Northern Australia Environmental Resources Hub

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Management options for gamba grass (*Andropogon gayanus*) in conservation areas of Cape York Peninsula

Final report

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Cover photographs

Front cover: Project team and partners from left to right: Helen Murphy (CSIRO), Matt Bradford (CSIRO), Andrew Ford (CSIRO), Natalie Rossiter-Rachor (CDU), Wayne Vogler (QLD DAF Biosecurity Queensland), Clare Warren (QLD DAF Biosecurity Queensland), Joe Vitelli (QLD DAF Biosecurity Queensland), John Clarkson (QLD DES) (photo Lyndal Scobell).

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Contents

List of tables

List of figures

Acronyms and abbreviations

NESP............. National Environmental Science Program

EPBC Act...... *Environment Protection and Biodiversity Conservation Act 1999*

NT.................. Northern Territory

WA .... Western Australia

QLD............... Queensland

QPWS .... Queensland Parks and Wildlife Service

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- All participants at the gamba workshop in Cairns July 2019 (Appendix 2) for openly sharing their successes, challenges and priorities for further research around management of gamba
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Executive summary

Andropogon gayanus (gamba grass) is a high-biomass grass native to tropical and subtropical Africa and introduced into Australia as a pasture grass. Under well-managed grazing conditions, gamba grass has proven a useful and palatable addition to tropical cattle pastures. However, it has also become a significant environmental weed and is considered an ecosystem transformer. In recognition of the significant threat posed by gamba grass, it has been listed (along with 4 other invasive grasses) as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

One of the major problems limiting the effective management of gamba grass once established as an environmental weed is the lack of registered herbicides for use in natural systems and conservation areas. Glyphosate is the primary herbicide in use in northern Australia.

There are several current and emerging issues which make a reliance on glyphosate for gamba grass control problematic. Application of glyphosate is logistically difficult in wet and remote areas, it has no residual action and largely relies on follow-up treatments, and there are emerging resistance issues. In addition, there is growing concern that glyphosate may be linked to carcinogenicity, genotoxicity and epidemiological disorders. Alternative herbicides are critical to allow long-term, effective and timely control of gamba grass in the environments encountered on Cape York Peninsula and across northern Australia.

The goal of this project was to collate existing knowledge related to control and management of gamba grass and test alternative herbicide options for use in natural areas of Cape York Peninsula. Three herbicides were tested alongside glyphosate in field trials and 10 residual pre-emergence herbicides were tested in pot trials. Neither the field nor pot trials identified a clear suitable alternative to glyphosate that selectively controlled gamba grass with low off-target effects in the contexts in which we tested them. However, there are several herbicides that warrant further testing at a range of additional application rates and in a range of environments (flupropanate, clomazone, oxyfluorfen, imazapyr and indaziflam). In particular, the granular form of flupropanate is worthy of further experimentation because of its portability in the field and flexibility in application, and because it showed the most promising results in the field trials.

Ultimately, land managers may need to trade-off significant, short-term, off-target effects for longer term, more effective and permanent control of gamba grass with herbicides.

1. Introduction

Gamba grass (*Andropogon gayanus*) is a high-biomass grass introduced to Australia in the 1930s from Africa as a tropical pasture grass. It was released commercially as *A. gayanus* cv. Kent in 1986 and was widely sown in the Northern Territory and parts of Queensland. It is now established in savanna ecosystems across northern Australia and has the potential to grow in a wide range of environments (Flores et al. 2005).

Under well managed grazing conditions, gamba grass has proven a useful and highly palatable addition to tropical cattle pastures in Australia and across the tropics. However, if not heavily grazed, burnt or cut annually it quickly produces large culms, becomes less palatable and readily seeds. The dominance of gamba grass in a landscape typically sees a reduction of native plant and animal diversity and abundance (Ferdinands et al. 2005; Kutt and Kemp 2012) with long-term floristic and diversity implications. Gamba grass has a demonstrated ability to reduce both plant (Brooks et al. 2010; Bowman et al. 2014; Setterfield et al. 2018) and animal (Brooks and Griffiths 2004) diversity and abundance through altered biomass accumulation and fire regimes, and changes in microclimate.

In 2009, the invasion of northern Australia by gamba grass and four other introduced grasses was recognised as a key threatening process and a National Threat Abatement Plan (Australian Government 2012) was developed under the EPBC Act to address ecosystem degradation, habitat loss and species decline. In 2012 gamba grass was recognised as one of 32 Weeds of National Significance (WoNS) and a Gamba Grass National Strategic Plan 2012–2017 was developed.

Despite the declaration of gamba grass as a key threatening process and weed of national significance, the species has continued to spread throughout the Northern Territory, Queensland and Western Australia. One of the major problems limiting the effective management of gamba grass once established is the lack of registered herbicides for use in natural systems and conservation areas, especially where infestations cover large areas. Chemical control currently relies heavily on minor use permits for the control of environmental weeds in non-crop areas. The use of non-selective herbicides such as glyphosate has off-target impacts on native vegetation, but there are few selectives available with on-label registration for control of invasive grasses in conservation areas. Herbicide research aimed at the selective control of gamba grass in native grassy ecosystems is needed urgently.

Glyphosate is the most widely used herbicide in the world. There is growing concern that glyphosate or other ingredients in glyphosate-based formulations are linked to carcinogenicity, genetoxicity and epidemiological disorders. Despite numerous studies on the use and over-use of glyphosate, it is not possible to categorically attribute any potentially harmful effect to humans (Torretta et al. 2018). There are also logistical issues with the widespread use of glyphosate. Widespread foliar spray applications rely on large, heavy and expensive spray equipment and access to clean water, which can be very difficult to manage in areas away from roads. Application of glyphosate also requires access to gamba infestations during the wet and humid growing season in northern Australia, which is often limited or impossible. Moreover, glyphosate has no residual action and largely relies on follow-up treatments, and there are emerging resistance issues.

Alternative herbicides are critical as insurance against future limitations on the use of glyphosate, to combat resistance, and to allow effective, timely control in the environments encountered on Cape York Peninsula and across northern Australia.

1.1 Aim of this project

The aim of this project was to collate existing knowledge related to control and management of gamba grass and test alternative herbicide options for use in natural areas of Cape York Peninsula. The project consisted of the following components:

(1) A **literature review** was conducted to consolidate information about the species' biology in its native and introduced environment to gain insights that may aid in developing effective management and control in Australia. We also review current knowledge about detection, management and control practices in Australia and identify research gaps and opportunities for future research. See Appendix 1 for the full literature review.

(2) A **workshop** was held in Cairns in July 2019 to bring together project partners and end-users from across the gamba grass range to agree on the detail of the research plan (i.e. experimental design, herbicide options etc.). The workshop also facilitated sharing of current knowledge about distribution, spread, biology and management practices for gamba grass. See Section 2.1 for a summary of the workshop and Appendix 2 for additional workshop notes.

(3) Results from the workshop and review informed the design and conduct of **field trials** on a range of potential herbicide options for on-ground management of gamba grass on the conservation estate in Cape York. The results of the field trials are reported in the main body of this report.

(4) Results from the workshop and review also informed the design of **pot trials** testing a broader range of herbicides than could be tested in the field. The aim of the pot trials was to test the tolerance of gamba grass, co-occurring native plant species plus one widely distributed exotic grass, *Bothriochloa pertusa* (Indian blue grass), to a range of residual pre-emergence herbicides in an effort to identify herbicides that selectively control gamba grass as it germinates while minimally impacting at least a few native plant species. The full results of the pot trial are included in Appendix 3.

2. Methodology

2.1 Gamba workshop

A 2-day workshop was held in Cairns in July 2019 to share knowledge about control successes and challenges with gamba grass. Over 40 land managers, scientists and weed control experts from across Cape York Peninsula and northern Australia attended the workshop to contribute their knowledge to the design of herbicide trials for the project. On-ground managers came from 18 organisations, including three Indigenous Ranger groups, Queensland state and local government, Northern Territory Government, Western Australian Government, South Endeavour Trust and natural resource management groups. A key outcome of the workshop was a consensus on the most promising herbicides and application methods. These outcomes were used to determine the treatment options trialled in this project.

A summary of the findings of the workshop is included in Appendix 2. Workshop attendees agreed that the current most promising herbicide option was flupropanate, which can be applied in liquid or granular form. Emerging promising herbicide candidates were terbacil, sulfometuron and imazapyr. Candidate herbicides still at experimental stage included clethodim, clomazone, bromacil, indaziflam, butroxydim, oryzalin and haloxyfop. A full summary of the herbicides considered for field and pot trials is included in Appendix 4.

The herbicide selection, rates, application methods and timing were designed in close collaboration with Biosecurity Queensland staff. Flupropanate (liquid and granular), sulfometuron and terbacil were ultimately included in the field trials along with glyphosate for comparison (control).

2.2 Field trial locations

Locations for suitable field trial sites were identified with the support of staff from Queensland Parks and Wildlife Service (QPWS) in early 2019.

Twelve field trial plots were established directly adjacent to the Hann Tableland National Park. Sites were located across two privately held properties, just outside the boundary to the national park but in areas where QPWS staff actively manage gamba and other high-biomass grasses with fire and herbicide to prevent incursions into the park. This approach (rather than siting trial plots in the park itself) allowed us to run trials without impacting normal on-park management of gamba grass where eradication is the goal and gamba grass distribution is currently very limited.

The density of gamba grass across the Hann Tableland study area is highly variable, though mostly low. We selected locations encompassing the range of observed gamba density. We arbitrarily classified cover as relatively low (2–5%) initial gamba cover, moderate (5–15%), or high (>15%) (Table 2.2).

In late 2019, an additional 6 trial plots were established at Alkoomie Station, a South Endeavour Trust property near Cooktown. However, travel restrictions across Cape York, commencing in March 2020, meant that these sites were unable to be treated with herbicide at an appropriate time and therefore were not included in ongoing field trials.

Access was maintained to the Hann Tableland sites other than for approximately 3 months between late March and June 2020. The Hann Tableland sites were treated with herbicide between late January and early March 2020, before the COVID field work restrictions.

2.3 Plot design and vegetation survey

A total of five blocks (10 m x 10 m or 0.01 ha) were established at each of the 12 plots (50 m x 10 m). Within each plot three replicate blocks using the same herbicide treatment (i.e. blocks 1, 3 and 5) alternate with two control blocks (i.e. blocks 2 and 4) (Figure 2.1). Thus, across all 12 plots a total of 60 blocks were established, with 36 treatment blocks and 24 control blocks. Four herbicide treatments were applied (see Section 2.4) to each of three plots resulting in each treatment being applied to a total of 9 blocks.

All control blocks were treated with glyphosate. Given the active gamba management (with glyphosate) undertaken in this area to prevent incursion into the adjacent national park, controls with no treatment were considered to pose a high risk of jeopardising the eradication efforts.

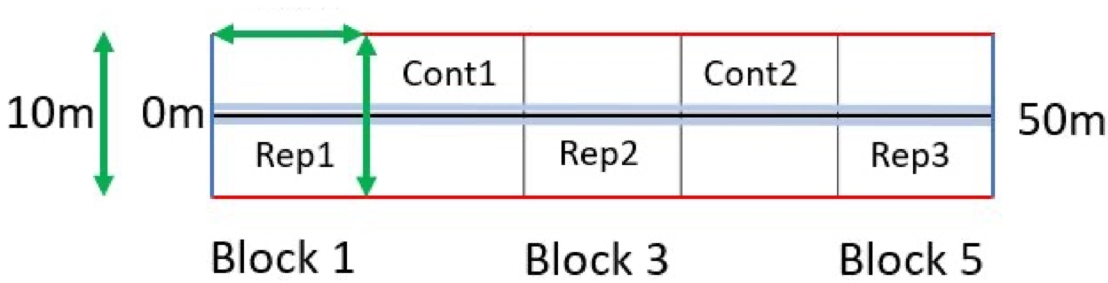

Figure 2.1. Plot design for herbicide trials.

A comprehensive survey of the native vegetation composition and structure, as well as the distribution and abundance of gamba grass and other invasive species, was conducted during baseline surveys and 3 post-treatment surveys.

Baseline vegetation surveys were conducted between March and June 2019. Herbicides were applied between January and March 2020. Post-treatment surveys were conducted in June–July 2020, November 2020, and May–June 2021. The following methodology was used to survey the plots:

The baseline and subsequent surveys included the following data:

1. The location of all gamba plants within each block.
2. Cover of gamba throughout each block as a percentage.
3. Health of gamba. For example, ‘vigorous growth, no tillers’ and ‘most plants with many tillers, post anthesis with some mature seed, basal leaves withering’.
4. Number of flowering and non-flowering gamba plants in each block in each of 3 cohorts: 1 = recent recruit, 2 = 2nd year recruit indicated by number of tillers and ‘woodiness’, 3 = mature plant/many tillers.

5. Ground cover of other native and non-native species: Total percentage ground cover, major species and their percentage cover.

2.4 Herbicide treatments

The herbicide treatments were (Table 2.1):

- Flupropanate granular form
  - https://www.granularproducts.com/content/uploads/pdf_Flup_Product-Guide.pdf
- Flupropanate liquid form
  - https://growchoice.com.au/wp-content/uploads/2015/05/TUSSOCK_HERBICIDE_DFU.pdf
- Terbacil-sulfometuron mix
  - https://www.agnova.com.au/content/custom/products/files/Sinbar-label.pdf
  - https://www.apparentag.com.au/documents/labels/68313_APPARENT_SHATTER_750_WG_HERBICIDE_Label_2.pdf
- Terbacil-sulfometuron glyphosate mix
  - As above
  - https://cdn.nufarm.com/wp-content/uploads/sites/22/2018/05/03075953/weedmasterDUO53576_58651071014.pdf
- Glyphosate (control)
  - https://cdn.nufarm.com/wp-content/uploads/sites/22/2018/05/03075953/weedmasterDUO53576_58651071014.pdf

Pre-treatment preparations included weighing the dry herbicides into individual bags or vials at the appropriate application rate, ensuring efficient and accurate delivery in the field. The chemical red dye (Rhodamine) was also used with each liquid herbicide treatment to assist with clear identification of treated plants. Each plot was completed at the same time for uniformity (i.e. treatment and control delivered on the same day).

All individual tussocks were treated by hand sprayer or a handgun for the liquid applications as mechanised sprayers were impractical to use due to the distance away from access roads and tracks. A hand spreader was used for the granular form of flupropanate which was applied evenly over the entire plot area. The following gives the 3 methods used to deliver the herbicides within the plots.

a. Flupropanate – granular; hand spreader; treat whole 10 m x 10 m block (Schotts – https://www.scottsaustralia.com.au/our-brands/scotts-lawn-builder/scotts-lawn-fertiliser-spreaders/scotts-easy-handheld-fertiliser-spreader/
b. Flupropanate – liquid; hand gun (NJ Phillips) with no tip; crown spotting each plant (https://www.phillipsgreen.com/epages/phph5632.sf/en_AU/?ObjectPath=/Shops/phph5632/Categories/%22Weed%20Control%22)
c. Terbacil, sulfometuron, glyphosate – liquid; crown spotting each plant, standard hand sprayer with fine mist control nozzle.

Herbicide was applied in the early wet season when gamba grass had achieved approximately 30–45 cm of leafy growth. The only exception was with the application of granular flupropanate at 2 plots which were burnt in the dry season (July 2019) requiring treatment following the first rains and subsequent active growth (early January) (Table 2.2).

Table 2.1. Herbicide treatment application and rates.

Treatment	Herbicide	Product	Application	Rate
1 – Flup_gran	Flupropanate (Group J) – granular	Flupropanate Granular Products 86.9 g/kg	Granular application	102.9 kg/hectare = 1.029 kg/block Using hand-spreader (e.g. Schotts)
2 – Flup	Flupropanate (Group J) - liquid	Tussock (745 g/L)	Liquid; crown application	5 ml crown application at 300 ml/L water Using hand gun (e.g. NJ Phillips) with no tip
3 – Terb_sulf	Terbacil (Group C) **and** Sulfometuron (Group B)	Sinbar (800 g/Kg AI) **plus** Shatter (750 g/kg AI)	Liquid; foliar spray	2000 g/ha (200 g/100L) Sinbar **plus** 200 g/ha (20 g/100L) Shatter Using standard hand sprayer, fine mist
4 – Terb_suf_gly	Glyphosate (Group M) **and** Terbacil (Group C) **and** Sulfometuron (Group B)	Weedmaster (360g/L AI) **plus** Sinbar (800g/Kg AI) **plus** Shatter (750g/kg AI)	Liquid; foliar spray	1 L/100L Weedmaster **plus** 2000 g/ha (200g/100L) Sinbar **plus** 400 g/ha (40 g/100L) Shatter Using standard hand sprayer, fine mist
C – Gly	Glyphosate (Group M)	Weedmaster (360 g/L AI)	Liquid; foliar spray	1 L/100L Using standard hand sprayer, fine mist

Table 2.2. Plots with initial gamba cover and treatment.

Plot	Initial gamba cover	Treatment	Date	Note
1	Moderate	Flup_gran	23/01/2020	Burnt mid-2019
2	Moderate	Flup_gran	23/01/2020	Burnt mid-2019
3	High	Terb_sulf	23/01/2020	
4	Low	Flup	6/03/2020	
5	Low	Flup_gran	6/03/2020	Grazed late 2019
6	Moderate	Flup	6/03/2020	
7	High	Flup	6/03/2020	Grazed late 2019
8	High	Terb_sulf	21/02/2020	Grazed late 2019
9	High	Terb_sulf	21/02/2020	
10	Moderate	Terb_sulf_gly	2/03/2020	
11	Low	Terb_sulf_gly	2/03/2020	
12	Moderate	Terb_sulf_gly	2/03/2020	Grazed early 2020

3. Field trial results

Gamba grass cover decreased under all treatments except the flupropanate liquid application within the first 4 months following treatment (Figure 3.1 and Figure 3.2 Baseline to late wet). The largest decreases in cover were seen in the glyphosate and glyphosaten–terbacil–sulfometuron treatments. By the late dry season survey (Figure 3.1 and Figure 3.2: Baseline to late dry), cover had decreased significantly in all treatments consistent with the dying back of ground cover for all native and non-native species generally across all plots (Figure 3.4). The final survey (Figure 3.1 and Figure 3.2: Baseline to late wet Year 2) shows that most treatments had no significant impact on gamba grass cover coming into the second growing season post-treatment. However, the flupropanate granular treatment did appear to produce some reduction in gamba cover at this time point.

The number of fertile stems in the first survey post-treatment (2020 flowering season) was lower across most treatments than in the final survey (2021 flowering season) when most stems were fertile (Figure 3.3a). Again, the exception was for the flupropanate granular treatment where the proportion of flowering stems was similar in the first and second flowering season.

Recruitment of gamba stems was evident in both growing seasons post-treatment. However there were fewer recruits in the second growing season (2021) across the glyphosate and terbacil–sulfometuron treatments (Figure 3.3b).

Ground cover of native species was slightly lower in the final survey compared with the baseline and first post-treatment (late wet season year 1) survey (Figure 3.4) although there was very high variability among plots. The cover of non-native species (excluding gamba) decreased through the late dry season but otherwise exhibited little change between the first and final survey.

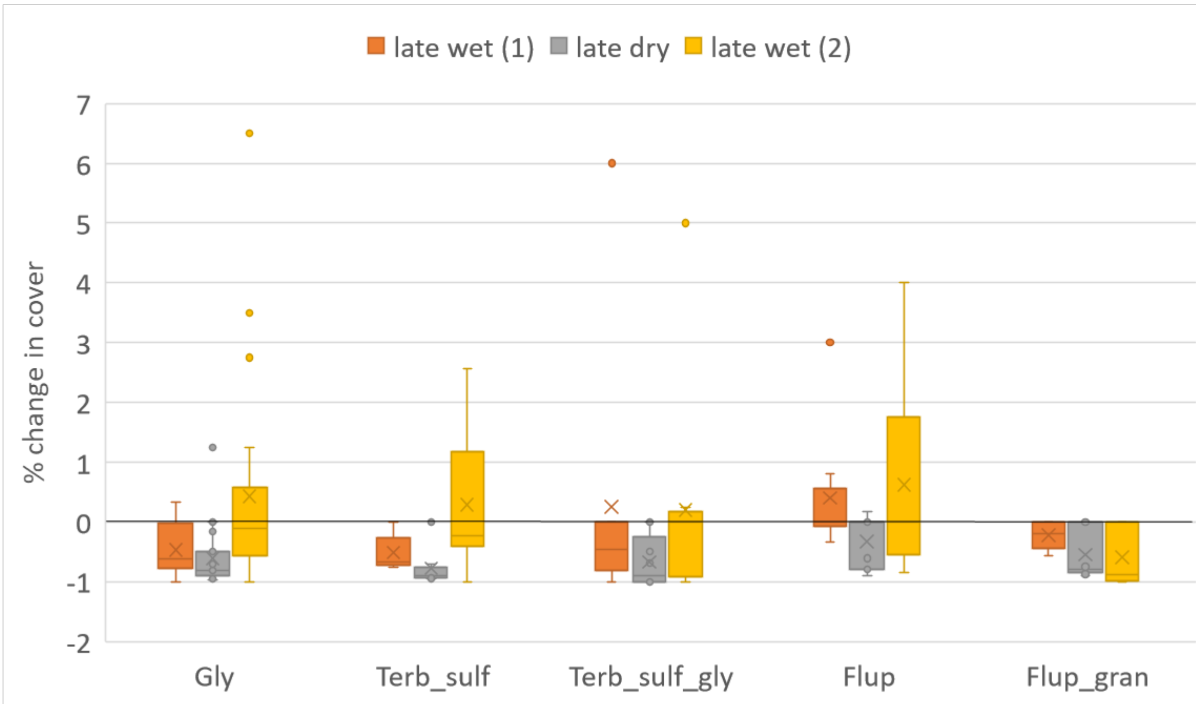

Figure 3.1. Change in cover of gamba grass from baseline survey to first post-treatment survey (late wet 1), second (late dry) and final survey (late wet 2). Positive values indicate an increase in gamba cover compared with the baseline, negative values indicate a decrease in gamba cover compared with the baseline.

Whiskers indicate the minimum and maximum values (except where there are outliers which are represented by filled dots), boxes represent the interquartile range (25% to 75%), and the median is represented by a cross.

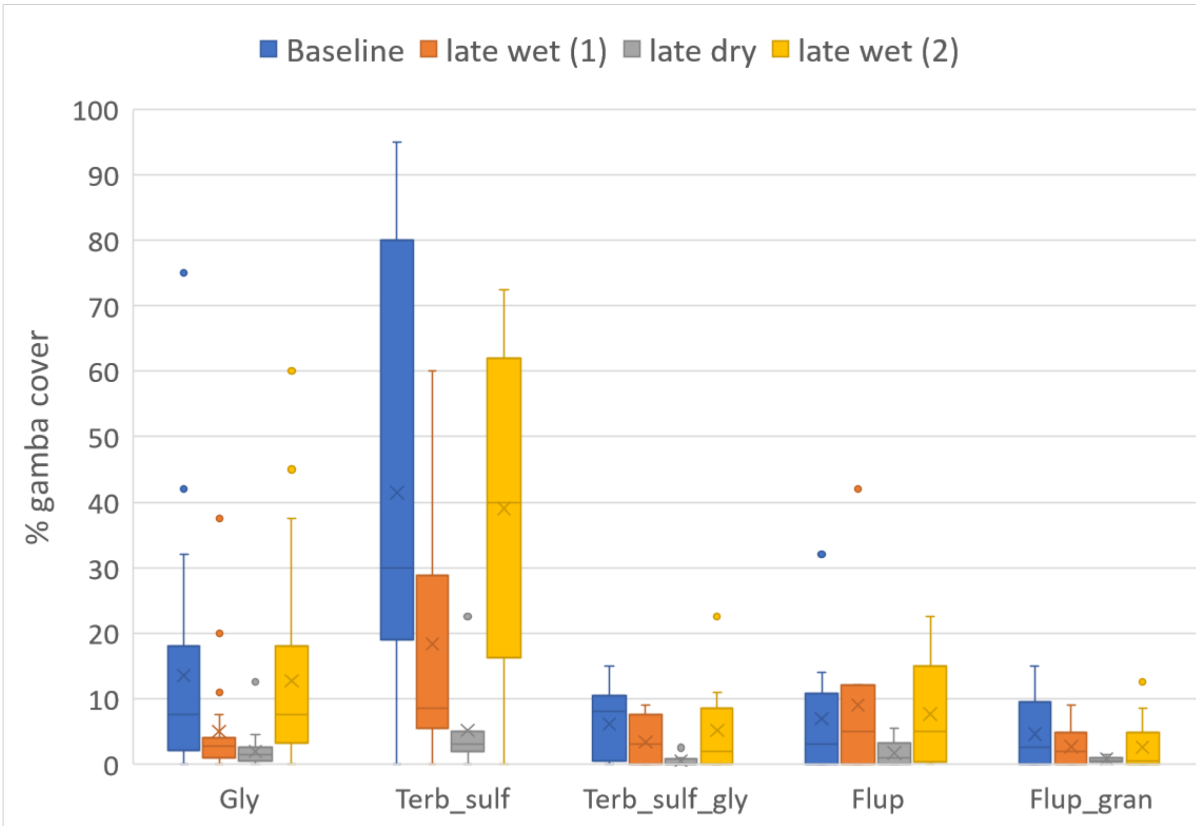

Figure 3.2. Change in total gamba cover from baseline survey to first post-treatment survey (late wet 1), second (late dry) and final survey (late wet 2).

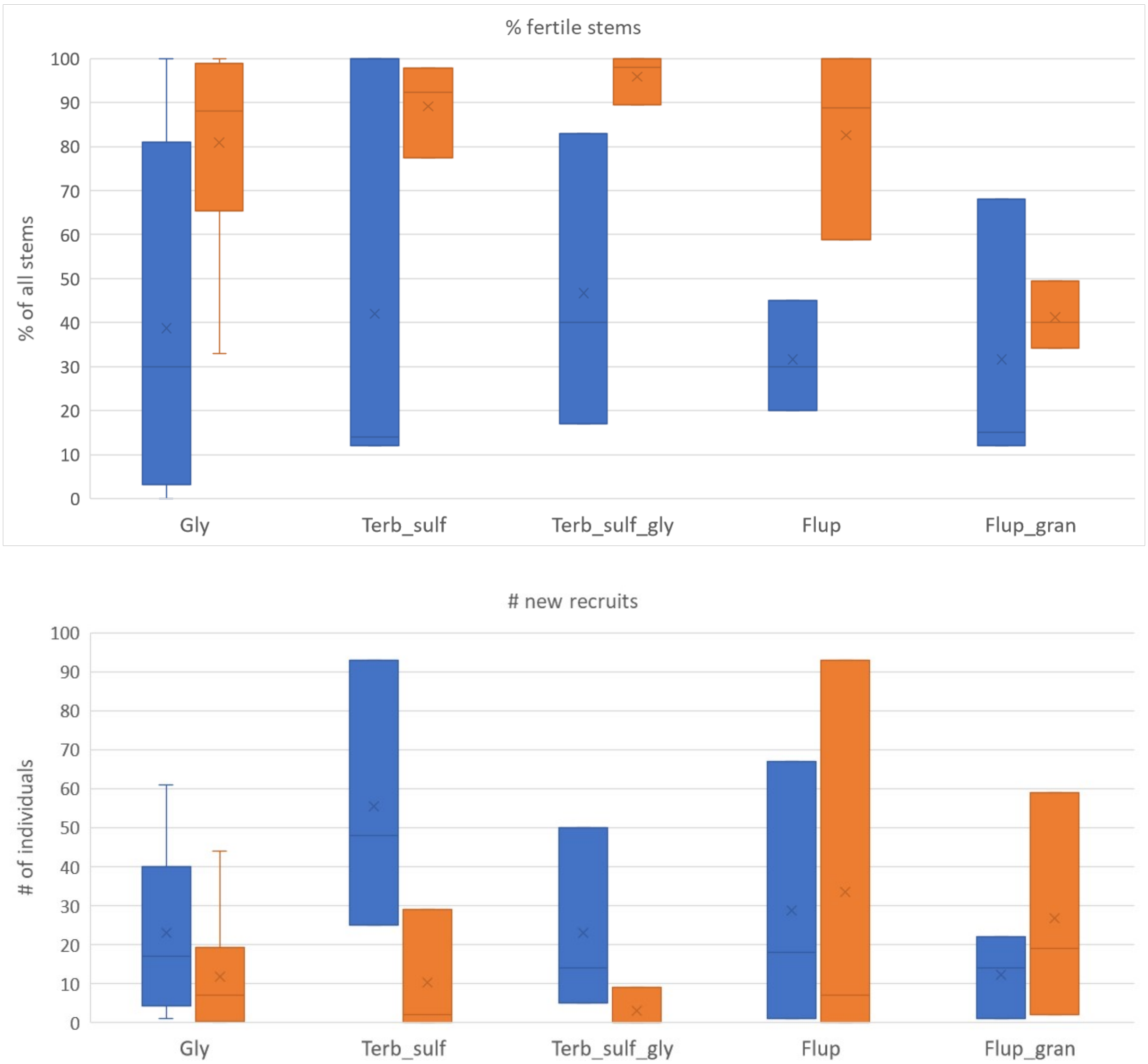

Figure 3.3. (a) The percentage of fertile gamba stems and (b) the number of recruiting gamba seedlings in the first post-treatment survey – late wet (blue bars) and in the final survey – late wet year 2 (orange bars).

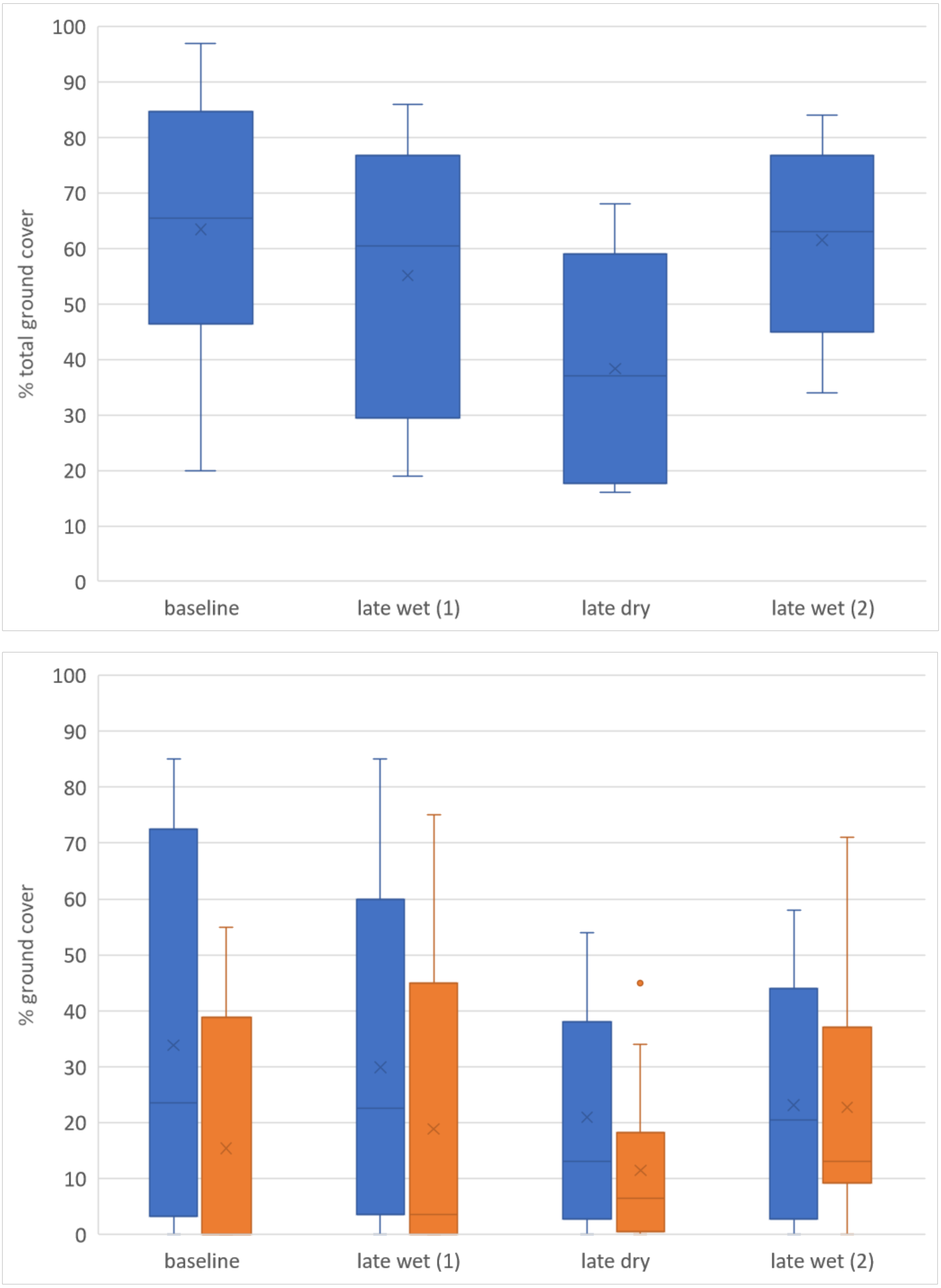

Figure 3.4. (a) Total ground cover, and (b) ground cover of native species (blue) and non-native species excluding gamba grass (orange) at each survey period.

