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Dr Marisa Paterson MLA (Chair), Ms Jo Clay MLA (Deputy Chair), Mr Ed Cocks MLA

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Distribution and abundance of African Lovegrass in the ACT and Capital Region and options for strategic control

Sarah Sharp

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Report to the Southern ACT Catchment Group

SOUTHERN ACT CATCHMENT GROUP INC

CARING FOR OUR COUNTRY

MOLONGLO CATCHMENT GROUP

Ginninderra Catchment Group

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Disclaimer

The views expressed in this report are those of the author, and do not necessarily reflect those of the ACT Government, Catchment Groups or those who have provided comment or data used in the report.

Frontcover photo: African Lovegrass in the median strip in O'Halloran Circuit looking east across Drakeford Drive, Tuggeranong (photo S. Welch).

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Executive summary

The past ('2000') and present ('2010') distribution of African Lovegrass in the ACT and surrounding region were collated from existing survey data and from surveys undertaken in 2011. Based on the current program, the likely 2020 distribution of African Lovegrass in the ACT was mapped, based on three scenarios. The scenarios were: the likely distribution resulting from 1) limited control of African Lovegrass; 2) the outcomes based on the ACT Parks and Conservation Service Weeds Strategy; and 3) a strategy to significantly reduce the geographical distribution overall.

The past distribution was collated from existing records and mapped. The current distribution was collated from existing records, roadside surveys of the major roads in ACT and surrounding region, and data from surveys undertaken by volunteers to the project. 31 volunteers supplied data for 81 sites.

African Lovegrass is most abundant along the Murrumbidgee River corridor, Lower Molonglo River corridor and in Tuggeranong. It is also common in Belconnen and Weston. Further north, east and west it is less abundant, except along the Federal Highway, where it is found at least as far as Collector. While records from previous years were far from comprehensive it is clear that African Lovegrass is extending north, invading into Gungahlin, although it is currently only found in Gungahlin as isolated plants along main roads such as Horse Park Drive.

The data showed that all land uses were susceptible to invasion by African Lovegrass, as it is readily spread along waterways, along roadsides by mowers and other vehicles, in the gut of animals and in contaminated feed and hay. It appears to be somewhat inhibited by more dense vegetation and by overshadowing from overstorey vegetation. Spreading of seed from mowers and other vehicles appears to be the most significant factor in spreading the grass and it becomes established where there is open space (e.g. during the drought and after site disturbance), and possibly also in more established vegetation.

The following steps are recommended to reduce the abundance and distribution of African Lovegrass in the ACT:

Priority 1:

- Ensure areas that are currently free of African Lovegrass or have only isolated infestations are sprayed whenever infestations are observed. Such areas include roadsides in Namadgi National Park, Gungahlin roadsides, Googong Foreshores Road and roads exiting the ACT with the exception of Federal Highway and Monaro Highway.
- Treat infestations in nature reserves and high conservation areas on public land which include some areas with threatened species or high native component, for example, Mt Rogers, Umbagong Grassland and Stirling Ridge, and on roadsides and open space adjacent to these sites.
- Use the 'Bradley Method' approach of moving in from least infested to most infested areas, along rural and urban roads including Cotter, Boboyan, Sutton, Majura, Tidbinbilla and Paddy's roads.

Priority 2:

- Reduce African Lovegrass populations to occasional and localised along major roads in north and south Canberra (with the exception of Tuggeranong), including Northbourne Ave, Belconnen Road, Ginninderra Drive, Gungahlin Drive and Barton Highway east of Gundaroo Drive through herbicide treatment and compliant application of vehicle hygiene practices.
- Reduce African Lovegrass populations to occasional and localised on secondary and roads in urban ACT.
- Gradually work in from the edges of infestations on the Murrumbidgee River Corridor and Lower Molonglo River, with the cooperation of landholders (and with the provision of financial assistance) adjacent to the riparian zones.
- Reduce African Lovegrass populations to common and localised along more heavily infested roads, including Monaro Highway and major urban roads in Tuggeranong.

Priority 3:

- Maintain populations along roadsides to occasional and localised, and contain the population along the Murrumbidgee River to within the river corridor.

Other actions that need to be undertaken if further spread is going to be contained include:

1. Follow up herbicide treatment with revegetation if bare areas are created, to prevent re-invasion by African Lovegrass or other weeds.
2. Review the rural road mowing strategy to only mow areas of rural roadsides for fire or safety reasons (e.g. line of sight).
3. Review the urban mowing program to mow areas infested with African Lovegrass only when the seed is not viable. Other methods of biomass control may be more effective when seed is ripe, for example, grazing or burning.
4. Work closely with weed managers in NSW to reduce abundance and minimise new invasions on a regional basis.
5. Undertake further education in the recognition of the species and the most effective ways of preventing new infestation and of controlling existing infestations, including practical training in the best use of herbicides and sprayers.
6. Use existing mechanisms to increase awareness of the species and the need to control it: through Weedswap, the Floriade weed display, providing information to residents in newly established suburbs and continuation of workshops.
7. Facilitate research, undertake trials and use results of monitoring to determine how best to control the species. Work in cooperation with universities, other state departments and non-government organisations to do so.
8. Continue to support ACTPCS/Cooma Monaro Council trials of using flupropanate on roadside infestations during the dormant period for African Lovegrass (to kill the African Lovegrass before mowers can spread seed). If this is successful it may well contain roadside infestations.

9. Involve urban landholders in undertaking control of African Lovegrass in urban areas including removal of infestations in their blocks and on nature strips and implementation of mower hygiene to reduce spread.
10. Anticipate likely places of invasion and constant surveillance and immediate control: along vehicle tracks in reserves, around places that are disturbed (e.g. by bridges on rural roads and where other roadworks occur); along rural roadsides and on rivers and creeks.
11. Ensure asset managers and their contractors apply vehicle hygiene practices when they enter a site to reduce the spread of weeds between sites: ACTEW, mobile phone companies etc;. ensure they provide resources to control weeds spread along their maintenance tracks.
12. Ensure strict compliance of slashers mowing from areas that are least to most contaminated.
13. Undertake regular vehicle hygiene compliance checks and undertake follow-up action if contractors and others are not compliant.
14. Increase and enhance existing cooperative action between managers of rural properties and government agencies responsible for roadsides for the implementation of complementary treatment across land uses.
15. Undertake animal quarantine prior to release of animals into clean areas.
16. Undertake monitoring of weed abundance and distribution and compliance.

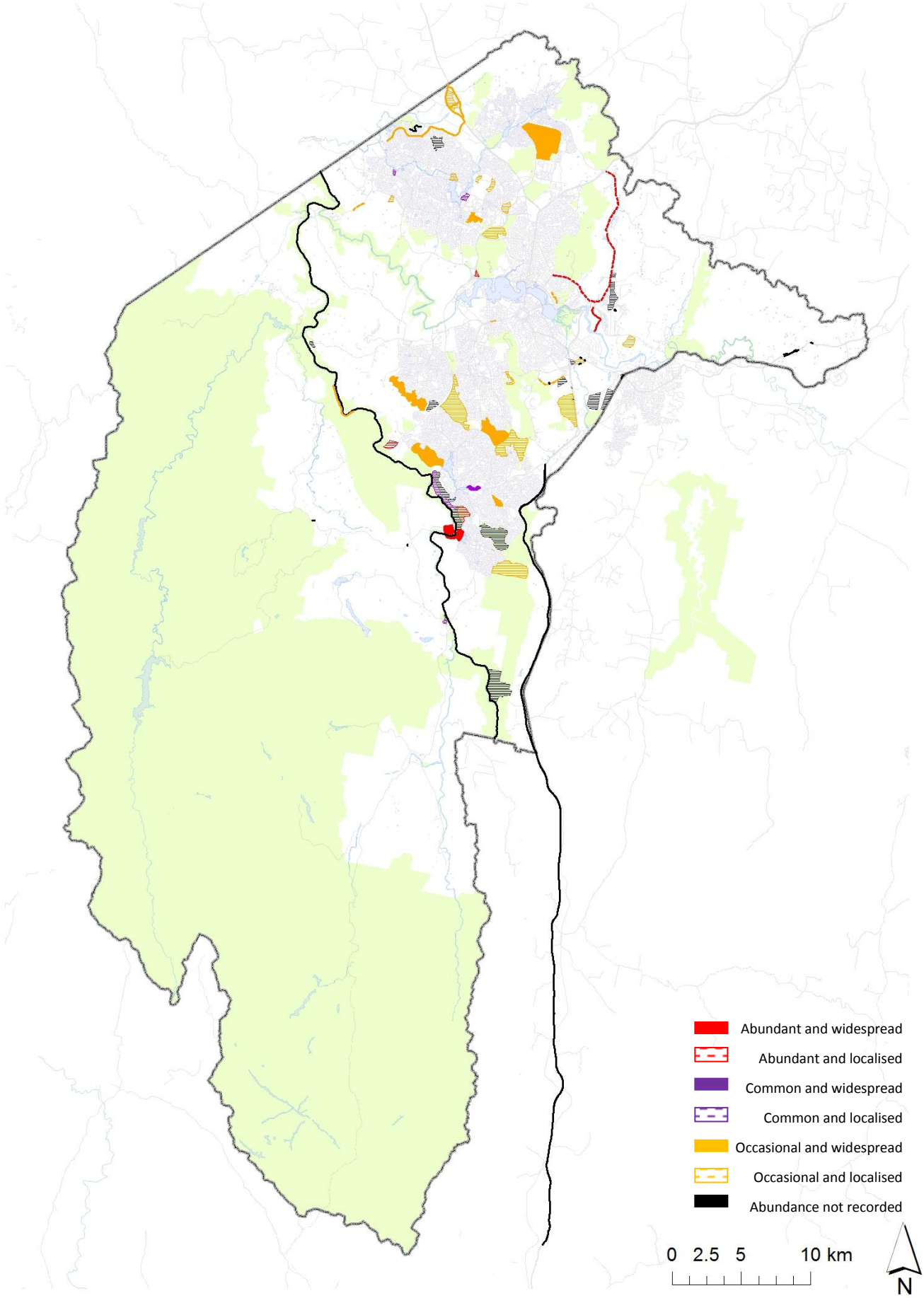
Measuring and monitoring results

- Establish and maintain a targeted monitoring program to ensure works undertaken are effective (with integral follow-up treatment if required). Monitoring will require a specific budget, but can be achieved through applying techniques such as those described in Appendix 3. Areas need to be monitored at select locations before and after treatment, with records maintained of what was treated, when, where and how.
- Ensure control work is assessed for a satisfactory result prior to sign-off on work completed.
- Establish a means by which isolated infestations can be reported, recorded and records of treatment be maintained.
- Remap abundance and distribution in selected areas in 5 years time.

Other mechanisms that may be considered

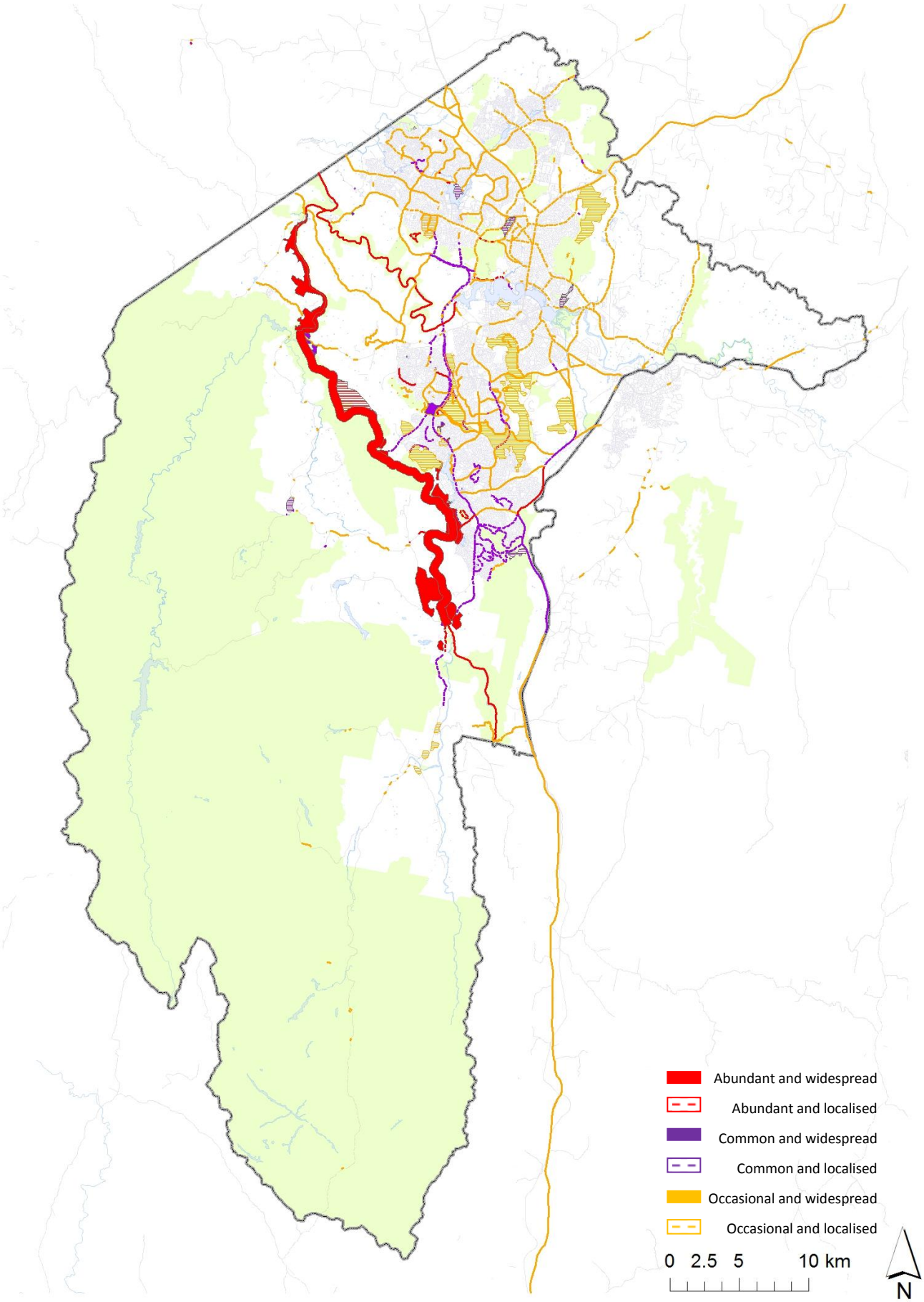
- Provide additional assistance to rural landholders in priority areas to control weeds.
- Hold an annual Clean Up Your Weeds day in Canberra. Provide incentives such as free plants or landscaping prizes for the cleanest areas.
- Encourage community groups including recreational and social groups to undertake African Lovegrass control in specified locations.
- Involve in the education program key members of the ACT community who can influence behaviour, such as well-known television and radio presenters.

The 2000 and 2010 distribution maps and modelled 2020 distribution map (Scenario 3) are presented in Maps 1-3.



