>HOW BUFFEL GRASS POSES A THREAT</td>
</tr>
<tr>
<td>-------------------------</td>
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</tr>
<tr>
<td>Petrogale lateralis MacDonnell Ranges Race</td>
<td>Black-footed rock-wallaby/Warru</td>
<td>Vulnerable</td>
<td>Declining populations across its range</td>
<td>Buffel grass promotes hot wildfires which can destroy fire sensitive vegetation on which warru rely, such as Figs (Ficus) and Spearbush (Pandorea sp.). Uncontrolled spread of buffel grass will threaten remaining populations of warru</td>
</tr>
<tr>
<td>Liopholis slateri virgata</td>
<td>Slater’s skink</td>
<td>Endangered</td>
<td>Only known from four individuals and not seen since 1914</td>
<td>Reduced food and feeding success in buffel dominated habitats. Increase in fire frequency. Total population currently thought to be 200-300 animals. The decline and disappearance of Slater’s skink is correlated with the introduction of buffel grass into central Australia in the late 1960s. This weed has radically altered the vegetation structure and species composition of drainage systems in central Australia. Buffel grass is now the dominant ground cover at the type locality and surrounding alluvial areas</td>
</tr>
<tr>
<td>Liopholis kintorei</td>
<td>Tjakura/ Great Desert Skink</td>
<td>Vulnerable</td>
<td>Seven isolated populations spread across WA, NT and South Australia totalling approximately 6000 individuals</td>
<td>Ongoing spread of buffel grass will change the structure of preferred open feeding grounds of Tjakura, as well as promoting frequent wildfires which will completely change the structure of preferred vegetation.</td>
</tr>
<tr>
<td>Stipiturs mallee</td>
<td>Mallee Emu-wren</td>
<td>Endangered</td>
<td>Few remaining populations. Extent of occurrence estimated at 3856 km² and declining very rapidly. Estimated population size 1440 to 2814 mature individuals and declining rapidly</td>
<td>Mallee Emu-wrens are restricted to Triodia and heath of particular age since fire. The invasion of buffel grass on the sandy country in which they live would result in an increase in fire frequency and replacement of native vegetation with buffel grass which is inappropriate for mallee emu-wrens replacement by buffel will remove habitat</td>
</tr>
<tr>
<td>Notomys fuscus</td>
<td>Dusky Hopping Mouse</td>
<td>Vulnerable</td>
<td>Has a restricted distribution to refuges during dry periods.</td>
<td>The refuges of the dusky hopping-mouse are in fire sensitive habitats which will be destroyed with the large fires that buffel monocultures can carry. The distribution of the dusky hopping-mouse corresponds with highly suitable buffel grass habitat, particularly along the ephemeral creeklines of the channel country</td>
</tr>
<tr>
<td>SPECIES SCIENTIFIC NAME</td>
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<tr>
<td>Croitana aestival</td>
<td>Desert Sand Skipper</td>
<td>Endangered</td>
<td>Four records. The extent of occurrence for the Desert Sand-skipper estimated to be less than 100 km²</td>
<td>The spread of Buffel Grass is expected to have degraded the habitat at all known locations and it is believed this will lead to the continued decline of the species (Braby et al. 2007; TSSC 2006v) through loss of their native grass larval food plants.</td>
</tr>
<tr>
<td>Acacia latzii</td>
<td>Latz's wattle</td>
<td>Vulnerable</td>
<td>Endemic to Finke bioregion where it is restricted to two areas about 200 km apart. Total known area of occupancy &lt;2000 km²</td>
<td>Acacia latzii is slow growing and sensitive to fire and requires low fire frequencies, and is therefore threatened by increased fire intensity and frequency from buffel grass fires</td>
</tr>
<tr>
<td>Prostanthera nudula</td>
<td>Naked Mintbush</td>
<td>Vulnerable</td>
<td>Small number of remaining populations endemic to the APY Lands. Area of occupancy &lt; 2000 km²</td>
<td>Prostanthera nudula is sensitive to fire is therefore threatened by increased fire intensity and frequency from buffel grass fires</td>
</tr>
<tr>
<td>Leiopoa ocellata</td>
<td>Malleefowl</td>
<td>Vulnerable</td>
<td></td>
<td>Continued invasion of buffel grass into arid woodlands will increase the fire frequency, removing key food plants and habitat in which they build their mounds – especially mulga / minyura woodlands and shrublands</td>
</tr>
<tr>
<td>Dasycercus cristicauda</td>
<td>Mulgara</td>
<td>Vulnerable</td>
<td></td>
<td>The invasion of buffel grass will significantly change the structure and composition of their preferred habitat and remove key resources through competition and wildfire</td>
</tr>
</tbody>
</table>
Disclaimer

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