4. Conclusions

Field trial results do not indicate a clear suitable alternative to glyphosate for gamba grass control among the herbicides we tested. In fact, even the glyphosate treatment was not effective at reducing cover or suppressing flowering or recruitment into the second growing season post-treatment in our field context.

It is possible that we have just begun seeing the full effect of the flupropanate granular treatment and that there may be a residual effect impacting gamba cover and flowering, though germination rates are still relatively high. Gamba cover has, on average, remained lower than the baseline through each of the post-treatment flupropanate granular surveys. It is important to note that flupropanate granular was the only herbicide to be applied over the entire 10 x 10 m block; all liquid herbicides were applied directly to live gamba tussocks. Therefore we would expect the granular application to have better suppression of gamba cover at the scale of the block than the liquid form of flupropanate. In addition, two of the plots to which flupropanate granular was applied were burnt (low intensity fire) between the baseline survey and the herbicide application. As a result, ground cover of both native species and non-native species was reduced across the entirety of those two plots leading into the first wet season and likely influenced the overall reduction in gamba cover seen between those two surveys.

Given the dynamic nature of vegetation cover and composition in our field trial location, it is difficult to discern subtle off-target effects of herbicides among the noise of natural variation. However, we did not detect significant changes in cover of native or other non-native species, or notable (visible) off-target effects on native vegetation that could be attributed to herbicide use.

Our results are largely consistent with the results of the pot trials undertaken as part of this project (Appendix 3). Neither flupropanate, nor a terbacil–sulfometuron mix effectively supressed gamba grass in pot trials. However, these herbicides also did not suppress native species germination indicating that higher rates could be trialled to determine if there is a point where they do selectively control gamba germination while minimising off-target effects. In the pot trials, the most effective herbicides for suppression of gamba germination were clomazone, oxyfluorfen, imazapyr and indaziflam. All had large off-target effects on native species. Indaziflam effectively suppressed all native and invasive species germination. The other three herbicides also effectively suppressed almost all native grass species germination. However, *Phyllanthus calycinus* and *Crotalaria medicaginea,* both dicotyledons, showed reasonable tolerance to most herbicides (except indaziflam).

Other field and experimental trials have also had varied results. While glyphosate is generally considered an effective herbicide for gamba grass control, the reported rate of application needed for a satisfactory mortality rate varies. Broadcast herbicide trials by Barrow (1995) show that applications of glyphosate or mixtures containing glyphosate applied at high rates were most effective in achieving the highest tussock kill rate. Glyphosate on its own gave a similar result as glyphosate mixed with amitrole/ammonium thiocyanate or sulfometuron. Even at relatively high rates, mortality after 7 months was in the range 60–75%.

Flupropanate is generally considered the most promising residual herbicide for gamba grass control. However, trials as a broadcast spray (Barrow 1995) and a spot spray (NT Government unpublished) have shown only moderate mortality rates on tussocks and little residual effect on germinants or mature plants post application. Subsequent field trials by Vogler (in prep) show unsatisfactory results as broadcast granular and spray application due to the prohibitively high application rates required to cause high tussock mortality and limited impact on seedling establishment. Results of a spot tussock application in both granular and liquid form applied in the late dry season were promising causing more than 80% tussock mortality. However, there was limited outward soil movement of the herbicide away from the tussocks resulting in little residual impact on emergent seedlings.

Sulfometuron, when mixed with terbacil, has also shown mixed results. It has proven largely ineffective in field trials in the NT (NT Government unpublished). However, in a recent mining rehabilitation trial in the NT, Luck et al. (2019) showed that sulfometuron (600g ai/ha), 2,2-DPA (29600g ai/ha), and terbacil (2000g ai/ha) applied to the soil after adult tussocks were killed with glyphosate all effected significant reductions in seedling emergence, and seedling survival at 5 months. Flupropanate (6705g ai/ha) showed a non-significant decrease in seedling density at both times. These results indicate that in some contexts, that is, correct pH, soil structure, clay content and climatic conditions, residual herbicides can be used as part of an integrated strategy.

The herbicide rates and applications used in our field trials were designed to be consistent with the rates and methods used by local land managers who are largely controlling a low-density gamba infestation on-foot, once per year. There are several potential reasons why the treatments used here in the field did not affect longer term reductions in gamba cover. One application is clearly not sufficient to provide effective population control by any of the herbicides we tested, and follow-up applications over multiple years are likely to be required. Higher rates of application are likely to be more successful in reducing cover, however they are also likely to have more off-target effects. It is also possible that some of the herbicide effects are still to be completely manifested in our field trials. For example, the flupropanate granular application label suggests that residual control may be up to 2 years depending on local conditions. Our field trials were conducted between 15 and 18 months.

In natural field settings there is a continual source of seed arriving from nearby plants and infestations. This is certainly the case in the Hann Tableland National Park and surrounds where dense infestations of gamba grass occur on neighbouring grazing properties. Therefore, it is difficult to understand the extent to which cover in the second-year post-treatment is a result of seed migrating from outside the plots or recruitment from the existing seed bank. In fact, we observed the spread of gamba across the area that our plots occur in through the study, as well as the increasing incursion of other invasive grasses including mission grass (*Pennisetum polystachion*) and giant rats tail grass (*Sporobolus pyramidalis*).

4.1 Recommendations

Although neither the field or pot trials identified suitable herbicides that selectively controlled gamba grass with low off-target effects, there are several herbicides that warrant further testing at a range of application rates and in a range of environments. These include flupropanate (liquid and granular), clomazone, oxyfluorfen, imazapyr and indaziflam.

In particular, flupropanate in the granular form is worthy of further experimentation. The granular form is appealing because it can be carried on-foot more easily into remote areas, it does not require water at the time of application, and there is no spray drift from liquid application so off-target effects can be minimised. Granules can sit on the soil surface where they remain intact until rain releases the active constituent and therefore the product has a flexible and long window of opportunity for application. It is reported to have significantly better residual control after 12 months than the liquid form (Flupropanate Granular Product Guide https://www.granularproducts.com/content/uploads/pdf_Flup_Product-Guide.pdf). However field trials comparing liquid and granule residual activity have not consistently supported this assertion (Vogler in prep).

Further tests could include a broader range of environments and co-occurring native species with the aim of refining the conditions where particular herbicides are most effective and identifying tolerant species that could be used as part of a restoration program.

Ultimately, land managers may need to trade-off short-term significant off-target effects for longer term more effective and permanent control of gamba grass. Some herbicides tested in this project, which effectively suppressed gamba grass and all other grass species, could be deployed to deplete the short-lived gamba grass seed bank. This approach, perhaps combined with assisted restoration of native species, could be used strategically to reduce infestations functioning as important seed sources in conservation areas.

Current on-ground management and control of gamba grass relies on integrated management, which includes a combination of restricting seed movement, herbicide application, and cultural management practices such as grazing, burning and slashing (NTGovernment 2018). For example, some herbicides have been shown to be more effective when combined with methods that reduce biomass initially (e.g. by slashing or grazing), or when used following control of adult plants killed with glyphosate. Examples of these approaches are discussed in detail in Appendix 1. Further exploration of integrated management approaches is warranted; however, like all approaches, success is usually context specific.

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Appendix 1: A review of the biology of gamba grass (*Andropogon gayanus* Kunth) relating to its effective management in Australia

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Executive summary

Andropogon gayanus (gamba grass) is a high-biomass grass native to tropical and subtropical Africa introduced into Australia as a pasture grass. Under well managed grazing conditions, gamba grass has proven a useful and highly palatable addition to tropical cattle pastures. However, it has also become a significant environmental weed and is considered an ecosystem transformer and has been listed nationally as a key threatening process of woodland ecosystems.

Gamba grass is now naturalised in tropical areas of Western Australia, Northern Territory and Queensland and the feasibility of eradication is low. Control and management efforts are largely directed towards containing the species to existing plantings, controlling it in strategic areas and eradicating new infestations and incursions. Current control methods are glyphosate application, cultural management practices such as grazing, burning and slashing, and enforcing compliance of plantings and seed movement. In conservation areas, control and eradication of gamba grass is usually the aim, however, widespread use of current management methods is often unfeasible due to a lack of resources, legal restrictions, and the remoteness of many locations. The detection of new isolated incursions in remote areas is also problematic. Therefore, land managers on these estates need new and novel tools to first detect incursions, then incorporate into effective control strategies.

In this work we review the species' biology in its native and introduced environment to gain insights that may aid in developing effective management and control in Australia. We also review current knowledge of detection, management and control practices in Australia to identify research gaps and opportunities for future research. From these reviews we propose a number of broad knowledge gaps:

- Detection and mapping of new incursions at a broad scale
- Modes and rates of dispersal
- Genetic diversity
- Emerging herbicides
- Biological control
- Biology – seed viability, response to fire, and response to nitrogen
- Costs of detection and management

Introduction

Gamba Grass (*Andropogon gayanus*) is a high-biomass grass introduced to Australia in the 1930s from Africa as a tropical pasture grass. It was released commercially as *A. gayanus* cv. Kent in 1986 and was widely sown in the Northern Territory and parts of Queensland. It is now established in savanna ecosystems across northern Australia and has the potential to grow in a wide range of environments (Flores et al. 2005).

Under well managed grazing conditions, gamba grass has proven a useful and highly palatable addition to tropical cattle pastures in Australia and across the tropics. However, if not heavily grazed, burnt or cut annually it quickly produces culms, becomes less palatable and readily seeds. It is able to outcompete native grass species through superior resource use efficiency (Bilbao and Medina 1990, Ens et al. 2015) resulting in higher rates of biomass accumulation (Setterfield et al. 2010, Setterfield et al. 2013). In addition, it has high seed yields (Gobius et al. 2001, Flores et al. 2005), and an ability to harvest water well into the dry season and respond quickly to storm season rains via a complex root architecture (Bowden 1963).

The invasive ability of gamba grass is further enhanced by its ability to colonise undisturbed ecosystems (Setterfield et al. 2005). Consequently, gamba grass is considered an ecological transformer species (Rossiter-Rachor et al. 2009) posing multiple threats to the savanna of northern Australia. Most obviously, the considerably larger fuel loads relative to native grasses (Rossiter et al. 2003, Setterfield et al. 2010) result in more intense fires (Rossiter et al. 2003). This rapidly and radically alters vegetation structure in the ecosystems it invades through high rates of tree loss (Ferdinands et al. 2006, Setterfield et al. 2010) and reduced recruitment of woody species (Setterfield et al. 2018). This risks transforming large areas of tropical savanna into grassland (Rossiter et al. 2003). Additionally, increased fuel loads and fire intensity accelerates nutrient loss (Rossiter-Rachor et al. 2008) and transforms soil nitrogen relations (Rossiter-Rachor et al. 2009) resulting in a rapid diminishment of nitrogen stores (Rossiter-Rachor et al. 2017).

The dominance of gamba grass in a landscape typically sees a reduction of native plant and animal diversity and abundance (Ferdinands et al. 2005, Kutt and Kemp 2012) with long-term floristic and diversity implications. Gamba grass has a demonstrated ability to reduce both plant (Brooks et al. 2010, Bowman et al. 2014, Setterfield et al. 2018) and animal (Brooks and Griffiths 2004) diversity and abundance through altered biomass accumulation and fire regimes, and changes in microclimate.

Gamba grass covers between 1 - 1.5 million ha in the NT (Northern Territory Department of Environment and Natural Resources 2017), approximately 60 000 ha in Queensland (Queensland Department of Agriculture and Fisheries 2016) and smaller areas in Western Australia. Along with the impacts on natural systems, the economic impacts of infestation are well recognised (see Beaumont et al. (2018)). The ability of gamba grass to radically alter fire regimes threatens the safety of residents on the peri-urban bushland fringes, impacts the viability of greenhouse abatement programs that rely on cool, early season burning (Adams and Setterfield 2013), and significantly increases the cost of fighting fires (Setterfield et al. 2013).

Gamba grass is a declared weed across Western Australia, Northern Territory, South Australia and Queensland. In 2009, the invasion of northern Australia by gamba grass and other introduced grasses was recognised as a key threatening process and a National Threat Abatement Plan (Australian Government 2012) was developed to address ecosystem degradation, habitat loss and species decline under the EPBC Act. In 2012 gamba grass was recognised as one of 32 Weeds of National Significance (WoNS) and a Gamba Grass National Strategic Plan 2012-2017 was developed. Management planning for the species is undertaken through a National Gamba Grass Taskforce set up to implement the plan. In 2013 the National Gamba Grass Research Workshop (March 2013) proposed eight themes of research gaps and opportunities: spread pathways and modelling, survey and delimitation, herbicide research, decision support, impact reduction, ecology, integrated management, social science.

In this work we review relevant aspects of the species' biology, management and control in its native and introduced environments with the aim of addressing a number of research gaps and identifying new knowledge gaps. We also discuss new and novel detection, management and control practices in Australia.

Nomenclature and taxonomy

The genus *Andropogon* lies within the tribe Andropogoneae, the subfamily Panicoideae, and the family Gramineae, and contains approximately 100 species mostly native to the tropical regions of Africa, the Americas and Asia. None are native to Australia. *Andropogon gayanus* is native to sub-Saharan tropical and subtropical African savanna and is almost absent from closed forest. The genus name is derived from the Greek *andro*, meaning male, and *pogon*, meaning bearded, referring to the hairiness of almost all plant parts. The species was named by Kunth in 1833 after the French botanist Claude Gay (1800-1873).

Andropogon gayanus is polymorphic and has been divided into four varieties, although there is some debate over the validity of all varieties (Foster 1962); var. *gayanus* (sometimes known as var. *genuinus* Hack.), var. *squamulatus* (Hochst.) Stapf, var. *bisquamulatus* (Hochst.) Hack, and var. *tridentatus*. The latter two have been placed in var. *bisquamulatus* Hack and subsequently this review recognises only three varieties. The variety *gayanus* is widespread across the species range and is common in swampy habitats. Varieties *bisquamulatus* and s*quamulatus* have a similar distribution to each other north of the equator but *bisquamulatus* is absent south of the equator. Foster (1962) notes that morphological variation is greater within than between these two varieties and the classification is unsatisfactory. Selection for cultivars has been restricted to var. *squamulatus* and var. *bisquamulatus* in Africa (Foster 1962), Australia (Oram 1990) and South America (Felippe et al. 1983). Studies on the biology of *A. gayanus* have largely been restricted to these two varieties (Foster 1962, Bowden 1964) and in this review they are treated as one.

The accepted common name in Australia is gamba grass, most likely named after the area around the once small fishing village of Gamba in Gabon, within the range of the species. Other names for the species are bluestem (Africa), Rhodesian andropogon (southern Africa), Rhodesian bluegrass (Zimbabwe), onga, tambuki grass (north-west Africa) and sadabahar (India).

Andropogon gayanus cv. Kent was registered in Australia in 1986 after a submission from the Northern Territory Department of Primary Production (Oram 1990). The cultivar most likely results from natural selection after cross fertilisations between material of CP 2312 from Nigeria in 1931, and CPI 9207 from an unknown source in Africa via Brazil in 1944. Cultivar Kent has some morphological characteristics of var. *squamulatus* and var. *bisquamulatus* so cannot be assigned to either variety.

Ecology

Distribution and habitat

The species naturally occurs in tropical and sub-tropical sub-Saharan Africa. Variety *bisquamulatus* is widespread across this distribution while var. *squamulatus* is restricted to areas north of the equator. Populations are generally limited to between 400 mm and 1500 mm rainfall. Below this value the climate becomes too seasonal and water availability becomes limiting in the dry season. Above this, either closed canopy communities dominate, or the dry season is not long enough for the species to have a competitive water use advantage. Latitudinal and altitudinal limits are presumed to be set by a mean minimum temperature of 4-5 ^{0}C (Bowden 1964).

Except for var. *gayanus,* the species responds poorly to seasonal flooding, waterlogged habitats or soils with impeded drainage (Bowden 1964, Baruch 1994, Barrow 1995, Flores et al. 2005) and requires a drying out period during the year for tussock persistence and seedling establishment. However, it grows well in moist environments just above swamp lines and in creek lines (Barrow 1995). In both its native (Vesey-Fitxgerald 1963, Bowden 1964) and introduced (Barrow 1995) range, gamba grass grows on a wide range of soil types and geologies and under a wide range of vegetation communities. The reported range of pH tolerance is 4.3 to 8.3 (Duke 1983). In its Australian distribution, germination and seedling establishment is enhanced by soil disturbance and removal of understory competition although in open woodland communities the canopy cover has little or no negative effect on invasion (Barrow 1995, Setterfield et al. 2005).

Growth and physiology

Gamba grass utilises a C_4 carbon fixation pathway like the vast majority of native grasses in the wet dry tropics of Australia (QLD 93%, NT 95%, WA 97%) (Hattersley 1983). It is a tussock forming perennial grass with reports of a tussock life span of >5 years (Bowden (1964) although the normal life span of a single tussock is undocumented. There are reports of mature tussocks and patches of tussocks senescing without explanation. Growth is vigorous during the wet season before flowering and seeding post wet season, followed by the cessation of growth and then curing in the late dry season. Regrowth starts at the beginning of the storm season although it can continue throughout the dry season if water is available. Tussocks readily resprout after fire, cutting and grazing, and mortality after fire is negligible. A tussock is capable of resprouting after fire within six months of germination (Setterfield et al. 2005).

Gamba grass has a complex root system comprised of three root types (Bowden 1963); 1) fine fibrous roots (0.5-2 mm diameter) just beneath the soil extending to >1m from the centre of the tussock, 2) thicker (2-3 mm diameter) starch filled cord roots that are little-branched extending outwards and downwards for a maximum 0.5 m anchoring the tussock, 3) vertical roots that are fine (0.5 mm) and little-branched growing vertically to the deeper layers of the soil reaching 1 m depth. The combination of these roots allows the plant to harvest water early in the wet season through the fibrous surface roots and well into the dry season through the deep vertical roots. The cord roots also provide a ready source of starch.

Gamba grass has a preference for ammonium (NH_4+) over nitrate (NO_3-) as a nitrogen source and maintains NH_4+ in the root zone through biological nitrification inhibition, a phenomenon common in tropical and subtropical pasture grass species (Subbarao et al. 2007). Inhibition occurs when nitrification inhibitors released by the roots block the action of nitrification bacteria (*Nitrosonoma* spp.) that transform NH_4+ to readily available, but volatile NO_3-. Gamba grass uptakes NH_4+ as a nutrient at higher rates than common native grasses (Rossiter-Rachor et al. 2009, Ens et al. 2015) and conversely there is evidence that native grasses uptake NO_3- at a higher rate than gamba grass (Rossiter-Rachor et al. 2009). In addition, grasses are able to vary the biological nitrification inhibition in response to high and low nitrogen sites (Lata et al. 2004). As a consequence, gamba grass is able to perform well at low levels of soil N, and soils associated with gamba grass infestations have reduced N pools with low NO_3- levels but significantly higher NH_4+ levels than natural systems (Rossiter-Rachor et al. 2009). The transformation of infested systems from NO_3- dominant to NH_4+ dominant coupled with an efficient use of nitrogen (Bilbao and Medina 1990, Ens et al. 2015) gives gamba grass a competitive nitrogen use advantage over native grasses. The consequence of high N uptake combined with a high above ground biomass of gamba grass is the high loss of nitrogen to the atmosphere during frequent fires in northern Australia with losses estimated to be up to 61 kg/ha/year (Rossiter-Rachor et al. 2008).

A further advantage over native Australian tropical grasses is gamba's superior ability to compete for light and water. Gamba grass produces more leaf area than native grasses and has higher photosynthetic and transpiration rates (Rossiter 2001). Measures of stomatal conductance, assimilation and transpiration in addition to photosynthetic nitrogen use efficiency are all higher than comparative native grass (Ens et al. 2015).

Dispersal

Field observations show that many gamba grass seeds fall unassisted within metres of the parent. When racemes are ripe and dry, they shatter at the joints and spikelet pairs separate allowing the seed to be released. As is the case for many species in the tribe Andropogoneae, the fertile spikelet bears a long awn which twists and straightens in response to humidity changes allowing the seed to migrate into soil cracks or favourable micro-topography. However, the gamba grass awn is not strongly held to the seed and many seeds on the ground are detached from the awn (MB pers. obs.).

Medium to long distance dispersal is predominantly via the vectors of wind, attachment and water. Ant and vertebrate dispersal is likely to be minor. Ant dispersal has been observed in temperate introduced grasses (Kelman and Culvenor 2007) but as grass seed lacks an ant attracting appendage, the seeds will mostly be predated with very few cached, and even then at distances similar to unassisted dispersal (but see Figure A-1). No vertebrate granivory has been reported on gamba grass, however non-specialist avian granivores are possible minor dispersers as they have been observed feeding on the introduced grass *Brachiaria decumbens* in northern Australia (Craig 2003). A more likely dispersal consequence of such feeding activity is seed attachment to feathers.

Vertebrate attachment and retention (epizoochory) is a common dispersal mechanism for grasses (Thomson et al. 2010). Initial attachment potential is regulated by both diaspore and infructescence morphology but has been shown to have little correlation with retention, dispersal propensity and dispersal distance (Will et al. 2007). Attachment is aided by hooks and hairs and, to a lesser extent, awns (Monty et al. 2016). The macrohairs on the lemma of a gamba grass spikelet are numerous and fine but are not hooked. However, the fineness of the hairs produces a static charge encouraging short term attachment. Moreover, the hairs are of singular orientation which enhance the ability of the seed to work its way into fur or feathers and be retained. We suspect that this results in only a moderate attachment and retention potential but still has the potential to result in minor long-distance dispersal on birds, and native and domestic mammals.

Of greater consequence is the deliberate and accidental dispersal by humans via cars, machinery, hay and trading of seeds (Figure A-2). While legislation prohibiting movement is in place and washdown facilities are often available, outlying incursions in the order of hundreds of kilometers from known infestations are an inevitable consequence of movement of seed and plant material.

Box 1. Estimating wind dispersal distance for gamba grass

Diaspores of Poaceae with a hairy lemma are effectively dispersed by wind (anemochory) (Hensen and Muller 1997). As part of this review, we sought to estimate maximum wind dispersal distance of gamba grass. First, we determined gamba grass seed traits relevant to wind dispersal, and initially assigned the seed to the wind dispersal syndrome with special mechanisms i.e. hairy glume and lemma. Second, we estimated mean seed fall velocity. Mean seed mass from a bulked seed sample of gamba grass (n=300) was 3.520 mg with the awn attached and 3.254 mg with the awn removed. The resultant mean fall velocity of a seed with the awn attached was 1.68 m/s (n=50, SD=0.27) with no significant difference when the awn was removed (1.77 m/s, n=50, SD=0.24). To estimate maximum wind dispersal distance at low wind velocities (<7 km/hr), we used the theoretical equation reported by Hensen and Muller (1997):

$$x = v * h/c$$

where v = wind speed (m/s), h = release height (m), and c = fall velocity (m/s).

At low wind velocities the horizontal dispersal distance is in the order of 5 m. However, with increasing wind speed, the dispersal distance increases in an approximately quadratic manner and the relationship reported by Hensen and Muller (1997) does not apply. To account for this, Tamme et al. (2014) proposed a model to estimate maximum dispersal distance by using maximum reported dispersal distances for a wide range of plants and incorporating specific seed mass, and release heights for seeds with specific structural traits. Presuming a release height of four meters, the potential dispersal distance of a gamba grass seed is estimated at 94 m, with a lower estimate of 21 m and an upper estimate of 430 m.

Figure A-1. Gamba grass seed (a) dispersed on the ground adjacent to an infestation and (b) surrounding an ant nest.

Figure A-2. Hay bale amid a gamba grass infestation in southern Cape York Peninsula

In seasonal tropical landscapes it is inevitable that water (hydrochory) will play a part in the dispersal of plants. Given that seed shed coincides with the dry season, water will act as a secondary dispersal vector during the following storm and wet season. Studies show that smaller seeds are carried shorter distances than larger seeds by water due to higher likelihood of entrapment in watercourse vegetation (de Jager et al. 2019) a phenomenon which is likely enhanced by the hirsute nature of gamba grass seed. Quantifying water dispersal distances in northern Australia is made difficult by extreme volumes of seasonal water, although it is safe to assume that maximum distances are limited only by contact with salt water. Given that gamba grass seeds are buoyant, dispersal onto large watercourses will cause a deposition of diaspores on the downwind shore (Sarneel et al. 2014).

Vegetative reproduction leading to dispersal has been observed in gamba grass. New individuals can be established from root stocks split from a mature tussock. Coppicing has been observed from detached tillers at the culm nodes and is a potential source of dispersal during flood events or forage hay transport. Lodging has been observed at high soil nitrogen levels (Gobius et al. 2001) and coppicing from nodes at soil contact is a potential mode of short distance vegetative dispersal.

Reproduction

Floral biology

Flowers are arranged in pairs of racemes on each culm, each raceme has approximately 12-20 spikelet pairs although up to 50 have been recorded (Bowden 1964). The sessile spikelet in each pair produces a caryopsis (fruit) while the pedicelled spikelet is sterile, although both produce pollen. The flowering process for both types of spikelets is similar, and rapid, and flowering takes place largely in the morning in response to heat, humidity and sunlight. Approximately two-thirds of sessile spikelets on a raceme will flower on the first day starting at the tips of the raceme, with the remainder flowering the next day (Bowden 1964) or into the third day (Foster 1962) progressing down the raceme. On the third day the pedicelled spikelets start opening from the tips and progress to the base with opening completed by the fifth day. Florets generally open within 5 minutes, remaining open for 30-60 minutes, then close, leaving the anther and stigma exerted. The anther can shed pollen immediately although it sheds more easily after several minutes. The stigma shrivels up on the second or third day after opening.

Flowering and seeding phenology

Flowering is initiated by short day lengths with a critical day-length for flowering between 12 and 14 hours with flowering becoming more intense as day-length shortens from 12 to 8 hours (Tompsett 1976). Growth hormone treatments will not initiate flowering on longer days (Tompsett 1976). In its native range, flowering culms emerge after the peak of the rains in early September and flowering starts immediately after the cessation of rains in October - December (Foster 1962, Bowden 1964). Flower production continues into the dry season (January-February). There is considerable variation in the date on which flowering commences; the timing coincides with the end of the wet season in a particular region. In Nigeria, dates of flowering commencement showed a range of 48 days within a range of approximately 600 km (Foster 1962).

In Australia, a similar seasonal pattern is followed with peak flowering in April following the wet season continuing into the early dry season (Oram 1990). However, late flowering or multiple flowering episodes are possible late into the dry season from culm production after slashing or burning (MB pers. obs.) in response to adequate soil moisture if the day length has not exceeded critical length. After cutting, burning or grazing, flowering can begin within 30 days (Gobius et al. 2001). After germination, plants are capable of tillering profusely and flowering within 10-15 weeks (Bowden 1963, 1964) which generally corresponds to the end of the wet season.

Each tussock has the potential to produce >100 culms per year although 30 -70 is more common (Bowden 1964, Flores et al. 2005). This can result in a culm density of 150 /m^2 although fertile culm numbers can be as low as 32% (Gobius et al. 2001). Glasshouse trials show that 25^0C is the optimal temperature for flowering and that plants flower more readily with tussock age (Tompsett 1976). The application of the growth regulators indol 3yl-acetic acid IAA (400 mg/L), abscisic acid ABA (25 mg/L), gibberellic acid GA (100 mg/L), N-dimethyl-aminosuccinamic acid B9 (100 mg/L) inhibit but do not eliminate flowering. Pollination is largely anemophilous (wind pollinated) although bees and insects collect pollen from the flowers (Bowden 1964) and can be assumed to be minor pollinators.

Seed production

Seed production is most influenced by the number of culms able to be produced by each tussock (de Andrade and Thomas 1984, Gobius et al. 1998, Flores et al. 2005). Early- to mid-wet season removal of biomass through cutting or grazing stimulates recovery and culm production. Late wet season removal of biomass through cutting or grazing reduces all metrics of seed production by minimising the accumulation of leaf mass and culm production before the onset of short days (de Andrade and Thomas 1984, Gobius et al. 1998). In this way, seed yield can be reduced by ~90% and germination success of seeds can be lowered (Gobius et al. 1998).

Seeds mature 4-5 weeks after flowering (Gobius et al. 1998, 2001). In its native range, a single tussock generally produces 12,000 seeds per year, although variation is high and >100,000 seeds per tussock per year is possible (Bowden 1964). In Darwin, Australia a mean of ~70,000 seeds are produced per tussock per year, ranging from 15,000 to 244,000 (Flores et al. 2005). Gobius et al. (2001) reports ~15,000 seeds /m2 from field trials in Thailand which equates to between 326 and 569 kg/ha of pure seed with a thousand seed weight of 3.35 g.

Box 2. Gamba grass reproductive timing and rate of seed production compared to native grasses.

The rate of seed production (period between culm elongation and seed fall) of gamba grass is approximately 10 weeks. This period is on average longer than, but still falls within the range of common native perennial and annual tropical grasses (Lazarides et al. 1965, Andrew and Mott 1983). Gamba grass produces multiple flowering culms in response to shortening day lengths at the end of the wet season. Seed fall occurs 4-5 weeks after flowering, generally from June to August. While the late seed production of gamba grass is a consequence of a critical short day length, it is aided by the species' ability to harvest available water well into the dry season due to a deep and complex root system.

Reproductive timing of common northern Australian native grasses in generally much earlier than gamba grass (Lazarides et al. 1965, Andrew and Mott 1983, Crowley and Garnett 1999, Garnett et al. 2005). The annual species *Aristida hygrometrica*, *Sorghum intrans, S. stipoideum* and the perennial *Chrysopogon fallax* and *C. latifolius* seed well before the end of the wet season. The perennial *Themeda triandra*, *Sehima nervosum* and *Heteropogon contortus* seed towards the end of the wet season. The annual *Schizachyrium fragile*, *S. pachyarthron*, *S. pseudeulalia*, *Sorghum australiense* and *S. brevicallosum* and the perennial *Sorghum plumosum* seed in the early dry season.

An advantage of late seed fall for invasion potential is a reduced time between seed fall and the first storms, giving less exposure time to seed predators. However, late seed production also provides opportunities for land managers to control incursions into the dry season while the plant is still actively growing and native grass seeds have already established a soil seed bank.

Seed germination

Germination occurs after the first rains of the storm or wet season after which dormancy rates are either low (Bebawi et al. 2018) or absent (Felippe et al. 1983). Drivers of germination are temperature and the availability of water; light has no effect on germination (Felippe et al. 1983). Germination takes place under a wide range of constant (~15 - 40°C, (Felippe et al. 1983, Bebawi et al. 2018)) and alternating day/night temperatures (16/12 - 47/39°C). Germination success declines towards the two extremes. At temperatures below ~15°C, seeds enter into dormancy with no effect on viability. Maximum seed viability is maintained at lower temperatures with a gradual decline in viability with increasing temperature (Bebawi et al. 2018). At temperatures above ~40°C both dormancy and loss of seed occurs and above 43°C seeds are rendered unviable within weeks. Imbibition of water by the seed takes approximately 1 day, the radicle emerges 2-6 days after wetting, and the coleoptile 1 day later. The vast majority of seeds germinate within 3-5 days at suitable temperatures. The coleoptile from a seed buried 3 cm in the soil will take 5-10 days to emerge to the soil surface (Bowden 1964).

In both the native and introduced range, the proportion of sessile spikelets containing seeds is generally low but is highly variable (Felippe et al. 1983), with values ranging from 1-63% (Bowden 1964, Felippe et al. 1983). Viability of harvested seed under laboratory storage conditions is in the order of 80% in the first year, falling to between 50-80% at 2 years, 20-70% at 3 years and 0% between 3-6 years (Bowden 1964). Viability of harvested seeds in the wet-dry tropics of Australia is notably less; ~64% (Bebawi et al. 2018), ~70% and ~46% (Flores et al. 2005). There is a rapid loss in viability under field conditions within the first 3-6 months. Bebawi et al. (2018) reports ~11% viability at 3 months, ~4% at 12 months and no viable seeds at 30 months. Flores et al. (2005) reports <5% viability at 6 months and <0.1% at 12 months. There is some evidence that higher clay content in the soil slightly lowers seed viability (Bebawi et al. 2018).

Initial germination percentages in laboratory conditions range from 71-77% (Gobius et al. 2001), ~70% (Felippe et al. 1983), to ~59% (Bebawi et al. 2018). Seed burial at depths >2.5 cm increases germination percent marginally at 3 months (Bebawi et al. 2018). Bowden (1964) also reports an optimum sowing depth for germination of approximately 3 cm.