Map 1. African Lovegrass abundance and distribution, 2000

13/12/2011



Map 2. African Lovegrass abundance and distribution, 2010

12/12/2011

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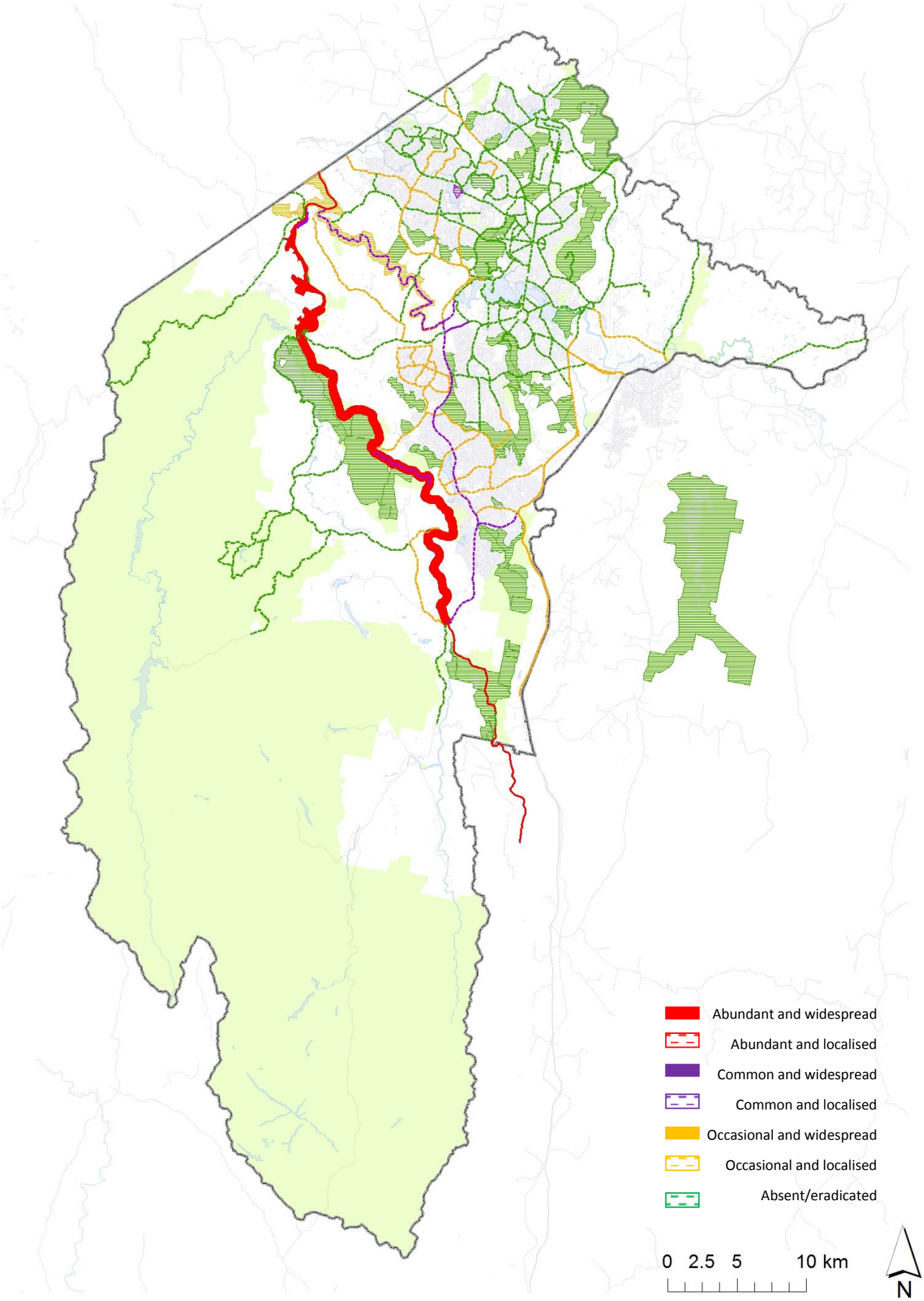


Map 3. African Lovegrass abundance and distribution, 2020 Scenario 3

1. Introduction

1.1 Status of African Lovegrass

African Lovegrass has been found to occur in every state and territory across Australia. It has also become an invasive weed in many other countries. It was probably inadvertently introduced to Australia in late 1800s, and it has spread readily in variable rainfall environments. It was subsequently deliberately introduced as a pasture species into rural areas throughout Australia (Johnston 1996).

African Lovegrass (*Eragrostis curvula*) is gazetted under the ACT's Pest Plants and Animals (Pest Plants) Declaration 2008 is a weed that must be contained (Category 3). In NSW it is a class 4 weed under the Noxious Weed Act 1993, requiring it to be controlled in specific areas (Figure 1), 'its growth managed in a manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction'. This classification recognises that it has already spread widely, and eradication is not possible. It is a declared pest plant for the whole of South Australia. In Victoria African Lovegrass is declared a Regionally Prohibited Weed in Mallee, North Central, North East, West and East Gippsland, Catchment and Land Protection Regions and is a Regionally Controlled Weed in Port Phillip West and Goulburn Broken. African Lovegrass is a declared weed in Tasmania under the Tasmanian *Weed Management Act 1999*. African Lovegrass is not a declared pest plant under Queensland legislation.

Figure 1. Distribution of African Lovegrass in NSW where it is classified as a control class 4 weed (map extracted from NSW Department of Primary Industries website, www.dpi.nsw.gov.au/ agriculture/pests-weeds/weeds/profiles/).

It is highly invasive in heathlands, woodlands, forests, grasslands and riverine environments (Muyt 2001), particularly establishing on disturbed and neglected sites, providing a nucleus to invade into more diverse habitats. 'African Lovegrass is an aggressive, tenacious, drought and frost tolerant species capable of dominating the ground-flora on lighter, low-nutrient soils' (p. 70, Muyt 2001). However, it does not compete as well where there are dense stands of other species, or under dense canopies (Johnston *et al.*, 2009).

African Lovegrass has spread downstream along the Murrumbidgee River into the ACT and along the roadsides. In the 1970s to late 1980s soil was imported from the Bredbo district into the ACT, and there was a lot of African Lovegrass in that district at the time. Its impact as a weed species was then not widely recognised. However, the significance of the

importation of soil into Canberra to the overall invasion into the ACT is not known (David Hogg, pers. comm.).

The tall form of African Lovegrass has been steadily increasing in the ACT, and it is believed to be even more invasive than the short form (Steve Taylor pers. comm.). This form significantly raises grassland fire danger when it invades.

African Lovegrass poses a threat to native species in the following ways:

- Direct competition with native plant species;
- Homogenisation of the flora present in a site;
- Simplification or degradation of habitat with the loss of a range of species;
- Alteration of habitat attributes such as open spaces for other plants to establish;
- High and flammable biomass and therefore increase in fire hazard;
- Disturbance to habitat as a result of weed control actions.

Although the species has been identified as an environmental and agricultural weed in the region and nationally, it is not a Weed of National Significance (WONS). One of the recommendations made by participants at a workshop on African Lovegrass held at Namadgi Visitors Centre in June 2010 was to nominate the species for listing as a Weed of National Significance. Subsequently, the ACT Parks and Conservation Service proposed to the Australian Weeds Committee that African Lovegrass be assessed as a WONS. Unfortunately the ACT did not have the resources to provide the state by state documentation required and no other states were able to provide support. This deficit influences the degree of support provided under grants by the Commonwealth into research and control of WONS species.

Using the NSW DPI Weed Risk Management System (Johnson 2009), ACT Parks and Conservation Service classified African Lovegrass as having the highest weed risk (very high), along with weeds like Blackberry, Gorse, Black Willow, Chilean Needlegrass, Mexican Feather Grass and Serrated Tussock (ACT Parks and Conservation Service 2011a). The weed risk management system measures invasiveness, environmental impacts and potential distribution. The system also measures the feasibility of coordinated control looking at costs of control, weed persistence and actual distribution. The values for African Lovegrass using the NSW DPI Weed Risk Management System detailed in the Updated Environmental Weed Control Operations Plan (ACT Parks and Conservation Service 2011a) are presented in Table 1.

Table 1. Weed risk values for African Lovegrass, based on the NSW DPI Weed Risk Management System (Johnson 2009).

Common name	**Species name**	**Weed risk score**	**Weed risk category**	**Feasibility of coordinated control score**	**Feasibility of coordinated control category**	**Management Strategy**
African Lovegrass	*Eragrostis curvula*	219	Very High (192+)	91	Low (56-113)	Manage weed and protect priority sites

1.2 Useful diagnostic features

African Lovegrass is a tussock with usually inrolled strappy leaves that are rough to the touch, running down towards the base. Leaf colour is variable between different varieties, ranging from blue-green to dark green. Leaf tips are usually bleached and curled. Sheaths are hairy, often straw coloured or purplish and the ligules (where the leaf joins the leaf sheath) contain a ring of hairs. Seeds are dark yellow to dark brown/grey. African Lovegrass can be confused with native poa grasses and native *Eragrostis* species, but the bleached and curled tips of leaves, the dark seed colour and the ring of hairs on the ligules are useful discriminating features.

1.3 Biology and ecology

African Lovegrass is a C4 perennial grass, growing over the summer months and the seeds ripen in late summer to early autumn. As a C4 grass it has a reduced transpiration rate, high temperature tolerance as well as a greater efficiency of photosynthesis. C4 grasses persist on poorer classes of land including sandy soils in seasonally water-deficient environments.

African Lovegrass has between 7 and 13 cultivars, of which several at least are in the Southern Tablelands. It is difficult to identify them individually, except for the height difference in the 'tall' and 'short' varieties. Different varieties of African Lovegrass may not act the same way.

It is a tufted perennial, up to about one metre high (depending on the variant). It has a two metre long root system, as well as fibrous surface roots. Although it is generally known to occur in sandy to gravelly soils, it appears to invade any soils within the ACT region. It is highly competitive in low nutrient soils. African Lovegrass survives in low to high levels of Nitrogen, and where pH ranges from 2 to 6.

It does not portray dormancy, but it grows readily and quickly, and produces a high abundance of fertile seed. African Lovegrass seed longevity appears to be 3 years, as it is a very small seed, but there have been no specific experiments conducted to date. African Lovegrass has an early production of seed in response to rain. It appears to be viable for 14 days during digestion by ruminants however, there has been no research conducted concerning germination success after passing (Firn 2008).

African Lovegrass requires light to germinate, so that pasture with low ground cover is particularly susceptible to invasion. However, under trees shrubs or high dominance of other species its propagation is reduced. This is a limiting factor that may assist with control.

Mature African Lovegrass plants have low palatability and digestibility, crude protein content particularly when tissue is mature. It is drought tolerant. It has high fecundity (with a high seed production and over 90% germination rate in the laboratory). Younger plants are palatable, a factor that may be used to assist in the control of the species (Muyt 2001). At Scottsdale, the Bush Heritage Australia property at Bredbo a trial is being undertaken to determine if grazing by cattle can be used to reduce the abundance of African Lovegrass. Early results may be indicating a reduction of African Lovegrass (Peter Saunders pers. comm., November 2011).

Firn (2008) undertook a 'Glasshouse Competition Trial' to determine competitiveness with native species, using different nutrient levels and water contents over a period of six months. The results indicated that native grasses generally decreased in growth when they

were planted with African Lovegrass, although if natives were established first, the growth rate of African Lovegrass was slowed.

Firn conducted a field trial on a cattle property in Queensland, managed as a low input native grass pasture farm that is now heavily infested with African Lovegrass. The impact of grazing and non-grazing was assessed and the variables, fertiliser (2kg/ha), herbicide (glyphosate), slashing and native seed addition were applied. The results indicated that herbicide was the most successful treatment for reducing African Lovegrass, and correspondingly, increasing native species abundance. In dry conditions, the effect of herbicide on African Lovegrass was more effective than in wet conditions, while in wet conditions grazing was effective at reducing African Lovegrass abundance (Firn 2008).

The combination treatment of grazing and fertilizer addition reduced the abundance of Lovegrass without the need for further treatments such as herbicides and slashing, and increased the abundance of native grasses. Fertiliser has the potential to increase the palatability of African Lovegrass which allows a shift in grazing pressure onto it, in conjunction with strategically timed grazing.

1.4 Vectors for the spread of African Lovegrass

Seed is dispersed primarily by water, vehicles and slashing, in the gut of animals, in contaminated hay and soil, but less frequently by wind.

Direct evidence exists for the spread of African Lovegrass on machinery. In summer 1994-95 a study was conducted to determine what seeds were collected on a range of slashers used on ACT roadsides, and the viability of the seeds was tested (Nazer *et al.*, 1996). Large numbers of viable African Lovegrass seed were found to be present on the machinery. The unpublished report provides recommendations to reduce the threat of seed spread by machinery that, after 15 years, have not yet been implemented.

African Lovegrass has spread downstream along waterways. In a survey of the Murrumbidgee River corridor in the ACT Johnston *et al.* (2009) found African Lovegrass in all vegetation communities along the riparian corridor except rocky outcrops.

Burning enhances African Lovegrass. Burning of infestations can stimulate fresh growth (Cooma Monaro Shire Council Noxious Weeds Fact Sheet, undated), however, burning will remove competitive species also, and so follow-up treatment (grazing, herbicide) is required to control the weed. In northern NSW roadside slashing and burning on access roads to National Park areas has increased the density and distribution of this weed dramatically over the previous 10 years (Border Rivers Gwydir Catchment Management Authority Invasive Species Management Plan, undated).

In addition, African Lovegrass will invade into undisturbed areas, presumably through dispersion by wind. It is also a contaminant of soils and gravels.

1.5 Recommended control and prevention measures

The most cost-effective treatment of African Lovegrass is to undertake preventive actions; for highly invasive weeds the greatest economic benefits are achieved when their populations are at low levels (DPI Victoria website 2011). Figure 2 is an economic model commissioned by the former Cooperative Research Centre for Australian Weed Management to help determine the optimum level of investment in weed management in the grains industry. This model demonstrates that the cost of controlling a weed that is widespread and abundant is up to 20 times more expensive than to prevent it occurring in the first place, and up to four times more expensive than to eradicate small localised populations (DPI Victoria website 2011).

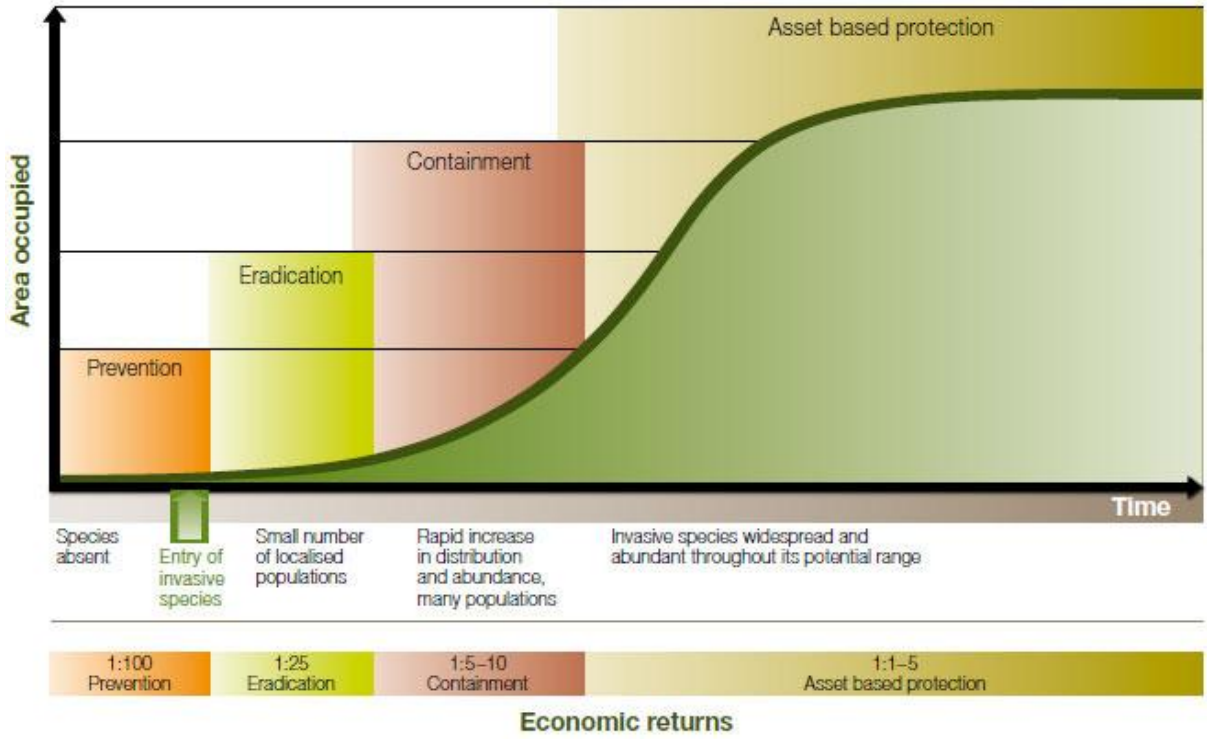


Figure 2. Model of the relative costs of controlling weeds under different abundance and distribution scenarios (Cooperative Research Centre for Australian Weed Management, in DPI 2011).

Control and prevention measures recommended by the NSW Department of Primary Industries (NSW DPI 2011) and ACT Parks and Conservation Service (2011b) are to:

- Quarantine stock that has been in African Lovegrass infested sites for at least 10 days to prevent seed spread through manure.
- Maintain the vigour, persistence and competitiveness of desirable plant species.
- If spraying, ensure competitive species are present to prevent re-infestation.
- In clean areas be vigilant and control any small infestations.
- Do not mow or slash when in seed
- Thoroughly clean mowers and slashers (and other vehicles including cars and trucks) that have operated in African Lovegrass areas before moving to clean areas.

- Work from clean to infested areas.
- Boundary spray infested paddocks with a 20 to 25 m strip to prevent seed movement into clean areas.
- Do not purchase hay which may be contaminated.
- Supplementary feed in a sacrifice paddock if necessary.
- Avoid or minimise soil disturbance (check disturbed areas for new infestations). If possible or feasible, re-seed disturbed areas immediately to provide competition.
- Maintain competitive ground cover at more than 70%.
- The residual herbicide flupropanate is viewed currently as the most effective herbicide.
- Glyphosate is also effective when applied to actively growing plants in spring and summer.
- Spraying can have adverse effects on non-target species.
- Grazing may be used to reduce seed establishment between October and March.
- Monitor treated areas for re-infestation.

The most effective time to spray it is November and April, although trials being conducted by ACTPCS and Cooma-Monaro Shire are indicating that flupropanate is effective when sprayed on dormant African Lovegrass during late winter, as it is absorbed into the root zone where it takes effect. The advantage of this is that the African Lovegrass is killed before mowers or slashers can spread early flowering/seeding African Lovegrass in spring. After boom spraying with flupropanate grazing or cutting hay is not allowed for four months.