Germination success under field conditions is much lower. Maximum reported values are 29% (Setterfield et al. 2005), 11% Barrow (1995), and <2% (Flores et al. 2005), the latter being more representative as the seeds lay *in situ* for 5 months to simulate realistic conditions. Factors increasing germination success in the field are canopy disruption and soil disturbance (Setterfield et al. 2005), particularly in wetter habitats (Flores et al. 2005). Removal of chaff from the seed does not affect germination percentage (Felippe et al. 1983).

Seedling survival after 3 to 5 months under field conditions is in the order of 80 to 100% (Flores et al. 2005), and 60 to 80% (Setterfield et al. 2005). Soil disturbance pre-emergence significant increases survivorship (Setterfield et al. 2005) while excessive soil moisture decreases seedling survival to the extent of total mortality in seasonally flooded habitats after rapid growth to >1 m in height (Flores et al. 2005). Conversely, emergent seedlings are tolerant to subsequent drying conditions largely due to rapid development of deep vertical roots and the proliferation of deep lateral roots (Buldgen et al. 1995).

Management

Legislation

The invasion of northern Australia by gamba grass and other introduced grasses is a key threatening process under the EPBC Act 1999. A National Threat Abatement Plan (Australian Government 2012) was developed to address ecosystem degradation, habitat loss and species decline due to invasion by introduced gamba grass, para grass, olive hymenachne, mission grass and annual mission grass. In 2012 gamba grass was recognised a Weed of National Significance (WoNS) and a National Strategic Plan was developed. A National Code of Practice for the containment of gamba grass to genuine grazing systems was developed by the National Gamba Grass Taskforce in 2013.

Gamba grass is a declared weed across Western Australia, Northern Territory, South Australia and Queensland. In Western Australia, gamba grass is a prohibited/declared weed under the Biosecurity and Agriculture management Act 2007 and is categorised as a P1 and P2 plant across the entire state. Introduction into, or movement of the plant within the state is prohibited and all known plants are to be eradicated by land managers.

In Queensland, gamba grass is declared restricted matter category 3 under the Queensland Biosecurity Act 2014, along with eight other invasive grasses. Category 3 regulation provides that a person must not distribute the invasive plant either by sale or gift, or release it into the environment. In addition, all persons have a ‘general biosecurity obligation’ which specifies that everyone is responsible for managing biosecurity risks under their control, and that they know about or should reasonably be expected to know about. Additional requirements or objectives for management may also be outlined in a Local Governments’ Biosecurity Plan.

The Northern Territory has a Weed Management Plan for Gamba Grass 2020-2030 (Northern Territory Government 2020) under the Weed Management Act (2001). The plans define A/C (eradication zones) and B/C (management zones) for gamba grass. Land managers within the eradication zones are required to actively identify and eradicate existing infestations and prevent the establishment of new infestations. Within the management zones, land managers must control the growth and spread of gamba grass on and between properties. Obligations with respect to management differ between small landholders (less than 20 hectares) and large landholders (greater than 20 hectares). Specific obligations also apply to landholders who wish to use gamba grass as pasture species, and to managers of service and transport corridors. All land users must ensure that there is no further introduction of gamba grass into the Northern Territory or into uninvaded areas.

Rate of spread and detection

Measured rates of spread from sown pastures range between 1 – 333 m/year and vary within sites with climatic conditions, and between sites with topographical, historical and cultural drivers (Barrow 1995). Spread predominantly occurs initially along drainage lines and then into higher elevation areas (Barrow 1995, Petty et al. 2012). In areas away from major roads, density of new plants through time is dependent on distance to the original source (Petty et al. 2012), while adjacent to major roads high abundance infestations are widespread and independent of source. Not surprisingly, the rate of spread along roadsides is higher, in the order of 1-3 km/year although in these cases sources of seed and mode of dispersal are likely to be numerous (Barrow 1995).

In discrete areas where infestations cover a relatively small area, foot surveys to detect (and simultaneously control) individual plants has proven successful in Western Australia (J.P Slaven pers. comm. See Box 3) and largely successful in Queensland (see Box 5). At larger scales, visual aerial surveys from helicopters (Petty et al. 2012) and drones have proven a comprehensive and economical method of assessing distribution patterns particularly in the early dry season when gamba grass is still actively growing.

Box 3. Management of an existing infestation in woodland – El Questro Wilderness Park, Western Australia

In 1991, gamba grass seed was sown by air and 1770 ha of pasture was established on El Questro Station (-15.89S, 128.18E). In 2006, the pasture was considered an infestation and has been managed annually by El Questro Wilderness Park, volunteers, contractors, the WA Department of Primary Industries and Regional Development, The WA Department of Biodiversity, Conservation and Attractions, and the Kimberly Rangelands Biosecurity Group. In Western Australia gamba grass is listed in the Control category 2 where the prohibited organism must be eradicated.

Each year between March and June control is undertaken by walking transects 10m apart, locating each tussock and chipping them out by hand. In the past when the tussock density was greater, some herbicide applications were used. Some aerial survey is done to map the extent of the infestation.

Control on El Questro Wilderness park has been largely successful and the infested area is rapidly decreasing. In 2018 only 450 ha of infested area was treated and 3086 plants found. In 2019, 200 ha was treated and 277 plants found. Of these, 5% were seedlings from the previous year. In 2020 only 23 plants were found including two flowering tussocks. As of 2021 the infestation area is 80 ha.

This case demonstrates that in small discrete areas of woodland, foot surveys to detect and simultaneously control individual plants can be effective. However, this control strategy is not without its issues. First, the cost to eradicate plants over 1770 ha is in the hundreds of thousands of dollars. As the area infested reduces the cost per area increases and the ability to attract funds decreases. Second, the effectiveness of each contractor and casual labour varies with each survey. Finally, there is always doubt whether the infestation is defined each year. A cost effective method of accurately detecting isolated plants at all scales is needed.

Airbourne LiDAR has emerged as a useful tool in detecting fine-scale structural characteristics of vegetation communities. Most applications of LiDAR focus on woody vegetation due to the large effort required for high resolution mapping. However, in 2015 gamba grass infestations were successfully mapped over a 30 km^2 area in the Northern Territory (Levick et al. 2015). The uniform nature of gamba grass is key to identifying its occurrence from images and distinguishing the structural differences between it and native grasses and shrubs. Using LiDAR at this scale allows for reliable mapping of current infestations which establishes a benchmark for rates of spread. Moreover, it allows for the assessment of the impacts of infestations on the structure and function associated woody vegetation.

While effective, the use of high-resolution LiDAR is expensive over large areas, therefore, detecting incursions at a continental scale needs a scale of mapping that can only be done from space. Detecting new or isolated small plants using satellite remote sensing becomes difficult due to the small size of the target and the spatial, temporal, spectral and radiometric restraints of technology. Recent developments in machine learning and the availability of very high resolution satellite imagery has allowed gamba grass to be mapped from space with a 91% accuracy during the dry season (Levick et al. 2018, Shendryk et al. 2020). While gamba grass can be similar in height and density to some native *Sorghum* spp. in the wet season, its ability to stay green into the dry season provides high potential to detect individuals. Encouragingly, there is also good potential to use machine learning to train freely available medium resolution, multispectral satellite imagery to achieve similar results.

Control and management

Current on-ground management and control of gamba grass relies on the restriction of seed movement, herbicide application, and cultural management practices such as grazing, burning and slashing. Management guidelines currently provided by local and state government recommend using a combination of grazing, slashing, fire and herbicide to manage incursions and infestations (Box 4). Control of isolated incursions involves removing and destroying seed heads and manually removing individual tussocks. There is no evidence of asexual reproduction from stolons so digging of individual plants is an effective means of removing isolated tussocks (Box 3).

Once an infestation has occurred, a seed bank is present and tussocks are widespread, slashing, grazing and fire can be used alongside herbicide application. In a well managed grazing system, light grazing can be introduced early in the wet season and a higher stocking rate introduced later in the wet season to control increased new growth. Continued grazing (or slashing) eliminates tiller production and dramatically decreases flower initiation in the late wet season (Gobius et al. 1998). If a tussock is allowed to grow above 90 cm, the plant becomes unpalatable and is allowed to flower and seed. A further advantage of grazing or slashing in the early wet season with the aim of control is the reduction of biomass and stimulation of new growth so that herbicide can be applied effectively.

Gamba grass is fire tolerant and each tussock will quickly regrow multiple tillers. Low intensity fire in the storm or early wet season is best used to reduce biomass and stimulate new growth to increase grazing desirability and herbicide effectiveness, and to improve access for slashing. Fires at this time can also kill newly emerged seedlings. Fires should be avoided during seed drop as updrafts caused by the fire will disperse the seeds. In wooded areas when fuel loads are high burning should be carried out in the early dry season or late in the wet season to avoid long-term damage to native vegetation. Alternately, medium term exclusion of fire as a control measure has been used with some success in the Northern Territory avoiding fire damage to native woody species and maintaining and intact canopy (Box 4). After approximately four years of heavy infestation, gamba grass biomass can accumulate and chokes out any new growth and seedling establishment. Any existing seeds either germinate and are smothered or lose viability over time. Strategic herbicide applications can be used while leaving the dead material in place. This approach avoids damage to native woody species and maintains an intact tree canopy.

Box 4. Excluding fire to suppress gamba grass regeneration

Fire can be a useful tool in the strategic control of gamba grass. However, when used in the incorrect setting, it can also negatively impactive native woody biomass and soil nitrogen levels and increase dispersal distance of seeds.

In the Mary River National Park (Northern Territory, -12.23S, 134.34E) national park rangers are reducing the frequency of burning and excluding fire by creating fire breaks. Within these breaks, gamba grass is sprayed with herbicide leaving the dead litter in place.

Over such a large area the application of herbicide is done in a strategic way: creating and increasing a buffer along the park boundary each year, treating under important trees, and creating a buffer along access tracks. In each case the treated area is increased each year and scattered recruits within existing treated areas are sprayed. Large, dense infestations are aerially sprayed.

After approximately four years of fire exclusion and then treatment, heavy infestations of gamba grass begin to accumulate enough litter to physically suppress seedling establishment. Seeds in the soil seed bank either germinate and are shaded out or fail to germinate and lose viability over time. This approach to control avoids damage to native woody species from fire and maintains an intact tree canopy.

This strategy is effective in the short term in reducing gamba grass recruitment in treated areas, however, knowledge gaps remain regarding the long-term effects of not burning. Will native species naturally regenerate from the soil seed bank and the existing canopy or by dispersal from nearby vegetation? Will gamba grass re-establish in unburnt areas via dispersal from other populations?

Glyphosate is the only effective herbicide in use in northern Australia and the only herbicide registered for use on protected land. The optimal time for spraying is during active growth when the leaves are at least 40 cm long which is generally in the months of December to March but may depend on when the plant has been slashed, grazed or burnt. Spraying plants prior to reaching full height will reduce herbicide requirements, although the plant is particularly sensitive to herbicide when flowering. Ideally, areas treated with herbicide should be followed up after 4 weeks and then before seed set to ensure plants are dead. Follow up to kill new germinants and any regrowth should be ongoing for 3 years.

Box 5. Management of isolated incursions into remnant woodland – Hann Tableland, Queensland

Gamba grass was first recorded on the south-eastern side of the Hann Tableland, QLD (-16.93S, 145.31E) in the 1980s as an escapee from adjacent sown pastures. The Hann Tableland has since been gazetted a National Park and is managed by Queensland Parks and Wildlife Service (QPWS) out of Mareeba. Gamba grass is still present on private land adjacent to the national park and is grazed and maintained at varied densities. Incursions in remnant forest on the National Park are considered at a low density and native grasses still dominate, however, the density of tussocks increases near roads and established pastures. A feature of the area is the rugged topography featuring granite outcrops. This not only makes control challenging but sees in the collection of moisture at the base of large granite boulders resulting in numerous micro-habitats favouring gamba grass establishment and persistence.

Control on the National Park is currently limited to spot spraying with glyphosate at the end of the wet season as an annual reduction program. Control teams walk systematically along the southern edge of the National Park where the density of tussocks is the highest and the risk of reinfestation from adjacent agricultural land is greatest. All visible gamba grass tussocks are sprayed. The area is burnt every second year in the dry season to maintain forest structure and floristics, to reduce the fuel load, and for ease of access for gamba grass control. If the fires are early enough in the dry season the seeding capacity of gamba grass is greatly reduced, however this is not usually achievable. In any case, a burnt tussock is able to produce new tillers and flower a second time if soil moisture is available. Mareeba Shire Council controls invasive weeds on road verges in and adjacent to the National Park.

Gamba grass control in the National Park has been mostly effective and has restricted incursions to areas close to the source of seed and at a relatively low density. QPWS maintains a series of photopoints to monitor the success of management.

While a dense pasture of gamba grass remains upwind of the National Park on private land there will always be an annual source of seed. QPWS would like to see the development of a residual herbicide, selective for grasses that can be easily carried in a granular form by its staff. This would eliminate the need to carry large volumes of prepared glyphosate in backpacks across difficult terrain.

Glyphosate is considered effective; however, the reported rate of application needed for a satisfactory kill rate varies. A glasshouse herbicide trial commissioned by Rio Tinto to find a suitable herbicide to use on the Weipa bauxite mine showed glyphosate at the currently recommended glyphosate/water mixture of 1:100 plus surfactant as the most effective herbicide. Broadcast herbicide trials by Barrow (1995) show that applications of glyphosate or mixtures containing glyphosate applied at high rates were most effective in achieving the highest tussock kill rate. Glyphosate on its own gave a similar result as glyphosate mixed with Amitrole/ Ammonium thiocyanate or Sulfometuron. Kill rates after 7 months were in the order of 60-75% indicating that gamba grass is difficult to kill although application timed with optimal growing conditions may increase kill rates.

Other herbicides have been trialled with varied degrees of success as soil and/or foliar applications. However, none have consistently proven effective in all environmental conditions at recommended rates of application, or if they are effective they have deleterious impacts on non-target species. Importantly, none have a consistent residual effect on emerging gamba grass seedlings.

- Group B herbicides (Sulfometuron, Imazapyr) shows mixed results particularly when used in combination with Group C herbicides but is largely ineffective in trials (NT Government unpublished).
- Group C herbicides (Diuron, Hexazinone, Tebuthiuron and Terbacil) have been shown to effect high kill rates (QLD Department of Agriculture and Fisheries, NT Government; unpublished), however, off-target damage to native woody species is high and unacceptable.
- Group I herbicides (2,4-D, Dicamba, Picloram) are typically used to control broadleaf crops, however, when applied to grasses while developing reproductive parts, fecundity can be dramatically reduced (Rinella et al. 2010).
- Group J herbicides (Dalapon, Flupropanate) show promise and Flupropanate in particular, has been put forward as a potential residual herbicide. However, trials as a broadcast spray (Barrow 1995) and a spot spray (NT Government unpublished) have shown only moderate kill rates on tussocks and little residual effect on germinants or mature plants post application. Subsequent field trials by Vogler (in prep) show unsatisfactory results as broadcast granular and spray application due to the prohibitively high application rates required to cause high tussock mortality and limited impact on seedling establishment. Results as a spot tussock application in both granular and liquid form applied in the late dry season were promising causing more than 80% tussock mortality. However, there was little outward soil movement of the herbicide away from the tussocks resulting in low residual impact on emergent seedlings.
- Group L herbicides (Paraquot) at sublethal rates mixed with glyphosate has been shown to suppress seed production on tussocks.

In a recent mining rehabilitation trial in the Northern Territory, Luck et al. (2019) showed that Sulfometuron (600g ai/ha), Dalapon (29600g ai/ha), and Terbacil (2000g ai/ha) applied to the soil after adult tussocks were killed with glyphosate all effected significant reductions in seedling emergence, then seedling survival at 5 months. Flupropanate (6705g ai/ha) showed a non-significant decrease in seedling density at both times. This research suggests that in some cases i.e. correct pH, soil structure, clay content and climatic conditions, residual herbicides can be used as part of an integrated strategy.

Box 6. Emerging herbicide options

The result of recent field and pot trials (undertaken as part of the Northern Australia NESP project – Management options for gamba grass in conservation areas of Cape York) for alternative herbicide options for gamba grass control do not indicate a suitable alternative to glyphosate. The herbicides Flupropanate, Terbacil and Sulfometuron were largely ineffective at reducing gamba cover, suppressing flowering or gamba recruitment. In fact, one treatment of glyphosate in the field was equally ineffective.

Neither Flupropanate nor a Terbacil-Sulfometuron mix effectively supressed gamba grass in pot trials either. However, these herbicides also did not suppress native species germination indicating that higher rates could be trialled to determine if there is a point where they do selectively control gamba germination without supressing native species.

In the pot trials, the most effective herbicides for suppression of gamba germination were Clomazone, Oxyflurorfen, Imazapyr and Indaziflam. All had large off-target effects on native species. Indaziflam effectively suppressed all native and invasive species germination. The other three herbicides also effectively suppressed almost all native grass species germination. However, dicotyledons in the trial showed reasonable tolerance to most herbicides (except Indaziflam).

Although neither the field or pot trials identified suitable herbicides that selectively controlled gamba grass with low off-target effects, there are several herbicides that warrant further testing at a range of application rates and in a range of situations (Flupropanate, Clomazone, Oxyflurorfen, Imazapyr and Indaziflam). It may be that suppressing all grass establishment for a period to deplete the short lived gamba grass seed bank prior to allowing natural site restoration is a longer term management strategy worth testing as a way of managing new infestations that are inaccessible for part of the year due to the northern wet season.

Biological control

In 2016 a prioritisation framework to guide biocontrol investment decisions for the Australian livestock industry was developed and applied (van Klinken et al. 2016). Gamba grass was identified as one of 72 exotic taxa for priority consideration. It was considered to have a moderate potential impact to the livestock industry but only low feasibility and likelihood of success for biological control and was therefore not shortlisted for further consideration. More recently, CSIRO have nominated gamba grass as a candidate weed for biocontrol (Dell et al. 2020) to the Federal Environment and Invasives Committee based on its impact as an ecological transformer and its fire threat, but also considering its value as a forage species.

Globally, very few invasive grass species have been targeted for biological control due to a perceived lack of sufficiently specialised and damaging natural enemies, and concerns that the risk posed to economically important crop and pasture species, and closely-related native species, is too high (Sutton et al. 2019). However, grasses can possess suitably host-specific and damaging natural enemies and the risk associated with grass biological control is no greater than for other weedy taxa (Sutton et al. 2019). Good candidate biological control agents for grasses in general include stem-galling wasps (*Tetramesa* spp.) *that* weaken stems and reduce biomass, Eriophyid mites that stunt growth and reduce reproductive output, shoot-galling flies that typically attack vegetative parts, and fungal pathogens (Sutton et al. 2019).

While the search for biological control agents of gamba grass is in a preliminary stage, a range of pathogens and insects associated with the species in its natural and introduced range have already been identified. Twenty-three fungal pathogens are recorded as occurring on gamba grass in Africa (Bunting 1928, Zundel 1937, Tarr 1955, Bowden 1964, Lenne and Calderon 1990), with *Puccinia versicolor* the most widespread and damaging. In addition, nine nematode pathogens (Caveness 1967), and six insect pathogens (Lenne and Calderon 1990) have been recorded. No diseases caused by bacteria, mycoplasms or virus are reported on gamba grass in its natural range (Lenne and Calderon 1990).

In South America, 25 fungi and 17 nematode species associated with gamba grass have been recorded (Lenne and Calderon 1990) and while few have been studied, a leaf spot (*Rhynchosporium oryzae*) and a inflorescence inhibitor (*Myriogenospora* sp.) have the potential to cause moderate damage. Fifty insect species are associated with gamba grass in South America (Lenne and Calderon 1990). Apart from leaf-cutting ants which cause considerable damage to newly emerged seedlings in some managed pastures, insects are considered to have limited potential for biological control.

Using Australian endemic pathogens as biocontrol candidates is an approach used for other invasive grass species in Australia with some success (Vitelli et al. 2019) and has potential to be effective for gamba grass. Isolates obtained from natural patch mortality in northern Australia have identified a fungal *Fusarium* sp. and *Curvularia* sp. species as prime candidates (Tenzin 2013) and both warrant further investigation. Incidences of patch mortality are anecdotally common in NT and QLD and are a likely source of future candidate pathogens.

Enhancement of nitrification

The competitive advantage afforded to gamba grass over native grasses by nitrification inhibition in the root zone and subsequent massive uptake of NH_4+ may be countered by artificially enhancing nitrification by applying nitrifying *Nitrosomonas* spp. bacteria in infested areas. As a consequence, nitrification of the preferred NH_4+ into volatile NO_3- may encourage growth in regenerating native grasses or at least force gamba grass to switch to a less preferred source of soil N. Trials will be required to determine whether gamba grass is able to maintain its advantage when using NO_3- as the predominant source of N, or whether it increases de-nitrification rates in response to higher NO_3- levels, as suggested by Lata et al. (2004). The application of nitrifying *Nitrosomonas* spp. bacteria is commonplace in industrial and waste management fields where it is beneficial to convert ammonia to nitrates. However, in agricultural systems the process is avoided due to the large losses of volatile NO_3- from the soil through leaching and to the atmosphere. Conversely, nitrification inhibitors are commonly applied to maximise N retention in the soil and optimise uptake into plants. Similarly, in natural systems, significant loss of NO_3- into the water table or marine systems is undesirable. However, short term or small-scale promotion of nitrification and the addition of supplementary N fertiliser may be a novel means of managing infestations and encouraging native species regeneration.

Succession following treatment

In the simplest of cases, successful re-establishment of native vegetation following treatment of gamba grass results from natural regeneration from sources onsite and by natural dispersal processes. After gamba grass control there will certainly be a shift in floristics away from the original vegetation, the magnitude of the shift depending on the duration and density of infestation. Soil seed banks of tropical native grass seeds are rapidly depleted after the onset of first rains following the dry season with seeds of annual species having a particularly transient seed bank (Stocker and Sturtz 1966, Andrew and Mott 1983, Crowley and Garnett 1999). In addition, a high proportion of native grass seeds break dormancy and germinate if stimulated by fire (Mott 1978, Scott et al. 2010) due largely to the removal of vegetation from the ground (Shaw 1957). Seed banks of tropical shrub and tree species are likely to be highly variable depending on the floristics at a site. *Eucalyptus* and *Corymbia* spp. in the tropics lack a canopy-stored seed bank seen in many temperate species and the soil seed bank is generally short lived (Williams et al. 2005) due to massive predation or germination following rainfall events. However, there are species with persistent seed banks; seeds of *Acacia* spp. can remain viable in the soil for several decades (Farrell and Ashton 1978) and *Banksia* spp. store seeds in the canopy and require fire to stimulate their release.

The potential for the success of in-situ or dispersal driven regeneration may be enhanced by intervention practices such as inducing germination from existing seed banks, prioritising sites near remaining intact vegetation, excluding herbivores, providing cover for establishing plants, and providing cover to attract invertebrate and vertebrate dispersers. For example, the use of storm season fires to remove gamba grass biomass gives the remaining soil seed bank an opportunity to germinate and establish. In addition, fire will stimulate sprouting from lignotubers and epicormics buds from the remaining tree and shrub species especially *Eucalyptus* and *Corymbia* spp. that predominantly regenerate vegetatively rather than from seed (Williams 2009).

Discussion

Gamba grass is now naturalised (Richardson et al. 2000) in tropical areas of Western Australia, Northern Territory and Queensland. According to the eradication framework proposed by Panetta (2015), the feasibility of eradication is low. As per the Code of Practice developed by the National Gamba Grass Taskforce (2013) every effort should now be made to contain the species to existing plantings, control it in strategic areas and eradicate new infestations and incursions. Particular effort should be targeted towards environmentally sensitive areas, and roadsides and public areas where the potential of spread is high.

Containment of a weed can be acheived by measures that influence dispersal agents and by those that reduce fecundity (Panetta and Cacho 2012). Dispersal driven invasions require a management scale that is determined by the plant’s dispersal processes (Fletcher and Westcott 2013). Short distance dispersal of gamba grass is generally abiotic, predominantly wind and water. We propose a maximum wind dispersal distance of 100 m (Box 1) which aligns well with estimations of up to 300 m by Barrow (1995) and Petty et al. (2012) who also take into account short distance dispersal along creek lines. These values provide an annual search guideline for new local infestations and outlying plants. Furthermore, the role of fire and weather events in turning short distance dispersal into medium distance dispersal need to be understood to determine management scales for particular events. Except for movement down waterways during rainfall events and a small amount of vertebrate assisted dispersal, long distance dispersal is almost entirely human assisted and thus, while difficult, can be managed. Elimination of seed movement via vehicles, machinery and forage hay to minimise the management scale is the first obvious step in the local containment of infestations.

Currently, the options for reducing the fecundity of gamba grass rely on reducing the number of tillers and therefore culms per tussock. Late wet season removal of tillers dramatically reduces seed production by minimising the accumulation of leaf mass and culm production before the onset of short days. Fortunately, a reproductive phenology which sees flower initiation 4-5 months after tussock development and a relatively long period between initiation and seed fall allows a wide window to implement management options. First, in established infestations, burning of tussocks before flower development can be achieved late in the wet season when conditions have generally dried out enough to carry a fire but are not too dry as to adversely affect native trees and shrubs. Similarly, grazing of tussocks to reduce tiller density can be introduced early in the dry season while tillers maintain a green pick. Second, late seed set and fall allows the timing of fire into the early dry as the seed is maturing to render a season's crop unviable. Third, the late reproductive phenology allows access to remotes areas that are inaccessible during the wet season to treat isolated incursions before seed fall.

Herbicide options to control and contain gamba grass are currently limited to glyphosate. Glyphosate is the most widely used herbicide in the world, and while mostly considered harmless since its first commercial use in 1974, there is now growing concern that glyphosate or other ingredients in glyphosate-based formulations are linked to carcinogenicity, genetoxicity and epidemiological disorders. Despite numerous studies on the use and over-use of glyphosate, it is not possible to categorically attribute any potentially harmful effect to humans (Torretta et al. 2018). However, numerous studies have highlighted negative effects of glyphosate or glyphosate formulations on non-human targets (Kier and Kirkland 2013, Herbert et al. 2014, Bailey et al. 2017) and on ecological processes (Glass 1984). Regardless of the effects on humans and the environment, glyphosate is a non-targeted herbicide and how and when we use it needs to be carefully considered within a strategic control approach.

There are also logistical issues with the widespread use of glyphosate. Its predominant use in the hot and humid wet season limits enthusiasm for staff, widespread foliar spray relies on large and expensive spray equipment, it's effective use relies on access to clean water, and access to remote areas during the wet season during the control window is often limited. Moreover, glyphosate has no residual action and largely relies on follow-up treatments, and there are emerging resistance issues.

Knowledge gaps

Based on information gathered in this review and discussions during the Gamba Grass Workshop in Cairns in 2019, we identify seven remaining knowledge gaps relevant to the successful management of gamba grass in Australia.

Detection and mapping of new incursions at a broad scale

- The most pressing problem is finding new small infestations at a broad scale. Helicopter and drone surveys are effective but can only by applied at small to medium scales.

- Methodology has been successfully developed for LiDAR (Levick et al. 2015) and high resolution satellite-based detection (Levick et al. 2018, Shendryk et al. 2020). This technology needs to be tested and applied across varied landscapes and growing seasons that change the spectral signature of both gamba grass and associated vegetation.

Modes and rates of dispersal

- In this review we propose a short term (water, wind and attachment) dispersal distance of 100 m which dictates a search zone around existing infestations.
- A knowledge gap exists in potential dispersal distances as a result of extreme events such as intense fires during seed fall and high-volume overland water flow.

Genetic diversity

- It is apparent that different phenotypes exist within and between populations. Is it unclear whether these are adaptions to the environment or a consequence of various sources of genetic material from initial and subsequent introductions to Australia.
- Recent advances in genetic studies have demonstrated that ploidy level is a critical factor affecting genetic diversity in particular taxa with implications for genetic differentiation, reproductive mode, and possibly speciation (Wallace et al. 2019). A lack of genetic diversity may expose a weak link in the species biology, therefore, determination of ploidy levels for a population will likely influence how we target integrated control programs.
- Ploidy levels will also determine the genetic diversity within and between populations which will aid in determining where introductions originated, both from within and outside of Australia.

Emerging herbicides

- To contain and control current infestations and to eliminate isolated incursions, a grass specific soil residual herbicide needs to work at all scales.
- At broad scales, a soil residual herbicide is needed that can be applied late in the dry season or early in the wet season, causing mortality to adult plants and controlling new germinants as they appear during the wet season.
- At smaller scales, a lightweight, residual pellet herbicide is needed that can be easily carried by land managers searching for outlying incursions.

Biological control

- A number of arthropods and pathogens have been recorded on gamba grass in its native and South American range.
- Gamba grass needs to stay in the conversation as a candidate weed for biological control (Dell et al. 2020). Both its impact as a transformer weed and the reliance on the species as an important pasture grass in some settings needs to be considered.
- There is also some potential for native pathogens as candidates for biological control.

Biology

- The viability of gamba grass seeds under multiple environmental and climatic conditions compared to that of native grasses, herbaceous and woody species could impact timing and efficacy of control. If the gamba seed viability window is considerably less than natives under certain conditions, then a short-term residual herbicide may be effective on emerging gamba grass but less effective on native species with a dormancy.

- The long-term effects of fire exclusion, and conversely, the effect of hot fires on the seed bank as novel methods in an integrated approach to cultural management of the species requires more research.
- Whether gamba grass is able to maintain its competitive nitrogen use advantage when NO_3^- is enhanced as the predominant source of N, or whether it increases de-nitrification rates in response to higher NO_3^- levels remains unclear.

Costs

- As infestations expand in coverage and density, or conversely, are managed, costs of surveillance, costs to infrastructure and cultural assets, and costs of fire control (Beaumont et al. 2018) will change.
- Lobbying governments for management funding will require accurate costs of new detection techniques and new control options.

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Appendix 2: Gamba grass management workshop (July 2019) – summary notes

Participants:

Helen Murphy	CSIRO
Matt Bradford	CSIRO
Andrew Ford	CSIRO
Natalie Rossiter-Rachor	Charles Darwin University
Samantha Setterfield	University WA
John Clarkson	DES, QPWS
Wayne Vogler	Biosecurity Qld
Joe Vitelli	Biosecurity Qld
Lyndal Scobell (2nd day)	NESP
Tom Price	NT Weeds Branch
Charles Creighton	DES, QPWS
Darryn Higgins	Cook Shire
Warren Strebbins	Tablelands Shire
Ken Golbey	Tablelands Shire
Scott Morrison	Tablelands Shire
Robert Gosam	Tablelands Shire
David Christen	Centrogen
Ray Gurney	MacSpread
Mark Francis (1st day)	MacSpread
Des Land	Rio Tinto
Trevor Meldrum	Cape York Weeds and Ferals
Phillip Mango	Nanum Wunthim (Napranum) Rangers
Jason Carrol	South Cape York Catchments
Jan Carson	South Endeavour Trust
John Witheridge	South Endeavour Trust
Peter Barker	DES, QPWS
Will Smith (2nd day)	Jabalbina

Jeff Arneth (2nd day)	Jabalbina
Travis Sydes	FNQROC
Sid Clayton (1st day)	Mareeba Shire
Melissa Setter	Biosecurity Qld
Steven Dwyer	Parks NT - Senior Ranger
Daniel Montesinos	Australian Tropical Herbarium
Matt Barrett	Australian Tropical Herbarium
John-Paul Slaven	DPIRD WA
Kylie Goodall	QPWS
Katrina Christen (by phone)	Centrogen
Alex Simpson (1st day)	CSIRO
Nic Inskeep	Yintjingga
Trinity Georgetown	Lama Lama
Karen Liddy	Lama Lama
Alsion Liddy	Lama Lama
Brendan Malone	DES QPWS

Observations:

- Not much gamba on the conservation estate in Queensland
- Difficult to distinguish from native grasses - often well established before it can be identified
- Killing a grass in a grassy sward is difficult. Some pain for some gain? What is the appetite for pain in the conservation estate?
- Different morphologies - glabrous type at Rio Tinto\Weipa; shorter spindly type on (some parts of) Tablelands.
- Control activities limited by access - wet season; remote locations; access on foot
- Permitting and registration - require more trials for Flupropanate - enough data to get a minor use permit?; no withholding period data for Sulfometuron;
- Prevention is always the best option; introduction of exclusion to the savanna burning methodology may serve well in terms of prevention.
- Seed longevity of native grass species may often surpass gamba - implications for timing of control and feasibility of bare earth control
- Herbarium records potentially under-represent current distribution
- Limiting disturbance is key to prevention - fire is a catalyst
- Gamba often associated with infrastructure - powerlines, towers etc are a big problem

What works:

- Glyphosate

    - Known resistance issues although not much direct evidence of this. Some anecdotal observations.
    - Needs to be applied in growing season. Wet season limits use/access – too hot, too wet.
    - Application options. Splattergun trial being conducted by BQ.
- Flupropanate - Flup
    - Some effectiveness mainly at very high rates (higher than other grasses). High seedling emergence (no residual).
    - Taskforce works well with stem injection/splatter gun, larger tussocks may take a few shots. Selective - no effect on surrounding veg. Can get a lot of plants with backpack and 4ml spray.
    - Not much lateral movement out so gamba plants can pop up right next door to treated tussock (works in terms of being selective)
    - Takes a while to work so could get seeds even after application
    - Application options. Squirting FL into tussock (or granules) in late dry season. Kills or reduces seed heads. Uptakes FL at first rain and dies.
    - Can do application anytime
    - Liquid versus granular?
- Terbacil:
    - Works well as a pre-emergent (but non-selective for grasses)
    - Approx 3 months residual - could be OK for some native grasses with longer seed bank
    - Eucmix at 4x label rate worked and residual effect. Turbacil seems to be the active ingredient
    - Very early plot trial for GG. Pre-emergent at 20 kg rates, double rates, triples rates. Double rates worked at 100% control
    - New mixture of Trimac? then 2 years of glyphosate touch up (combination over 4 years) got rid of GG and native grasses re-colonised
    - Tankmix, Trimax, Enviromac, Velmac granules mixture at low rates has success but only for one growing season.
    - Organosilicon assists uptake and penetration
    - Liquid versus granular?
- Sulfometuron:
    - Didn’t seem to have good knock-down effect
    - Unknown withholding period
    - Good on seedling suppression (TP)
    - Fair bit of lateral movement - effects on grasses

Other approaches:

- Strategic herbicide application: leave dead GG material and spray. No recruitment of GG thru mulch. Start at one spot and slowly increase zone each year, spraying the odd GG recruit
- Hand pulling, chipping out - feasible for spindly plants without huge biomass or root ball. Isolated/individual occurrences.
- Getting the timing right.
    - April/May good in NT - control when gamba is at chest height and spear grasses have mostly finished.

- Burning
    - plus glyphosate at 2 months works well
    - excluding burning - after 4 years GG seems to choke itself out. Canopy is allowed to grow back
    - long-term effects of fire exclusion not known
- Aerial control and survey
    - For large/dense infestations - much cheaper
    - Concern about canopy, at low rates effects were minimal mostly. Best results with application in April.
    - Survey can be difficult for isolated plants - timing
- Other integrated approaches:
    - Glyphosate, fencing, cattle exclusion
    - Restore canopy to shade out GG.
    - Bare earth for a couple of years with glyphosate to get rid of seedbank, allow natives with longer seedbanks to return
    - Buffers and containment
- Engagement and compliance
    - Follow-up, regularity
    - engaging community and landholders, providing tools, equipment, support, providing training
    - compliance - compliance orders (NT style)

What doesn't work:

- Mechanical control for large infestations
- Carrying chemical and water over long distances on foot
- Diuron, Velmac, Grasslan - worked to some extent but killed trees quicker than grasses
- Hexazine does work well on gamba but kills everything else
- Finding gamba before seeding - experience of field operators, high turnover
- Difficulty related to particular tenures or mixed tenures

What are the knowledge gaps

- Need grass specific soil residual that can be applied dry early wet season = Graslan for gamba
- Seed bank longevity of GG seeds compared to native species. If we can apply a residual granule that lasts a year it will stop GG and not natives.
- Long-term effects of fire exclusion not known
- Biggest problem is finding new small infestations - application of remotely sensed imagery, drones.
- E-Dna.
- Different morphologies. Is it adaption to environment or consequence of various introductions? What does it mean for management?
- Seed bank and hot fires?
- Potential weak link in the (lack of?) genetic diversity of the species. What do we need to understand about genetic diversity as it relates to control?
- Dispersal - as it relates to buffers
- Costs - surveillance, costs to infrastructure, cultural assets etc

- Calculate costs through project trials

Current, emerging and experimental herbicides:

Current: Glyphosate, Flupropanate

Emerging: Terbacil, Sulfometuron, Imazapyr

Experimental: Clethodim, Clomazone, Bromacil, Indaziflam, Butroxydim, Oryzalin and Haloxyfop

Appendix 3: Tolerance of gamba grass (*Andropogon gayanus)* and other exotic and native plant species to pre-emergence herbicides

Feb 08 2021

A report to the Australian Government National Environmental Science Program

Prepared by Queensland Department of Agriculture and Fisheries[1]

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This project is for subcontracted services to CSIRO as agreed under the Northern Australia NESP CSIRO Research Services Plan V4 for 2.10 Management options for high-biomass grassy weed management in Cape York Conservation areas.

Cover photo: Various pots at 13 weeks after treatment.

All photographs are by DAF Biosecurity staff unless specified

Introduction

Gamba grass (*Andropogon gayanus* Kunth.) is a tussock-forming perennial species capable of out-competing other pasture grasses to form dense stands up to 4 m tall. Infestations occur in the Northern Territory, Queensland and Western Australia, but its current distribution is only a small proportion of its potential range (e.g. Csurhes & Hannan-Jones, 2016, Setterfield et al, 2014). Once established, *Andropogon gayanus* negatively impacts on the biodiversity and ecosystem function of an area, whilst also imposing a significant fire hazard due to the large biomass it produces.

Reducing *Andropogon gayanus* populations is problematic as it is well adapted to the northern wet dry tropics, is a prolific producer of wind dispersed seeds and responds well to periodic burning (Bebawi et al, 2018 Rossiter et al, 2003). It is highly competitive due to its rapid growth, high biomass and its soil nitrogen harvesting process which limits nitrogen availability (e.g. Rossiter-Rachor et al, 2009, Setterfield et al 2005) to other plants within the ecosystem it invades.

This, along with the largely inaccessible landscapes it currently inhabits, sparse human population, limited effective herbicides available which can control/selectively control *Andropogon gayanus* further limits the effectiveness of control programs. It is hoped that residual pre-emergence herbicides may offer a solution for controlling small infestations which are inaccessible during the northern wet season when foliar herbicides should be applied, although no effective soil applied residual herbicide has currently been identified.

Aims

The aim of this study is to test the tolerance of *Andropogon gayanus*, co-occurring native plant species plus one widely distributed exotic grass, *Bothriochloa pertusa* (Indian blue grass) (Kutt & Fisher, 2011), to a range of residual pre-emergence herbicides in an effort to identify herbicides that selectively control *Andropogon gayanus* as it germinates while minimally impacting at least a few native plant species. *Bothriochloa pertusa* is included as it is a widely distributed grass which has significant potential to occupy space vacated by *Andropogon gayanus* if it were to be controlled using soil applied residual herbicides. This study if successful will provide information that will improve the management of *Andropogon gayanus* and the restoration of native plant communities following *Andropogon gayanus* control.

Materials and methods

The study included nine native plant species, plus *Andropogon gayanus* and *Bothriochloa pertusa* (Table 1). The native plant species were determined in consultation with relevant colleagues with expertise in the ecosystems of the northern tropics of Australia. Seed of the selected native plant species were sourced from a Western Australian native seed supplier (Nindethana Australian Seeds) while *Andropogon gayanus*, *Bothriochloa pertusa* and *Heteropogon contortus* seed was collected from populations near Mareeba, Charters Towers and Woodstock respectively.

The initial germination of each species was determined by placing two replicates of 25 seeds of each species on filters papers moistened with distilled water in individual covered petri dishes. The petri dishes were place in a germination cabinet and subjected to a 12 hour 20/30^{o}C temperature alternation with light during the high temperature phase for up to three months depending on species. The initial germination of seed of each species was reasonable apart from *Stylidium graminifolium* which failed to germinate during initial testing (Table 1).

Ten commercially available herbicides which are known to have activity on grasses were chosen as a result of discussions at the Gamba Workshop in Cairns on 31 Jul-1st Aug 2019, and subsequent discussions with relevant experts in the field from Biosecurity Queensland, with input from stakeholders from Queensland, Northern Territory and Western Australia. The test herbicides and rates are listed in Table 2 and herbicide labels are included at Appendix A.

The trial commenced in September 2020 at the Centre for Wet Tropics Agriculture in South Johnstone. A randomised split plot design with three replicates was used, with species as the whole plot and herbicide as the sub plot. Treatments were randomly allocated to individual pots and treated pots placed randomly on shade house benches for grow-out. The number of seedlings in each pot was recorded weekly for 3 months until December 3, 2020.

The soil used in this trial (a sandy loam) was steam sterilised prior to being placed in 200mm squat pots. The pots were given an overnight watering of 1.5 mm from overhead sprinklers the night before the trial commenced. On the day the trial was initiated, 50 seeds of each species were placed 0.5 - 1cm below the soil surface in each pot. Prior to planting, seeds of *Crotalaria medicaginea* was scarified by placing the seed in concentrated sulphuric acid for 25 minutes, then rinsed with distilled water and drying.

Following herbicide application, the equivalent of 3mm of rain was applied daily by overhead sprinklers to each pot for the three months of the experiment. Due to the limitations of the watering system in the shade house all test species were subjected to a single watering regime. This may have resulted in less than optimum germination and seedling survival conditions for at least some test species. Despite this the trial will result in a meaningful comparison of the herbicide effects between treated and untreated species.

The herbicides, as listed in Table 2, were applied using an overhead gantry (Figure 1) using Teejet ® AIXR110015 nozzles at 2 bar pressure producing a spray volume of 288L/ha. All herbicides were applied without the addition of a wetter as the herbicides were applied directly to the soil surface. Species herbicide tolerance assessment was recorded weekly until 3rd December (12 weeks).

Table 1. Plant species and their mean initial seed germination (%) under laboratory conditions.

Scientific name	Common Name	Seed germination (%)
Andropogon gayanus	Gamba Grass	58
Heteropogon contortus	Black Spear Grass	74

Heteropogon triticeus	Giant Spear Grass	36
Bothriochloa bladhii	Forest Blue Grass	66
Bothriochloa pertusa	Indian Blue Grass	60
Themeda triandra	Kangaroo Grass	11
Sorghum plumosum	Plume Canegrass/Sorghum	46
Eriachne burkitti	Burkitt's wanderrie Grass	24
Crotalaria medicaginea	Trefoil Rattlepod	56
Stylidium graminifolium	Grass triggerplant	0
Phyllanthus calycinus	False Boronia	54

Fig 1. Setting up pots (L), and herbicide treatments being applied to the pots (R).

Table 2.Treatment herbicides and application rates.

Product Trade Name	Active ingredient	Product rate L/Kg per ha
Control		
Command 480 EC	480g/L clomazone	1L/ha
Mako	750g/kg Sulfometuron methyl	0.4kg/ha
Oxyfluorfen 240	240g/L Oxyfluorfen	4L/ha
Poacher 750	700g/kg Imazapyr	2kg/ha

Sinbar	800g/kg Terbacil	2.5kg/ha
Specticle	200g/L Indaziflam	0.25L/ha
Surflan 500	500g/L Oryzalin	4.5L/ha
Taskforce	745g/L Flupropanate	3L/ha
Trimac	880g/kg Terbacil and 40g/kg Sulfometuron	1kg/ha
Uragan WG	800g/kg Bromacil	2.5kg/ha

Results

The mean number of plants (% of seeds planted) present in pots of each treatment at 12 weeks after treatment with each herbicide are shown in Table 3. Plant numbers of most species in the untreated controls were relatively high apart from *Eriachne burkittii*, *Sorghum plumosum* and *Themeda triandra* where plant numbers were low (Table 3). There were no plants of *Stylidium graminifolium* in any treatment including the untreated controls (Table 3).

The herbicides Command, Oxyflurofen, Poacher and Specticle showed high efficacy reducing *Andropogon gayanus* plant numbers to zero or near to zero (Figures 2 and 4) (Table 3). They were also highly effective against all grass species except with *Heteropogon triticeus* and *Bothriochloa pertusa* where there were low plant numbers present in the Command, Oxyflurofen and Poacher treatments (Table 3).

The remaining herbicides were not highly efficacious against *Andropogon gayanus* with Mako, Sinbar and Uragan reducing plant numbers of all other grasses to zero or near zero. Although Mako had low efficacy against Andropogon gayanus it did however severely stunt any surviving Andropogon gayanus plants (Figure 3). Surflan, Taskforce and Trimac were perhaps the least efficacious overall with low efficacy on *Andropogon gayanus*, *Bothriochloa pertusa* and *Heteropogon triticeus*, and little impact on the non-grass species (Table 3).

All herbicides apart from Specticle allowed at least some non-grass species to survive. *Phyllanthus calycinus* and *Crotalaria medicaginea,* both dicotyledons, showed reasonable tolerance to most herbicides (Table 3) (Figures 2,3 and 4), but it is not clear whether these species could be used as the basis for a restoring *Andropogon gayanus* invaded sites following herbicide treatment.

Figures 2, 3 and 4 show some of the herbicide effects on the *Andropogon gayanus* and some other species. The herbicide effects on *Andropogon gayanus* and all other test species are shown in Appendix A.

Table 3. Mean number of plants (% of seeds planted) present in pots of each treatment at 12 weeks after treatment.

Species	Herbicide										
	Control	Command	Mako	Oxyflurofen	Poacher	Sinbar	Specticle	Surflan	Taskforce	Trimac	Uragan
Andropogon gayanus	44.7	0.7	19.3	0	0	6.00	0	12.0	18.0	20.0	12.0
Bothriochloa bladhii	44.0	0	0	0	0	0	0	0	0	4.0	0
Bothriochloa pertusa	23.3	0	0	0	8.0	0	0	12.0	18.7	11.3	0
Crotalaria medicaginea	20.7	29.3	4.0	0.7	14.0	26.0	0	28.7	20.0	22.0	1.3
Eriachne burkittii	1.3	0	0	0	0	0	0	0	0	2.7	0
Heteropogon contortus	34.0	0	0	0	0	0	0	6.0	5.3	16.7	2.0
Heteropogon triticeus	30.0	1.3	1.3	1.3	4.7	2.0	0	22.7	14.0	10.7	2.0
Phyllanthus calycinus	26.0	29.3	2.7	33.3	2.7	0	0	42.0	32.7	46.0	0
Sorghum plumosum	9.3	0	0	0	0	0	0	2.0	2.7	4.0	0.7
Stylidium graminifolium	0	0	0	0	0	0	0	0	0	0	0
Themeda triandra	9.3	0	0	0	4.7	0	0	4.0	0.7	0	0

Conclusions

There was unfortunately no herbicide in this study that effectively suppressed *Andropogon gayanus* while also selectively allowing a significant number of desirable native grass plants of any species to survive. Those herbicides (Surflan, Taskforce and Trimac) that did not effectively suppress *Andropogon gayanus* generally also had less of an impact on desirable native grass species. This indicates that there may be an opportunity to further test these herbicides at higher application rates in order to determine if they can selectively control *Andropogon gayanus* whilst not significantly affecting desirable plant species. In contrast it may be beneficial to test the herbicides such as Command, Oxyflurofen, Poacher and Specticle which effectively suppressed most grass species in order to determine if any native grass species exhibits some tolerance at lower application rates.

These results indicate that field testing at more than a single application rate of those herbicides which effectively suppressed *Andropogon gayanus* may be warranted in order to determine if any grass selectivity exists under field conditions. An expansion of the test species list should be considered for any future pot or field herbicide studies in an attempt to find native species that are tolerant of the relevant herbicides while at the same time are a suitable species for restoring *Andropogon gayanus* invaded areas.

Although this study did not identify suitable pre-emergence herbicides that selectively controlled *Andropogon gayanus* whilst not damaging native grass species, it did identify several herbicides (Command, Oxyflurofen, Poacher and Specticle) that warrant further testing at a range of application rates and in a range of situations. It may be that suppressing all grass establishment for a period to deplete the short lived Andropogon gayanus seed bank prior to allowing natural site restoration is a longer term management strategy worth testing as a way of managing new infestations that are inaccessible for part of the year due to the northern wet season.

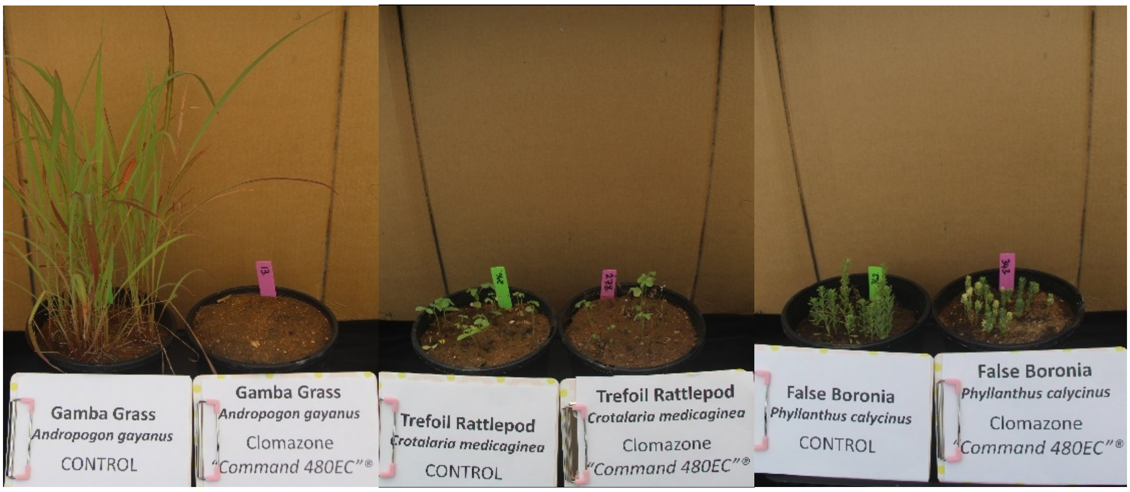

Figure 2. L – R, Command-treated pots of Andropogon gayanus, Crotalaria medicaginea, and Phyllanthus calycinus at 12 weeks after treatment.

Figure 3. L – R, Mako-treated pots of *Andropogon gayanus*, *Phyllanthus calycinus* and *Heteropogon triticeus* at 12 weeks after treatment.

Figure 4. L – R, Oxyflurofen-treated pots of *Andropogon gayanus*, *Phyllanthus calycinus* and *Heteropogon triticeus* at 12 weeks after treatment.

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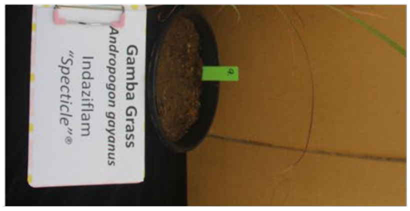
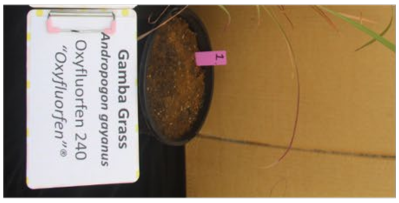
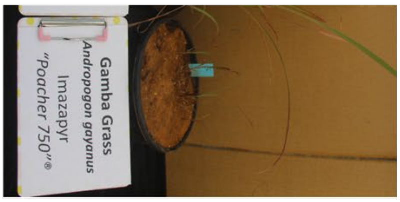
- Joe Vitelli for herbicide advice.

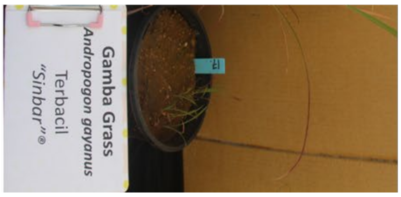
Appendix A. Plant species responses to herbicide treatment at 12 weeks after treatment.

Gamba grass response to each herbicide 12 weeks after treatment

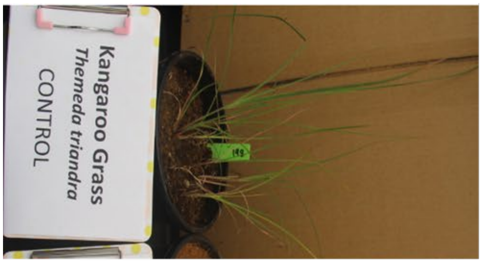


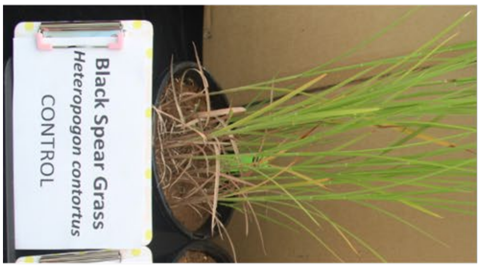


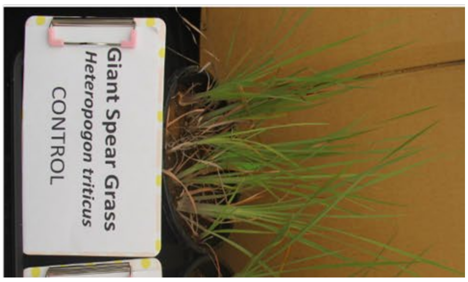




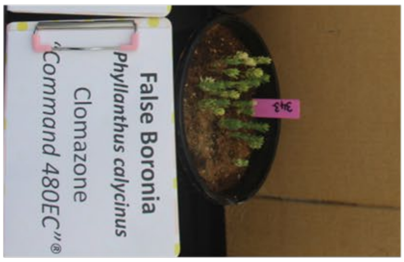
Untreated control plants of each species 12 weeks after treatment.

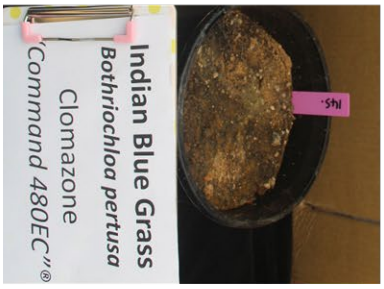


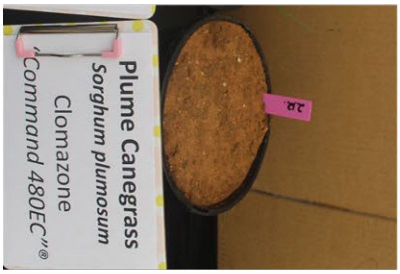




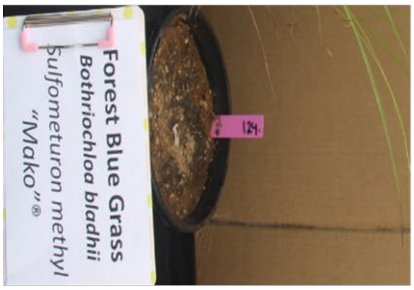
Species response to Clomozone12 weeks after treatment.

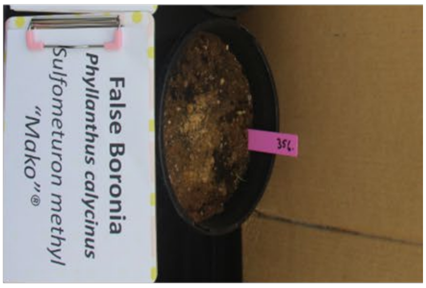


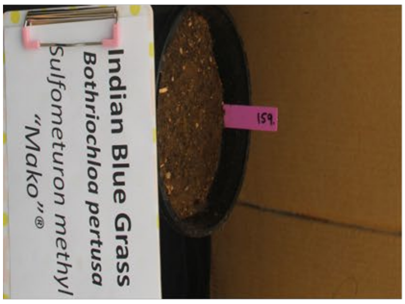


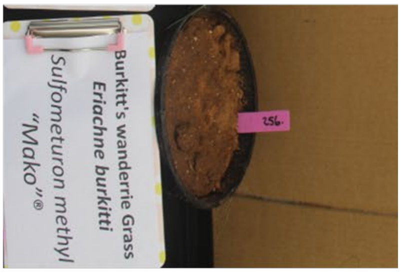


Species response to Mako 12 weeks after treatment.



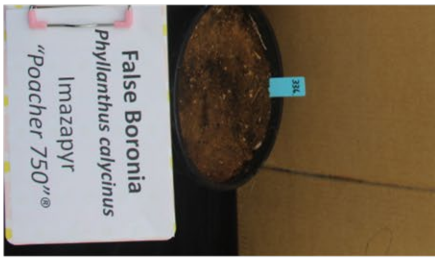


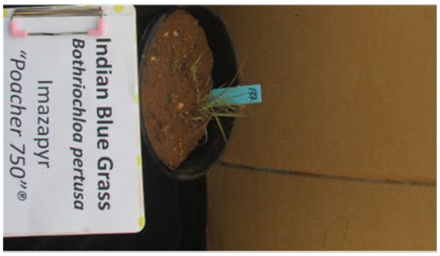


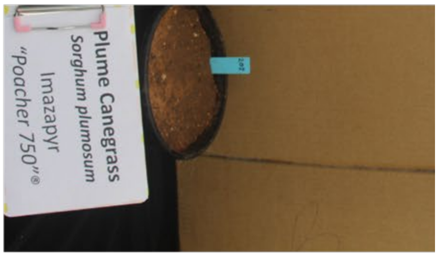


Species response to Oxyflurofen 12 weeks after treatment.

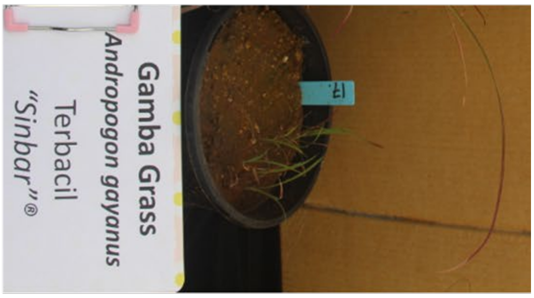
Species response to Poacher 750 12 weeks after treatment.

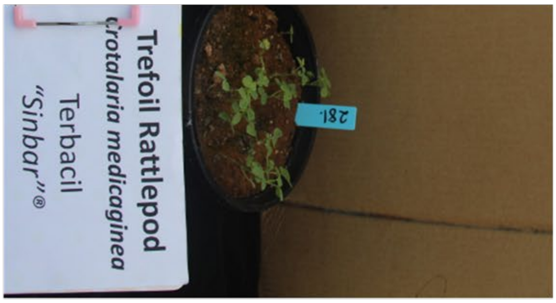


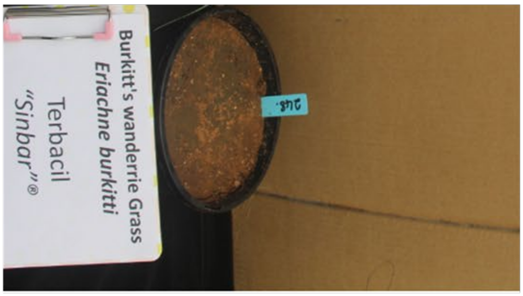


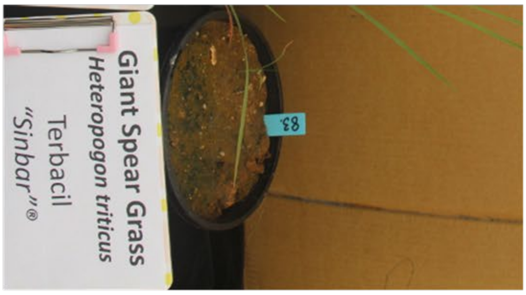


Species response to Sinbar 12 weeks after treatment.

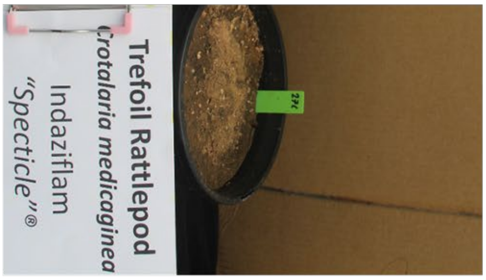


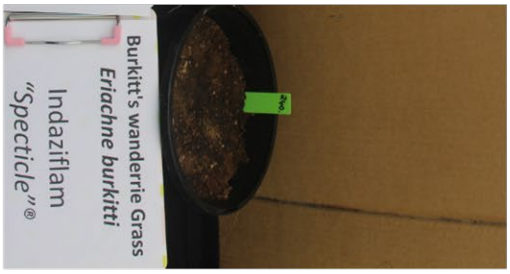




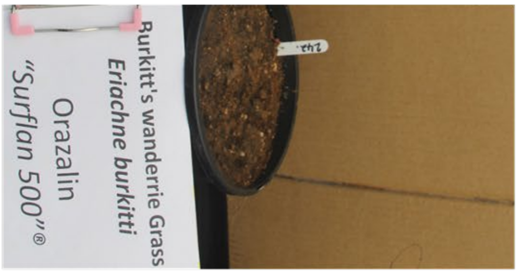


Species response to Specticle 12 weeks after treatment.

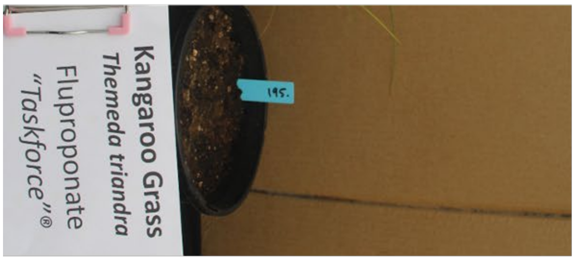


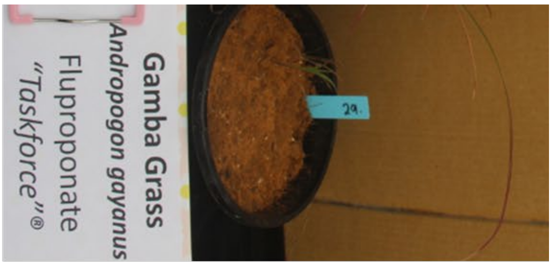


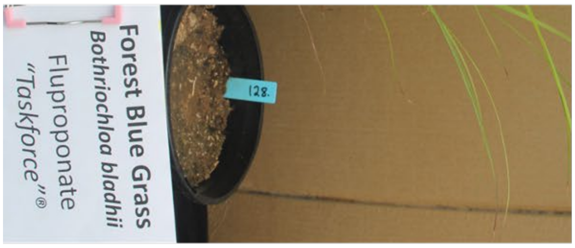
Species response to Surflan 500 12 weeks after treatment.

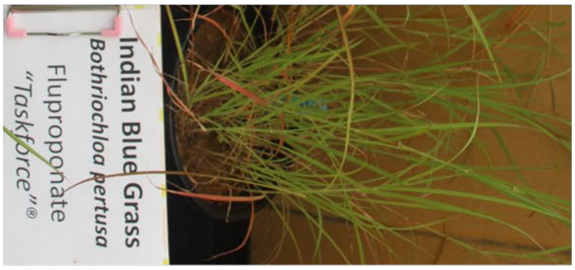


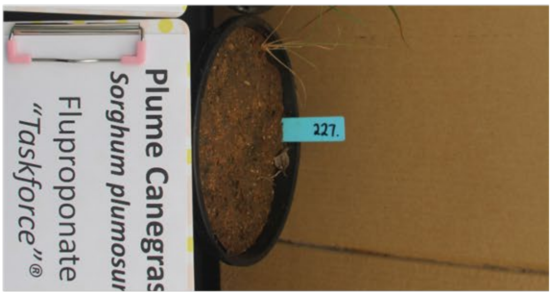
Species response to Taskforce 12 weeks after treatment.