Recommendations for treatment of African Lovegrass are presented in Appendix 1.

African Lovegrass control undertaken by the ACT Parks and Conservation Service and ACT Department of Territory and Municipal Services over the past four years is presented in Table 2 (data from annual weed reports supplied by Steve Taylor, Senior Weed Management Officer, ACT Parks and Conservation Service). Between July 2009 and October 2011 the ACT Parks and Conservation Service controlled 819 ha of African Lovegrass (including 24 ha of Tall African Lovegrass) (data from mapping supplied by ACTPCS Rangers to Steve Taylor).

Table 2. African Lovegrass control undertaken by the ACT Parks and Conservation Service and Territory and Municipal Services, ACT Government since 2008.

	2008-09	**2009-10**	**2010-11**	**2011-2012 (allocated)**
Contractor $	$200,000	$280,000	$112,000	$160,000
Park Ranger hrs (spraying and supervising contractors)	440	700	300	382
Percentage of total environmental weed control expenditure	10%	15%	7%	5%
Notes		Initiative funding provided to increase control in urban arterial roadside areas	Follow-up control of old and new sites from the initiative work in the previous year.	Actual resources for control has increased but due to a large allocation for willow control the percentage of resources allocated to African Lovegrass has fallen in 2011-12.

1.6 Background to the project

This study is a part of a larger project, *'Regional education on African Lovegrass - an integrated approach'* funded under an Australian Government Community Action Grant, to produce educational materials on the impacts of African Lovegrass, best-practice control and identify priority areas for control. It also aims to increase community participation and improve coordination in African Lovegrass control and containment. This study relates to the mapping component of the project.

1.7 Aims of this study

1. Map current distribution of African Lovegrass;
2. Compare current distribution and abundance with the past ('2000') distribution;
3. Identify which land uses and/or management are particularly susceptible to invasion by African Lovegrass;
4. Identify the likely distribution in 2020 under the current program;
5. Identify areas for priority control and develop options for strategic control; and
6. Increase community awareness through involvement in the survey.

2. Methods

2.1 Collation of existing data

Past distribution (2000)

Records were investigated from previous surveys in order to collate a map of the locations of African Lovegrass approximately ten years ago. Data were obtained from surveys of woodlands and grasslands undertaken by ACT Government (Conservation Planning and Research) between 2001 and 2005, with a few records from between 1992 and 2000, including those collated in Berry and Mulvaney (1995), which included records of all weeds in the ACT, from existing data and additional surveys. A survey of Chilean Needlegrass undertaken in 2002 in selected locations in grasslands and some additional reserves provided additional locations, where African Lovegrass was also encountered. The locations of African Lovegrass were also collated from records filled out by volunteers for the Chilean Needlegrass project in 2005.

Current distribution (2010)

Data from riparian surveys of the Murrumbidgee River (Johnston *et al.*, 2009) and other rivers in the ACT (Ishiyama *et al.*, 2010) undertaken between 2006 and 2010 were also collated, but were taken as representing the current distribution, not the past distribution, and these locations mapped onto the current distribution map (2010). Data collected by the author from recent surveys in Canberra Nature Park were also used for mapping.

Distributions described in the ACT Environmental Weed Control Operations Plan 2011-2019 (ACT Parks and Conservation Service 2011a) were also collated and incorporated into the 2010 distribution map.

2.2 Roadside Survey, 2011

A survey was undertaken along major roads in the ACT and surrounding NSW between March 2011 and June 2011. Slow drives were undertaken along major roads, recording the location of African Lovegrass on 1: 25 000 scale maps. At a moderate scale of approximation, the actual location of the patches was marked on the map, so that they could be re-found for later treatment or follow-up survey. The clumps and patches were given an abundance score as developed by the Bureau of Rural Sciences and utilised by ACT Parks and Conservation Service (2011a) (Table 3).

The roads chosen were those linking across Canberra and the rural areas, major roads leading out of the ACT, roads linking suburbs within districts and main roads through each of the suburbs. Other roads were mapped if African Lovegrass was observed while driving past.

The roadsides had different levels of biomass, ranging from unmown, where identification of African Lovegrass was easy, through to very recently mown. In these latter sites unmown tussocks that were near trees or other impediments to mowers were often the best way of determining if African Lovegrass was present. In less recently mown sites the characteristic form of African Lovegrass tussocks without stems was generally apparent. It is very likely that the abundance of African Lovegrass in many of the urban roadsides sites, however, has been underestimated, and some locations missed altogether.

Table 3. Description of abundance and distribution ratings used for this study (ACT Parks and Conservation Service 2011a).

Classes	Description	Percentage cover
Absent	Not detected.	0%
Occasional and localised	Scattered individual plants confined to limited areas of the block of land.	<1%
Occasional and widespread	Scattered individual plants across the block of land.	1 – 10%
Common and localised	Scattered patches with isolated plants interspersed, confined to limited areas of the block of land.	11 – 50%
Common and widespread	Scattered patches with isolated plants interspersed across the block of land.	11 – 50%
Abundant and localised	Large dense infestations confined to limited areas of the block of land.	>50%
Abundant and widespread	Large dense infestations across the block of land.	>50%

The data were transferred to a map at approximately 1: 100 000 scale, and roadside 'units' were identified, defined by intersecting roads, bridges, property entrances or other recognisable attributes (for example, a roadside directly adjacent to a nature reserve). Each unit was given an abundance score, as described in Table 3. The data were digitised at this scale and were also generalised onto a gridded map, each grid being 2.5 minutes.

2.3 Volunteer surveys, 2011

Requests for volunteers to map locations of African Lovegrass in other sites were circulated through various networks – newsletters and e-bulletins of community groups, Parkcare, the Catchment Groups and professional associates. An interview on the ABC local radio in March with Sarina Locke and on the gardening program also requested assistance from volunteers.

The volunteers were asked to map locations, and to estimate abundance as per the scores used in the roadside survey. Information on the attributes of the site were also requested, within categories, for land use, disturbance levels, management, drainage and associated vegetation. These data were collated and analysed for trends in African Lovegrass distribution and abundance across the ACT, according to land use and management in particular. Locations provided by volunteers were added to the map of the current distribution of African Lovegrass.

2.4 2020 scenario

The potential 2020 distribution of African Lovegrass in the ACT was mapped, based on three scenarios:

Scenario 1: distribution and abundance under reduced or fluctuating annual budgets.

Scenario 2: the existing program as identified by ACT Parks and Conservation Service (ACT Parks and Conservation Service 2011).

Scenario 3: a modified program based on a higher community volunteer involvement and a greater emphasis on treating outlying populations.

2.5 Mapping

The distribution and abundance of African Lovegrass was mapped and digitised as points or polygons (as relevant). The distribution and abundance was also generalised onto a map in grids of 2.5 minutes (the Canberra Ornithologist Grid locators), which was how the data were presented in the Berry and Mulvaney report, as it presents the data in an easily interpreted pattern across the landscape.

3. Results

3.1 Historical distribution

Mapping of a likely '2000' distribution of African Lovegrass across the ACT and within the region was limited by the lack of data available and the unevenness of how and where the data were collected. There are undoubtedly areas where African Lovegrass was present but not recorded. African Lovegrass was present at the following locations that are significant for conservation:

- On the Murrumbidgee River corridor African Lovegrass was present for the entire length of the river through the ACT, and was abundant and widespread from Pine Island south to Tharwa and abundant or common and localised at various locations to the north-west of Pine Island.
- African Lovegrass was present along the Monaro Highway in and south of the ACT.
- In Canberra Nature Park south and west African Lovegrass was recorded as being present in the following nature reserves: Tuggeranong Hill (present), north Rob Roy (abundant and localised), Pine Island (common or abundant), Wanniassa Hills (abundant and localised), Farrer Ridge (abundant and widespread), Mt Taylor (abundant and localised), Cooleman Ridge (abundant and widespread) and West Jerrabomberra Grassland (abundant and localised). It was present on the edge of Mt Mugga Mugga NR and Fisher Hills.
- In Canberra Nature Park north African Lovegrass was recorded as being present in some reserves (Bruce Ridge (occasional and localised), Mulanggari (occasional and widespread), or on the edge of other reserves (Black Mountain, Mt Pleasant, Dunlop nature reserves).
- African Lovegrass was recorded as being present in Canberra Airport, the Airport Communications Facility, Callum Brae grassland, Belconnen Naval Station, Wells Station Road (all of which contain Natural Temperate Grassland and associated threatened species).
- There were no records of it being present in Gungahlin.

The 2000 locations were mapped (Map 1).

3.2 Current distribution

3.2.1 Roadside surveys

600 km of major linking roads and major suburb roads throughout ACT and the region, to Cooma in the south, Murrumbateman, Collector and Sutton in the north, Bungendore and Googong Dam in the east and the border of NSW at Piccadilly Circus in the west were surveyed between February and May 2011. During the time of the survey an extensive slashing program was being undertaken throughout the ACT, on rural as well as urban roadsides. There was difficulty in identifying the weed when freshly mown, and so it is highly likely that the abundance of the species, and to some extent, the distribution has been underestimated.

The roadside surveys indicated the following trends:

Districts: from highest to lowest the abundance and distribution in the districts was: Tuggeranong, Weston, Belconnen, inner suburbs and Gungahlin.

Corridors and roads: from highest to lowest the abundance and distribution along major corridors was: Murrumbidgee River Corridor, Lower Molonglo River corridor, Monaro Highway (from Tuggeranong to Cooma), Federal Highway (to at least Collector), southern urban roads, western urban roads, inner north and south roads, rural roads and Gungahlin roads.

Roadsides with no or only small isolated infestations of African Lovegrass present included: most of Gungahlin, with the exception of Gundaroo Drive south of the town centre, much of western Belconnen Way, the Gungahlin Drive Extension, roads in the vicinity of Civic, southern Majura Road, northern section of Sutton Road in ACT, Parkes Way from the city to Majura Road, Monaro Highway north of Fyshwick, major roads around Kingston and Griffith, Paddy's River Road, Brindabella Road and Boboyan Road (except near the Glendale Depot).

Within NSW, only isolated patches of African Lovegrass were found on Gundaroo Road, Barton Highway north of the ACT, Old Cooma Road and Kings Highway east of Queanbeyan. No patches of African Lovegrass were found on Mac's Reef Road.

3.2.2 Volunteer surveys, 2011

32 participants submitted responses to the community survey. In total the participants provided information on over 80 sites. The size of the areas surveyed varied from less than one hectare to all roadways and open space in all roadsides in a suburb (Weetangera and Fisher). Some surveyors did not provide information on site characteristics at each recorded location, so not all data could be used in analysis. In some of these situations some details could be added due to personal knowledge about the sites.

All results from the community survey need to be interpreted with care, for the following reasons:

- The number of surveys undertaken was small;
- There was no replication or systematic approach undertaken in terms of geographic distribution, habitat, land use or management
- The assessment of abundance was not correlated across surveyors; and
- Not all volunteers provided descriptive information on the sites or omitted some details, so results were incomplete.

The community survey results, however, provide a snapshot that, together with the roadside surveys, was used to identify trends in African Lovegrass abundance and distribution. The results are presented below.

Abundance

The vast majority of records submitted indicated that where African Lovegrass was recorded it was common (49% of records) or abundant (30% of records) (Figure 3). Over 50% of infestations recorded were classified as being localised. In 7% of the records submitted African Lovegrass was recorded as being absent.

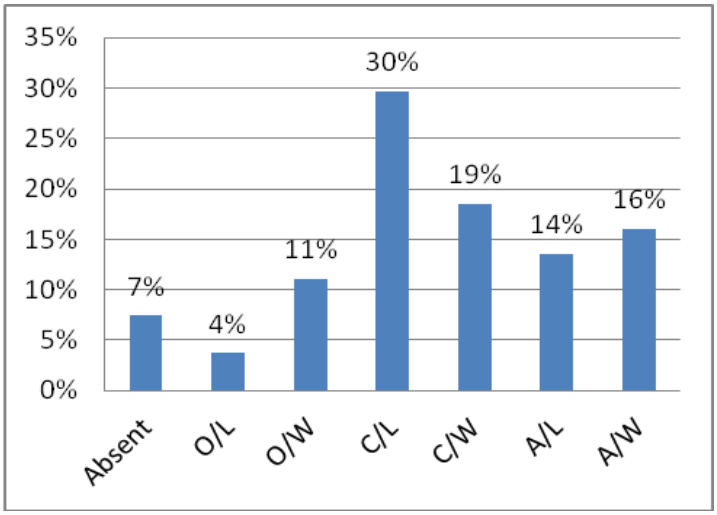


Figure 3. Percentage of site records of African Lovegrass grouped by abundance classes (n=81)[1]. Data are from the volunteer surveys.

Distribution

The majority of records of populations of African Lovegrass (a total of 75 records) sent in by participants were from the urban areas of Canberra (80%), with the highest number of records from the urban areas of Canberra south of Lake Burley Griffin (Figure 4). The six records where African Lovegrass was not found were from Namadgi National Park (3 records), Black Mountain Nature Reserve (1 record) and two urban parks in Cook. The highest abundance classes where African Lovegrass was recorded were in the urban south of Canberra, and African Lovegrass in all riparian sites was recorded as being abundant and widespread (Figure 5). When this was analysed by catchment, Tuggeranong followed by Murrumbidgee then Ginninderra were the areas where the highest abundance of African Lovegrass was recorded (Figure 6).

[1] Key: O/L: occasional and localised; O/W: occasional and widespread; C/L: common and localised; C/W: common and widespread; A/L: abundant and localised; A/W: abundant and widespread.

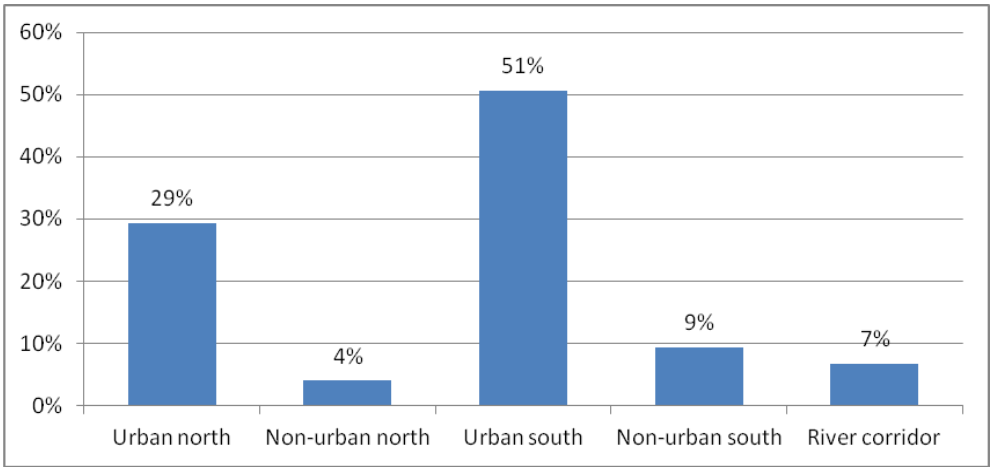


Figure 4. Percentage of records of populations of African Lovegrass grouped by distribution across the ACT (n=75). Data are from the volunteer surveys.

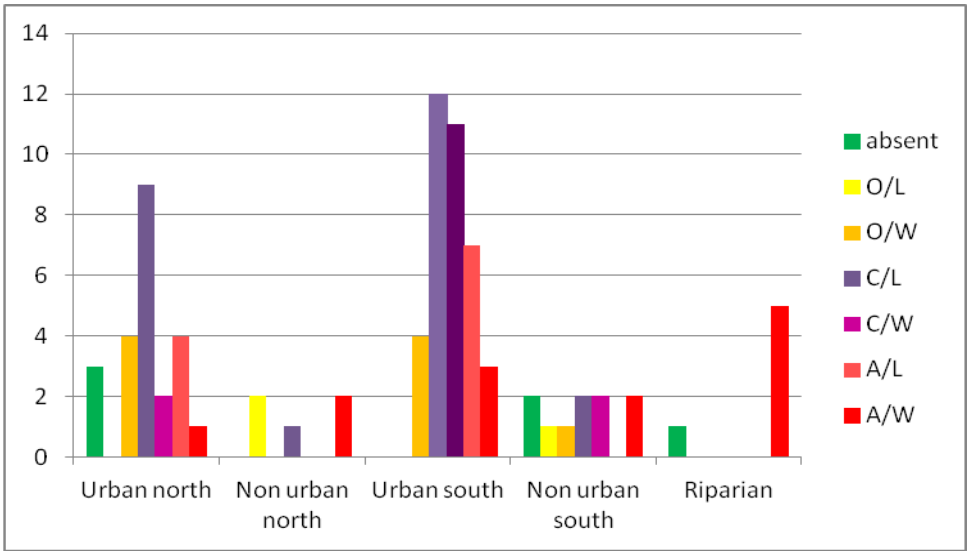


Figure 5. Frequency of abundance classes of African Lovegrass grouped by distribution across the landscape (n=81). Data are from the volunteer surveys.