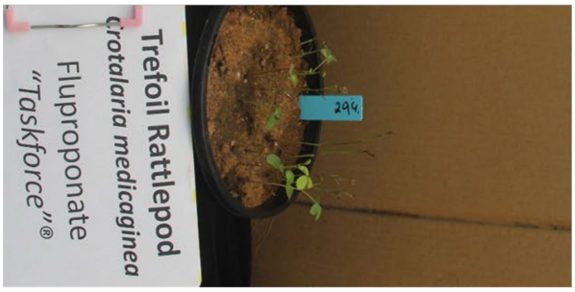


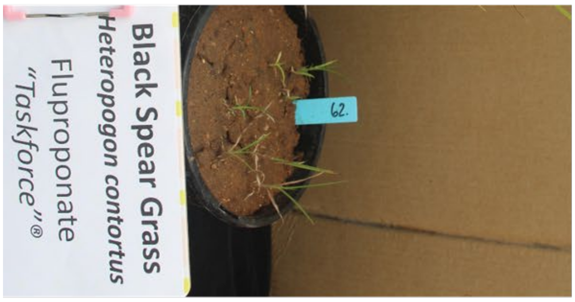




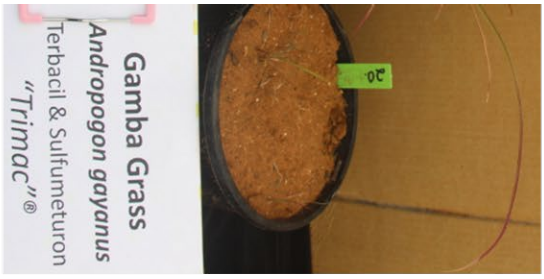


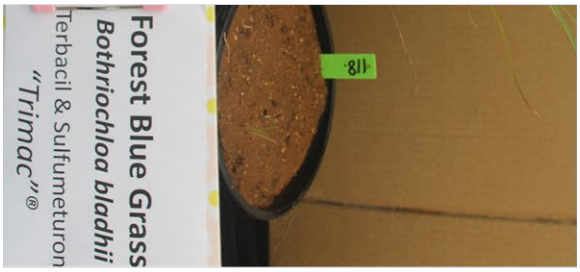


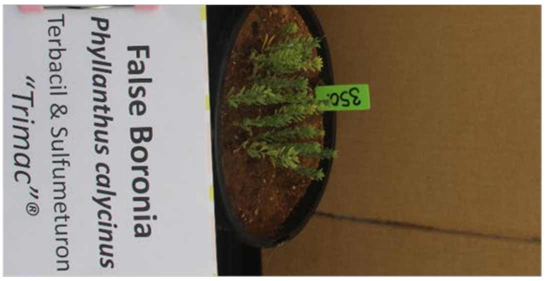


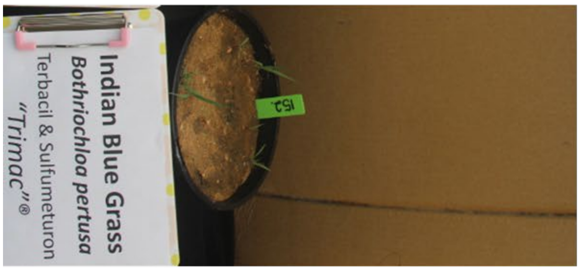


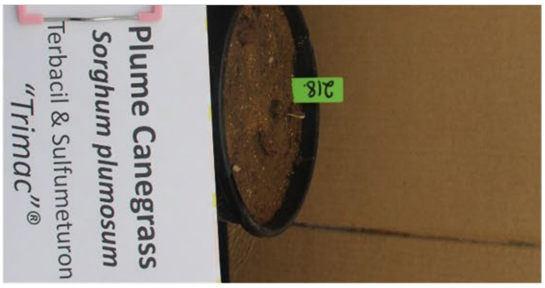
Species response to Trimac 12 weeks after treatment.

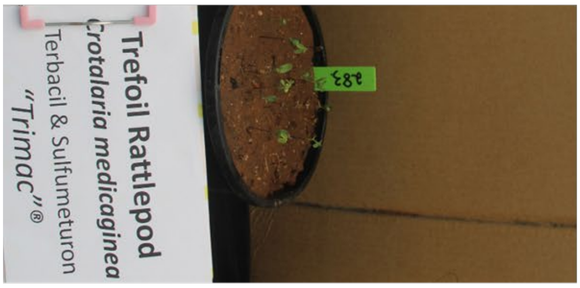


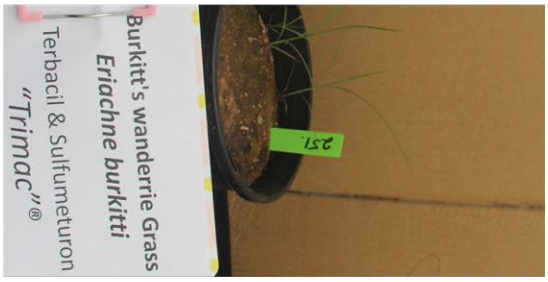


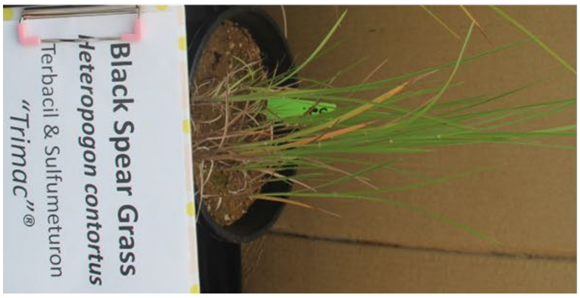




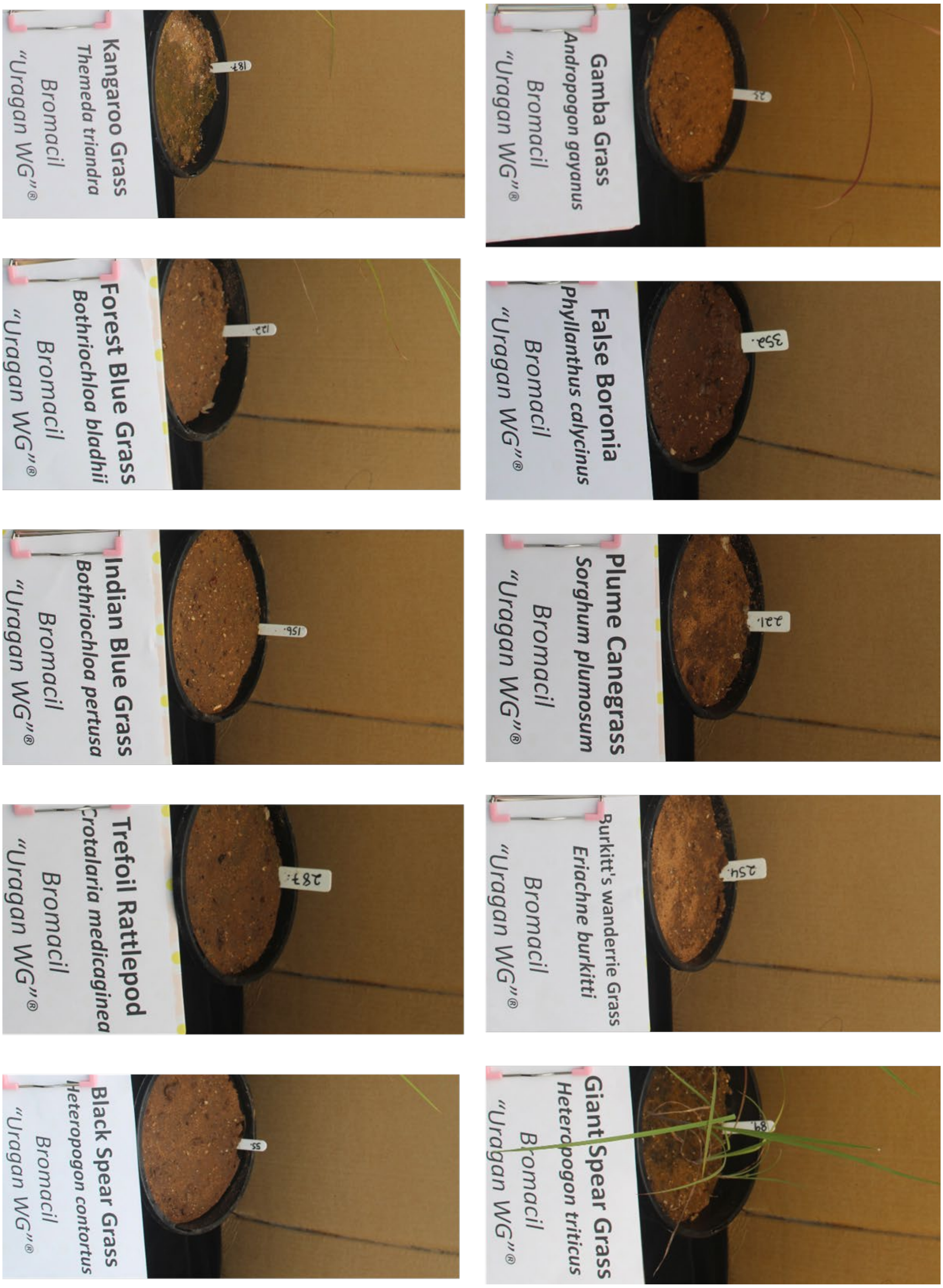








Species response to Uragan WG 12 weeks after treatment.



Appendix B. Herbicide labels

POISON

KEEP OUT OF REACH OF CHILDREN

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

GENERAL INSTRUCTIONS

Command® 480 EC Herbicide is primarily a soil applied herbicide for the control of certain annual weeds. Plant uptake of Command occurs through both the roots and the foliage. The movement of the active constituent clomazone within the plant occurs upward and outwards to the leaf. Clomazone is not downward systemic, or translocated from leaf to leaf.

When using Command as a post plant pre-emergence herbicide all emerged weeds should be controlled by application of a non-selective, non-persistent herbicide or by tillage. The soil surface should be left free of large clods of soil that might protect weed seedlings during emergence. Best weed control is achieved when overhead irrigation is used to grow the crop. Command should not be mechanically incorporated into the soil as unacceptable crop injury and variable weed control may occur. When using Command as a post emergence herbicide ensure weeds are young and actively growing.

SYMPTOMS

Clomazone, the active constituent Command, inhibits the biosynthesis of photosynthetic pigments of both chlorophyll and carotenoids. Accordingly the foliage of susceptible plants show signs of chlorosis (whitening or bleaching), followed by necrosis (browning). In some situations, one or more of the following conditions such as; higher use rates, sandy soils, soils of low organic matter, or soils of low pH, may cause an increase in the activity of Command and crop damage may occur. Do not apply Command on to soils with both organic carbon content less than 2% and clay content less than 15%, excluding poppy and tobacco crops, which have a higher crop tolerance to clomazone at label rates. Some crop varieties may show differing levels of tolerance to Command. It is recommended to test on a small area to ensure tolerance is acceptable before adoption on a wider scale. For more specific information consult with your local dealer.

Directions for use

RESTRAINTS:

DO NOT apply by aircraft or through irrigation equipment.

DO NOT apply more than a combined total of 2L/ha on any one paddock in any 12 month period.

DO NOT apply in fog or in conditions conducive to fog.

DO NOT apply to soil intended for seedling transplants, with the exception of tobacco.

DO NOT mechanically incorporate Command into soil.

DO NOT apply to soils with both organic carbon content less than 2% and clay content less than 15%, excluding poppy and tobacco crops which have a higher crop tolerance to clomazone at label rates.

How to use tables:

1. Select rate, or rate range, for use in your crop from Table 1.
2. Check crop tolerance using crop tolerance soil type (Table 2) of the soil that your crop is to be grown in, to determine maximum crop tolerance range. Crop damage may occur if using rates higher than shown in Table 2.

Note: Use lower rate (500 mL/ha) in combination with other post plant pre emergent herbicides to broaden weed spectrum.

Table 1.

CROP	WEEDS CONTROLLED	RATE	CRITICAL COMMENTS
Cucumber, Pumpkins, Kabocha squash, Rockmelons, Watermelon, & Zucchini	Apple of Peru (*Nicandra physalodes*), Blackberry nightshade (*Solanum nigrum*), Fat hen (*Chenopodium album*), Pig Weed (*Portulaca oleracea*), Potato Weed (*Galinsoga parviflora*), Amaranth (*Amaranthus powellii*) (Suppression only)	0.5 - 1L/ha	DO NOT apply to soil intended for cucurbit seedling transplants. Watermelons are sensitive to Command. Only the minimum suggested rate should be used. Apply post plant pre-emergence before weeds emerge. Some cucurbit varieties may show differing levels of tolerance to Command. See section on SYMPTOMS. The use of Command in combination with post plant pre-emergent herbicides will broaden the weed spectrum.
Green Beans (French beans)		0.5-1L/ha	Apply post plant pre-emergence before weeds emerge. Command can be used in tank mix with other post plant pre emergent herbicides. Use lower rates in combination with other post plant pre emergent herbicides to broaden weed spectrum.
Navy Bean		0.5-1 L/ha	Apply post plant pre-emergence before weeds emerge. Command can be used in tank mix with other post plant pre-emergence herbicides. Use lower rates in combination with other post plant pre emergent herbicides to broaden weed spectrum.
Poppies (Tas only)			Apply post emergence to actively growing weeds as early as the 2 leaf stage of the crop through to the 8 leaf stage. Command is compatible with other poppy herbicides. To broaden weed spectrum, Command can be used in tank mixes or in a multiple spray strategy with other poppy herbicides. Use higher rates on heavier soil types and lower rates on sandy, low organic matter soils. Use in accordance with advice from contracting Company's Advisory Officers.
	Amaranth (Suppression only)	0.5 - 1 L/ha	Use the lower rate for small weeds cotyledon to 2 leaf in size. Use the higher rate for high weed pressure or weeds 4-6 leaf in size.
	Fat Hen		Use the lower rate for small weeds cotyledon to 2 leaf in size. Use the higher rate for high weed pressure or weeds 2-4 leaf in size.
	Hogweed (*Polygonum aviculare*)	0.25 - 0.5 L/ha	
	Stagger Weed (*Stachys arvensis*)	0.5 L/ha	Apply at the cotyledon to 4 leaf stage.
	Wild radish (*Raphanus raphanistrum*) (Suppression only)	1 L/ha	Apply at the cotyledon to 4 leaf stage. Useful suppression only may be achieved. If weed population is high or weeds are greater than 4 leaf in size, use a dedicated wild radish herbicide.
Potatoes (Tas only)	Apple of Peru, Blackberry nightshade, Fat hen, Pig Weed, Potato Weed, Amaranth (Suppression only)	0.5 L/ha	Apply Command in tank mixes with other post plant pre-emergence herbicides to broaden weed spectrum. Apply post plant pre-emergence before weeds emerge. Do not apply to emerged potatoes as crop injury may occur.
Tobacco (Transplanted tobacco only. Do not use on seedling beds.)		1-2 L/ha	Apply pre transplant or up to 7 days post transplant before weeds emerge. If weeds have emerged before application can be made, cultivate shortly before or at the time of treatment, or if prior to planting use in a tank mix with a knockdown herbicide. Use higher rates when high weed pressure is expected or in heavier soil types. Use lower rates on sandy, low organic matter soils.

Table 2 is a crop tolerance calculator for use with all crops with the exception of Poppies and Tobacco which have a higher crop tolerance to clomazone at label rates.

Table 2. Maximum crop tolerance recommended rates based on soil type (clay and organic carbon content).

Soil texture	Clay content	Organic Carbon Content			
		< 1%	1 - < 2%	2-3%	> 3%
Sand, Loamy Sand, Silt	< 15%	Only use in poppies and tobacco		500 mL	500 mL
Loam, Sandy Loam, Silt Loam, Sandy Clay loam	15-30%	Only use in poppies and tobacco	500 mL	500 mL	1 L
Sandy Clay, Clay Loam, Silt Clay Loam, Silty Clay, Clay.	> 30%	500 mL	500 mL	1 L	1 L

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

WITHHOLDING PERIOD:

All Crops: **HARVEST: Not required when used as directed.**
GRAZING: Do not graze or cut for stock food until after harvest.

COMPATIBILITY

Command may be tank mixed with other post plant pre-emergent herbicides to broaden the weed control spectrum compared to products applied alone. Lower rates of Command may be used when tank mixing.

POPPIES - Command is compatible with Asulox*, Brodal* and Frontier Optima*. Command is not compatible with Tramat* and efficacy can be reduced in tank mixes using Starane*. Other herbicide combinations should be used with caution and in accordance to advice from contracting Company's Advisory Officers.

OTHER CROPS - when tank mixing with other herbicides (eg: Frontier*) refer to both product labels to ensure use patterns are compatible ie. post plant pre-emergence and observe all application precautions, rotational guidelines and replanting instructions of each product label.

RESISTANT WEEDS WARNING

GROUP F HERBICIDE

Command is a member of the Isoxazolidinone group of herbicides. Command has the inhibitors of carotenoid biosynthesis mode of action. For weed resistance management Command is a Group F Herbicide.

Some naturally occurring weed biotypes resistant to Command and other Group F herbicides may exist through normal genetic variability in any weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by Command or other Group F Herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, FMC accepts no liability for any losses that may result from the failure of Command or other Group F Herbicides.

MIXING

Add half the required volume of water in spray tank and start agitation. If tank mixing with wettable powders or Water Dispersible Granules add these first, Liquid Suspensions (ie. Flowables) are added next, and Command is added last. Maintain good agitation at all times until spraying is completed.

APPLICATION

Inappropriate application techniques can result in highly visible symptoms of spray drift. Command can be applied as a broadcast or banded application. Use conventional sprayers with either mechanical or by-pass agitation. Apply using flat fan nozzles producing medium to coarse droplets, Spray equipment should be properly calibrated to ensure correct application. To minimise off target movement use the lowest pressure and boom height which provides uniform coverage, using 150 to 400 litres per hectare. Do not apply to very wet soils or to soils with a rough surface.

Band spray rate

The rate of Command for band spraying per hectare of crop is calculated from the broad area rates as follows:

$$\frac{\text{Band width (cm)}}{\text{Row spacing (cm)}} \times \text{Broadcast Rate (L)}$$

= Band Rate (L) per hectare of crop for band spraying

CROP ROTATION RECOMMENDATIONS

Command treated area may be replanted to any of the specified crops after the interval indicated in the following table.

Minimum Recropping Intervals
For Command

Rate	Minimum Recropping Interval (months after application)					
	0	3	6	9	12	15
0.5 L/ha or less	Poppies, Potatoes, Cucurbits, Beans, Tobacco, Rice		Barley, Oats, Wheat, Lucerne, Rye grass Onions, Canola, Sub- clover	All other crops		
1.0 L/ha	Potato, Cucurbits, Beans, Tobacco, Rice	Poppies		Barley, Oats, Wheat, Lucerne, Rye grass, Onions, Canola, Sub-clover	All other crops	
2.0 L/ha	Cucurbits, Beans, Tobacco	Potato, Poppies, Rice			Barley, Oats, Wheat, Lucerne, Rye grass, Onions, Canola, Sub- clover	All other crops

Tolerance of other crops (grown through to maturity) should be determined on a small scale before sowing into larger areas.

Cover crops, however may be planted anytime but stand reductions may occur in some areas. Do not graze, or harvest for food or feed, cover crops.

Replanting: If initial seedlings fail to produce a stand, the crop maybe replanted in fields treated with Command alone. Do not retreat field with a second application of Command. Do not replant treated fields with any crop at intervals, which are inconsistent with the rotational crop guidelines on this label. When tank mixing observe all application precautions, rotational guidelines and replanting instructions of each product label.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

DO NOT apply under meteorological conditions or from spray equipment, which could be expected to cause spray drift onto nearby susceptible plants, adjacent crops, crop lands or pastures.

OFF TARGET WHITENING

Command can cause whitening of sensitive plants (ie. some species of trees, shrubs, flowers, agronomic crops and fruit and vegetables) by either spray drift or volatilisation. The application and recommendation for the use of this product should be undertaken only by persons adhering to the following requirements:

Precautions to be taken to minimise potential off-target effects:

- DO NOT spray within 100 metres of residential or industrial properties or homes on neighboring properties,
- Where it is proposed to spray within 100 metres of a neighbouring property which is used for primary production, the owner of the property must be given written notice of the intention to spray and information which includes the name of the product being sprayed and its effects on susceptible plant species,
- Ensure that when the product is being diluted prior to application that it is done away from desirable plants,
- DO NOT empty or clean sprayers near homes and sensitive plants,
- DO NOT apply by aircraft, or through irrigation equipment, and
- Remove contaminated clothing before entering areas where sensitive plants exist e.g. homes, nurseries, greenhouses and other crops.

Application equipment/calibration:

- Use coarse nozzles with pressure not exceeding 35PSI/250 kPa (2.5 bar) with boom height no greater than 60 cm above the target, and
- Apply only with calibrated equipment.

Minimisation of product volatilisation:

- Apply to dry soils in 150-400L water per hectare,
- DO NOT apply to wet soils and or wet plants,
- DO NOT spray poppy crops beyond the 8 leaf stage,
- DO NOT apply in wind gusts over 12km/hr or when weather conditions favor the formation of inversion layers,
- Weather resulting in warm, high moisture soils increase the volatility potential of Command. Sunlight may also heat the soil surface, evaporating soil moisture and causing an inversion effect. This inversion effect causes the product to move to the soil surface where it is more subject to volatilisation, and
- DO NOT apply in fog or in conditions conducive to fog.

PROTECTION OF WILDLIFE, FISH, CRUSTACEA, AND ENVIRONMENT

DO NOT contaminate dams, streams, rivers or waterways with Command or used container.

STORAGE AND DISPOSAL

Do NOT store near (or allow to contact) fertilisers, fungicides or pesticides. Store in the closed, original container in a well ventilated area, as cool as possible. Do not store for prolonged periods in direct sunlight. Store in a locked room or place away from children, animals, food, feed stuffs, seed and fertilisers.

Spillage - In case of spillage, confine and absorb spilled product with absorbent material such as sand, clay or cat litter. Dispose of waste as indicated below or according to Australian Standard 2507 - Storage and Handling of Pesticides. Do NOT allow spilled product to enter sewers, drains, creeks or any other waterways.

Triple or (preferably) pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. Break, crush, puncture and bury empty containers in a local authority landfill. If not available bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, vegetation and roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS

Harmful if inhaled or swallowed. Will irritate the eyes and skin. Avoid contact with eyes and skin. Do not inhale vapour. When opening the container and preparing spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow length nitrile gloves and face shield or goggles. When using the prepared spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and elbow length nitrile gloves. If product in eyes, wash out immediately with water. Wash hands after use. After each day's use, wash gloves, face shield or goggles and contaminated clothing.

FIRST AID

If poisoning occurs, contact a doctor or Poisons Information Centre. Phone Australia 13 11 26. If swallowed, do not induce vomiting. Give a glass of water.

MATERIAL SAFETY DATA SHEET (MSDS)

Additional information is listed in the Material Safety Data Sheet, which is available from the supplier.

WARRANTY

FMC makes no warranty expressed or implied, concerning the use of this product other than that indicated on the label. Except as so warranted the product is sold as is. Buyer and user assume all risk of use and/or handling and/or storage of this material when such use and/or handling and/or storage is contrary to label instructions.

APVMA Approval No: 49604/0304

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Mako®

Herbicide

ACTIVE CONSTITUENT: 750g/kg SULFOMETURON METHYL

GROUP B HERBICIDE

For the control of certain annual and perennial grasses and broadleaf weeds in commercial and industrial areas: around agricultural buildings, rights of way, and for Pre and Post Planting *E. globulus, E. nitens* and *P. radiata* plantations as per directions for use.

IMPORTANT: READ THE ATTACHED LEAFLET BEFORE USING THIS PRODUCT

® Mako is a registered trademark of Nufarm Australia Limited

nufarm.com.au

Nufarm Australia Limited
ACN 004 377 780
103-105 Pipe Road
Laverton North Victoria 3026
Tel: (03) 9282 1000
Fax: (03) 9282 1001

Contents: 250g
Contents: 500g
Contents: 1kg
Contents: 1.5kg
Contents: 2kg

APVMA Approval No: 51666/57613

STORAGE AND DISPOSAL
During storage keep from contact with fertilisers, other pesticides and seeds. Store in the closed original container in a well-ventilated area, as cool as possible but out of direct sunlight. Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500mm in a disposal pit specifically marked and set up for this purpose, clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS
Will irritate eyes, nose and throat, and skin. Avoid contact with eyes and skin. DO NOT inhale dust and spray mist. If product in eyes, wash it out immediately with water. When opening the container and preparing product for use, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow length chemical resistant gloves, goggles and half facepiece respirator. When using the prepared spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow length chemical resistant gloves. Wash hands after use. After each day's use, wash gloves, goggles, respirator and if rubber wash with detergent and warm water, and contaminated clothing.

FIRST AID
If poisoning occurs, contact a Doctor or Poisons Information Centre Phone Australia 13 11 26.

MATERIAL SAFETY DATA SHEET
Additional information is listed in the Material Safety Data Sheet (MSDS), which can be obtained from your supplier or from the Nufarm website – www.nufarm.com.au

In case of emergency: Phone 1800 033 498 Ask for shift supervisor. Toll free 24 hours.

CONDITIONS OF SALE
"Any provisions or rights under the Competition and Consumer Act 2010 or relevant state legislation which cannot be excluded by those statutes or by law are not intended to be excluded by these conditions of sale. Subject to the foregoing, all warranties, conditions, rights and remedies, expressed or implied under common law, statute or otherwise, in relation to the sale, supply, use or application of this product, are excluded. Nufarm Australia Limited and/or its affiliates ("Nufarm") shall not accept any liability whatsoever (including consequential loss), or howsoever arising (including negligence) for any damage, injury or death connected with the sale, supply, use or application of this product except for liability which cannot be excluded by statute." BN / DOM / Barcode /

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Nufarm

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For the control of certain annual and perennial grasses and broadleaf weeds in commercial and industrial areas: around agricultural buildings, rights of way, and for Pre and Post Planting *E. globulus, E. nitens* and *P. radiata* plantations as per directions for use.

READ COMPLETE DIRECTIONS FOR USE BEFORE USING THIS PRODUCT.

® Mako is a registered trademark of Nufarm Australia Limited

nufarm.com.au APVMA Approval No.:51666/57613

DIRECTIONS FOR USE

RESTRAINTS

DO NOT apply Mako to drainage ditches and channels.
DO NOT apply Mako during periods of intense rainfall, or to soils saturated with water as off-target movement may occur.
DO NOT store tank mixes of Mako with other materials for more than 24 hours as product breakdown may occur.
DO NOT store a suspension of Mako for more than 2 days as it may degrade, particularly in acid solutions.

FOR ALL STATES

SITUATION	WEEDS	RATE			CRITICAL COMMENTS
		Boom	Hand Gun	Knap sack	
Commercial & Industrial areas, around Agricultural buildings, Rights-of-Way including road sides, around guide posts, railways, power lines and telephone lines	**Easy-to-Kill Annual Weeds** **Grasses** - Annual ryegrass, Barnyard grass, Summer grass/Crab grass, Wild oats, Winter grass **Broadleafs** – Blue Billygoat weed, Capeweed, Corkscrew/Erodium, Paterson's curse/Salvation Jane, Subterranean clover, Turnip weed **Easy-to-Kill Perennial Weeds** **Grasses** – Prairie grass **Broadleafs** - Dandelion, Dock, White clover **Hard-to-Kill Annual Weeds** **Grasses** - Rats tail fescue, Squirrel tail fescue **Broadleafs** – Black thistle/Spear thistle	200 or 400g/ha	20 or 40g/100L	3 or 6g/15L	For roadside applications confine treatment to the area between the edge of the bitumen and the roadside shoulder. For weeds advanced beyond the 4 leaf stage or when more rapid knockdown is required, tank mix with Roundup® Attack™ in accordance with its label recommendations. Always add a surfactant - except when tank mixing with Roundup® Attack™. Use the higher rate plus Roundup® Attack™ (in accordance with its label recommendations), for dense weed infestations and where weeds are greater than 15cm in height or diameter. Use the higher rate for longer term residual control. For handgun or knapsack application, apply the spray evenly to the required area. Spray to wet the foliage of the weeds present, but not excessively so as to cause run-off. Over application may reduce knockdown results and significantly increase period of residual control.
	Hard-to-Kill Perennial Weeds **Grasses** - African lovegrass, Columbus grass, Couch, Elastic grass, Guinea grass, Johnson grass, Kikuyu, Paspalum, Phalaris	400 or 800g/ha	40 or 80g/100L	6 or 12g/15L	For roadside applications confine treatment to the area between the edge of the bitumen and the roadside shoulder. Always tank mix with Roundup® Attack™ in accordance with its label directions – a surfactant is not required. Use the higher rate plus Roundup® Attack™ (in accordance with its label recommendations), for dense weed infestation and where weeds are greater than 15cm in height or diameter. Use the higher rate for longer term residual control. For handgun or knapsack application apply the spray evenly to the required area. Spray to wet the foliage of the weeds present, but not excessively so as to cause run-off. Over application may reduce knockdown results and significantly increase the period of residual control.

FORESTRY - FOR SOUTHERN NSW, VIC, ACT, TAS, SA, AND WA ONLY

Pre-Plant Application

SITUATION	WEEDS	RATE	CRITICAL COMMENTS
E. globulus, *E. nitens* and *P. radiata* plantations (Including farm tree plantations of these species)	**Annuals** Fleabane, Clover **Perennials** Dock, Fog grass, Flatweed, Sorrel	50-70g/ha	DO NOT TRANSPLANT SEEDLINGS WITHIN 6 WEEKS (50g) OR 8 WEEKS (70g) OF APPLICATION. DO NOT APPLY TO ALKALINE SOIL For weeds advanced beyond the 3-4 leaf stage or to increase the knockdown spectrum of weeds controlled, tank mix with Roundup® Attack™ in accordance with its label recommendations. Use the higher rate of Mako Herbicide for longer-term residual control. Apply with Pulse® Penetrant at a rate of 200mL/100L of water except when tank mixing with Roundup® Attack™. May be used in newly coppiced eucalypt plantations after harvest. Apply in pre-plant situations by ground based or aerial application. Wherever possible areas of application should have some type of cover, i.e. weed biomass or residual organic matter (trash), and be mounded along the contour. For further information refer to General instructions sections attached.

Post-Plant Application

SITUATION	WEEDS	RATE	CRITICAL COMMENTS
P. radiata (Including farm tree plantations of this species)	**Annuals** Fleabane Clover **Perennials** Dock Fog grass Flatweed, Sorrel	50-70g/ha	For trees in the establishment phase only (2 months to 15 months post-transplant) ONLY APPLY this product between the months of May through to the end of September. Apply when trees are dormant only. Applications may result in tip damage. The Tip damage seen is transitory and will not have any long-term impact on tree form or growth rate. Application in spring months when trees may be coming out of dormancy will increase the chance of tip damage occurring. Best results are obtained when applied to bare ground or to weeds no larger than the 3 leaf stage. Use the higher rate for longer-term residual control. Apply in pre-plant situations by ground based or aerial application. Wherever possible areas of application should have some type of cover, i.e. weed biomass or residual organic matter (trash), and be mounded along the contour. For further information refer to General instructions sections attached.

Post-Plant Application

SITUATION	WEEDS	RATE	CRITICAL COMMENTS
E. globulus, *E. nitens* (Including farm tree plantations of these species)	**Annuals** Fleabane Clover **Perennials** Dock Fog grass Flatweed, Sorrel	50-70g/ha	Allow 12 months after transplanting before application. Apply Mako Herbicide as a DIRECTED SPRAY ONLY using a SHIELDED SPRAYER between tree rows. DO NOT allow spray or spray drift to contact any part of the Eucalypt seedling as severe injury or tree death may result. Best results are obtained when applied to bare ground or to weeds no larger than the 3 leaf stage. Use the higher rate for longer-term residual control. For further information refer to General instructions sections attached. May be used in newly coppiced eucalypt plantations after harvest. Apply in pre-plant situations by ground based or aerial application. Wherever possible areas of application should have some type of cover, i.e. weed biomass or residual organic matter (trash), and be mounded along the contour.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

WITHHOLDING PERIOD: NOT REQUIRED WHEN USED AS DIRECTED

GENERAL INSTRUCTIONS

Mako is a soil residual herbicide with some knockdown action. It controls susceptible weeds through both post-emergence and pre-emergence (residual) action. Mako may be applied pre-emergence or post emergence to the weeds; best results are obtained if application is made before or during the early stages of weed growth. Adequate soil moisture is required for Mako to be activated so it can provide optimum weed control. Under limited rainfall conditions, Mako may not provide satisfactory control of hard-to-kill annuals and perennial weeds. The higher use rates give longer term residual control. The degree of control and duration of effect will vary with the rate of application, soil texture, organic matter content, soil pH, rainfall and other environmental conditions. As soil pH increases the rate of Mako breakdown decreases so that longest term residual control is obtained on alkaline soils. As soil moisture increases the rate of Mako breakdown decreases, so that longest term residual control is obtained when rainfall is low. As soil organic matter content increases the rate of Mako breakdown increases, so that longest term residual control is obtained in low organic matter soils.

FORESTRY

• Transplant seedlings should be healthy and showing good vigour at time of transplanting and be a minimum of 20cm in height. DO NOT transplant seedlings into areas treated with Mako Herbicide if they are smaller than 20cm in height or are showing poor levels of vigour due to disease, or environmental factors such as drought, frost, moisture or water logging.
• DO NOT apply to alkaline soils (soil pH >7), or on leached, sandy soils, low in organic matter as unacceptable crop phytotoxicity may occur.
• DO NOT apply product to poorly drained soils, to gravel or rocky soils and exposed subsoils.
• This product is not suitable for use where seed is to be sown directly in to the treated areas.
• DO NOT broadcast apply to uncultivated or non-mounded or bare ground on slopes exceeding 30%

RESISTANT WEEDS WARNING

GROUP	B	HERBICIDE

Mako is a member of the sulfonylurea group of herbicides. Mako has the acetolactate synthase (ALS) inhibitor mode of action. For weed resistance management Mako is a Group B herbicide. Some naturally-occurring weed biotypes resistant to Mako and other ALS inhibitor herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by Mako or other ALS inhibitor herbicides. Since the occurrence of resistant weeds is difficult to detect prior to use, Nufarm Australia Limited accepts no liability for any losses that may result from the failure of Mako to control resistant weeds. Strategies to minimise the risk of herbicide resistance are available. Consult your farm chemical supplier, consultants, local Department of Agriculture of Primary Industries, or local Nufarm representatives.

SPRAY PREPARATION

Mako is a dry flowable formulation to be mixed with water and applied as a spray. Partially fill the spray tank with water. Using the graduated measuring cylinder provided, measure the amount of Mako required for the area to be sprayed. DO NOT shake the Mako down as the measuring cylinder is graduated for Mako in an uncompacted state. Add the correct amount of Mako to the spray tank with agitation system engaged. Top up the correct volume with water. THE MATERIAL MUST BE KEPT IN SUSPENSION AT ALL TIMES BY CONTINUOUS AGITATION. (NB: The measuring cylinder provided is graduated in grams of Mako ONLY. DO NOT use for measuring other materials.) In tank mixes, Mako must be in suspension before adding the companion herbicide or surfactant. Where prepared spray solutions have been allowed to stand, thoroughly reagitate before using.

USE OF SURFACTANT - For Industrial use

Add a surfactant either non-ionic at the rate of 0.25%v/v (250mL/100L of Chemwet 1000) or the organosilicone Pulse® Penetrant at the rate of 0.2%v/v (200mL/100L) when Mako is used alone. When Mako is tank mixed with the Roundup® Attack™ and Weedmaster® Duo no surfactant addition is necessary.

USE OF SURFACTANT - For Forestry use

Always add the organosilicone Pulse® Penetrant at the rate of 0.2%v/v (200mL/100L) when Mako is used alone preplant. When Mako is tank mixed with Roundup® Attack™, no surfactant addition is necessary.

SPRAY EQUIPMENT - For Industrial Use

DO NOT apply by aerial application equipment or mist spray application equipment.

BOOM SPRAY

Mako is recommended for application by ground spraying equipment only. Use a boom spray properly calibrated to a constant speed and rate of delivery to ensure thorough coverage and a uniform spray pattern and rate of application over the area to be treated. Adjust boom height to ensure correct spray overlap. Avoid spraying where drift can go onto neighbouring areas as injury may occur. Avoid overlapping and shut off spray booms while starting, turning, slowing or stopping. Apply a minimum of 100L prepared spray/ha and use a Medium to Coarse Spray Quality.

HANDGUN/KNAPSACK

Wet the foliage of the weeds present but not excessively so as to cause run-off. Handgun - Use 1000-2000L of spray mix per hectare. Mako residues in the spray tank can damage sensitive plants. Following a Mako application the spray tank should not be used for other than non-crop applications.

SPRAY EQUIPMENT - For Forestry Use

BOOM SPRAY - Use a boom spray properly calibrated to a constant speed and rate of delivery to ensure thorough coverage and a uniform spray pattern and rate of application over the area to be treated. Adjust boom height to ensure correct spray overlap. Avoid spraying where drift can go onto neighboring areas as injury may occur. Avoid overlapping and shut off spray booms while starting, turning, slowing or stopping as injury to the trees may result. Apply a minimum of 100L prepared spray/ha and use a Coarse to Very Coarse Spray Quality (Based on BCPC Specifications).

Aerial Application (For Forestry use Only) - Avoid spraying in still conditions and in winds likely to cause drift onto adjacent sensitive crops or fallow areas likely to be planted to these crops. Turn off spray boom whilst passing over creeks and dams. DO NOT apply when a temperature air inversion is likely to occur. Use of micronair equipment is not recommended due to greater drift potential. Apply in a minimum of 50L/ha water.

COMPATIBILITY

Mako is compatible with the Roundup®, Roundup Biactive® Weedmaster® Duo, Roundup® Attack™, Asset®, Associate®, Nufarm Diuron 900 DF, Nufarm Nu-trazine 900DF, Nufarm Simazine 900 DF, Nufarm Grunt® 750 WDG and Nufarm Archer®.

SPRAYER CLEANUP

Mako residues in the spray tank can damage sensitive plants. It is recommended that a sprayer be dedicated to the use of Mako. Where equipment is also used for crop spraying, it is particularly important that all traces of Mako be removed from mixing and spraying equipment immediately after spraying. The recommended sprayer cleanup is as follows:

1. Drain tank, then flush tank, boom, filters and hoses with clean water for a minimum of 10 minutes.
2. Fill the tank with clean water and add 300mL chlorine bleach (containing 4% chlorine) per 100L water. Flush through boom, filters and hoses, then allow to sit for 15 minutes with agitation engaged, then drain.
3. Repeat Step 2.
4. Nozzles and screens should be removed and cleaned separately. To remove traces of chlorine bleach, rinse the tank thoroughly with clean water and flush through boom, filters and hoses.

CAUTION

DO NOT use chlorine bleach with ammonia.

If mixing with Glyphosate, DO NOT mix or store or apply this product in galvanised steel, unlined steel containers or spray tanks, since a highly flammable gas mixture may be formed. So use only spray tanks and equipment made of plastic or plastic lined fibreglass, rubber, aluminium, brass, copper, or stainless steel.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS
DO NOT apply to drainage ditches (including roadside ditches and table drains) and channels, as some of the chemicals may wash away in drainage water and be deposited in areas where it may cause damage to desirable trees and other plants. DO NOT apply under weather conditions or from spraying equipment that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures, or onto agricultural land scheduled to be planted to crops or pastures, as injury to the crop or pasture may occur. DO NOT apply via aerial application equipment post plant except in Pinus spp. Plantations only. DO NOT apply within 48 hours of or during periods of intense rainfall, or when wind speed exceeds 30kph (for ground application) or 20kph (for aerial application). DO NOT apply on or near desirable non-target trees or other plants, or on areas where their roots may extend. DO NOT apply to any drainage line. DO NOT used on leached, sandy soils, low in organic matter or on alkaline soils.

PROTECTION OF LIVESTOCK
DO NOT graze treated areas or cut for stock food.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT
DO NOT apply or drain or flush equipment on or near desirable trees or other plants, or on areas where their roots extend, or in locations where the chemical may be washed or moved into contact with their roots. DO NOT contaminate any body of water by spraying, cleaning of equipment, disposal of waste, including chemical or used containers, or run-off from treated areas. If accidental contamination does occur, the water must not be used for irrigation. DO NOT broadcast apply to uncultivated or non-mounded or bare ground on slopes exceeding 30% (15 degrees). DO NOT apply within 10m of point sources susceptible to runoff, such as tracks, snig tracks and compacted log dumps. DO NOT apply sulformeturon-methyl within 60m of a waterway or dam, or further if native riverbank vegetation may be damaged. DO NOT load or apply within 20m of any well, sink hole, intermittent or perennial stream. DO NOT handle, mix or test operations in areas (such as roads) where drainage facilitates rapid entry into waterways. DO NOT apply to water-logged or saturated soil. DO NOT use in irrigation channels or drains. DO NOT empty equipment in situations reflected in the above dot points. Dangerous to algae and aquatic plants. DO NOT contaminate streams, rivers or waterways with chemical or used containers.

STORAGE AND DISPOSAL
During storage keep from contact with fertilisers, other pesticides and seeds. Store in the closed original container in a well-ventilated area, as cool as possible but out of direct sunlight. Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500mm in a disposal pit specifically marked and set up for this purpose, clear of waterways, desirable vegetation and tree roots. Empty containers and product should NOT be burnt.

SAFETY DIRECTIONS
Will irritate eyes, nose and throat, and skin. Avoid contact with eyes and skin. DO NOT inhale dust and spray mist. If product in eyes, wash it out immediately with water. When opening the container and preparing product for use, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow length chemical resistant gloves, goggles and half face piece respirator. When using the prepared spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow length chemical resistant gloves. Wash hands after use. After each day's use, wash gloves, goggles, respirator and if rubber wash with detergent and warm water, and contaminated clothing.

FIRST AID
If poisoning occurs, contact a Doctor or Poisons Information Centre Phone Australia 13 11 26.

MATERIAL SAFETY DATA SHEET
Additional information is listed in the Material Safety Data Sheet (MSDS), which can be obtained from your supplier or from the Nufarm website – www.nufarm.com.au

In case of emergency: Phone 1800 033 498 Ask for shift supervisor. Toll free 24 hours.

CONDITIONS OF SALE
"Any provisions or rights under the Competition and Consumer Act 2010 or relevant state legislation which cannot be excluded by those statutes or by law are not intended to be excluded by these conditions of sale. Subject to the foregoing, all warranties, conditions, rights and remedies, expressed or implied under common law, statute or otherwise, in relation to the sale, supply, use or application of this product, are excluded. Nufarm Australia Limited and/or its affiliates ("Nufarm") shall not accept any liability whatsoever (including consequential loss), or howsoever arising (including negligence) for any damage, injury or death connected with the sale, supply, use or application of this product except for liability which cannot be excluded by statute."

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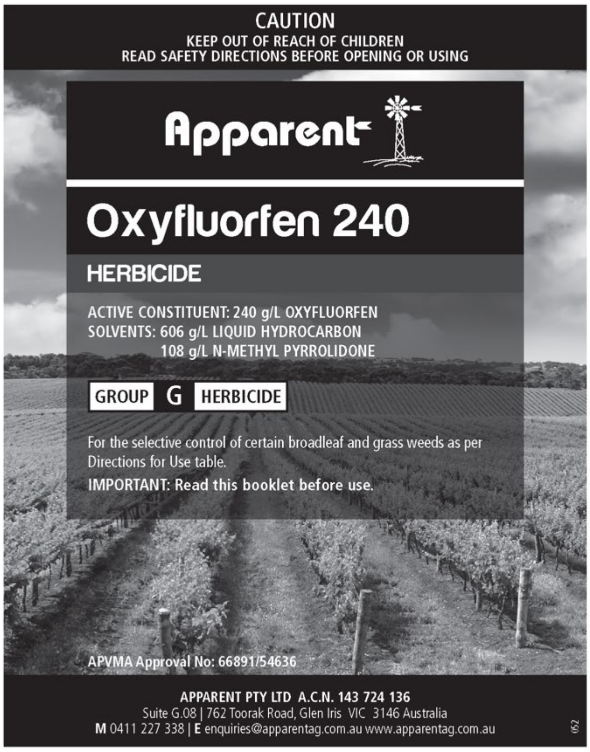

DIRECTIONS FOR USE

Apparent Oxyfluorfen 240 Herbicide can be used on weed-free soil to prevent germination of a wide variety of weeds or it can be applied to existing weeds at seedling stage especially with a tank mix partner to increase the variety of weeds controlled and/or the length of residual control. Apparent Oxyfluorfen 240 Herbicide can also be added at a low rate as a 'spike' to glyphosate or paraquat and diquat/paraquat herbicides to improve knockdown.

1. Apparent Oxyfluorfen 240 Herbicide applied as a 'spike' with glyphosate OR with either paraquat or a diquat/paraquat mixture.

RESTRAINT: DO NOT disturb weeds by cultivation or sowing for 1 day following application to annual weeds and 7 days for perennial weeds to ensure herbicide absorption, unless specified in the CRITICAL COMMENTS.

SITUATION	FOR WEEDS CONTROLLED & TIME OF APPLICATION	RATE of Apparent Oxyfluorfen 240 Herbicide	CRITICAL COMMENTS
Fruit & nut trees, vines including: Grapevines, Olive trees, Pome fruit (eg. apple, pear, nashi, quince), Stone fruit (eg. apricot, cherry, nectarine, peach, plum) Tree nuts (eg. almond, macadamia, pecan, walnut)	Refer to label of the glyphosate product (such as Apparent Glyphosate)	75 mL/ha **plus** a glyphosate product at its recommended label rate	Addition of Apparent Oxyfluorfen 240 Herbicide to glyphosate products will improve knockdown and increase the speed at which treated weeds develop visible symptoms of phytotoxicity (compared to results achieved with glyphosate applied alone) and give control of annual nettles, (Urtica spp.), and smallflowered mallow. For rates of glyphosate, refer to the appropriate label. Read and follow all label directions. **DO NOT apply** the tank mix of glyphosate and Apparent Oxyfluorfen 240 Herbicide near trees or vines less than 3 years old unless they are effectively shielded from spray and spray drift.
	Refer to label of the paraquat or diquat/paraquat products (such as Apparent Paraquat or Apparent Weedy Seedy)	250 mL/ha **plus** a paraquat or diquat/paraquat product at its recommended label rate	Addition of Apparent Oxyfluorfen 240 Herbicide in a tank mix with a paraquat or diquat/paraquat product will improve control of small flowered mallow, evening primrose and other weeds sensitive to Apparent Oxyfluorfen 240 Herbicide. For the rate of the paraquat or diquat/paraquat product, refer to the appropriate label. Read and follow all label directions.

2. Apparent Oxyfluorfen 240 Herbicide applied to weed-free soil or weeds at seedling stage.

RESTRAINT: If applying to weed seedlings, DO NOT disturb weeds by cultivation or sowing for 1 day ollowing application to annual weeds and 7 days for perennial weeds to ensure herbicide absorption, unless specified in the CRITICAL COMMENTS.

CROP	WEEDS CONTROLLED	TIME OF APPLICATION	RATE	CRITICAL COMMENTS
Brassica Crops Broccoli, Cabbages, Cauliflower	Refer to Weeds Controlled list	Weed free soil (prior to crop transplanting)	1.5 to 2 L/ha	Apply Apparent Oxyfluorfen 240 Herbicide to prepared ground 4 to 7 days prior to transplanting. If soil is dry irrigation or rainfall is required prior to transplanting for activation of Apparent Oxyfluorfen 240 Herbicide. Utilise transplanting techniques, which cause minimal soil disturbance. Excessive soil disturbance will lessen herbicide activity. **Use the higher rate** in situations where weed pressure is known to be heavy.
Coffee	Refer to Weeds Controlled list	Weed free soil	2 or 4 L/ha	Use the higher rate where longer residual activity (up to 4 months) is required.
		Weeds at 2 to 4 true leaf stage		When seedlings are present, apply as a tank mix with paraquat to produce both knockdown and residual control. Addition of a non-ionic surfactant such as Apparent Wetter 1000 and Apparent Gold Wetter 1000 at 150 mL/100 L should be used in the spray mixture. Apply as a directed spray to avoid contact with coffee plants. Mature established weeds must be eliminated by mechanical or chemical means prior to application.
Duboisia	Refer to Weeds Controlled list (best results are achieved when applied to moist soil free of weeds)	Weed free soil	4 or 8 L/ha	Use higher dosage where longer residual control (up to 6 months) is required. 'Over-the-top' application will be tolerated.
		Weeds at 4 to 6 true leaf stage		Recently germinated small seedling grasses and broadleaf weeds (4 to 6 true leaves) will be controlled at these rates. Established larger weeds must be eliminated by mechanical means prior to the application of Apparent Oxyfluorfen 240 Herbicide. Add a non-ionic surfactant such as Apparent Wetter 1000 and Apparent Gold Wetter 1000 (250 mL/100 L) to enhance activity.
Forestry Plantations: *Eucalyptus* spp. *Pinus* spp. (either before or preferably within 4 weeks of transplanting)	Refer to Weeds Controlled list	Weed free soil (either before or preferably within 4 weeks of transplanting)	3 or 4 L/ha	Under weed-free conditions, apply as a directed or 'over-the-top' spray. Disturbance of the herbicidal barrier on the soil surface at transplantation may reduce the length of weed control. If weed seedlings are present, apply as an 'over-the-top' spray. In either situation, use the higher rate for longer residual control. Apparent Oxyfluorfen 240 Herbicide can be applied in a tank mix with simazine to extend the spectrum and length of weed control. **DO NOT** use this tank mix in Eucalyptus plantations grown on sands, with no clay or organic matter. The likelihood of foliar damage to trees (especially eucalypts) will increase if applied to foliage that has not hardened off and/or if the temperature exceeds 20°C. However Apparent Oxyfluorfen 240 Herbicide is generally regarded as safe to commonly planted forestry species but the sensitivity of less common species should be tested on small areas before a large-scale application is made.
		Weeds at 4 to 6 true leaf stage		

2

3

CROP	WEEDS CONTROLLED	TIME OF APPLICATION	RATE	CRITICAL COMMENTS
Forestry Trees	Broadleaf weeds and grasses	Weeds at 4 to 6 true leaf stage	4 L/ha or 4 mL/10 m²	For the establishment of trees for approved farm practices such as wind breaks, erosion control, woodlots and forestry plantings. When applying as a post-plant spray, ensure spray is directed to the base of seedlings, or that seedlings are protected. **Do not apply** under hot or windy conditions.
Pyrethrum - as bare rooted transplants or seedlings	Refer to Weeds Controlled list (except chickweed)	Pre-plant incorporated into weed free soil worked to a fine tilth	4 or 6 L/ha	Apply prior to final soil preparation. The preferred implements for final soil preparation would be either a multiple tyne cultivator or rotary harrows. Use the 6 L/ha rate for heavy black clay soils only (as found in the Derwent and Coal River Valleys, Tasmania). Apparent Oxyfluorfen 240 Herbicide will not provide consistent control of chickweed.
Pyrethrum - more than 4 leaves	Blackberry nightshade, Cleavers, Field bindweed, Fumitory, Groundsel, Sorrel, Volunteer potato, Wireweed	Emerged weeds present	100 to 150 mL/ha	Apply when pyrethrum growth stage is greater than 4 true leaf.
Pyrethrum - established crops, > 1 year old	As above plus Sow Thistle, Spear Thistle		200 mL to 4 L/ha	Apply when pyrethrum is > 10 cm rosettes. Apply rates of more than 1.0 L/ha ONLY between 1st of February and 31st of March. **DO NOT apply later than 25 weeks before harvest.**
Tobacco	Refer to Weeds Controlled List	Weed free soil	4 L/ha	Use to control weeds along spray lines only. **DO NOT apply to tobacco crop.** Apply to soil after solid-set irrigation system has been laid out in the field. Apparent Oxyfluorfen 240 Herbicide should be applied to moist soil. Where very small weeds (2 to 3 leaf) emerge prior to spraying, the addition of a wetting agent to the spray mixture is necessary for effective control. Should the weeds be more advanced, the addition of 2 L/ha diquat (200 g/L) is required. Avoid spray drift.
Trees (Fruit & Nuts) and Vines at least 3 years old as a dormant application, including: Grapevines, Olive trees, Pome fruit (eg. apple, pear, nashi, quince), Stone fruit (eg. apricot, cherry, nectarine, peach, plum), Tree nuts (eg. almond, macadamia, pecan, walnut)	Refer to Weeds Controlled list	Weed free soil	3 or 4 L/ha	**DO NOT apply once bud swell has occurred.** Apply to freshly cultivated weed free soil. Use higher rate for longer residual control (up to 4 months). Where grass weeds are expected to be the major problem, or when control of a wider weed spectrum is needed, mix the lower rate with 4.5 L oryzalin (500 g/L) per treated hectare. Read and follow all label directions.
		Weeds at 4-6 leaf stage		**DO NOT once bud swell has occurred.** Use higher rate for longer residual control (up to 4 months). When light infestations of weeds are present, apply as a tank mix with glyphosate or paraquat/diquat to produce both knockdown and residual control. Read and follow all label directions. Where weed growth is large and dense, weeds must be eliminated prior to application of Apparent Oxyfluorfen 240 Herbicide, using glyphosate or by mechanical or chemical means. **Macadamias:** Apply in 250 to 500 L water/ha. Apply after harvest to prevent spray contacting nuts. Avoid spray contact with the foliage and stem. DO NOT apply to nuts on the ground.
Tropical and Subtropical fruit crops (inedible peel) including; Avocado, Cherimoya, Custard apple, Durian, Feijoa, Guava, Jackfruit, Kiwifruit, Longan, Lychee, Mango, Mangosteen, Papaya, Passionfruit, Persimmon, Rambutan, Star apple	Refer to Weeds Controlled List	Weed free soil	4 L/ha	Best results are obtained when applied to moist soil, free of weeds.
		Emerged weeds present		If weeds are present Apparent Oxyfluorfen 240 Herbicide should be applied as a tank mix with the recommended rates of glyphosate or paraquat or diquat/paraquat. Read and follow all label directions.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION

THIS PRODUCT IS TOO HAZARDOUS FOR USE IN THE HOME GARDEN

WITHHOLDING PERIODS:
Grazing – **DO NOT GRAZE TREATED WEEDS**
Harvest – **NOT REQUIRED WHEN USED AS DIRECTED**

4

5

WEEDS CONTROLLED
BEFORE GERMINATION

Amsinckia (*Amsinckia* spp.)	Prickly lettuce (*Lactuca* spp.)
Barley grass (*Hordeum leporinum*)	Red natal grass (*Rhynchelytrum repens*)
Barnyard grass (*Echinochloa* spp.)	Redshank (*Amaranthus cruentus*)
Blackberry nightshade (*Solanum nigrum*)	Ryegrass (*Lolium* spp.)
Bladder Ketmia (*Hibiscus trionum*)	Sesbania pea (*Sesbania cannabina*)
Burrgrass (*Cenchrus australis*)	Shepherd's purse (*Capsella bursa-pastoris*)
Caltrop (*Tribulus terrestris*)	Smallflower mallow (*Malva parviflora*)
Capeweed (*Arctotheca calendula*)	Soursob (*Oxalis pes-caprae*)
Chickweed (*Stellaria media*)	Sowthistle (*Sonchus oleraceus*)
Crowsfoot grass (*Eleusine indica*)	Starburr (*Acanthospermum hispidum*)
Deadnettle (*Lamium amplexicaule*)	Stinkgrass (*Eragrostis cilianensis*)
Fat hen (*Chenopodium album*)	Summer grass (*Digitaria* spp.)
Giant pigweed (*Trianthema portulacastrum*)	Thornapple (*Datura stramonium*)
Liverseed grass (*Urochloa panicoides*)	White eye (*Richardia brasiliensis*)
Lovegrass (*Eragrostis* spp.)	Wild mustard (*Sisymbrium* spp.)
Pigeon grass (*Setaria* spp.)	Wild radish (*Raphanus raphanistrum*)
Pigweed (*Portulaca oleracea*)	Wireweed (*Polygonum aviculare*)

SEEDLINGS

Amsinckia (*Amsinckia* spp.)	Pigweed (*Portulaca oleracea*)
Bellvine (*Ipomoea* spp.)	Potato weed (*Galinsoga parviflora*)
Capeweed (*Arctotheca calendula*)	Redshank (*Amaranthus cruentus*)
Common cotula (*Cotula australis*)	Shepherd's purse (*Capsella bursa-pastoris*)
Crowsfoot grass (*Eleusine indica*)	Sowthistle (*Sonchus oleraceus*)
Deadnettle (*Lamium amplexicaule*)	Stinging nettle (*Urtica urens*)
Groundsel (*Senecio vulgaris*)	Stinkgrass (*Eragrostis cilianensis*)
Liverseed grass (*Urochloa panicoides*)	Wild radish (*Raphanus raphanistrum*)
Marshmallow (*Malva parviflora*)	

6

GENERAL INSTRUCTIONS

Apparent Oxyfluorfen 240 Herbicide is a selective herbicide for the control of certain annual grasses and broadleaf weeds in dormant apples, grapes, peaches, pears, plums, apricots, almonds, macadamia, Duboisia, tobacco, coffee, pyrethrum, winter cereals, tropical/sub tropical crops, brassicas, *Eucalyptus* and *Pinus* spp and other forestry trees used in forestry applied either to a weed free soil or to seedling weeds at the 4 to 6 true leaf stage.

Apparent Oxyfluorfen 240 Herbicide applied to well prepared, weed free soil should not be disturbed or incorporated after application. Weed control for up to 6 months can be expected with high label rates, but spot treatment of escape weeds or perennial grasses may be necessary with knockdown herbicides.

When Apparent Oxyfluorfen 240 Herbicide is applied to seedling weeds at the 4 to 6 leaf stage, a non-ionic surfactant such as Apparent Wetter 1000 and Apparent Gold Wetter 1000 should be added at recommended rates to improve activity. Apparent Oxyfluorfen 240 Herbicide can also be used at low rates as a 'spike' to improve the weed spectrum of knockdown herbicides such as glyphosate and paraquat or diquat/paraquat mixtures. Duboisia seedlings and mature plants will tolerate 'over-the-top' applications. Eucalypt and pine transplants and established trees can tolerate "over-the-top" applications. When using Apparent Oxyfluorfen 240 Herbicide in combination with other herbicides, refer to the appropriate label and read and follow all label directions.

RESISTANT WEEDS WARNING

GROUP G HERBICIDE

Apparent Oxyfluorfen 240 Herbicide is a member of the diphenyl ether group of herbicides. The product has the inhibitor of protoporphyrinogen oxidase mode of action. For weed resistance management, the product is a Group G Herbicide.

Some naturally occurring weed biotypes resistant to Apparent Oxyfluorfen 240 Herbicide and other Group G Herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by Apparent Oxyfluorfen 240 Herbicide or other Group G Herbicides. Since the occurrence of resistant weeds is difficult to detect prior to use, Apparent Pty Ltd accepts no liability for any losses that may result from the failure of Apparent Oxyfluorfen 240 Herbicide to control resistant weeds.

TIMING

Residual Control

For optimum residual weed control, Apparent Oxyfluorfen 240 Herbicide should be applied to the soil surface prior to weed emergence after all other agricultural operations have been completed, such as mechanical cultivation and reshaping of irrigation furrows, have been completed. The area should be left undisturbed during the period of desired weed control. When applied to seedling weeds, they should be young and actively growing. Weed control for up to 6 months is expected but spot treatment, with knockdown herbicides, for escape weeds and perennial grasses may be necessary.

Post-emergence weed control

For optimum post-emergence weed control, Apparent Oxyfluorfen 240 Herbicide + glyphosate tank mixes should be applied to small seedling weeds up to 4 - 6 true-leaf stage. Use of a non-ionic surfactant such as Apparent Wetter 1000 and Apparent Gold Wetter 1000 is recommended to improve activity. Weeds should be actively growing and free from environmental stress (drought, cold, insect attack, nutrient deficiency). Cultivation after treatment and prior to or at planting is beneficial for final fallow weed control.

MIXING

Shake well before use. When using Apparent Oxyfluorfen 240 Herbicide alone, fill the spray tank, at least one-third full with clean water, add the recommended amount of Apparent Oxyfluorfen 240 Herbicide while the pump and agitator are running, then complete filling the spray tank.

A non-ionic surfactant, if required by label directions, should be added near the end of the filling process to minimise foaming.

When tank mixing with oryzalin, add to one-third filled tank, then the Apparent Oxyfluorfen 240 Herbicide during the filling operation. Maintain agitation during mixing and until spraying is completed.

When tank mixing with glyphosate products, paraquat/diquat or diquat, add these after Apparent Oxyfluorfen 240 Herbicide during the filling operation.

7

When using Apparent Oxyfluorfen 240 Herbicide in mixtures always refer to the appropriate label and read and follow all label directions.

Apparent Oxyfluorfen 240 Herbicide + Glyphosate tankmixes

Ensure thorough agitation when mixing, filling the spray tank and during application, irrespective of glyphosate formulation used. Follow recommended order and directions for tank mixing Apparent Oxyfluorfen 240 Herbicide and glyphosate. Use all spray mix immediately after preparation.

- DO NOT tank mix Apparent Oxyfluorfen 240 Herbicide and glyphosate without agitation.
- DO NOT allow mix to stand unagitated.
- DO NOT store Apparent Oxyfluorfen 240 Herbicide and glyphosate tank mixes.
- DO NOT mix other agrochemical products with Apparent Oxyfluorfen 240 Herbicide and glyphosate tank mixtures.

APPLICATION

Spray equipment should be calibrated carefully before use.

Apparent Oxyfluorfen 240 Herbicide should be applied uniformly with an accurately calibrated, low pressure herbicide sprayer, as a directed treatment to the base of tree and vine crops using flat fan or hollow cone nozzles. Complete coverage of seedling weeds is required for maximum knockdown effect. Ensure both weed foliage and the soil surface are sprayed.

Apply using a vehicle mounted boom, calibrate to deliver a droplet spectrum classification defined as medium by the American Society of Agricultural Engineers (ASAE) Standard S572, using water volume of 250 to 500 litres per hectare for bare soil or 100 to 1350 litres per hectare when seedling weeds (4 to 6 leaf stage) are treated. Use the higher volumes where weed density is high.

Tank mixtures of 75 mL/ha of Apparent Oxyfluorfen 240 Herbicide with glyphosate herbicides should be applied in 30 to 200 litres spray volume per hectare. For maximum residual control, Apparent Oxyfluorfen 240 Herbicide should NOT be incorporated or disturbed after application.

CROP SAFETY

Apparent Oxyfluorfen 240 Herbicide may be applied as directed around dormant peach, plum, apricot, almond, apple and pear trees and grape vines of all ages when applied at rates of less than 1.0 L/ha. When applied at 3.0 L/ha and above, the trees and grape vines should be at least 3 years of age. Do NOT apply Apparent Oxyfluorfen 240 Herbicide once bud swell has occurred when using rates greater than 1.0 L/ha.

Duboisia seedlings and mature plants will tolerate 'over-the-top' applications of Apparent Oxyfluorfen 240 Herbicide. When using the 75 mL/ha rate, Apparent Oxyfluorfen 240 Herbicide may be applied as directed prior to sowing winter cereals.

SAFE SOWING INTERVALS

Apparent Oxyfluorfen 240 Herbicide at up to 75 mL/ha may be safely applied 1 day prior to planting broadacre crops such as cereals (wheat, barley, oats, triticale), canola, pulses (lupins, faba beans, field peas) and undersown pastures (lucerne, clover, medics, ryegrass, phalaris, cocksfoot) and 7 days minimum prior to planting cotton or soybeans, provided minimum tillage planting equipment is used with minimal soil disturbance. Inversion, mixing of surface soil with that in the planting zone or covering seed with treated soil may result in injury to emerging crop seedlings. Avoid covering the seed with soil treated with Apparent Oxyfluorfen 240 Herbicide during the planting operation to minimise crop injury.

Apparent Oxyfluorfen 240 Herbicide has residual soil activity, especially when applied at rates greater than 75 mL/ha and on small-seeded horticultural crops. Plant back intervals in the following table for horticultural crops must be observed if more than 75 mL/ha Apparent Oxyfluorfen 240 Herbicide has been applied.

Safe Sowing Intervals for Horticultural Crops (days)

Apparent Oxyfluorfen 240 Herbicide	Up to 75 mL/ha	1 L/ha
Beans	7	60
Brassicas	14	90
Capsicums	14	90
Carrots	14	90
Cucurbits	14	60
Lettuce	14	90
Potatoes	7	60
Tomatoes	14	60

COMPATIBILITY

Apparent Oxyfluorfen 240 Herbicide is compatible with glyphosate products (with agitation), oryzalin, paraquat/diquat, diquat and glufosinate products.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby water bodies, susceptible plants/crops, cropping lands or pastures.

PROTECTION OF LIVESTOCK

Use with care when applying in areas frequented by stock.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

This product is highly toxic to wildlife and fish. DO NOT contaminate lakes, ponds, streams, rivers or waterways with the chemical or used containers. Use care when applying in areas frequented by wildlife or adjacent to any body of water. DO NOT apply when weather conditions favour drift from target areas.

STORAGE AND DISPOSAL

Store in the closed, original container in a dry, cool, well-ventilated locked room or place away from children, animals, food, feedstuffs, seed and fertilisers. Do not store for prolonged periods in direct sunlight.

Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on-site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush or puncture and deliver empty packaging for appropriate disposal to an approved waste management facility. If an approved waste management facility is not available, bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots, in compliance with relevant Local, State or Territory government regulations. DO NOT burn empty containers or product.

For Refillable Containers

Store in the closed, original container in a dry, cool, well-ventilated locked room or place away from children, animals, food, feedstuffs, seed and fertilisers. DO NOT store for prolonged periods in direct sunlight. Empty contents fully into application equipment. Close all valves and return to point of supply for refill or storage.

SAFETY DIRECTIONS

Will damage eyes and will irritate the skin. Avoid contact with eyes and skin. When opening the container and preparing spray and using the prepared spray, wear cotton overalls buttoned to the neck and wrist and a washable hat, elbow length butyl rubber gloves and goggles. If product on skin, immediately wash area with soap and water. If product in eyes, wash it out immediately with water. Wash hand after use. After each day's use, wash gloves, goggles and contaminated clothing.

FIRST AID

If poisoning occurs, contact a doctor or Poisons Information Centre. Phone Australia 13 11 26. If swallowed, do NOT induce vomiting. Give a glass of water.

SAFETY DATA SHEET

Additional information is listed in the Safety Data Sheet, which can be obtained from the supplier.