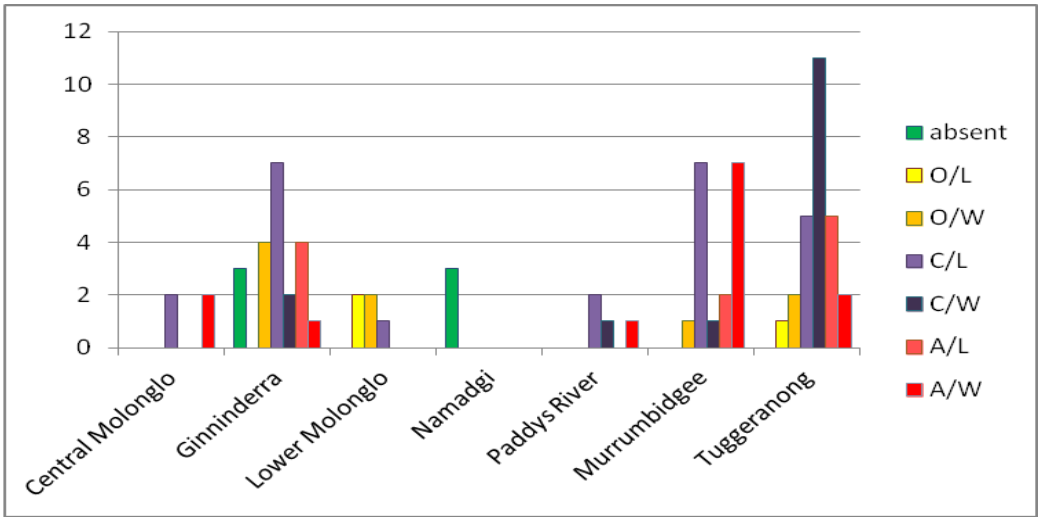


Figure 6. Frequency of abundance classes of African Lovegrass grouped by distribution across catchments (n=81). Data are from the volunteer surveys.

Land use

African Lovegrass was recorded as being widely distributed across land uses (Figure 7). Abundance did not appear to be relatively higher in any land use category (Figure 8). Several volunteers undertook extensive surveys in several suburbs: Aranda, Weetangera, Fisher and Kaleen. In each case surveys indicated that African Lovegrass was widespread on the major roads. Surveys of other streets, walkways and other open space indicate that where African Lovegrass was widespread on the major roads it is also widespread within the suburbs.

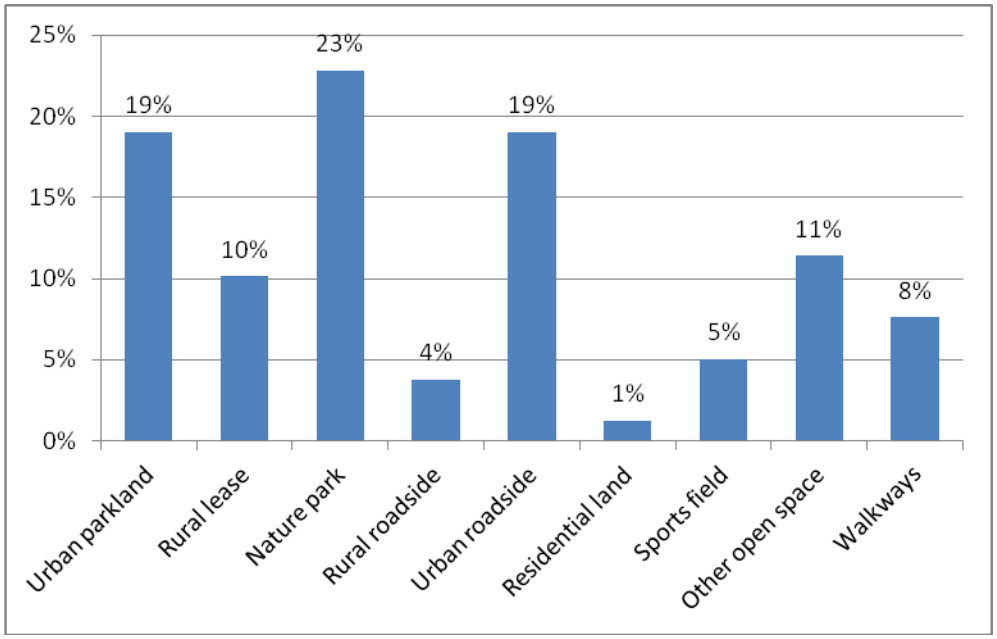


Figure 7. Percentage of records of African Lovegrass grouped by land use (n=79). Data are from the volunteer surveys.

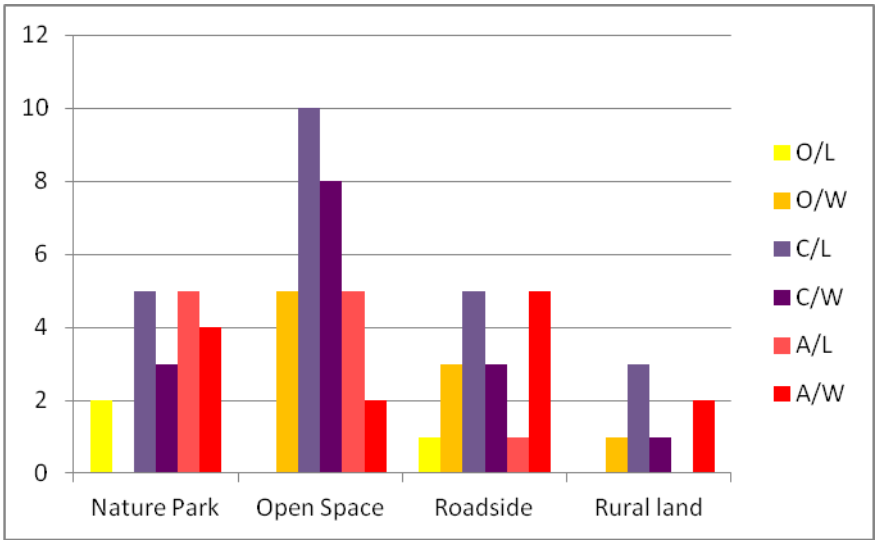


Figure 8. Frequency of abundance classes of African Lovegrass grouped by land use (n=79). Data are from the volunteer surveys.

Management

There was a high proportion of occurrence of African Lovegrass on land that was either mown recently or is at times subject to mowing (61% of the records) (Figure 9). 28% of sites, however, were recorded as receiving no active management. Figure 10 indicates that there where African Lovegrass was present in sites managed by grazing, the abundance could be as high as in mown areas, or if there was no active management in the sites.

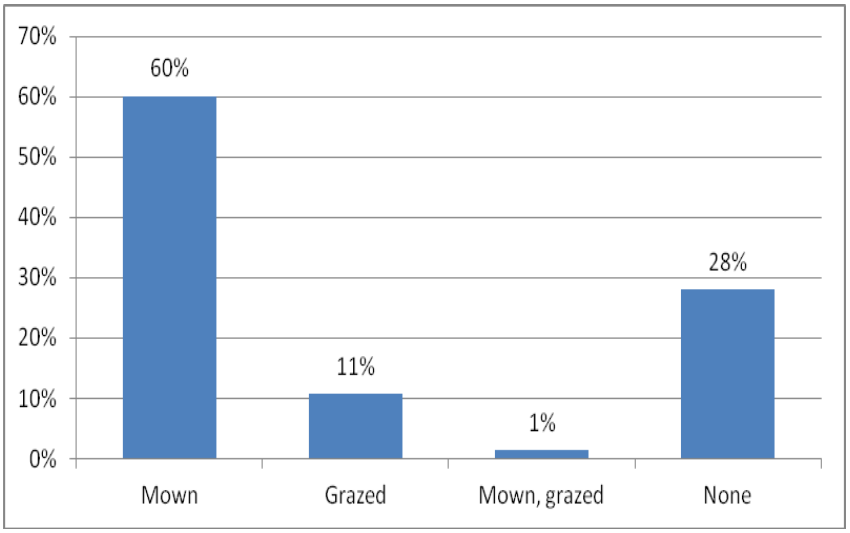


Figure 9. Percentage of records of African Lovegrass grouped by management (n=75). Data are from the volunteer surveys.

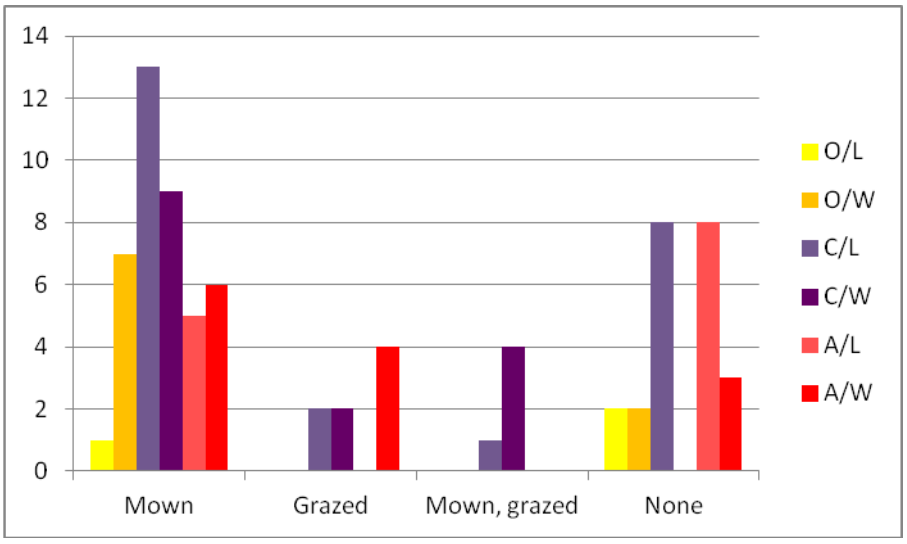


Figure 10. Frequency of abundance classes of African Lovegrass grouped by management (n=75). Data are from the volunteer surveys.

Habitat

58 of the survey records provided details of the drainage conditions at the sites. The majority of the sites where African Lovegrass occurred were classified as well drained or containing areas that were well and poorly drained (Figure 11). The well drained sites appeared to have higher abundance of African Lovegrass than poorly drained sites (Figure 12). However, it is clear by the high abundance of African Lovegrass along the Murrumbidgee River that seed survives being washed downstream.

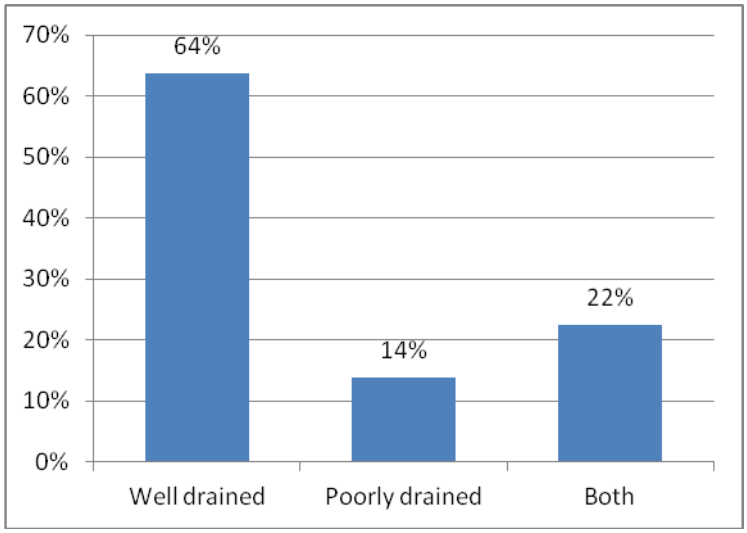


Figure 11. Percentage of records of African Lovegrass grouped by drainage conditions (n=58). Data are from the volunteer surveys.

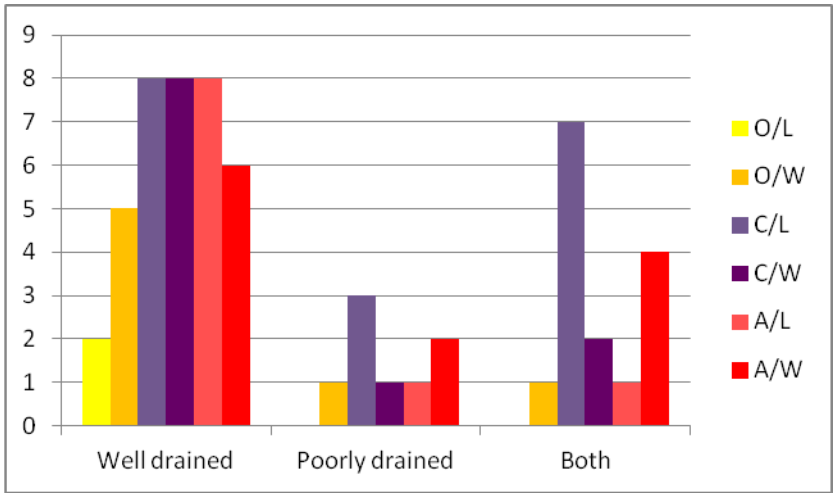


Figure 12. Frequency of abundance classes of African Lovegrass grouped by drainage conditions (n=58). Data are from the volunteer surveys.

56 records were submitted that contained details of the overstorey vegetation that grew with African Lovegrass (Figure 13). The majority of the sites (63%) had no overstorey.

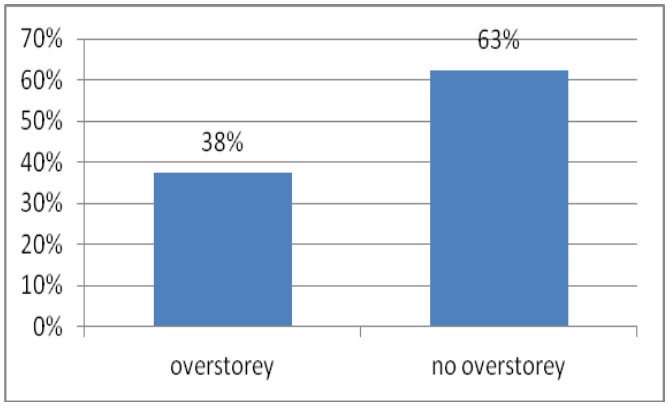


Figure 13. Percentage of records of African Lovegrass with and without overstorey vegetation (n=56). Data are from the volunteer surveys.

54 records were available to compare the origin of the vegetation growing with African Lovegrass at the sites (Figure 14). The majority of associated vegetation was classified as being native or a combination of native and exotic. There appears to be a higher frequency of sites where African Lovegrass was more abundant in sites where associated vegetation was predominantly native (Figure 15).

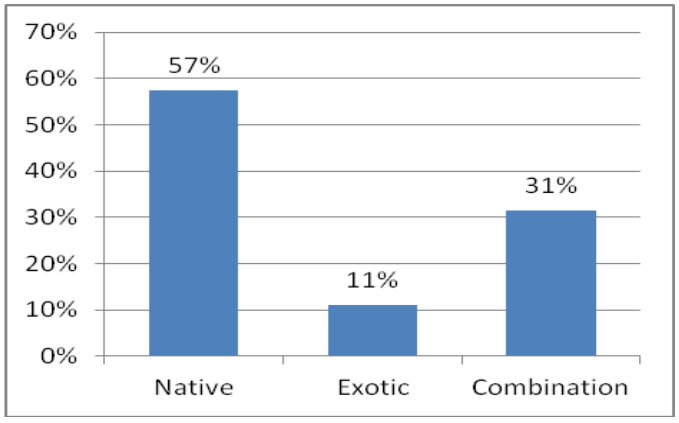


Figure 14. Percentage of records of African Lovegrass grouped by origin of other vegetation occurring at the site (n=54). Data are from the volunteer surveys.

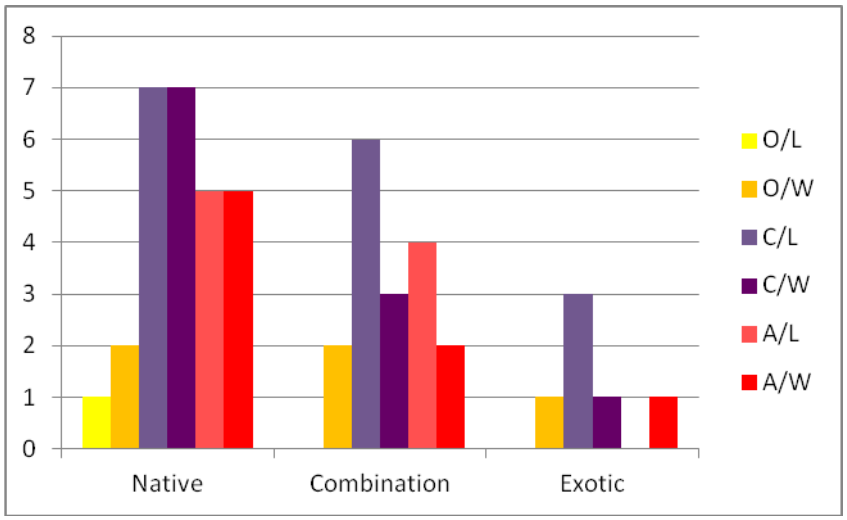


Figure 15. Frequency of abundance classes of African Lovegrass grouped by origin of other vegetation occurring at the site (n=54). Data are from the volunteer surveys.