CONDITIONS OF SALE

Apparent Pty Ltd shall not be liable for any loss injury damage or death whether consequential or otherwise whatsoever or howsoever arising whether through negligence or otherwise in connection with the sale supply use or application of this product. The supply of this product is on the express condition that the purchaser does not rely on Apparent Pty Ltd's skill or judgement in purchasing or using the same and every person dealing with this product does so at his own risk absolutely. No representative of Apparent Pty Ltd has any authority to add to or alter these conditions.

10

CAUTION

KEEP OUT OF REACH OF CHILDREN

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Apparent

Poacher 750

HERBICIDE

ACTIVE CONSTITUENT: 700 g/kg IMAZAPYR

GROUP B HERBICIDE

For the control of various annual and perennial weeds in non-crop situations as indicated in the Directions for Use table.

IMPORTANT: Read this booklet before use.

APVMA Approval No: 69538/102235

APPARENT PTY LTD A.C.N. 143 724 136

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214

DIRECTIONS FOR USE
RESTRAINTS:
DO NOT apply by AIRCRAFT as spray drift may cause damage to desirable surrounding species.

Situation	Weed
Around agricultural buildings and other farm non-crop situations, commercial, industrial, and public service areas, tights of way and waste land, away from desirable vegetation.	Annual ryegrass (*Lolium rigidum*), Barnyard grass (*Echinochloa crus-galli*), Blady grass (*Imperata cylindrica*), Buckbush (*Salsola kali*), Deadnettle (*Lamium amplexicaule*), Feathertop Rhodes grass (*Chloris virgata*), Fleabane (*Conyza canadensis*), Hexham Scent (*Melilotus indices*), Liverseed grass (*Urochloapanicoides*), London rocket (*Sisymbrium irio*), Mayne's pest (*Verbena tenuisecta*), Medics (*Medicago* spp.), Mintweed (*Salvia reflexa*), Blackberry Nightshade (*Solanum nigrum*), Paterson's curse (*Echium plantagineum*), Plains grass (*Stipa aristiglumis*), Prairie grass (*Bromus unioloides*), Prickly Lettuce (*Lactuca serriola*), Purple Top (*Verbena bonariensis*), Scented Top (*Capillipedium* spp.), Sedges (*Cyperus* spp.), Slender Celery (*Apium leptophyllum*), Sowthistle (*Sonchus oleraceus*), St Barnaby's thistle (*Centaurea solstitialis*), Summer grasses (*Digitaria* spp.), Thornapples (*Datura* spp), Turnip weed (*Rapistrum rugosum*), Variegated Thistle (*Silybum marianum*), Vasey grass (*Paspalum urvillei*), Warrego grass (*Paspalidium juborum*), Wild Oats (*Avena* spp.), Wild Turnip (*Brassica tournefortii*), Wireweed (*Polygonum aviculare*)
Around agricultural buildings and other farm non-crop situations, commercial, industrial, and public service areas, tights of way and waste land, away from desirable vegetation.	Bokhara clover (*Melilotus albus*), Bracken (suppression only) (*Pteridium esculentum*), Capeweed (*Arctotheca calendula*), Couch (*Cynodon dactylon*), Docks (*Rumex* spp.), Johnson grass (*Sorghum halepense*), Panics (suppression only) (*Panicum* spp.), Paspalum (*Paspalum dilatatum*), Queensland bluegrass (*Dichanthium sericeum*), Stinging Nettle (*Urtica incisa*)

2

State	Rate	Critical Comments
All States	1.3 kg/ha	Applications can be made pre- or post-emergence. Post-emergence applications also provide pre-emergence control. **Medium Volume:** 1.3 kg Apparent Poacher 750 Herbicide should be applied using spray volumes ranging between 50 and 200 L/ha. **High Volume:** Apply sufficient spray to wet the surfaces visibly without producing runoff. Measure how much spray is required to cover 10 m x 10 m. Add Apparent Poacher 750 Herbicide at the rate of 13 g in this measured volume.
All States	2 kg/ha	Applications can be made pre- or post-emergence. Post-emergence applications also provide pre-emergence control. Medium Volume: 2 kg Apparent 750 SG should be applied using spray volumes ranging between 50 and 200 L/ha. High Volume: Apply sufficient spray to wet the surfaces visibly without producing runoff. Measure how much spray is required to cover 10 m x 10 m. Add Apparent 750 SG at the rate of 20 g in this measured volume.

Situation	Weed
Around agricultural buildings and other farm non-crop situations, commercial, industrial, and public service areas, tights of way and waste land, away from desirable vegetation.	Rubber vine (*Cryptostegia grandiflora*)
	Thunbergia (*Thunbergia* spp.)

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

GENERAL INSTRUCTIONS

Apparent Poacher 750 Herbicide is a soluble granule herbicide which will kill a range of standing weeds and emerging seedlings. It stops growth rapidly, although symptoms may take over 30 days to develop. Affected plants are discoloured and often growth is distorted.

The active material in Apparent Poacher 750 Herbicide is rapidly absorbed through foliage and roots, and translocated throughout plants. Foliage treatments will provide pre-emergence control as the active material is released to the soil following plant decay.

Residual control of weeds, for which the lower rate of Apparent Poacher 750 Herbicide is recommended, will increase when the higher rate is used.

RESISTANT WEEDS WARNING

GROUP B HERBICIDE

Apparent Poacher 750 Herbicide is a member of the imidazolinone group of herbicides. Apparent Poacher 750 Herbicide has the inhibition of acetolactate synthase (ALS) mode of action. For weed resistance management, Apparent Poacher 750 Herbicide is a Group B herbicide. Some naturally-occurring weed biotypes resistant to Apparent Poacher 750 Herbicide and other Group B herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by Apparent Poacher 750 Herbicide or the Group B herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, Apparent Pty. Ltd accepts no liability for any losses that may result from the failure of Apparent Poacher 750 Herbicide to control resistant weeds.

APPLICATION

Faster control of standing weeds will result if growing conditions are favourable at and after application. Rainfall within two hours of the spray mixture drying on leaves may result in reduced weed control.

SPRAYING INSTRUCTIONS

For medium volume spraying, apply through a spray boom calibrated to ensure even coverage. Use spray nozzles suitable to prevent spray drift onto surrounding desirable vegetation.

For high volume application, use a hand gun or knapsack to apply sufficient spray to wet the surface visibly without producing run-off.

4

State	Rate	Critical Comments
Qld only	1.3 g/L water	Post emergence application. Apply sufficient spray to wet the surface visibly to the point of run-off. For effective control, apply when the plant is actively growing and not stressed, yellowing or bearing pods. Flowering is a good indication of the best time for application. Use high volume application as detailed in the General instructions section.
	2.5 g/L water	Post emergence application. Apply sufficient spray to wet the surface visibly to the point of run-off. For effective control, apply when the plant is actively growing. Use high volume application as detailed in the General instructions section.

MIXING

Pour the required amount of Apparent Poacher 750 Herbicide into a spray container which already holds the total amount of water required. Mix thoroughly. If Apparent Poacher 750 Herbicide is added during filling, foaming may occur. If excessive foaming is a problem, add a suitable antifoaming agent. Consult your distributor for specific information.

Apparent Poacher 750 Herbicide may be applied in hard or soft water. The product is corrosive to mild steel. Use ONLY stainless steel, fibreglass, plastic or plastic-lined containers for mixing, storage and application.

COMPATIBILITY

For faster knockdown of weeds, certain other herbicides may be mixed with Apparent Poacher 750 Herbicide.

Bipyridyl herbicides (eg. paraquat) are NOT compatible with Apparent Poacher 750 Herbicide. Mixtures of this type will result in poor weed control.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

Do NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

Do NOT apply on or near desirable trees or other plants, or on areas where their roots may extend, or in locations where the chemical may be washed or moved into contact with their roots.

Do NOT apply where run-off water may flow onto agricultural land or other desirable vegetated areas. Dispose of washings away from desirable plants and their roots.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

DO NOT contaminate streams, rivers or waterways with this product or used containers.

STORAGE AND DISPOSAL

Store in the closed, original container in a dry, cool, well-ventilated area out of direct sunlight. Triple-rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush, or puncture and deliver empty packaging to an approved waste management facility. If an approved waste management facility is not available, bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose, clear of waterways, desirable vegetation and tree roots, in compliance with relevant local, state or territory government regulations. Do not burn empty containers or product.

5

SAFETY DIRECTIONS

Will irritate the eyes and skin. Avoid contact with eyes and skin. When opening the container and preparing spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing), elbow-length PVC gloves, goggles and disposable dust mask. When using the prepared spray, wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and elbow-length PVC gloves. If product in eyes, wash it out immediately with water. Wash hands after use. After each day's use, wash gloves, goggles and contaminated clothing.

FIRST AID

If poisoning occurs, contact a Doctor or Poisons Information Centre. Phone Australia: 13 11 26.

Material Safety Data Sheet

Additional information is listed in the Material Safety Data Sheet which is available from the supplier.

CONDITION OF SALE

The use of Apparent Poacher 750 Herbicide being beyond the control of the manufacturer no warranty expressed or implied is given by Apparent Pty Ltd regarding its suitability, fitness or efficiency for any purpose for which it is used by the buyer, whether in accordance with the directions or not and Apparent Pty Ltd accepts with no responsibility for any consequences whatsoever resulting from the use of this product.

6

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Sinbar®

herbicide

ACTIVE CONSTITUENT: 800 g/kg TERBACIL

GROUP **C** HERBICIDE

For selective weed control in apples, peaches, seed lucerne and peppermint as per Directions for Use Table

IMPORTANT: READ THE ATTACHED LEAFLET BEFORE USE

NET 2 kg

Distributed by:
AgNova Technologies Pty Ltd
Suite 10, 857 Doncaster Rd
Doncaster East Vic 3109
Tel: 03 9840-2333.

Manufactured in USA by:
Tessenderlo Kerley, Inc.
2255 N. 44th Street, Suite 300
Phoenix, Arizona 85008 USA

PEEL GENTLY TO OPEN - PRESS TO RECLOSE

In a transport emergency dial 000, Police or Fire Brigade.

For specialist advice in an emergency only, call 1800 033 111 (24 hours).

Sinbar is a registered trademark of Tessenderlo Kerley, Inc.

APVMA Approval No: 45853/2Kg/0909

Item #NSV1PLAU1109

GENERAL INSTRUCTIONS
Sinbar® herbicide is a soil residual herbicide, mainly entering weeds through their roots. For best results apply to weed free, moist, well prepared soil, as free as possible from trash and clods. Remove well established weeds before application. DO NOT cultivate soil surface after application as efficiency may be reduced and/or injury may result. For best results, sufficient moisture, either by rainfall or irrigation, is required within 3-4 days after treatment to carry the product into the soil. With irrigation, thoroughly wet the entire area.

Resistant Weeds Warning GROUP **C** HERBICIDE

Sinbar herbicide is a member of the Uracils group of herbicides. Sinbar herbicide has the inhibitors of photosynthesis at photosystem II mode of action. For weed resistance management Sinbar herbicide is a Group C herbicide.

Some naturally-occurring weed biotypes resistant to Sinbar herbicide and other inhibitors of photosynthesis at photosystem II herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds may not be controlled by Sinbar herbicide or other inhibitors of photosynthesis at photosystem II herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, Tessenderlo Kerley, Inc. accepts no liability for any losses that may result from failure of Sinbar herbicide to control resistant weeds.

Strategies to minimise the risk of herbicide resistance are available. Consult your farm chemical supplier, consultant, local Department of Agriculture or Primary Industries, or local AgNova Technologies Pty Ltd representative.

EQUIPMENT & MIXING INSTRUCTIONS
Mix required amount of product into a minimum of 20L for each kg of product.

Large Areas
Use a spray boom or handgun. To prevent nozzle blockage, strainer and nozzle screens should be 50 mesh or coarser. Continuous agitation in the spray tank is required to keep the material in suspension.

a. Spray Booms - Use 250 - 450 L/ha water at 200 to 350 kPa pressure.

b. Handgun - Use 1000 - 2000 L/ha at 600 - 800 kPa pressure.

Small Areas
Use a knapsack or pressurised hand sprayer or watering can. Shake or stir frequently.

TANK CLEANOUT
Immediately after application, completely drain spray equipment. Thoroughly rinse sprayer and flush the hoses, boom and nozzles with clean water. Loosen and physically remove visible deposits. Remove and clean nozzles, screens and strainers. Flush the entire system with clean water. Take all necessary precautions when cleaning equipment.

CROP ROTATION
DO NOT replant treated areas to any crop within two (2) years of last application as injury to subsequent crops may result.

CROP SAFETY
Apples & Peaches
DO NOT apply to trees less than three (3) years old as injury may occur.
DO NOT spray foliage or use on eroded areas where sub-soil and/or tree roots are exposed as injury to trees may result. Avoid contact of fruit with spray mist as damage may result.

Lucerne (for seed)
DO NOT apply to seedling lucerne.
DO NOT apply to established lucerne where root penetration is unusually shallow.
DO NOT use a surfactant/wetting agent as crop injury may result.

DIRECTIONS FOR USE

CROP	WEEDS CONTROLLED	STATES	RATE kg/ha Light to Medium Soils	RATE kg/ha Heavy Soils	CRITICAL COMMENTS
APPLES & PEACHES At least three (3) years old	**ANNUAL WEEDS:** Amaranthus, Barley grass, Vic, Tas Only active weed growth. Barnyard grass, Bathurst Burr, Brome grasses, Capeweed, Fat-hen, Innocent weed, Milk Thistle, Paterson's Curse, Pigweed, Shepherd's Purse, Threecornered jack(s) (Spiny Emex, Doublegee), Whorled Pigeon grass, Wild Lettuce, Wild Oats, Wild Radish, Wild Turnip	Qld, NSW Vic, Tas Only			Apply to moist soil just before or during active weed growth.
			2.2 kg	4.5 kg	**Light Weed Infestation**
			3.5 kg	4.5 kg	**Heavy Weed Infestation**
PEACHES At least (3) years old	As above	SA Only	2.2-3.5 kg		Use higher rates for heavy weed infestation.
APPLES & PEACHES At least eight (8) years old	**PERENNIAL WEEDS:** Couch grass, Kikuyu, Johnson grass, Nutgrass	Qld, NSW, Vic, Tas SA Only	4.5 kg		Apply as a broadcast spray
			200 g/100 L*		**Spot Treatment** Complete coverage of weeds is essential. DO NOT apply on sandy or gravelly soils. **Note:** Where limited rainfall occurs during the growing period, satisfactory control of hard to kill, deep rooted, perennial weeds will not occur. If weeds are present & cannot be removed, add a wetting agent*.
LUCERNE SEED CROPS At least one (1) year old	Annual Ryegrass, Charlock, Chickweed, Deadnettle, Fat-hen, Fumitory, Melilotus, Milk Thistle, Mustard, Rough Poppy, Paterson's Curse, Sheepweed, Shepherd's Purse, Soursob, Storksbill (Geranium), Three Cornered Jack(s) (Spiny Emex, Doublegee), Wild Oats, Wild Radish, Wild Turnip, Wireweed, Yellow Burrweed.	SA Only	Light Sandy Soils: 1 kg Medium Soils: 1.4 kg	Heavy High Organic Content Soils: 1.75 kg	Apply any time after lucerne becomes dormant, but before growth begins in spring. For best results apply just before the spring germination of weeds. DO NOT use a surfactant/wetting agent.
PEPPERMINT	Amaranthus, Barley grass, Brome grasses, Barnyard grass, Capeweed, Fat-hen, Shepherd's Purse, Sowthistle, Whorled Pigeon grass, Wild Oats, Wild Radish, Wild Turnip.	Tas Only	2 kg		Apply during the dormant stage, July to August
		NSW, Vic Only			Apply 2 to 3 weeks after planting in April-May or to existing plants between the months of April and September.

*Add a surfactant at the use rate on its label.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION

PROTECTION OF LIVESTOCK
DO NOT contaminate rivers, dams, domestic water or streams with the pesticide or used containers.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS
DO NOT apply or drain or flush equipment on or near desirable trees or other plants or on areas where their roots may extend. Prevent drift of dry powder or spray to desirable plants.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT
Dangerous to fish.
DO NOT contaminate rivers, dams, domestic waters or streams with the pesticide or used containers.

STORAGE AND DISPOSAL
KEEP OUT OF REACH OF CHILDREN. Store in the closed, original container in a dry, well ventilated area, as cool as possible out of direct sunlight. Store in a locked room or place away from children, animals, food, feedstuffs, seed and fertilisers. DO NOT re-use container. Triple or (preferably) pressure rinse containers before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. Break, crush, puncture or bury empty containers in a local authority landfill. If not available bury the container below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, vegetation and roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS
Avoid contact with eyes and skin. When preparing spray wear face shield or goggles.

FIRST AID
If poisoning occurs contact a doctor or Poisons Information Centre. Phone Australia 13 11 26

MATERIAL SAFETY DATA SHEET
For further information refer to the Material Safety Data Sheet which is available from AgNova Technologies Pty. Ltd.

CONDITIONS OF SALE
AgNova Technologies Pty. Ltd. and Tessenderlo Kerley, Inc. shall not be liable for any consequential or other loss or damage relating to the supply or subsequent handling or use of this product, unless such liability by law cannot be lawfully excluded or limited. All warranties, conditions or rights implied by statute or other law which may be lawfully excluded are so excluded. Where the liability of AgNova Technologies Pty. Ltd. and Tessenderlo Kerley, Inc. for breach of any such statutory warranties and conditions cannot be lawfully excluded but maybe limited to it re-supplying the product or an equivalent product or the cost of a product or an equivalent product, then the liability of AgNova Technologies Pty. Ltd. and Tessenderlo Kerley, Inc. for any breach of such statutory warranty or condition is so limited.

POISON

KEEP OUT OF REACH OF CHILDREN

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Specticle®

HERBICIDE

ACTIVE CONSTITUENT **200 g/L INDAZIFLAM**

GROUP O HERBICIDE

For pre-emergent control of summer grass, crowsfoot grass and winter grass in turf

1 L

64673/107687 Specticle Herbicide registered label 2017.08.04 *Page 1*

DIRECTIONS FOR USE

RESTRAINTS

DO NOT apply to turf under stress.

DO NOT apply with aircraft.

DO NOT apply with a nozzle height greater than 50cm above the ground.

DO NOT apply through any type of irrigation equipment.

DO NOT apply if heavy rain or storms that are likely to cause run-off are forecast within 48 hours (golf courses) or 3 days (other turf areas).

DO NOT apply to waterlogged soil.

DO NOT irrigate turf to the point of run-off within 48 hours (golf courses) or 3 days (other turf areas) of application.

SPRAY DRIFT RESTRAINTS

DO NOT apply with spray droplets smaller than a **COARSE** spray droplet size category according to *"APVMA Compliance Instructions for Mandatory COARSE or Larger Droplet Size Categories"* located under this title in the GENERAL INSTRUCTIONS section of this label.

DO NOT apply when wind speed is less than 3 or more than 20 km per hour as measured at the application site.

DO NOT apply during surface temperature inversion conditions at the application site.

Users of this product **MUST make an accurate written record** of the details of each spray application within 24 hours following application and KEEP this record for a minimum of 2 years. The spray application details that must be recorded are:

1. date with start and finish times of application;
2. location address and paddocks/areas sprayed;
3. full name of this product;
4. amount of product used per hectare and number of hectares treated;
5. crop/situation and weed;
6. wind speed and direction during application;
7. air temperature and relative humidity during application;
8. nozzle brand, type, spray angle, nozzle capacity and spray system pressure measured during application;
9. name and address of person applying this product. (Additional record details may be required by the state or territory where this product is used.)

MANDATORY NO-SPRAY ZONES

DO NOT apply if there are sensitive crops, gardens, landscaping vegetation, protected native vegetation or protected animal habitat within 25 metres (golf courses) or 30 metres (other turf areas) downwind from the application area.

64673/107687 Specticle Herbicide registered label 2017.08.04 *Page 2*

DO NOT apply if there are aquatic or wetland areas including aquacultural ponds, surface streams and rivers within 5 metres (golf courses) or 10 metres (other turf areas) downwind from the application area.

DIRECTIONS FOR USE

SITUATION	WEEDS CONTROLLED	RATE	CRITICAL COMMENTS
TURF Warm season turf grasses only, including: Bahia grass (*Paspalum notatum*); Buffalo grass (*Stenotaphrum secundatum*); Common couch (*Cynodon dactylon*) and Hybrid couches; Queensland Blue Couch (*Digitaria didactyla*); Kikuyu (*Pennisetum clandestinum*); Zoysia (*Zoysia* spp.)	Summer grass or Crab grass (*Digitaria* spp.) Crowsfoot grass (*Eleusine indica*) Winter grass (*Poa annua*)	250 mL/ha in 200 to 500 L water per ha	Turf should be in robust and healthy condition at the time of treatment. Apply prior to germination of the weeds. Ensure adequate coverage for optimum weed control. A repeat application may be required after not less than three months. Do not apply more than two applications per annum. Refer to the Application section in the General Instructions for detailed information.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION

GENERAL INSTRUCTIONS

SPECTICLE is a selective, pre-emergent herbicide that provides residual control of certain grass weeds on established warm-season turf. Specticle controls weeds by reducing the emergence of seedlings through inhibition of cellulose biosynthesis (CB inhibitor). Specticle needs to be activated prior to weed germination for most effective control. For maximum activity against germinating weeds, Specticle requires rainfall or irrigation prior to weed germination.

MIXING

Ensure that the spray tank is completely clean prior to mixing. Half fill the spray tank with water, then with agitators in motion, add the correct amount of Specticle directly into the spray tank. Complete filling the tank with agitators in motion. Agitation must continue before and during spraying.

APPLICATION

Ensure spraying equipment is properly calibrated before use. Uniform application is essential for satisfactory weed control. Ensure that complete and even spray coverage is achieved. DO NOT overlap sprayed areas.

APVMA Compliance Instructions for Mandatory COARSE or Larger Droplet Size Categories

Important Information: These instructions inform users of this chemical product how to lawfully comply with the requirement of a COARSE or larger spray droplet size category for spray application. Spray droplet size categories are defined in the ASAE S572 Standard (newer name may also be shown as ASABE) or the BCPC guideline. Nozzle manufacturers may refer to one or both to identify droplet size categories, but for a nozzle to comply with this requirement, the manufacturer must refer to at least one.

Complying with the label requirement to use a specific droplet size category means using the correct nozzle that will deliver that droplet size category under the spray operation conditions being used. The APVMA has approved only the following specific methods for choosing the correct nozzle. Use one of the methods specified in these instructions to select a correct nozzle to deliver a COARSE or larger droplet size category.

USE ONLY nozzles that the nozzles' manufacturer has rated to deliver a COARSE, a VERY COARSE or an EXTREMELY COARSE droplet size category as referenced to ASAE S572 or BCPC. Choose a nozzle specified to provide the droplet size category required in the label Spray Drift Restraints.

DO NOT use a higher spray system pressure than the maximum the manufacturer specifies for the selected nozzle to deliver the droplet size category required in the label Spray Drift Restraint.

SPRAYER CLEAN UP

The sprayer must be thoroughly decontaminated before being used again to spray susceptible plants or turf. Ensure that the following operation is carried out in an area that is clear of waterways, desirable vegetation and tree roots, and preferably in an area where drainings can be contained.

1. Drain sprayer completely and wash out tank, boom and hoses with clean water.
2. Drain again.
3. Fill the tank with clean water and add 300 mL of chlorine bleach (containing 4% chlorine) per 100 L of water with agitation running.
4. Flush some bleach solution through booms and hoses and allow remainder to agitate in tank for 10 minutes.
5. Remove nozzles and filters and leave to soak in a bleach solution of 500 mL per 10 L of water while tank cleaning is in progress.
6. Briefly run the pump at periodic intervals to refresh chlorine solution in spray lines.
7. Drain tank and repeat the procedure of flushing with bleach solution.
8. Flush the tank, boom and hoses with clean water.

USE OF SPECTICLE ON TURF IN COARSE AND SANDY SOILS: Soil conditions can affect the tolerance of turf to Specticle. Coarse or sandy soils may allow for downward movement of Specticle into the root zone and cause significant damage and phytotoxicity. Prior to application of Specticle in coarse or sandy soils, confirm texture with a soil test. Turf grown in soil exceeding 80% sand or 20% gravel may be at risk. If Specticle is to be applied on these soils, evaluate treated soils for tolerance prior to large scale application.

IRRIGATION AND WATERING AFTER APPLICATION: Specticle will provide residual weed control when adequate moisture is present and the application is followed by rain or irrigation (3 to 6 mm) within 21 days and prior to weed seed germination. DO NOT create conditions that cause visible run-off of irrigation water. Adequate rainfall following an application will negate the need for irrigation.

APPLICATION NEAR SENSITIVE GRASSES: Specticle can cause turf injury and stand reduction to sensitive grasses. Specticle may affect sensitive grasses downslope from treated areas after excessive rainfall. To minimize off-target effects of Specticle on sensitive grasses, irrigate after application as directed in the IRRIGATION AND WATERING AFTER APPLICATION section of this label and observe the MANDATORY No-Spray zones. Allow turf to dry before allowing foot traffic or equipment through treated areas near sensitive grasses. DO NOT apply Specticle on uphill slopes and adjacent to greens overseeded with cool season grasses. DO NOT apply Specticle to annual and perennial ryegrass or to couchgrass overseeded with ryegrass. Specticle may be applied in situations where warm season grasses such as couchgrass are adjacent to sensitive cool season grasses. The applicator, however, must take care not to apply Specticle directly to sensitive grasses or injury may occur. Application of Specticle may be made adjacent to sensitive cool season grasses if the grass is established for at least 16 months.

DEACTIVATING SPECTICLE: Activated charcoal has been shown to deactivate Specticle if applied within several days of application. Application of activated charcoal within 2 weeks of an application of Specticle will not reverse phytotoxic symptoms immediately but it will aid in recovery over time. If it should be necessary to re-sod areas treated with Specticle, remove damaged turf to a depth of at least 5 cm, cultivate the soil and apply activated charcoal to bare ground prior to laying sod. Follow directions for the amount of charcoal to apply on the label of the activated charcoal.

SEEDING, RE-SEEDING AND OVERSEEDING: Timing of seeding, re-seeding, overseeding, sprigging and sodding turf relative to an application of Specticle needs to be monitored carefully. Specticle can inhibit root development as well as the emergence of seed. Roots of newly emerged seedlings may be damaged and establishment of sod may be affected if Specticle is applied to turf that is not well established.

APPLICATION OF SPECTICLE PRIOR TO OVERSEEDING COUCHGRASS WITH PERENNIAL RYEGRASS OR RESEEDING INTO WARM-SEASON TURF: Specticle may be used to control weeds in couchgrass prior to overseeding with a cool season grass or re-seeding seeded cultivars of couchgrass, provided that the interval between application and seeding is appropriate. The minimum interval between application of Specticle and seeding or overseeding is 12 months. Applications made sooner than the minimum interval may decrease the establishment of the new seedlings and reduce turf coverage.

WARM-SEASON GRASSES ESTABLISHED WITH SPRIGS: Specticle may be applied to sprigs of warm season grasses. The sprigs need to be well rooted prior to application. Apply Specticle no sooner than 16 months after sprigging to allow for good stand establishment. Prior to application, check rooting to make sure new roots are developing. If roots are not growing, delay application of Specticle.

SODDING WARM SEASON GRASSES: Delay sodding into bare ground or turf treated with Specticle until 6 months after application. Sodding before 6 months may inhibit stand establishment and reduce turf quality. For maximum establishment of sod, follow the directions for use for deactivation of Specticle using activated charcoal. Sod needs to be actively growing / established at least 3 months prior to an application of Specticle. Prior to application, check the turfgrass sod to make sure new roots are developing. If roots are not growing, delay application of Specticle.

COMPATIBILITY

As formulations of other manufacturers' products are beyond the control of Bayer and water quality varies with location, any mixture should be tested prior to mixing commercial quantities.

INTEGRATED PEST MANAGEMENT

The possible effects of this product on integrated pest management (IPM) strategies in the turf industry have not been studied at the proposed rates.

HERBICIDE RESISTANCE WARNING

GROUP	O	HERBICIDE

SPECTICLE Herbicide is a member of the O group of herbicides (alkylazines) and has the inhibitor of cell wall [cellulose] synthesis mode of action. For weed resistance management SPECTICLE is a Group O herbicide. Some naturally-occurring weed biotypes resistant to SPECTICLE, and other Group O herbicides, may exist through normal genetic variability in any weed population. These resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by SPECTICLE or other Group O herbicides. DO NOT rely exclusively on SPECTICLE for weed control. Use as part of an integrated weed management program involving herbicides with other modes of action and non-chemical methods of control. Since occurrence of resistant weeds is difficult to detect prior to use Bayer CropScience Pty Ltd accepts no liability for any losses that may result from the failure of SPECTICLE to control resistant weeds.

PRECAUTIONS

DO NOT use on golf greens, tees or collars.

DO NOT use on turf:

- exhibiting injury from previous applications of other products;
- stressed under cool or cold growing season conditions;
- which is newly seeded, sodded or sprigged;
- which is not well established (turf is defined as established at least 16 months after seeding or sprigging);
- recovering from wear, scarification, aeration or coring.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

Very toxic to aquatic life. DO NOT contaminate wetlands or watercourses with this product or used containers.

PROTECTION OF LIVESTOCK

DO NOT graze treated turf or feed turf clippings from any treated area to poultry or livestock.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures. DO NOT use clippings from treated areas for mulch around vegetables or fruit trees.

STORAGE AND DISPOSAL

Store in the closed, original container in a cool, well-ventilated area. Do not store for prolonged periods in direct sunlight. Triple-rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point. If not recycling, break, crush, or puncture and deliver empty packaging to an approved waste management facility. If an approved waste management facility is not available, bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose, clear of waterways, desirable vegetation and tree roots, in compliance with relevant local, state or territory government regulations. Do not burn empty containers or product. DO NOT re-use empty container for any other purpose.

SAFETY DIRECTIONS

May irritate the eyes. Avoid contact with eyes. When opening the container, mixing and loading and using the prepared spray, wear cotton overalls buttoned to the neck (or equivalent clothing). If applying by equipment carried on the back of the user wear cotton overalls, over normal clothing, buttoned to the neck and wrists and elbow-length chemical resistant gloves. Wash hands after use. After each day's use, wash gloves and contaminated clothing.

FIRST AID

If poisoning occurs contact a doctor or Poisons Information Centre. Phone Australia 13 11 26; New Zealand 0800 764 766.

SAFETY DATA SHEET

Additional information is listed in the Safety Data Sheet which may be found at www.environmentalscience.bayer.com.au.

EXCLUSION OF LIABILITY

This product must be used strictly as directed, and in accordance with all instructions appearing on the label and in other reference material. So far as it is lawfully able to do so, Bayer CropScience Pty Ltd accepts no liability or responsibility for loss or damage arising from failure to follow such directions and instructions.

APVMA Approval No.: 64673/107687

Specticle® is a Registered Trademark of the Bayer Group

FOR 24 HOUR SPECIALIST ADVICE IN EMERGENCY ONLY PHONE 1800 033 111
Bayer CropScience Pty Ltd
ABN 87 000 226 022
Level 1, 8 Redfern Rd

Hawthorn East, Vic. 3123
Phone: (03) 9248 6888
Technical enquiries: 1800 804 479
Website: www.environmentalscience.bayer.com.au

Batch Number:
Date of Manufacture:

Main Panel label

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Surflan* 500

Flowable Herbicide

ACTIVE CONSTITUENT: 500 g/L ORYZALIN

GROUP	D	HERBICIDE

For pre-emergent control of certain annual grasses and broadleaf weeds in non-bearing and bearing fruit and nut orchards, vineyards, nursery stock, ornamentals and amenity plantings as specified in the Directions for Use Table.