3.2.3 Other data

The surveys of the river systems in the ACT indicated that African Lovegrass was broadly distributed along the length of the Murrumbidgee River in the ACT, except at two locations: "African Lovegrass is spread throughout the entire river corridor on both the valley slopes and prolifically on the riparian flood plains where it thrives in the sandy soils in the absence of canopy cover. In only a few places is it unable to get a foothold, firstly where the surface is predominantly exposed solid bedrock (although it establishes within small cracks where soil occurs), and beneath the shade of dense overhead canopy, either tree or shrub." (p. 99, Johnston *et al.*, 2009). The surveys of the other river systems in 2009 by Ishiyama *et al.* (unpublished) indicated that African Lovegrass was present in the Lower Molonglo River Corridor, but not in the other river systems of the ACT.

Data provided to ACT Parks and Conservation Service for mapping the current distribution indicated that the highest abundance and most widely distributed populations of African Lovegrass were in southern Canberra Nature Park and urban open space and Belconnen Canberra Nature Park and urban open space. On-going control is occurring in most of these sites, however, under the strategy identified in the ACT Weeds Operations Plan (ACT Parks and Conservation Service 2011a).

3.2.4 Collation of all data

The current distribution and abundance, based on all available data is presented in Map 2. A spreadsheet with all locations where African Lovegrass has been found since 1995 has been collated and is presented in Appendix 2.

3.3 2020 scenarios

Based on the current distribution of African Lovegrass, the resulting potential 2020 abundance and distribution of African Lovegrass was determined, based on three scenarios. The differences in the outcomes of these three scenarios is summarised in Table 4.

Scenario 1: if only minimal effort is applied to control African Lovegrass on a reduced or fluctuating budget, with the major effort being to reduce abundance in and adjacent to high conservation areas, the outcome is a likely increase in abundance and distribution across the ACT.

Scenario 2: this scenario is that which is identified in the ACT weeds operations plan (ACT Parks and Conservation Service 2011), which aims to:

- Retain high conservation value that have low or nil infestation;
- Reduce the abundance of the species in areas of high conservation value, particularly areas containing threatened ecological communities;
- Reduce abundance in riparian areas;
- Reduce the spread and protect native understorey along the Murrumbidgee River;
- Reduce infestations on rural roadsides;
- Undertake control work on urban arterial roads opposite Canberra Nature Park; and
- Provide additional support where complementary control is being undertaken by rural landholders.

Scenario 3: this scenario aims to concentrate effort on reducing the geographical distribution of the species in the first instance. The scenario aims to:

- Constantly and immediately eradicate new populations as they are detected;
- Remove African Lovegrass grass in districts and roadsides where it was found to be present in isolated patches in 2011;
- Eradicate or reduce African Lovegrass in or adjacent to areas of high conservation value;
- Undertake complementary action where adjacent neighbours are applying additional control in areas of high abundance; but
- Undertake only minimal effort in areas of high abundance until peripheral populations are reduced.

Scenario 2 and 3 make the assumption that there will be consistent and adequate annual budgets provided for African Lovegrass management, as opposed to variable annual budgets. Additionally, Scenarios 2 and 3 recognise that spread is likely to continue from upstream on the Murrumbidgee River, so that constant re-invasion into the ACT from this source is highly likely. Scenario 3 assumes that there will be a considerable increase in volunteer effort (and government support for that effort) to reduce isolated infestations as they are found, in both rural and urban areas.

Table 4. Comparison in the level of treatment applied for control of African Lovegrass in different areas under three scenarios and likely outcomes in 2020.

2020	**Scenario 1**	**Scenario 2**	**Scenario 3**
Budget	Minimum	Current, sustained	Current budget, sustained, additional budget to support volunteer efforts
In and adjacent to HCV areas	High	High	High
Murrumbidgee River Corridor	Low to none	High	Low
Rural roadsides	Low	High	High
Adjacent rural landholdings	Low	High	High
Other isolated patches	Low	High	Very high
Outcomes	Increase in abundance and distribution	Decrease in abundance, distribution similar	Significant decrease in distribution, decrease in abundance except in the Murrumbidgee River Corridor.

3.4 Comparison of geographical distribution and abundance since 2000

The 2000 and 2010 distributions were represented within 2.5 minute grids (Figures 16A, 16B). The representation of the current (2010) abundance of African Lovegrass distributed across the ACT was used to model the distribution of the grass in 2020 under the three scenarios (Figures 16C, D, and E).

The empty grids do not contain major roads that were traversed in the survey in 2011. It is unknown if African Lovegrass was present or not in these grids. These include areas where it is very unlikely that African Lovegrass is present, such as within much of the wilderness areas of Namadgi National Park, and other areas such as rural areas in southern ACT where it is quite likely to occur.

Where only the presence of African Lovegrass was recorded in previous surveys, these were converted to an abundance rating, based on the current abundance (Figure 16A).

Scenario 1 of 2020, based on the potential situation of a reduced budget for weed control, the modelling shows a likely decrease in abundance in and surrounding Canberra Nature Park, but an overall increase in abundance and distribution elsewhere in the ACT (Figure 16C).

The targeted cover abundance for African Lovegrass in 2019, outlined in the ACT Environmental Weed Control Operations Plan 2011 - 2019 (ACT Parks and Conservation Service 2011a) was used to model the second scenario (Figure 16D). In this model there is an expected general reduction in the abundance of African Lovegrass across the ACT, but not any significant reduction in the distribution.

The third scenario for 2020 is based on the 'Bradley Method' of weed control. Under this scenario abundance is likely to be similar to the current abundance within the core areas of African Lovegrass infestation on the Murrumbidgee and surrounding areas of Tuggeranong, but reduced further away from this area (Figure 16E), particularly areas containing currently only isolated plants. Ideally populations would reduce to absent or occasional, where infestations would be promptly treated before they have the ability to establish. This scenario is based on the cost-benefit analysis in which it is much cheaper to eradicate isolated plants than to control more established populations (Figure 2, Section 1.5). Under this scenario there is a fourth category, absent/eradicated, referring to areas where any future infestations are recommended to be immediately eradicated, to prevent populations from becoming established.

Table 5 and Figure 17 summarise these results. In comparison to the earlier records, in which African Lovegrass was recorded as being present in 41 2.5 minute grids, in 2010 it was recorded as being present in 81 grids in the ACT. Under Scenario 1 in 2020, African Lovegrass is likely to be present in 98 grids, including those where it is known to be currently absent, with an increase in abundance, with eight cells with no African Lovegrass currently increasing to occasional abundance, eight increasing from occasional to common abundance and one increasing from common to abundant. Under scenario 2 there is unlikely to be a change in distribution of African Lovegrass across the ACT (distribution remaining in the same 81 grid cells as at 2010), but a significant decrease in abundance. Under Scenario 3 of 2020 only 38 grids would contain African Lovegrass and in 60 grids it would be absent (but requiring constant eradication of new infestations). However, there would likely be no decrease in abundance along the Murrumbidgee River Corridor in 2020, except in selected

locations adjacent to rural properties where, in cooperation with the rural landholders, there would be persistent control to reduce invasion from the river corridor.

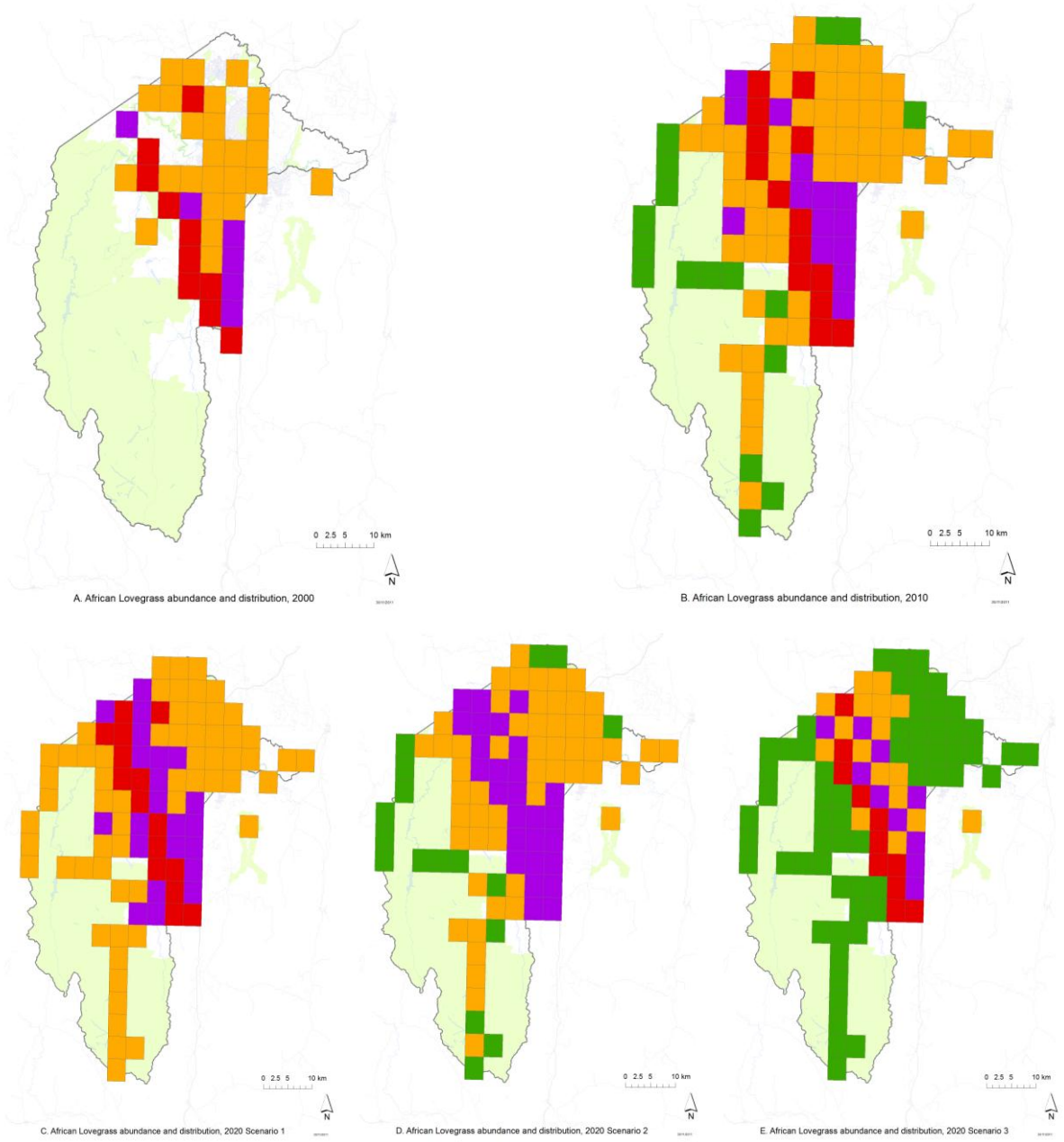


Figure 16. Generalised distribution and abundance of African Lovegrass in the ACT, represented in 2.5 minute grids; A) Distribution in 2000; B) Distribution in 2010; C) Distribution in 2020, Scenario 1, low level of control; D) Distribution in 2020, Scenario 2, control under the current ACT Government strategy (ACT Parks and Conservation Service 2011a); and E) Distribution in 2020, Scenario 3, eradication of outlying populations.

Key: Red: abundant; Purple: common; Orange: occasional; Green: absent/eradicated

Table 5. Presence of African Lovegrass in 2.5 minute survey grids overlapping within the ACT (excluding surrounding NSW) and likely presence in 2020 under three scenarios.

Abundance	2000	2010	2020 Scenario 1	2020 Scenario 2	2020 Scenario 3
Number of grids in which African Lovegrass is absent, or if found to be present, eradicated	unknown	17	0	17	60
Isolated or occasional	25	53	61	54	17
Common	6	14	22	27	10
Abundant	10	14	15	0	11
Total number of grids in which African Lovegrass is present	41	81	98	81	38

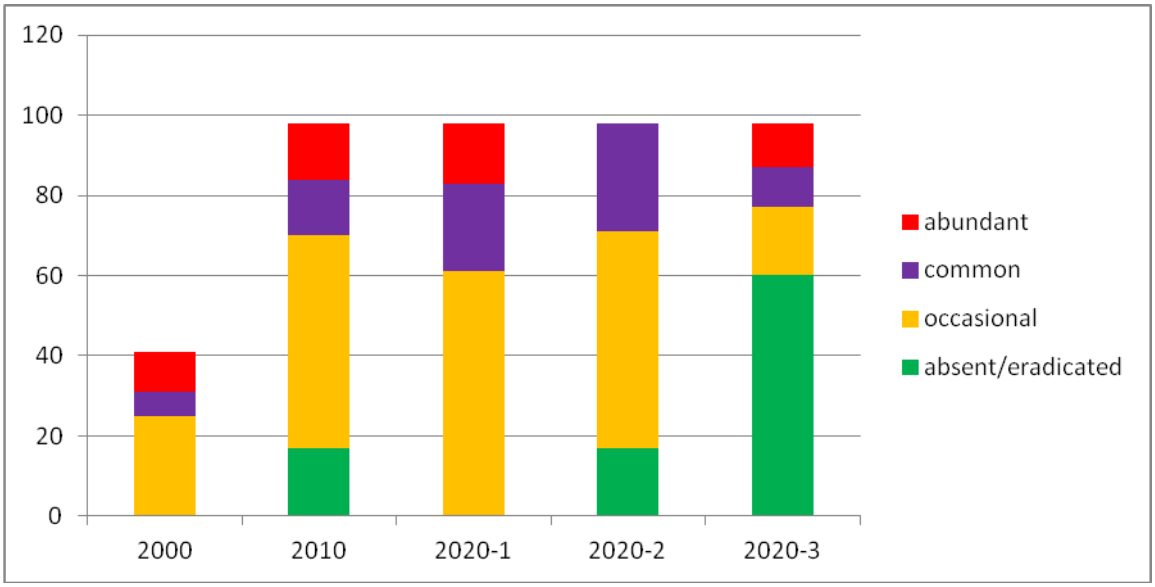


Figure 17. Comparison of African Lovegrass abundance from 2000 to 2010 and modelled outcomes of three scenarios for 2020 in 2.5 minute grids in ACT.

4. Discussion

4.1 Associated vegetation

There was little evidence that areas dominated by exotic vegetation, whether planted or invaded, contained any more African Lovegrass than areas of less disturbed native vegetation (Figures 14, 15), although anecdotally it is evident that African Lovegrass invades readily into more open areas.

While the volunteers recorded that there African Lovegrass was growing underneath other vegetation in 38% of the sites, other more thorough studies, especially that undertaken by Johnston *et al.* (2009) along the Murrumbidgee River Corridor, indicate that African Lovegrass is significantly reduced in abundance under the canopy of trees and shrubs (Figure 18).

Figure 18. African Lovegrass is replaced by Horehound (*Marrubium vulgare*) and Soapwort (*Saponaria officinalis*) under River She-oak (*Casuarina cunninghamiana*) on the Murrumbidgee River (Photo: L. Johnston).

4.2 Land use

African Lovegrass was found on land subject to every land use in the ACT: nature reserves and other open space, roadsides, some riparian areas, rural leases, residential land.

Riparian areas: there is currently very abundant and widespread infestation along the Lower Molonglo River below Scrivener Dam and along the Murrumbidgee River (Figure 19), except, notably, in two rocky gorges on the Murrumbidgee River (Johnston *et al.* 2009). African Lovegrass, however, was not recorded in any other river systems in the ACT (Ishiyama *et al* 2010). The infestations on the Murrumbidgee River corridor were present over ten years ago (Map 1), and do not appear to have diminished (Map 2). It is not known

what the distribution of African Lovegrass was on the Lower Molonglo River corridor ten years ago, but it is now abundant and widely distributed (Map 2).

Nature reserves: There was a high number of records submitted by volunteers regarding infestations within Canberra Nature Park. However, the high percentage of records probably represents a level of concern of the participants observing it in the nature parks of the ACT, rather than there being a higher distribution of African Lovegrass in nature parks than other land uses. It appears from comparing data from earlier with current records that, in some nature reserves, the abundance of African Lovegrass has been reduced over the past 10 years, presumably due to on-going herbicide treatment at those sites. However, in some reserves there is a very high abundance of African Lovegrass, notably in Farrer Ridge (Figure 20).

Other urban open space with identified conservation values: in 2011 African Lovegrass was recorded as being present in or adjacent to Stirling Ridge, native grassland on Constitution Avenue, Umbagong grassland, Monash grassland, Yarramundi Reach and Mt Rogers. All of these locations were recorded as containing African Lovegrass more than 10 years ago.

Other urban open space *(including urban parks, sports fields, and walkways)*: in suburbs with a high abundance of African Lovegrass along major roadsides the abundance of African Lovegrass in all areas of open space was correspondingly high. This presumably is related to the use of the same machinery to slash the open space and roadsides as well as inadvertent spread from other vehicles.

Figure 19. African Lovegrass with Red-leaved Wattle (*Acacia rubida*), Murrumbidgee River Corridor (Photo: L. Johnston)

Figure 20. African Lovegrass on Farrer Ridge Nature Reserve (photo J. Lindner).

Urban roadsides and nature strips: the highest African Lovegrass dominance was on urban roadsides and nature strips in the geographical areas of Tuggeranong, Weston and Belconnen. While African Lovegrass was more abundant and widespread on the major roads, it was recorded as scattered locations on roadsides throughout many suburbs. In the surveys undertaken by volunteers systematically throughout several suburbs (Weetangera and Fisher) African Lovegrass was found extensively in all land uses: roadsides, nature strips, walkways and open space. It is likely that it was significantly under-estimated on urban roadsides because only the more major roads were surveyed. It is also likely that where African Lovegrass is more abundant on the major roads it is more widespread and abundant within the suburbs.

Rural roadsides: the invasion of African Lovegrass along rural roadsides is most likely to occur through mowing, seed spread from moving vehicles or from roadworks which involve importation of soil or other contaminated material. It appeared that rural roadsides which are not regularly slashed or are less frequently travelled contained less African Lovegrass. Frequently isolated groups of plants were observed on the edges of side roads, bridges or other areas where work may have been undertaken or where vehicles may stop.

Rural leases: were not surveyed specifically, but there is very high infestation of rural lands adjacent to the Murrumbidgee River in the district near Tharwa and near the Cotter River confluence. This is despite enormous efforts applied by some landholders to reduce the invasion (S. Howiesson pers. comm.). According to their personal comments, the abundance of African Lovegrass in these paddocks does not appear to have changed in ten or more years. Abundant infestations were also observed in paddocks adjacent to Monaro Highway south of the ACT and near Point Hut Crossing.

4.3 Management

The major factor in discriminating where African Lovegrass would be found appeared to lie more in the type of management that was applied, with the roadsides or areas that were slashed having more African Lovegrass, or in the case of riparian areas, where seed has been washed downriver. Grazed land also was clearly susceptible to invasion (Figures 9, 10), probably again as a result of opening of the canopy of other grasses allowing for invasion from nearby populations. It needs to be noted that grazed lands that were reported or recorded as having high abundance of African Lovegrass were adjacent to large populations on the Murrumbidgee River and Monaro Highway (Map 2), the two major conduits along which African Lovegrass has mostly spread. This presence of African Lovegrass in adjacent paddocks is, despite at least in some cases, there having been extensive and expensive management of the species (Sue Howiesson pers. comm.)

There is no evidence from this survey that fire has had an effect, but other studies indicate that African Lovegrass is enhanced by burning. It is highly flammable and as a result creates a fire hazard. Any control of this weed along roadsides and other high fire danger areas would assist with reducing fire hazard.

The reports from the volunteers indicated that 28% of the sites containing African Lovegrass were not subject to any management (Figure 10). It is very likely that seed is spread alongside roadsides not subject to management by passing vehicles or water movement. However, these sites may include those that were classified as having no management at the time, but that are subject to some management at other times. There does not appear to be very much information available as to the ability of African Lovegrass to invade into areas with a relatively high biomass of other species.

The trials by ACT Parks and Conservation Service using the herbicide flupropanate during the dormant period for African Lovegrass, before the slashers can spread seed, may have success in containing roadside infestations.

4.4 Comparison of the geographical distribution since 2000

Comparing Map 1 with Map 2 and Figure 16A with Figures 16B indicates that African Lovegrass has spread in the past 10 years, even taking into account that mapping was less complete in earlier years. Concentration of African Lovegrass up to 2000 appeared to be mainly in the districts that were developed in the 1970s (Tuggeranong and Belconnen) and along the Murrumbidgee River. It is apparent, however, from the current distribution, that areas containing the species were not identified at the time as containing African Lovegrass (for example the Lower Molonglo Corridor), so the distribution is undoubtedly too conservative.

Personal observations and Steve Taylor (pers. comm.) indicate that there has been a significant increase in abundance in the south and a steady increase in distribution in the north during the period of the drought between 2002 and 2009. It is likely that invasion was enhanced by a decrease in cover of competitive species during the drought.

The compiled data for the 2010 distribution (Map 2 and Figure 16B) indicates that African Lovegrass is widely distributed throughout those areas of Canberra that were built before the 1990s, and it was especially evident throughout Tuggeranong on land subject to a range of land use and on Weston and Belconnen roadsides and residential nature strips. It has

spread since 2000 and is invading the newest suburbs. Major roads in Gungahlin contained occasional and localised occurrences of African Lovegrass. Namadgi National Park was largely free of African Lovegrass along roadsides, although there were isolated patches on some roads, and an established but small population adjacent to the Parks depot. African Lovegrass was widespread and often common or abundant on rural roadsides in southern Canberra, and less common on the northern rural roadsides (Map 2).

Within the region surrounding the ACT African Lovegrass was particularly abundant on the roadsides and adjacent paddocks on the Monaro Highway from Cooma north, on the Federal Highway (common in some localised patches, but mostly occurring as occasional but widespread to at least Collector). Common and localised patches were typically recorded on roads leading out of suburbs that had higher abundance, for example, on Parkwood Road leading out of Belconnen. On rural roadsides leading out of areas with lower infestations, isolated patches were more likely to be encountered. Counter to that, however, was Paddy's River Road, which may have been expected to have a high abundance, but which contained only localised occurrences.

4.5 2020 scenarios

Without constant control, there is no doubt that African Lovegrass will continue to expand in distribution and populations will increase in abundance. Scenario 1 presents a model which may occur if there is an inadequate budget provided by ACT and Commonwealth government and other major landholders in the ACT to undertake control on public land and to provide assistance to private landholders for the control of African Lovegrass. Under a tighter or variable budget it is likely that only populations within areas of highest conservation value will be treated and a likely increase in abundance and distribution across the ACT will result (Figure 16C).

Scenario 2 represents the operations plan for the ACT for control over the next ten years (ACT Parks and Conservation Service 2011a). This plan aims to retain a low or nil infestation rate in currently 'clean' areas of high conservation value; reduce the abundance of the species in areas of high conservation value, particularly areas containing threatened ecological communities; reduce the spread and protect native understorey along the Murrumbidgee River; reduce infestations on rural roadsides; undertake control work on urban arterial roads opposite Canberra Nature Park; and provide additional support where complementary control is being undertaken by rural landholders. Implementing the ACT Environmental Weed Control Operations Plan 2011 – 2019 will assist in containing the weed and reduce populations at selected locations (Figure 16D).

However, with a more concerted effort by a larger cohort of volunteers, it is anticipated that greater control of the weed is possible. Scenario 3 (Map 3 and Figure 16E) aims to address more fully the reasons behind why African Lovegrass is currently still being spread, and where it is likely to spread to. Scenario 3 aims to implement a high concentration of effort to achieve removal in districts and roadsides where African Lovegrass was found to be in isolated patches in 2011; constant eradication of new populations; reduction and/or removal in or adjacent to areas of high conservation value. Together with Scenario 2, Scenario 3 recognises that spread is likely to continue from upstream on the Murrumbidgee River, so that re-invasion is highly likely. Therefore, in Scenario 3 minimal effort would be applied to populations with high abundance within areas along the Murrumbidgee, except along the outer boundaries of these areas, to prevent or reduce further spread, and

particularly where complementary effort is being applied by adjacent landholders. It may be possible with considerable effort to reduce the population of African Lovegrass along lower Molonglo River corridor, however, as there is no constant supply of seed from upstream (as long as water from Lake Burley Griffin is not contaminated). Scenario 3 aims to reduce the vectors for spread – changing the patterns of mowing: reduce the amount of mowing, cleaning vehicles, mowing from clean to contaminated areas and minimising mowing when seed is ripe. It is this scenario which is the preferred option, and is used as the basis for recommendations provided in Section 5 of the report.

5. Conclusions

There has been concerted effort to reduce the abundance of African Lovegrass at many sites over the past 15 years. Specifically, control has occurred in and adjacent to nature reserves, along the Murrumbidgee River and along rural roadsides (ACT Parks and Conservation Service 2011a). Despite this, however, there are few locations where the weed has been eradicated, except when it occurred only as very isolated plants in localised populations. This lack of ability to control the species is not unique to the ACT, and reflects the extreme difficulty of controlling this highly invasive weed.

Invasion from infected vehicles is clearly the most common vector for the continuing spread of African Lovegrass, particularly by mowers, but also other vehicles including cars. It is well known that mowers spread African Lovegrass, as well as other weeds such as Chilean Needlegrass. However, it is not feasible or practical to cease mowing in infested areas, as mowing is applied for several reasons of public safety along lines of sight on roadsides and to reduce fuel loads (ACT Parks and Conservation Service 2011a). Continuous spread of seed with water as a vector along the Murrumbidgee River corridor and then by wind into adjacent paddocks is maintaining the populations of African Lovegrass at other locations. It is clear from its rate of spread in the ACT over the past 10 years that African Lovegrass is highly resistant to drought, and utilises open space left by other less drought tolerant species to actively invade new areas.

In addition, it would be safe to say that there is a significant lack of awareness by many people of the highly invasive nature of the species (with the exception of most rural land managers, particularly in and south of the ACT), a lack of ability to recognise it and of the need to treat it. It is likely that many people inadvertently distribute African Lovegrass plants or seed when they move locations and take contaminated lawnmowers with them, lend them to other people, or in some cases, buy or relocate contaminated soil or hay.

This does not mean that it is a ‘lost cause’, neither does it mean that there should be no further effort applied to control it.

What appears to be the most important control measure that needs to be applied is to eradicate all isolated infestations before they become established, with a high level of effort being applied to prevent new infestations through more concentrated effort of applying vehicle hygiene, frequency and timing of mowing and vigilance to the presence of isolated plants in new locations. This is the most cost-effective way of controlling he species It can be predicted with some certainty where African Lovegrass is likely to invade over the next 10 years:

- the new suburbs of Molonglo are likely to be invaded relatively quickly, given that African Lovegrass is already occurring along the Molonglo River corridor and in Weston and it is already within topsoil being stored for future use (it has been seen growing in the topsoil piles);
- further infestation into Gungahlin along mown roadsides is likely;
- new roads such as Gungahlin Drive extension are likely to become infested;
- in rural areas where works are undertaken, such as at bridges or for road repairs, it is likely to germinate, from contaminated introduced soil, hay or from vehicles.

Assistance from more fully aware and better educated members of the public will assist in retaining vigilance and control of new infestations.

The next highest priority is to contain it within the area where it is already established (as presented in the Weeds Operations Plan (ACT Parks and Conservation Service 2011a).

A monitoring program to determine whether current control measures are effective and relate these to when and how control was undertaken will further enhance our understanding and enable application of adaptive management.

Alongside these is the need to increase the general population's awareness of the invasive nature of the weed, and to try to instil a sense of personal responsibility in reducing the spread of the weed.

5.1 Recommendations

Direct control actions

On the basis that it is cheaper to eradicate isolated plants than to control the species once populations are established, the following staged approach to implementing management actions is recommended:

Priority 1:

- Ensure areas that are currently free of African Lovegrass or have only isolated infestations are sprayed whenever infestations are observed. Such areas include roadsides in Namadgi National Park, Gungahlin roadsides, Googong Foreshores Road and roads exiting the ACT with the exception of Federal Highway and Monaro Highway.
- Treat infestations in nature reserves and high conservation areas on public land which include some areas with threatened species or high native component, for example, Mt Rogers, Umbagong Grassland and Stirling Ridge, and on roadsides and open space adjacent to these sites.
- Use the 'Bradley Method' approach of moving in from least infested to most infested areas, along rural and urban roads including Cotter, Boboyan, Sutton, Majura, Tidbinbilla and Paddy's roads.

Priority 2:

- Reduce African Lovegrass populations to occasional and localised along major roads in north and south Canberra (with the exception of Tuggeranong), including Northbourne Ave, Belconnen Road, Ginninderra Drive, Gungahlin Drive and Barton Highway east of Gundaroo Drive through herbicide treatment and compliant application of vehicle hygiene practices.
- Reduce African Lovegrass populations to occasional and localised on secondary and roads in urban ACT.
- Gradually work in from the edges of infestations on the Murrumbidgee River Corridor and Lower Molonglo River, with the cooperation of landholders (and with the provision of financial assistance) adjacent to the riparian zones.
- Reduce African Lovegrass populations to common and localised along more heavily infested roads, including Monaro Highway and major urban roads in Tuggeranong.

Priority 3:

- Maintain populations along roadsides to occasional and localised, and contain the population along the Murrumbidgee River to within the river corridor.

Indirect actions

Other actions that need to be undertaken if further spread is going to be contained include:

1. Follow up herbicide treatment with revegetation if bare areas are created, to prevent re-invasion by African Lovegrass or other weeds.
2. Review the rural road mowing strategy to only mow rural roadsides for fire or safety reasons (e.g. line of sight).
3. Review the urban mowing program to mow areas infested with African Lovegrass only when the seed is not viable. Other methods of biomass control may be more effective when seed is ripe, for example, grazing or burning.
4. Work closely with weed managers in NSW to reduce abundance and minimise new invasions on a regional basis.
5. Undertake further education in the recognition of the species and the most effective ways of preventing new infestation and of controlling existing infestations, including practical training in the best use of herbicides and sprayers.
6. Use existing mechanisms to increase awareness of the species and the need to control it: through Weedswap, the Floriade weed display, providing information to residents in newly established suburbs and continuation of workshops.
7. Facilitate research, undertake trials and use results of monitoring to determine how best to control the species. Work in cooperation with universities, other state departments and non-government organisations to do so.
8. Continue to support ACTPCS/Cooma Monaro Council trials of using flupropanate on roadside infestations during the dormant period for African Lovegrass (to kill the

African Lovegrass before mowers can spread seed). If this is successful it may well contain roadside infestations.

9. Involve urban landholders in undertaking control of African Lovegrass in urban areas including removal of infestations in their blocks and on nature strips and implementation of mower hygiene to reduce spread.
10. Anticipate likely places of invasion and constant surveillance and immediate control: along vehicle tracks in reserves, around places that are disturbed (e.g. by bridges on rural roads and where other roadworks occur); along rural roadsides and on rivers and creeks.
11. Ensure asset managers and their contractors apply vehicle hygiene practices when they enter a site to reduce the spread of weeds between sites: ACTEW, mobile phone companies etc; ensure they provide resources to control weeds spread along their maintenance tracks.
12. Ensure strict compliance of slashers mowing from areas that are least to most contaminated.
13. Undertake regular vehicle hygiene compliance checks and undertake follow-up action if contractors and others are not compliant.
14. Increase and enhance existing cooperative action between managers of rural properties and government agencies responsible for roadsides for the implementation of complementary treatment across land uses.
15. Undertake animal quarantine prior to release of animals into clean areas.
16. Undertake monitoring of weed abundance and distribution and compliance.

Measuring and monitoring results

- Establish and maintain a targeted monitoring program to ensure works undertaken are effective (with integral follow-up treatment if required). Monitoring will require a specific budget, but can be achieved through applying techniques such as those described in Appendix 3. Areas need to be monitored at select locations before and after treatment, with records maintained of what was treated, when, where and how.
- Ensure control work is assessed for a satisfactory result prior to sign-off on work completed.
- Establish a means by which isolated infestations can be reported, recorded and records of treatment be maintained.
- Remap abundance and distribution in selected areas in 5 years time.

Other mechanisms that may be considered

- Provide additional assistance to rural landholders in priority areas to control weeds.
- Hold an annual Clean Up Your Weeds day in Canberra. Provide incentives such as free plants or landscaping prizes for the cleanest areas.
- Encourage community groups including recreational and social groups to undertake African Lovegrass control in specified locations.
- Involve in the education program key members of the ACT community who can influence behaviour, such as well-known television and radio presenters.

6. References

ACT Parks and Conservation Service, 2011a. Updated Environmental Weed Control Operations Plan 2011-19, ACTPCS October 2011.

ACT Parks and Conservation Service, 2011b. *Environmental Weed Management Guidelines*. ACT Government, Canberra. October 2011

Berry S. and Mulvaney M., 1995. *An environmental weed survey of the Australian Capital Territory*. Report to the Conservation Council of the South-East Region and Canberra.

Border Rivers Gwydir Catchment Management Authority Invasive Species Management Plan, undated. http://www.feral.org.au/wp-ontent/uploads/2010/11/9.Weeds_.pdf

Cooma Monaro Shire Council Noxious Weeds Fact Sheet, undated. http://www.cooma.nsw.gov.au/files/docs/environmental_management/noxious_weeds/factsheets/African%20Lovegrass%20Factsheet.pdf

David Hogg pers. comm., November 2011 (David Hogg Pty Ltd).

Firn J, 2008. African Lovegrass Control Workshop Proceedings, Unpublished. 'Scottsdale' Bush Heritage Australia site, 12th Dec 2008.

Ishiyama L., Skinner S., Johnston L., Frawley K., Grant F. and Evans L., 2010. *Survey of Vegetation and Habitat in Key Riparian Zones in Tributaries of the Murrumbidgee River in the ACT: Cotter, Molonglo, Gudgenby, Naas and Paddy's Rivers, ACT*. Department of Territory and Municipal Services, Canberra.

Johnson, S. (2009) *NSW Weed Risk Management System*, NSW Department of Primary Industry.

Johnston L., Skinner S., Ishiyama L. and Sharp S., 2009. *Survey of vegetation and habitat in key riparian zones*. Final report to the National Action Plan. Research and Planning, Parks Conservation and Lands, Canberra.

Johnston W. H., 1996. The place of C4 grasses in temperate pastures in Australia. *New Zealand Journal of Agricultural Research, 1996, Vol. 39:* 527-540.

Muyt A., 2001. *Bush Invaders of South-East Australia. A guide to the identification and control of environmental weeds found in South-East Australia*. R.G. and F.J. Richardson, Meredith Victoria.

Nazer C., Ridgway J. and Arney M., 1996. *Roadside Weed Spread Survey – December 1994 to April 1995*. Parks and Public Places Asset Management, City Operations, City Services Group, unpublished report.

NSW Department of Primary industries website, 2011. http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/profiles/african-lovegrass

Peter Saunders, pers. comm., November 2011, at African Lovegrass forum, November 2011, Scottsdale, Bredbo.

Steve Taylor, pers. comm., November 2011 (ACT Parks and Conservation Service).

Sue Howiesson pers. comm., March 2011 (rural lessee, ACT).

Victoria Department of Primary Industries website 2011. http://www.dpi.vic.gov.au/agriculture/science-and research/biotechnology/biotechnology-policy/invasive

Appendix 1. Recommended control methods for African Lovegrass

ACT Parks and Conservation Service 2011. Environmental Weed Management Guidelines, February 2011.

Declared Pest Plant. Must be Contained.

HABIT

Densely tufted, erect perennial tussock grass species, 30-120cm tall (short and tall form).

DISTRIBUTION

Establishes readily along rivers, roadsides, parkland areas and disturbed sites. From these locations it rapidly spreads into neighbouring land including un-disturbed areas.

REPRODUCTION

Contaminant of soils and gravels used in road making. Also dispersed by wind, animal coats, machinery, water and clothing.

CONTROL

Cultural control: Maintain a strong, dense, competitive cover of desired vegetation. Minimise disturbance. Do not mow or slash when in seed. Thoroughly clean all mowers and slashers that have operated in African Lovegrass areas before moving to un-infested areas.

Biological control: No biological control agents have been investigated to date.

Chemical control: The Taskforce or Kenock® rates below are from Australian Pesticides & Veterinary Medicines Authority (APVMA) www.apvma.gov.au off-label permit no: PER9792.

Chemical	**Spot spray rate per 100L water**	**Boom spray rate per ha**	**Comments**
Roundup Biactive® (glyphosate 360)	1L		Apply when plants are actively growing.
Taskforce ® or Kenock® (flupropanate)	150mL to 300mL	1.5L to 3L per hectare with 150L water per hectare	Off-label permit rates. Do not boom spray in native grasslands or native pasture.
Taskforce® or Kenock® & Roundup Biactive®	150mL to 300mL Taskforce® or Kenock® and 335mL Round-up Biactive®	1.5L to 3L per hectare plus 380 to 630mL/ha of Roundup Biactive® plus 150L water per ha	Apply when plants are actively growing. Combined herbicides to ensure seed set suppression.

Appendix 2. Locations where African Lovegrass has been found since 1995

Sites not surveyed in 2010, but where African Lovegrass occurred in 2000 have been labelled as 'unknown' if it may still contain the weed, or 'likely' to still contain the weed, or the site had recently been visited and no African Lovegrass was observed.

Site Name	District	Land use	1995	2000	2010
Lower Molonglo River	Non urban north	MRC			a/w
Molonglo River, Oaks Estate	Non urban north	MRC			c/w
Kama south	Non urban north	Nature reserve			o/w
Amtech, Fyshwick	Non urban north	Rural lease		o/l	Unknown
Molonglo R east	Non urban north	Rural lease			a/w
Pegasus Riding School	Non urban north	Rural lease		o/w	Unknown
Stockdill Dr 'Strathnairn'	Non urban north	Rural lease		o/l	c/w
Stockdill Dr Trevaskis Property	Non urban north	Rural lease		o/l	c/w
Tuppenterry Springs via Hall	Non urban north	Rural lease			c/l
Antill St nth to Federal Hwy	Non urban north	Rural roadside			o/w
Barton Hwy rural	Non urban north	Rural roadside			o/w
Barton Hwy NSW	Non urban north	Rural roadside			o/l
Coppins Crossing	Non urban north	Rural roadside	c/w		o/w
Cotter Road opposite Morisset's	Non urban north	Rural roadside			c/l
Federal Highway NSW	Non urban north	Rural roadside			o/w
Gundaroo Rd NSW	Non urban north	Rural roadside			o/l
'Jerramalee' roadside Macgregor	Non urban north	Rural roadside			c/l
Kings Hwy ACT	Non urban north	Rural roadside		c/l	o/w
Kings Hwy NSW east to Bungendore	Non urban north	Rural roadside			o/l
Kowen Forest	Non urban north	Rural roadside			c/l
Kuringa Drive Fraser	Non urban north	Rural roadside			o/w
Majura Rd	Non urban north	Rural roadside		o/l	o/w
McIntosh Rd Scullin	Non urban north	Rural roadside			c/l
Mountain Rd	Non urban north	Rural roadside			c/l
Nimrod Rd	Non urban north	Rural roadside			c/l
Oaks Estate Rd	Non urban north	Rural roadside			o/w
Parkwood Dr Holt	Non urban north	Rural roadside			o/w
Pialligo Road	Non urban north	Rural roadside		o/w	o/w
Stockdill Dr Holt	Non urban north	Rural roadside			o/w
Sutton Rd north	Non urban north	Rural roadside			o/l
Sutton Rd south	Non urban north	Rural roadside			o/w
Wallaroo Rd Hall	Non urban north	Rural roadside			o/w
Woods Lane Harman	Non urban north	Rural roadside			o/w
Airport Services (Beacon)	Non urban north	Telecommunications		p	Unknown
Lanyon Dr, Hume	Non urban north	Urban roadside			c/l
William Hovell Dr Belconnen	Non urban north	Urban roadside	p		c/l

Site Name	District	Land use	1995	2000	2010
Urambi Hills to McQuoids Hill equestrian trails	Non urban south	Equestrian trails			c/l
Uriarra Crossing	Non urban south	Murrumbidgee River Corridor			a/w
Apollo Rd, NNP	Non urban south	Namadgi NP			o/l
Boboyan Rd NNP	Non urban south	Namadgi NP			o/w
Brindabella Rd Thompsons Cnr	Non urban south	Namadgi NP			o/w
Frank and Jacks Hut	Non urban south	Namadgi NP			c/l
Glendale depot	Non urban south	Namadgi NP			c/l
Grassy Ck Bridge	Non urban south	Namadgi NP			c/l
Middle Creek NNP	Non urban south	Namadgi NP			c/l
Mt Clear dozer tracks and rake hoe trails from Gap Ck fire	Non urban south	Namadgi NP			c/l
Mt Tennant lower slopes	Non urban south	Namadgi NP			c/l
Naas Road	Non urban south	Namadgi NP			o/w
Orroral Rd	Non urban south	Namadgi NP			c/l
Orroral Valley	Non urban south	Namadgi NP			o/l
Ranger HQ NNP	Non urban south	Namadgi NP			c/l
Ranger Station Helipad	Non urban south	Namadgi NP			c/l
Ranger Station Woodland	Non urban south	Namadgi NP			c/l
Rendezvous Ck	Non urban south	Namadgi NP			c/l
Top Naas Rd	Non urban south	Namadgi NP			o/w
Bullen Range	Non urban south	Nature reserve		o/w	Unknown
Camp Cottermouth	Non urban south	Nature reserve		o/w	Likely
Gigerline Reserve	Non urban south	Nature reserve		p	o/w
Glenloch Interchange	Non urban south	Nature reserve		o/l	o/w
Googong Foreshores	Non urban south	Nature reserve			o/w
Rob Roy Foothills	Non urban south	Nature reserve		p	o/l
Rob Roy NR east	Non urban south	Nature reserve			o/w
Tidbinbilla NR	Non urban south	Nature reserve			c/l
Cotter Reserve	Non urban south	Open space			a/w
Casuarina Sands	Non urban south	Riparian			a/w
Castle Hill, Tharwa	Non urban south	Rural lease			a/w
Kambah Pool Agistment	Non urban south	Rural lease		o/l	a/w
Naas Road	Non urban south	Rural lease			c/l
Stromlo Forest Park	Non urban south	Rural lease		o/w	c/w
Tennent - Lonergan Agistment	Non urban south	Rural lease		o/l	Unknown
Tennent - Martin Agistment	Non urban south	Rural lease		o/w	Unknown
Tharwa Dr rural leases	Non urban south	Rural lease			a/w
Tidbinbilla Rd paddocks	Non urban south	Rural lease			a/w
Tuggeranong Creek Agistment	Non urban south	Rural lease		o/w	Unknown

Site Name	District	Land use	1995	2000	2010
Angle Crossing east	Non urban south	Rural roadside			o/w
Birragai Time Trial link rd	Non urban south	Rural roadside			c/l
Boboyan Rd north	Non urban south	Rural roadside			c/l
Booroomba,	Non urban south	Rural roadside			c/l
Brindabella Rd east	Non urban south	Rural roadside			o/w
Canberra Ave	Non urban south	Rural roadside			c/l
Corin Rd Tidbinbilla	Non urban south	Rural roadside			o/l
Cotter Road	Non urban south	Rural roadside			o/w
Discovery Rd Tidbinbilla	Non urban south	Rural roadside			o/l
Fairlight Rd	Non urban south	Rural roadside			o/w
Freshford	Non urban south	Rural roadside			c/l
Googong Rd	Non urban south	Rural roadside	p		o/w
Jerrabomberra Ave	Non urban south	Rural roadside			c/w
Kambah Pool Road	Non urban south	Rural roadside			c/l
Long Gully Rd,	Non urban south	Rural roadside			o/w
Monaro Highway non urban	Non urban south	Rural roadside	p		o/w
Monaro Highway sth ACT	Non urban south	Rural roadside			c/w
Monaro Hwy NSW	Non urban south	Rural roadside			c/w
Mountain Ck Road	Non urban south	Rural roadside			c/w
Mt Stromlo Observatory road	Non urban south	Rural roadside			c/w
Mugga Lane	Non urban south	Rural roadside			o/l
Paddy’s River Road	Non urban south	Rural roadside			o/l
Point Hut road and paddocks	Non urban south	Rural roadside			a/w
Shanahan Lease road	Non urban south	Rural roadside			c/l
Smith's road	Non urban south	Rural roadside			c/w
Sunshine Rd	Non urban south	Rural roadside			o/w
Tharwa Dr rural roadsides	Non urban south	Rural roadside	p		c/w
Tidbinbilla Rd Corin Rd to Tharwa	Non urban south	Rural roadside			o/w
Tidbinbilla Rd w of Corin Rd	Non urban south	Rural roadside		o/l	o/l
Uriarra Rd	Non urban south	Rural roadside			o/w
Hume TSR	Non urban south	Travelling Stock Reserve		o/w	Unknown
Melrose TSR	Non urban south	Travelling Stock Reserve		o/l	c/l
Naas TSR	Non urban south	Travelling Stock Reserve		o/l	o/l
Paddys River TSR	Non urban south	Travelling Stock Reserve		o/w	Unknown
Williamsdale TSR	Non urban south	Travelling Stock Reserve		o/w	a/l
Old Cooma Rd	Non urban south				o/l
Clear Range – Forest Hut area	Non urban south	Namadgi NP			c/l
Murrumbidgee opp Howiesson's	River corridor	Murrumbidgee River Corridor			a/w

Site Name	District	Land use	1995	2000	2010
Pine Island	River corridor	Murrumbidgee River Corridor		c/l	a/w
Pine Island Agistment	River corridor	Murrumbidgee River Corridor		c/w	Likely
Point Hut Hill	River corridor	Murrumbidgee River Corridor		p	a/l
Point Hut to Pine Island	River corridor	Murrumbidgee River Corridor		p	a/w
Red Rocks	River corridor	Murrumbidgee River Corridor	p		c/w
Tharwa Sand wash to Point Hut	River corridor	Murrumbidgee River Corridor		p	a/w
Murrumbidgee River Corridor	River corridor	Nature reserve	p	p	a/w
Point Hut Crossing	River corridor	Rural roadside		a/l	a/w
Tharwa TSR (Tharwa Common)	River corridor	Travelling Stock Reserve		o/w	Likely
Canberra International Airport	Urban north	Airport		p	Unknown
Hall Horse Paddocks	Urban north	Horse paddocks		o/l	Unknown
Kaleen horse paddocks	Urban north	Horse paddocks		c/l	Unknown
Aranda Bushland NR	Urban north	Nature reserve			o/l
Black Mountain NR	Urban north	Nature reserve			c/l
Bruce Ridge	Urban north	Nature reserve		o/l	None observed
Gossan Hill	Urban north	Nature reserve		o/w	None observed
Mt Majura NR	Urban north	Nature reserve			c/l
Mt Painter	Urban north	Nature reserve			c/l
Mt Pleasant NR	Urban north	Nature reserve			c/w
Mulanggari Grassland Reserve	Urban north	Nature reserve		o/w	Unknown
O'Connor Ridge	Urban north	Nature reserve			c/l
The Pinnacle NR tracks	Urban north	Nature reserve	p		c/l
Cook walkways and roadsides	Urban north	Open space			o/w
John Knight Park	Urban north	Open space			o/w
Weetangera minor roadsides	Urban north	Roadside			o/l
William Slim Dr Belconnen	Urban north	Roadside			o/w
William Webb Dr Evatt	Urban north	Roadside			o/l
Newline Quarry	Urban north	Rural lease		o/l	Unknown
Victoria St Hall	Urban north	Rural roadside			o/w
Wells Station Rd Kenny	Urban north	Rural roadside			c/l
Pialligo holding paddocks	Urban north	Travelling Stock Reserve		o/w	Unknown
ANU Old Canberra House	Urban north	Urban open space			c/l
Aranda oval	Urban north	Urban open space			o/w
Bruce	Urban north	Urban open space	p		Unknown

Site Name	District	Land use	1995	2000	2010
Challinor St Reserve Florey	Urban north	Urban open space			c/l
Constitution Avenue Reid grassland	Urban north	Urban open space		p	None observed
Diddams Close Lake Ginninderra	Urban north	Urban open space			a/w
Evatt Powerlines William Webb Dr	Urban north	Urban open space		o/l	a/l
Flynn to Latham walkways	Urban north	Urban open space			c/l
Giralang Hill	Urban north	Urban open space			o/w
Lake Ginninderra	Urban north	Urban open space			o/w
Lawson Commonwealth	Urban north	Urban open space	p	o/l	Unknown
Macgregor open space	Urban north	Urban open space			c/l
Mt Rogers	Urban north	Urban open space		p	a/l
Russell Offices	Urban north	Urban open space		o/w	Unknown
Umbagong Park	Urban north	Urban open space		c/l	c/l
Antill St to Stirling Ave	Urban north	Urban roadside			o/l
Aranda suburb roadsides	Urban north	Urban roadside			c/l
Baldwin Dr Kaleen	Urban north	Urban roadside			o/w
Banjalong St Aranda	Urban north	Urban roadside			o/l
Barry Drive	Urban north	Urban roadside			c/l
Barton Hwy urban	Urban north	Urban roadside			c/w
Bellenden St, Crace	Urban north	Urban roadside			o/l
Bindubi St, Cook	Urban north	Urban roadside			c/w
Binns St Fraser	Urban north	Urban roadside			o/w
Black Mountain Dr entrance	Urban north	Urban roadside			a/l
Carlile St Evatt	Urban north	Urban roadside			o/l
Caswell Dr Aranda	Urban north	Urban roadside			o/l
Chuculba Cr Giralang	Urban north	Urban roadside			o/w
Clunies Ross St	Urban north	Urban roadside			o/l
College St, Bruce	Urban north	Urban roadside			o/w
Copland Drive Evatt	Urban north	Urban roadside			o/w
Coulter Dr nth of Belconnen Way	Urban north	Urban roadside			o/l
Coulter Dr sth of Belconnen Way	Urban north	Urban roadside			c/w
Drake Brockman Drive Holt	Urban north	Urban roadside			o/w
Dryandra St, Lyneham	Urban north	Urban roadside			c/w
Eastern Valley Way Belconnen	Urban north	Urban roadside			o/w
Ellenborough St Kaleen	Urban north	Urban roadside			o/l
Fairbairn Ave Campbell	Urban north	Urban roadside		p	o/w
Federal Highway	Urban north	Urban roadside			o/w
Flemington Rd, Mitchell	Urban north	Urban roadside			o/w
Florey Dr Latham	Urban north	Urban roadside			o/l
Flynn	Urban north	Urban roadside			o/w

Site Name	District	Land use	1995	2000	2010
Frith Rd, Acton	Urban north	Urban roadside			c/w
Ginninderra Drive	Urban north	Urban roadside			o/w
Ginninderra Drive west	Urban north	Urban roadside			o/l
Gladstone St Hall	Urban north	Urban roadside			o/w
Gundaroo Dr to Gungahlin Dr	Urban north	Urban roadside			o/w
Gungahlin Dr	Urban north	Urban roadside			o/l
Haydon Dr, Bruce	Urban north	Urban roadside			o/w
Horse Park Drive, Gungahlin	Urban north	Urban roadside			o/l
Kaleen suburb	Urban north	Urban roadside			o/w
Kerrigan St, Dunlop	Urban north	Urban roadside			o/l
Kings Ave	Urban north	Urban roadside			o/l
Kingsford Smith Drive	Urban north	Urban roadside			o/w
Lhotsky St Charnwood	Urban north	Urban roadside			o/l
Limestone Ave Ainslie	Urban north	Urban roadside			o/l
Macarthur Ave O'Connor	Urban north	Urban roadside			o/l
Maribyrnong Ave Kaleen	Urban north	Urban roadside			o/w
Mouat St Lyneham	Urban north	Urban roadside			o/l
Mt Ainslie Dr	Urban north	Urban roadside			o/w
Northbourne Ave	Urban north	Urban roadside			o/l
Northcott Dr, Campbell	Urban north	Urban roadside			o/w
Parkes Way	Urban north	Urban roadside			o/w
Randwick Rd Mitchell	Urban north	Urban roadside			o/w
Redfern St Cook	Urban north	Urban roadside			o/w
Shakespeare St Dunlop	Urban north	Urban roadside			o/l
Shumack St Weetangera	Urban north	Urban roadside			o/w
Skinner St Cook	Urban north	Urban roadside			o/w
Southern Cross Drive	Urban north	Urban roadside			o/w
Spalding St Flynn	Urban north	Urban roadside			o/l
Spofforth St Holt	Urban north	Urban roadside			o/w
Springvale Dr, Weetangera	Urban north	Urban roadside			o/w
Tillyard Ave Charnwood	Urban north	Urban roadside			o/l
Wakefield Ave Ainslie	Urban north	Urban roadside			o/l
Owen Dixon Drive Evatt	Urban north	Urban roadside			o/w
Charnwood walkways	Urban north	Walkways			c/l
Cooleman Ridge NR	Urban south	Nature reserve		o/w	a/l
Farrer Ridge	Urban south	Nature reserve		o/w	o/w
Isaacs Ridge NR	Urban south	Nature reserve			c/l
Jerrabomberra grasslands	Urban south	Nature reserve		o/l	o/w
McQuoids Hill NR	Urban south	Nature reserve			o/w
Mt Mugga Mugga	Urban south	Nature reserve		o/w	o/w
Mt Taylor	Urban south	Nature reserve		o/l	c/l
Oakey Hill NR	Urban south	Nature reserve		o/w	o/w
Red Hill NR	Urban south	Nature reserve			o/w

Site Name	District	Land use	1995	2000	2010
Stirling Ridge	Urban south	Nature reserve			o/w
Tuggeranong Hill Nature Reserve	Urban south	Nature reserve		p	c/l
Urambi Hills	Urban south	Nature reserve		o/w	c/l
Wanniassa Hills CNP	Urban south	Nature reserve		o/l	c/l
Narrabundah Lane, Symonston	Urban south	Rural roadside			c/l
Ballarat St Park Waramanga	Urban south	Urban open space			o/w
Barney's Hill/Mt Stranger	Urban south	Urban open space		p	a/l
Dudley St Yarralumla	Urban south	Urban open space			c/l
Duffy Park	Urban south	Urban open space			a/l
Fisher bikepaths	Urban south	Urban open space			c/w
Fisher nature strips	Urban south	Urban open space			o/w - c/w
Fisher Parkland	Urban south	Urban open space		p	c/w
Gilmore Hill	Urban south	Urban open space			c/l
Kambah Open space	Urban south	Urban open space			c/w
Kintore St Yarralumla	Urban south	Urban open space		o/w	None observed
Lake Tuggeranong east	Urban south	Urban open space			o/w
Monash Hill Tuggeranong	Urban south	Urban open space			a/l
Mt Stranger	Urban south	Urban open space		a/l	a/l
Scrivener Hill O'Malley	Urban south	Urban open space			o/w
Tuggeranong Homestead	Urban south	Urban open space		o/w	c/l
William Hudson Cres Monash	Urban south	Urban open space		c/w	o/w
Wright's Creek Banks	Urban south	Urban open space		p	Unknown
Tharwa	Urban south	Urban roadsides			c/w
Adelaide Ave	Urban south	Urban roadside			o/w
Ashley Dr Gowrie	Urban south	Urban roadside			o/w
Athllon Dr nth of Drakeford Dr	Urban south	Urban roadside			o/w
Athllon Dr sth of Drakeford Dr	Urban south	Urban roadside			c/w
Badimara St Waramanga	Urban south	Urban roadside			o/w
Banks roadsides	Urban south	Urban roadside			c/l
Bateman St Kambah	Urban south	Urban roadside			o/w
Beasley St Torrens, Mawson	Urban south	Urban roadside			o/w
Boddington Crt Kambah	Urban south	Urban roadside			c/l
Box Hill Ave Conder	Urban south	Urban roadside			c/l
Bugden Ave, Fadden	Urban south	Urban roadside			c/w
Canberra Ave	Urban south	Urban roadside			o/w
Capital Circle	Urban south	Urban roadside			o/l
Carruthers St Lyons	Urban south	Urban roadside			o/w
Chapman	Urban south	Urban roadside			o/w
Clive Steele Ave Monash	Urban south	Urban roadside			c/l
Colquoun St Kambah	Urban south	Urban roadside			c/w

Site Name	District	Land use	1995	2000	2010
Conder roadsides	Urban south	Urban roadside			c/l
Currie St Manuka	Urban south	Urban roadside		p	Unknown
Darwinia Tce Chapman	Urban south	Urban roadside			a/w
Drakeford Dr Tuggeranong	Urban south	Urban roadside			c/w
Eggleston Dr Chifley	Urban south	Urban roadside			o/w
Erindale Dr, Tuggeranong	Urban south	Urban roadside			c/w
Eucumbene Dr Duffy	Urban south	Urban roadside			c/w
Greenway	Urban south	Urban roadside	p		Unknown
Harricks Cres Monash	Urban south	Urban roadside			c/l
Heysen St Weston	Urban south	Urban roadside			c/w
Hindmarsh Dr east	Urban south	Urban roadside			o/w
Hindmarsh Dr Weston	Urban south	Urban roadside			a/w
Hodgson St Pearce	Urban south	Urban roadside			o/w
Isaacs roadsides	Urban south	Urban roadside			c/l
Isabella Dr Tuggeranong	Urban south	Urban roadside			c/w
Johnson Dr Calwell	Urban south	Urban roadside			o/w
Julia Flynn Ave Isaacs	Urban south	Urban roadside			o/w
Kings Hwy Queanbeyan	Urban south	Urban roadside			o/l
Lady Denman Dr	Urban south	Urban roadside			o/w
Learmonth Dr, Kambah	Urban south	Urban roadside			c/w
Macfarland Cr Pearce	Urban south	Urban roadside			o/w
Monaro Hwy urban	Urban south	Urban roadside			c/l
Namatjira Dr south	Urban south	Urban roadside			o/w
O'Malley roads	Urban south	Urban roadside			o/w
Red Hill Dr	Urban south	Urban roadside			c/w
Richardson roadsides	Urban south	Urban roadside			a/l
Streeton Dr Weston	Urban south	Urban roadside			o/w
Sturt Ave Narrabundah	Urban south	Urban roadside			o/w
Sulwood Dr Kambah	Urban south	Urban roadside			o/w
Tamar St Red Hill	Urban south	Urban roadside			o/l
Tharwa Dr, urban Canberra	Urban south	Urban roadside		c/l	o/w
Tom Roberts Ave, Conder	Urban south	Urban roadside			c/l
Tuggeranong Pkwy	Urban south	Urban roadside			c/w
Waldock St, Chifley	Urban south	Urban roadside			c/w
Wentworth Ave Kingston	Urban south	Urban roadside			o/l
Woodcock Dr Gordon	Urban south	Urban roadside			a/w
Yamba Dr sth of Farrer	Urban south	Urban roadside			c/l
Yamba Dr Woden	Urban south	Urban roadside			o/w

Appendix 3: Recommended monitoring program

1. Herbaceous abundance

This indicator is used to measure changes in abundance of species in the groundlayer (plants less than 0.5 m tall).

It provides an insight into how well a community is responding to management interventions such as weed control, stock removal and so on, and compares changes between sites or changes within one site over time.

This method is useful for undertaking an initial assessment of the frequency of African Lovegrass in a site, as well as monitoring changes over time in response to management actions.

Timing & Frequency

For monitoring, this indicator should be scored once a year, and ideally repeated at roughly the same time each year.

Resources & Techniques Needed

It is not necessary to identify every species. The major categories that species can be defined as are: African Lovegrass; Native herbaceous plants; Annual exotics; Perennial exotics; litter; bare ground; and rocks.

Resources required are: permanent markers for beginning and ideally end point, field recording sheet and a fine straight wire. It is quicker if two people do this, but it can be done alone.

Field Procedure

The method used is the 'point step' method. Choose a 'typical' area in each site being monitored to mark your transect. Because this is a measure of groundlayer, try to take a straight line that avoids plants more than 0.5 m tall. If this is not possible, walk around the shrub or tree and continue in the straight line. Come back to the same transect location each time you monitor.

1. Walk one or more transects. Measure from either the right or the left side. At each right or left footstep, randomly point a fine straight wire onto the ground adjacent to your foot but about 30 cm away and record what is touching the wire. Note that total distance doesn't matter for this indicator but for measuring again at the same site it is useful to always take the steps in a single direction. You may wish to put in another permanent marker at the end of the transect, or you can walk towards a particular target each time (write down what it is for future reference).

2. Identify and record the plant species (or groups of plants e.g. native or introduced) being 'hit'. Keep a tally of scores on the recording sheet in Attachment 1.

If you 'hit' two or more species at one time, mark in both species.

Litter: record any vegetative material that is not attached to live plants as litter. Mark African Lovegrass plants as 'dead' rather than litter (see 3. below).

3. Weed Abundance and Threat: If the monitoring program is set up to monitor the change in abundance of weeds as a result of weed control measures, for each weed “hit” there may be a measure of health or control success: – alive– dead– partial kill.

4. For sites where you are monitoring change as a result of management intervention, repeat this step where intervention has not occurred, (a ‘control’ site) to compare the differences.

5. Take photos along the transect.

Interpretation

1. Write down and keep a record of what has occurred at the site over time. This may require only a few words.

2. Convert the tally to a percentage (number of hits per species/total number of hits) multiplied by 100. Enter data onto the summary sheet (see example).

3. Create a graph showing the changes in the frequency of a particular species (or groups of species) over time (see example).

Compare the results to help assess whether:

a) The herbicide treatment method was successful or not in reducing the amount of African Lovegrass on the site;

b) African Lovegrass seedlings have germinated; and/or

c) The type of plants (native or exotic, annual or perennial) that have replaced African Lovegrass.

Herbaceous Plant Species Abundance

Property ID	
Assessment Site	

Date:	Recorder:	Treatment

Notes:

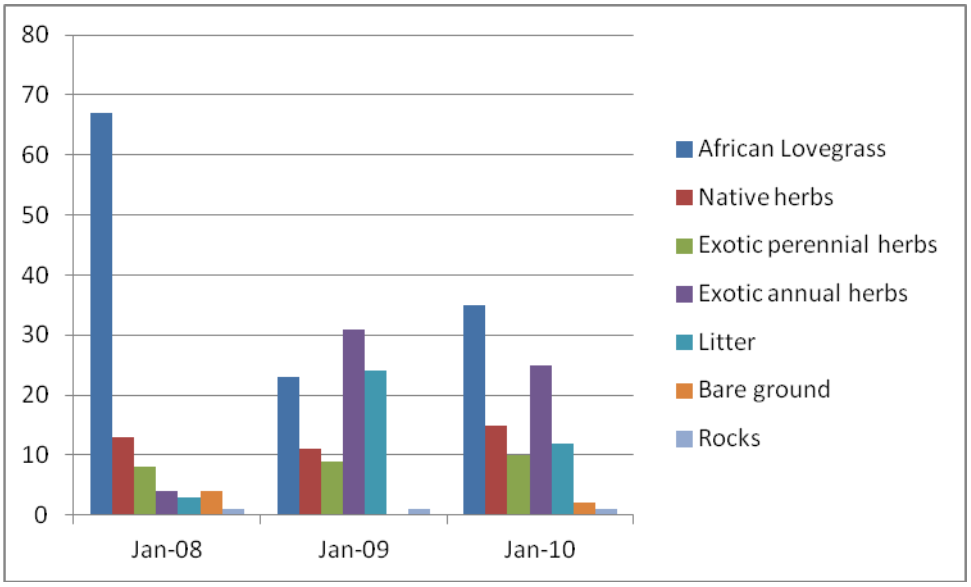
Species Name (or descriptive-name)	Tally	Total	%
African Lovegrass	e.g. ~~1111~~ 111	8	
Native herbs			
Annual exotic herbs			
Perennial exotic herbs			
Bare ground			
Litter			
Rocks			
Total hits			

% is the number of hits for each species or group of species divided by the total number of hits multiplied by 100.

Example:

Notes: African Lovegrass was sprayed in December 2008, but no follow up spraying undertaken.

	May 2008	May 2009	May 2010
African Lovegrass	67%	23%	35%
Native herbs	13%	11%	15%
Exotic perennial herbs	8%	9%	10%
Exotic annual herbs	4%	31%	25%
Litter	3%	24%	12%
Bare ground	4%	0%	2%
Rocks	1%	1%	1%



a) Interpretation: African Lovegrass mainly replaced by exotic annual herbs. No change in dominance of native plants, but slight increase in perennials. Without follow-up treatment African Lovegrass has either resprouted from only partially dead plants or has germinated from seed. Undertake follow-up treatment and keep monitoring.

2. Treatment success

This indicator is used to determine how successfully treatments have controlled African Lovegrass. This may be measured on the transect above (see point 3), but may be undertaken in more or different locations.

Timing

Following treatment application

Resources

Field sheet

Field procedure

In a line, identify 20 African Lovegrass plants that have been treated, and mark it as alive, dead or partial kill. If plants are in the line that have not been sprayed, indicate as not sprayed, alive.

Repeat this at least twice in different parts of the area treated, to get a good representative sample of the level of success. Convert the total to a percentage.

Take photos of areas monitored.

Interpretation:

Summarise the results. Compare with results from other sites to help assess whether:

d) The herbicide treatment method was successful or not;

e) Seasonal conditions or timing of spraying have affected results;

f) Contractors have missed plants on the site;

g) African Lovegrass seedlings have germinated; and

h) Follow-up treatment may be required.

Treatment Success

Property id	Assessment site	Photos
Date:	Recorder:	Treatment:

Notes:

Status: Alive treated: AS; alive not treated: ANT; Dead: D; Partially alive: P

Plant ID	Status A ANT P D	Health Strong = 3 Mod = 2 Weak = 1	Plant ID	Status A ANS P D	Health Strong = 3 Mod = 2 Weak = 1	Plant ID	Status A ANS P D	Health Strong = 3 Mod = 2 Weak = 1
1			21			41		
2			22			42		
3			23			43		
4			24			44		
5			25			45		
6			26			46		
7			27			47		
8			28			48		
9			29			49		
10			30			50		
11			31			51		
12			32			52		
13			33			53		
14			34			54		
15			35			55		
16			36			56		
17			37			57		
18			38			58		
19			39			59		
20			40			60		

Estimation of survival rate of African Lovegrass overall	≤10%	11-20%	21-40%	41–60%	61-80%	80%+
Survival patchiness of African Lovegrass overall	Uniform		Slightly Patchy		Very Patchy	

Example; sprayed in December 2008

Year	Dead	Partially alive	Alive, treated	Alive not treated
2009	60	23	10	7