APVMA Approval No. 31814/10/0604 (31814/5/0604, 31814/20/0604)

Contents (5 Litres, 10 Litres, 20 Litres)

* Trademark of United Phosphorus Ltd

UNITED PHOSPHORUS LTD
ABN 76 066 391 384
Suite 14, L3, 30 ATCHISON ST.
ST LEONARD'S NSW 2065 AUSTRALIA
TELEPHONE 02 9460 8480 FACSIMILE 02 9460 8980

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 1 of 7

Ancillary panel 1

Surflan 500 Flowable Herbicide

DIRECTIONS FOR USE

CROP GROUP				WEEDS CONTROLLED	RATE L/HA	CRITICAL COMMENTS
Banana[1]				**Grasses:** Barnyard Guineagrass Love Paradoxa Pigeon Spiny burr (Gentle Annie/Innocent Weed) Summer grass (Crabgrass [3]) **Broadleaf Weeds:** Deadnettle Fathen Fumitory *Portulaca* (Pigweed) Sowthistle Wireweed (Hogweed) **Brassica species**[4] Blackberry nightshade Caltrop Paddymelon Silverleaf nightshade	Short term control (up to 4 months) 4.5 L Long term control (6 to 8 months) 6.8 L	See GENERAL INSTRUCTIONS [1] DO NOT use as a pre-emergent at the time of planting with tissue culture banana planting material. [2] **Western Australia only:** Vineyards on medium loam or heavier soil types, heavily infested with crabgrass may be sprayed with up to 9.5 L/ha of Surflan 500 and together with pome fruit and all *Prunus* species on these soils spraying can be immediately after transplanting from nurseries providing buds are still dormant and no functional leaves are present. [3] **Western Australia only:** Apply early in summer for crabgrass (*Digitaria sanguinalis*) control and incorporate with overhead irrigation [4] Control of these weeds may range from poor to excellent depending upon soil temperature, time of germination, depth of weed seed in the soil, and amount and timing of soil moisture.
Grape[2]						
Pome Fruit	Apple	Pear	(see also non-bearing fruits)			
Stonefruit	Apricot Cherry	Peach Plum & prune	Nectarine			
Citrus Fruit	Grapefruit	Orange	(see also non-bearing fruits)			
Nuts	Almonds Macadamia	Pecan Walnut				
Non-bearing berryfruits	Blackberry Blueberry Boysenberry	Currant Gooseberry Loganberry	Raspberry			
Non-bearing – fruits, including nursery stock of the following:	Avocado Custard apple Feijoa Guava Kiwifruit	Lemon Litchi Mandarin Mango Nashi	Olive Passionfruit Pawpaw Persimmon Rambutan			
Nursery stock and/or seedling stage conifers including species of the following genus:	*Abies* (fir trees) *Chamaecyparis* (Lawson and false cypress) *Cryptomeria* Cupressus (cypress) *Juniperus* (Junipers)	*Picea* (spruces) *Pinus* (pine) *Platycladus orientalis* (oriental arborvitae) *Podocarpus*	*Pseudotsuga menziesii* (Douglas fir or Oregon pine) *Sequoia sempervirens* (Coastal redwood) *Taxus cuspidata* (Japanese yew) *Thuja*			

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 2 of 7

Ancillary panel 1 continued

Nursery stock, ornamentals, and amenity plantings comprising of the following:	Australian native species of the genus: *Acacia* (wattles) *Agonis* (WA Peppermint, Willow (or Honey) myrtle) *Allocasuarina* *Banksia* *Boronia* *Callistemon* (Bottlebrush) *Callitris* (Cypress pine) *Calytrix* *Cassia*	*Casuarina* (Oaks and sheoak) *Chamaelauci um uncinatum* (Geraldton wax) Clematis *Correa* *Eriostemon myoporoides* (Wax flower) *Eucalyptus*	*Grevillea* *Hakea* *Hardenbergia* (sarsaparilla) *Hibbertia* *Kennedia* *Lechenaultia* *Leptospermum and Melaleuca* (teatrees) *Prostanthera* (Mintbush) *Thryptomene* *Westringia*	**Grasses:** Barnyard Guineagrass Love Paradoxa Pigeon Spiny burr (Gentle Annie/Innocent Weed) Summer grass (Crabgrass[3]) **Broadleaf Weeds:** Deadnettle Fathen Fumitory *Portulaca* (Pigweed) Sowthistle Wireweed (Hogweed) **Brassica species**[4] Blackberry nightshade Caltrop Paddymelon Silverleaf nightshade	Short term control (up to 4 months) 4.5 L Long term control (6 to 8 months) 6.8 L	See GENERAL INSTRUCTIONS [1] DO NOT use as a pre-emergent at the time of planting with tissue culture banana planting material. [2] **Western Australia only:** Vineyards on medium loam or heavier soil types, heavily infested with crabgrass may be sprayed with up to 9.5 L/ha of Surflan 500 and together with pome fruit and all *Prunus* species on these soils spraying can be immediately after transplanting from nurseries providing buds are still dormant and no functional leaves are present. [3] **Western Australia only:** Apply early in summer for crabgrass (*Digitaria sanguinalis*) control and incorporate with overhead irrigation. [4] Control of these weeds may range from poor to excellent depending upon soil temperature, time of germination, depth of weed seed in the soil, and amount and timing of soil moisture.

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 3 of 7

Ancillary panel 2

DIRECTIONS FOR USE (*continued*)

CROP GROUP				WEEDS CONTROLLED	RATE L/HA	CRITICAL COMMENTS
Nursery stock, ornamentals, and amenity plantings comprising of the following:	**Exotic species** *Abelia* *Acalypha* *Acer* (maples) *Arctostaphylos* *Ardisia* *Azalea* *Baccharis* (groundsel bush) *Bauhinia Berberis* (barberry) *Betula* (birch trees) *Bignonia* *Buxus* (box) *Calluna* *Camellia* *Ceanothus* *Cistus* *Clyostoma* *Coleonema* *Coprosma* *Cotoneaster* *Cuphea* *Cytisus* (broom) *Dodonea* (hopbush) *Erica* (heath) *Escallonia*	**of the genus:** *Euonymus* *Eutaxia* *Fatshedera* *Fuchsia* *Felicia* *Gardenia* *Gingko* *Hibiscus* *Ilex* *Jasminum* *Justicia* *Kalmia* *Koelreuteria* *Lagenaria* *Lagerstroemia* *Lantana* *Lavendula* (lavender) *Leucodendron* *Leucothoe* *Ligustrum* *Liquidambar* *Liriope* *Lonicera* (honeysuckle) *Magnolia* *Mahonia* *Metrosideros* *Monstera* *Myrtus* *Nandina* *Nerium* (oleander)	*Osmanthus* *Parahebe* *Philadelphus* *Philodendron* *Phoenix* *Photinia* *Pieris* *Pittosporum* *Populus* *(poplar)* *Prunus* *Pseudopanax* *Pyracantha* *Quercus* *Rhaphiolepis* *Rhododendron Rosa* (roses) *Rosmarinus* *(rosemary)* *Russelia* *Spiraea* *Trachelospermum* *(Rhyncospermum)* *Umbellularia* *Viburnum* *Washingtonia* *Weigela* *Xylosma* *Yucca*	**Grasses:** Barnyard Guineagrass Love Paradoxa Pigeon Spiny burr (Gentle Annie/Innocent Weed) Summer grass (Crabgrass[3]) **Broadleaf Weeds:** Deadnettle Fathen Fumitory *Portulaca* (Pigweed) Sowthistle Wireweed (Hogweed) **Brassica species**[4] Blackberry nightshade Caltrop Paddymelon Silverleaf nightshade	Short term control (up to 4 months) 4.5 L Long term control (6 to 8 months) 6.8 L	See GENERAL INSTRUCTIONS [1] DO NOT use as a pre-emergent at the time of planting with tissue culture banana planting material. [2] **Western Australia only:** Vineyards on medium loam or heavier soil types, heavily infested with crabgrass may be sprayed with up to 9.5 L/ha of Surflan 500 and together with pome fruit and all *Prunus* species on these soils spraying can be immediately after transplanting from nurseries providing buds are still dormant and no functional leaves are present. [3] **Western Australia only:** Apply early in summer for crabgrass (*Digitaria sanguinalis*) control and incorporate with overhead irrigation. [4] Control of these weeds may range from poor to excellent depending upon soil temperature, time of germination, depth of weed seed in the soil, and amount and timing of soil moisture.

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 4 of 7

Tea-tree oil plantations[5]	Tea-tree *(Melaleuca alternifolia)*		6.8 L	[5]Apply at time of planting and soon after harvesting. Apply in 200 to 450 L/ha water.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 5 of 7

Ancillary panel 2 continued

GENERAL INSTRUCTIONS:

Surflan 500 Flowable Herbicide is a pre-emergent surface applied herbicide which will control the specified annual grasses and broadleaf weeds in the crops listed.

Soil Preparation: Areas to be treated should be free of established weeds. Remove or thoroughly mix trash (weed residue, prunings, etc) into the soil before applying the product.

Soil Activation: Moisture in the form of rain or sprinkler irrigation (12.5 mm) is required within 21 days of application to activate the product otherwise efficacy may be reduced. If moisture is not received within the period, incorporate the product into the top 2.5 cm of soil.

MIXING

The required amount of Surflan 500 should be added to a half-full spray tank and agitated well during completion of filling. Do not leave spray solutions to stand over night.

APPLICATION

Apply Surflan 500 in 200 to 450 litres water per hectare. Apply uniformly, especially within the dripline of trees and shrubs, so that application above label rates does not occur. Use a properly calibrated low pressure (170 to 340 kPa) herbicide sprayer.

Provide good by-pass or other agitation of the spray suspension in the tank before and during application. Soil treated with this product may be shallow cultivated without loss of herbicidal activity. Surflan 500 is compatible with paraquat, glyphosate, oxyfluorofen and simazine.

RESISTANT WEEDS WARNING

GROUP	D	HERBICIDE

Surflan 500 Flowable Herbicide is a member of the dinitroanilines group of herbicides. The product has the inhibitor of tubulin formation mode of action. For weed resistance management, the product is a Group D herbicide.

Some naturally occurring weed biotypes resistant to the product and other Group D herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by this product or other Group D herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, United Phosphorus Ltd accepts no liability for any losses that may result from the failure of this product to control resistant weeds.

Strategies to minimise the risk of herbicide resistance are available. Contact your farm chemical supplier, consultant, local Department of Agriculture, or local United Phosphorus Ltd representative.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

- When applying spray, avoid contact with leaves and other parts of trees and vines.
- Do not apply under weather conditions, or from spraying equipment, that may result in chemical movement by spray drift or storm run-off onto nearby susceptible plants/crops, cropping lands or pastures.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT:

DO NOT contaminate streams, rivers or waterways with the chemical or used container.

STORAGE AND DISPOSAL:

- Keep out of reach of children
- Store in the closed, original container in a cool, well-ventilated area. Do not store for prolonged periods in direct sunlight.
- Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on-site. If recycling, replace cap and return clean containers to recycler or designated collection point.

Surflan 500 Flowable Herbicide draft label 13/03/08
31814/0604 5 L, 10 L, 20 L Version 2 page 6 of 7

If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS:

- Avoid contact with eyes and skin.
- Do not inhale spray mist.

FIRST AID

If poisoning occurs, contact a doctor or Poisons Information Centre. Phone 13 11 26.

MATERIAL SAFETY DATA SHEET

Additional information is listed in the Material Safety Data Sheet for Surflan 500 Flowable Herbicide which is available from United Phosphorus on request. Call Customer Service 02 9580 9790.

CONDITIONS OF SALE: United Phosphorus accepts responsibility for the consistent quality of the product; however since the use and application of the product is beyond control, the company accepts no responsibility whatsoever for any loss, damage or other result following the use of the product whether used in accordance with directions or not; other than those mandatorily imposed by statutes, the liability is limited to the replacement of the goods and is conditional upon a claim made in writing and, where necessary, a sufficient part of the goods being returned for proper examination by the company within thirty days of sale.

Batch No. DOM Bar Code

READ THE ENCLOSED LEAFLET BEFORE USING THIS PRODUCT.

DIRECTIONS FOR USE:

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

Restraints:

Do NOT apply this product to steeply sloping sites when applying high rates recommended for perennial grass control.

Do NOT allow spray drift onto susceptible crops and ornamentals.

Do NOT spray near desirable trees.

WITHHOLDING PERIODS:

AREAS RECEIVING BLANKET TREATMENT (THAT IS TREATMENT OTHER THAN SPOT SPRAYING) ARE NOT TO BE GRAZED OR CUT FOR STOCK FOOD FOR AT LEAST 4 MONTHS AFTER SPRAYING. AREAS RECEIVING SPOT SPRAY TREATMENT ARE NOT TO BE GRAZED OR CUT FOR STOCK FOOD FOR AT LEAST 14 DAYS AFTER SPRAYING. STOCK IS NOT TO BE GRAZED IN 'TASKFORCE®' TREATED AREAS FOR AT LEAST 14 DAYS PRIOR TO SLAUGHTER. LACTATING COWS OR GOATS MUST NOT BE GRAZED IN 'TASKFORCE®' TREATED AREAS.

FIRST AID:

If poisoning occurs contact a medical practitioner or Poisons Information Centre (Phone: Australia 13 11 26). If skin contact occurs, remove contaminated clothing and wash skin thoroughly.

POISON

KEEP OUT OF REACH OF CHILDREN

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

TASKFORCE

Water Soluble Herbicide

ACTIVE CONSTITUENT: 745 g/L FLUPROPANATE (present as sodium salt)

GROUP **J** HERBICIDE

A component of integrated management of serrated tussock, giant parramatta grass, Giant rats tail grass, Chilean needle grass, African lovegrass and certain other grasses as per the direction for use table

VEE DRI (AUST) PTY. LIMITED 5223 Oallen Ford Rd. Bungonia NSW 2580 Ph: 0408 404 505 Fax: 02 4844 4358

NET 5 LITRE

STORAGE & DISPOSAL:

Store in the closed original container in a cool, well ventilated area. Do not store for prolonged periods in direct sunlight.

Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point.

If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS:

Avoid contact with eyes and skin. Do not inhale spray mist. When preparing spray wear elbow length PVC gloves and face shield or goggles. If product on skin ,immediately wash area with soap and water.

Always use in the open or a well ventilated area. After use and before eating, drinking, smoking wash hands, arms and face thoroughly with soap and water. After each days use, wash gloves, face shield or goggles and contaminated clothing .

APVMA No: 53015/5L/0700505

www.taskforceherbicide.com

IN A TRANSPORT EMERGENCY Call 000

SPECIALIST ADVICE IN EMERGENCY ONLY Call Bill Dobbie 0408 404 505 (Australia wide)

Batch: D.O.M.:

WHILE EVERY EFFORT HAS BEEN MADE TO ENSURE THAT THERE ARE NO ERRORS, IT REMAINS THE CLIENTS RESPONSIBILITY TO PROVIDE THE FINAL INDEPENDENT INSPECTION. PLEASE CHECK THE MATERIAL CAREFULLY.

• Please check all copy, legal standards and sign and date your approval for print • Colours are representational only.

SIZE: 155 X 540mm **FILE NAME:** TASKFORCE 5 Litre **ART MEMO:** 100068

ARTIST: James

COLOURS: PMS 485 PMS 072 BLACK DIE LINE

VERSION:	1. Alts artwork							
DATE:	22/06/2011							
ALTERATIONS:								

CLIENT APPROVAL: **DATE:**

Crop/ Situation	Weeds controlled	States	Rate				Critical Comments	
			Ground per ha	Air	Wiper	Spot spraying per 100L		
Pastures and non-crop situations	Serrated Tussock *(Nassella trichotoma)*	Vic, Tas., WA only	2L	2L	-	200mL	Apply during November to February inclusive. Graze to reduce cover of desirable species before spraying. **Re-seeding:** Desirable pasture species such as phalaris, cocksfoot, ryegrass, red and white clovers, subterranean clovers and lucerne must not be sown until at least 100mm of leaching rain has fallen. If drought conditions prevail defer sowing until next season. **Spot Spraying:** Spray to run-off at anytime from spring through to autumn but observe above precautions on re-seeding.	**Application volumes:** Pastures Aerial: 40-80L water per ha Ground Boom Spray: 150L water per ha Spot Spraying: NSW & Qld: 1000L/ha or for a 15L knapsack treat 150sqm
	Serrated Tussock *(Nassella trichotoma)*	Qld only	2L	2L	-	200mL	Apply September to May inclusive. (See Note below)	
Pasture – broadacre treatment	Serrated Tussock *(Nassella trichotoma)*	NSW, ACT, Vic, WA, only	1.5-2L	1.5-2L	1:20 via a rotating wiper		Apply September to March and June to August inclusive. TASKFORCE® will kill serrated tussock at any time of year but application timing should take into regard other desirable pasture species such as clovers/sub clovers Use the higher rate on heavy basalt and alluvial soils. The lower rate can be used on lighter granite and shale derived soils	**Aerial application:** apply in a volume of 35-80L of water. In more difficult country, use higher rates of water, anti-drift additives and larger droplets. **Ground application:** apply in a volume of 80-150L. **Rotating Wiper:** graze heavily prior to treatment to ensure height differential between pasture and serrated tussock. In dense serrated tussock, stock may not not graze heavily and some pasture damage may result. Apply as single or double pass. **Winter application:** avoid application in very dry winters.
Pasture – broadacre treatment -to remove seedlings from improved pasture			0.5-2L	-	-		Apply September to February inclusive	Seedlings of serrated tussock are susceptible to shading and low rates of TASKFORCE® In all situations, use conservative stocking rates and fertilize to maintain a vigorous pasture after spraying. Use the lower rate for slate and granite soils. Serrated Tussock plants must be less than 10cm high, and have less than 80 leaves. Apply September to November before pastures "bolt" in the spring flush, or December to February when improved species are dormant.
Pasture – broadacre treatment - spray topping			1.5-2L + 0.6 -1.25L glyphosate 360 Herbicide + wetting agent	1.5-2L + 0.6 -1.25L glyphosate 360 Herbicide + wetting agent	1:20 via rotating wiper	-	Apply September to November inclusive	TASKFORCE® alone needs to be applied prior to August in most years to stop serrated tussock setting seed. After August the mixture with glyphosate will prevent seeding if applied by November in most years. The added glyphosate will cause damage to other pasture species and will reduce the efficacy of TASKFORCE® and may reduce the period of residual control. Rotating wiper – Apply as a double pass 2 to 8 weeks before seed heads begin to emerge. Add a wetting agent at the recommended label rates. Graze heavily prior to treatment to ensure height differential between pasture and serrated tussock. In dense serrated tussock, stock may not graze heavily and some pasture damage will occur.
Pasture – spot treatment - to destroy serrated tussock			-	-	-	150-200mL	Can be applied all year round	Calibrate spray equipment to apply to 1000L water per hectare. Lower rates of may be used on slate and granite soils. Use a dye marker. Area may need re-treatment in subsequent years. TASKFORCE® may take several months to affect plants. Seed set may be prevented by the addition of a knockdown herbicide, such as Glyphosate, at a rate of 400mL per 100L .
Pasture – spot treatment - to destroy serrated tussock and prevent seeding			-	-	-	150-200mL + 120mL glyphosate 360 Herbicide	Apply September to November inclusive	To prevent seed set, spray before stem elongation begins. See critical comments for Pasture, "spot treatment to destroy serrated tussock" above.

Crop/ Situation	Weeds Controlled	States	Rate			Critical Comments
			Per ha	Per 100L	Knapsack (15L)	
Non-crop situations	Paspalum	Qld, NSW, WA only	9L	500mL	75mL	For optimum results apply during active growth, preferably from November to April. Apply in 800-2000L water per ha. Spray must completely wet all surfaces. The addition of wetting agent is recommended. **Johnson grass:** Spray when actively growing and not less than 30-50cm high. Use 12L in winter rainfall areas when rainfall is below 80cm per annum. Use 18-22L in summer rainfall areas or where rainfall exceeds 80cm per annum. Follow up spraying may be required in following season. Spot Spraying: Spray thoroughly to run-off with the recommended dilution rates.
	Couch					
	Johnson grass		12-22L	1L	200mL	
	Kikuyu grass	Qld, WA only	9L	500mL	75mL	
	Columbus grass	NSW, WA only	12-22L	1L	200mL	
Note: The optimum timing of 'TASKFORCE®" application to avoid damage to desirable pasture species and/or to allow 'TASKFORCE®" residues to be leached from the soil prior to autumn re-seeding is the period November to February inclusive. Precautions on re-seeding and protection of pasture legumes must be observed.						

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

GENERAL INSTRUCTIONS

Resistant Weeds Warning

GROUP **J** HERBICIDE

WITHHOLDING PERIODS

AREAS RECEIVING BLANKET TREATMENT (THAT IS TREATMENT OTHER THAN SPOT SPRAYING) ARE NOT TO BE GRAZED OR CUT FOR STOCK FOOD FOR AT LEAST 4 MONTHS AFTER SPRAYING.

AREAS RECEIVING SPOT SPRAY TREATMENT ARE NOT TO BE GRAZED OR CUT FOR STOCK FOOD FOR AT LEAST 14 DAYS AFTER SPRAYING.

STOCK IS NOT TO BE GRAZED IN 'TASKFORCE® TREATED AREAS FOR AT LEAST 14 DAYS PRIOR TO SLAUGHTER.

LACTATING COWS OR GOATS MUST NOT BE GRAZED IN 'TASKFORCE® TREATED AREAS.

TASKFORCE® is a member of the alkanoic acids group of herbicides. TASKFORCE® has the inhibitor of fat synthesis mode of action. For weed resistance management TASKFORCE® is a Group J Herbicide.

Some naturally occurring weed biotypes resistant to TASKFORCE® and other inhibitors of fat synthesis mode of action herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are repeatedly used. These resistant weeds will not be controlled by TASKFORCE® or any other inhibitors of fat synthesis mode of action herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, Vee Dri (Aust) Pty.Limited accepts no liability for any losses that may result from the failure of TASKFORCE® to control resistant weeds.

Important

- This product is very slow acting and control of existing growth will take 3-12 months depending on weather conditions and senescence of plant foliage.
- The actual length of satisfactory residual control will depend on soil type and rainfall until regeneration occurs from grass seed or surviving rhizomes.
- TASKFORCE® is liable to leaching and movement in the soil under heavy rainfall or irrigation, and dry conditions favour its persistence in the soil. In light sandy soils with little or no clay content leaching will be more pronounced.
- Avoid use in channels and drains and where roots of desirable plants may extend; and in other situations where desirable plants grow close to the treated area.
- Control of grasses growing in shaded conditions may be reduced.
- Some desirable grasses, such as native species and perennial improved species, subterranean clovers and other annual legumes may be damaged by this product if exposed to the spray or if they germinate and grow before product residues have dissipated from the soil. Do not treat pasture land with this product more than once per year. Obtain advice from your district agricultural officer.

Mixing

This product is highly water soluble and the required amount can be added direct to the spray tank while stirring or with the agitator running. Maintain good agitation during application.

Wetting agent

No wetting agent/surfactant needs to be added unless specifically stated in the direction for use table as the predominant mode of action is via root absorption of the herbicide and not by contact with the leaf surface.

Compatibility

It is not recommended to mix TASKFORCE® with chemicals other than glyphosate. For more rapid knockdown glyphosate may be added in accordance with the direction for use table. Note a reduction in efficacy of 5-15% may occur in respect of kill and a reduction in the period of residual control may also occur when used with glyphosate.

Application

- Boom spray equipment needs to be accurately calibrated to deliver the required spray volumes and nozzles checked to ensure uniform spray pattern
- Spot spray equipment should be calibrated
- For aerial application in more difficult country, for example, where slopes and/or large trees are present use higher water volumes, anti-drift additives and coarser droplets

Paddock Preparation

Graze desirable species prior to spraying to prevent them covering weeds

Re-seeding

Desirable pasture species such as phalaris, cocksfoot, ryegrass, red and white clovers, subterranean clovers and lucerne may be sown after at least 100mm of leaching rain has fallen.

Clean up

Equipment should be cleaned after use.

ARTWORK STATUS

23/6/05 New Artwork
24/6/04 Amend
29/6/05 Amend

w/t: 00000 file name: TASKFORCE LEAFLET
date: 29/6/05 size: 297 x 420mm
artist: peter

client use labelcraft phone 9550 0999 fax 9550 9734

ok

date please proof art carefully, any errors overlooked become the client's liability

BLACK
DIELINE

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS
Do not apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT
Do not contaminate streams, rivers or waterways with the chemicals or used containers.

STORAGE AND DISPOSAL
Store in the closed original container in a cool, well ventilated area. Do not store for prolonged periods in direct sunlight.
Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point.
If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available, bury the containers below 500mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

SAFETY DIRECTIONS
Avoid contact with eyes and skin. Do not inhale spray mist. When preparing spray wear elbow length PVC gloves and face shield or goggles. If product on skin ,immediately wash area with soap and water.
Always use in the open or a well ventilated area. After use and before eating, drinking, smoking wash hands, arms and face thoroughly with soap and water. After each days use, wash gloves, face shield or goggles and contaminated clothing .

FIRST AID
If poisoning occurs contact a Doctor or Poisons Information Centre (Phone Australia 13 11 26). If skin contact occurs, remove contaminated clothing and wash skin thoroughly.

MATERIAL SAFETY DATA SHEET
For further hazard information refer to the Material Safety Data Sheet (MSDS) which is available from the supplier.

FURTHER INFORMATION
Refer to TASKFORCE® website at ***www.taskforceherbicide.com***, your supplier or Bill Dobbie on 0408 404 505

CONDITIONS OF SALE:
Vee Dri (Aust) Pty. Limited will not accept any responsibility whatsoever and howsoever arising, whether consequential loss or otherwise, in connection with the supply of this product other than the responsibility for the merchantable quality and such conditions imposed by law. Any liability is restricted to the replacement of the product.

IN CASE OF TRANSPORT EMERGENCY
Call 000

SPECIALIST ADVICE
Call Bill Dobbie 0408 404 505

APVMA APPROVAL NO: 53015/1L0505

VEE DRI (AUST) PTY. LIMITED 20 Tunstall Ave. Kensington NSW 2033 Ph: 0408 404 977 Fax: 02 9662 1648

www.taskforceherbicide.com

POISON

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

TASKFORCE

Water Soluble Herbicide

ACTIVE CONSTITUENT: 745 g/L FLUPROPANATE
(present as sodium salt)

GROUP **J** HERBICIDE

A component of integrated management of serrated tussock, giant parramatta grass, Giant rats tail grass, Chilean needle grass, African lovegrass and certain other grasses as per the direction for use table

DIRECTIONS FOR USE
Restraints
Do NOT apply this product to steeply sloping sites when applying high rates recommended for perennial grass control.
Do NOT allow spray drift onto susceptible crops and ornamentals.
Do NOT spray near desirable trees.

Crop/ Situation	Weeds Controlled	States	Rate			Critical Comments	
			Ground per ha	Air per ha	Spot Spraying per 100L		
Industrial use	Paspalum *(Paspalum dilatatum)*	Tas., WA, SA and Vic. only	9L	-	500mL	Apply to existing growth during November to February inclusive. Apply the recommended rate of 'Tussock Herbicide' in 800-2000L of water per ha. Ensure that the spray completely wets all leaf surfaces. **Spot spraying:** spray thoroughly to ensure run-off.	
	Kikuyu grass *(Pennisetum clandestinum)*						
	Couch *(Cynodon dactylon)*						
	African Feathergrass *(Pennisetum macrourum)*	Tas. , WA only,	9L	-	-		
Pastures and non-crop situations	Parramatta grass *(Sporobolus* spp.*)*	Qld, NSW, WA only	2L	2L	200mL	Apply December to February inclusive.	**Application volumes:** Pastures Aerial: 40-80L water per ha Ground Boom Spray: 150L water per ha Spot Spraying: NSW & Qld: 1000L/ha or for a 15L knapsack treat 150m².
	Giant Parramatta Grass *(Sporobolous fertilis)* Giant Rat's Tail Grasses *(S. pyramidalis* and *S. natalensis)*	NSW only	1.5-2L	-	200mL	In Northern NSW apply from July to December inclusive, during the drier time of year. Use the higher rate for heavy infestations. To obtain better herbicide selectivity and less damage to desirable pasture species, apply when the pasture is dormant, semi-dormant. For example in NSW, the optimum application time is late winter and early spring. DO NOT apply in severe droughts or to weeds retarded by burning.	
	African love grass *(Eragrostis curvula)*	NSW, WA, QLD only Vic only	3L	-	300mL	Apply July to December. Apply July to December inclusive. All other Critical Comments as for Serrated Tussock (Vic.).	
	Rats tail grasses	Qld, WA only	2L	-	200mL	**Spot Spraying:** Spray to run-off.	
Urban open space, woodlands, roadsides, nature reserves and pastures	Chilean needle grass *(Nassella neesiana)*	NSW, ACT, Vic, Qld, SA, WA only	1.5-3L	-	200mL+150mL glyphosate 360 Herbicide	Apply tank mix to actively growing plants from Spring to autumn. Spray to run off.	
					100-300mL	Calibrate spray equipment to apply 1000L water per hectare. Apply to actively growing and stress free plants. Control will take 3-12 months depending on weather conditions and senescence of plant foliage. High rates will kill native grasses. Apply once per year Avoid use in channels or drains. Do NOT re-seed treated areas until at least 100mm of leaching rain has fallen.	
Perennial Pastures	Coolatai Grass (Small patchy infestations) *(Hyparrhenia* spp)	NSW only	-	-	300mL per 100L water	Apply in winter and spring between the months of July and October. Apply using high volume spot spray applicators. Apply herbicide solution to Coolatai grass to the point of run-off from leaf surfaces.	

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

MACSPRED
TRIMAC™ INDUSTRIAL HERBICIDE

ACTIVE CONSTITUENTS: 880 g/kg TERBACIL
40 g/kg SULFOMETURON METHYL

GROUP	B C	HERBICIDE

For the control of certain annual and perennial weeds in certain situations as per the directions for use table.

NET 1kg
Contains10 X 100g measure packs which it is illegal to sell separately

MACSPRED PTY LTD
A.B.N.85 011 029 495
Lot 22 Kennedy's Drive
DELACOMBE VIC 3350
Tel: 03 53 358522

™ Macspred Trademark

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

MACSPRED
TRIMAC™ INDUSTRIAL HERBICIDE

ACTIVE CONSTITUENTS: 880 g/kg TERBACIL
40 g/kg SULFOMETURON METHYL

GROUP	B C	HERBICIDE

For the control of certain annual and perennial weeds in certain situations as per the directions for use table.

NET 5 kg
Contains 5 X 1kg measure packs which it is illegal to sell separately

MACSPRED PTY LTD
A.B.N.85 011 029 495
Lot 22 Kennedy's Drive
DELACOMBE VIC 3350
Tel: 03 53 358522

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8th June 2011 *Page 2 of 9*

GENERAL INSTRUCTIONS
HandGun

- Apply this product with a water volume of approximately 1000 litres per hectare for handgun applications.
- Macspred Trimac™ Industrial Herbicide is a soil residual with some knockdown. It controls susceptible weeds through both post-emergence and pre-emergence (residual action).
- Best results are obtained if this product is applied to bare ground or to small weeds (up to 10 cm in height or diameter. The product should be applied to actively growing weeds which are not stressed by factors such as moisture (drought or waterlogging), frost etc.
- For dense weed infestations and where weeds are greater than 10 cm in height and diameter, add Glymac Dri 700 or other glyphosate formulations registered for the purpose (in accordance with label recommendations),
- This product is a water dispersible formulation that mixes readily in water.
- Sufficient moisture is required after treatment to enable root absorption by the weed species.
- The degree of control and duration of effect will vary with the soil texture, organic matter content, soil pH and rainfall.
- As soil pH increases the rate of herbicide breakdown decreases so that on soils with a high pH the efficacy on weeds may be higher (over time) than on soils with a lower pH.
- As soil organic matter increases the rate of herbicide breakdown increases so that longest residual control is obtained in soils with low organic matter.
- Do not apply during periods of intense rainfall or under conditions which will cause drift or movement to non-target areas.

Boom Spray (Commercial and Industrial Areas)

- When using Macspred Trimac™ Industrial Herbicide for application by ground spraying equipment only. Use a boom spray (or off-centre nozzle if necessary) properly calibrated to a constant speed and rate of delivery to ensure thorough coverage and a uniform spray pattern and rate of application over the area to be treated.
- Apply a minimum of 100 L prepared spray/ha.
- When using a flat fan nozzles select a nozzle designed to reduce drift and provide larger sized droplets and 110^0 fan angle.
- When spraying using offset nozzles select nozzles that produce larger sized droplets at the lowest pressure and the correct width.
- Use no finer than 100 mesh filters.
- Clean spray equipment immediately after use.

CLIMATIC CONDITIONS GUIDELINES

- Spray when the wind is steady 3 to 12 km/h.
- Spray when the wind direction is away from sensitive areas.
- Spray when the Delta T is between 2 and 8 and no greater than 10.
- Avoid spraying:
  - in gusty or blustery wind conditions
  - when inversion conditions exist
  - in an unstable atmosphere
  - in calm conditions
- Record and check weather conditions at regular intervals

Loading, Application and Equipment

Macspred Trimac™ Industrial Herbicide is a wettable formulation. The product is mixed with water and applied at the recommended rates by handgun application or boom (see directions for use tables).
The product is contained in pre-measured dosages . The contents of the "water soluble bag" should be mixed with 100L water using the following method:

1. Partially fill the spray tank with water
2. Add the appropriate number of water soluble bags (these are in pre-measured 1000 m^2 doses or larger bags for hectare application).
3. With the agitation system engaged, top up to the correct volume with water.

The material should be kept in suspension at all times by continuous agitation.
To prevent nozzle blockage, strainer and screens should be 100 mesh or coarser.

Sprayer Cleanup
Residues in the spray tank can damage sensitive plants. It is recommended that a sprayer be dedicated to the use of

herbicides which are used to control weeds in industrial situations. The recommended sprayer cleanup is as follows:-
1. Drain tank, then flush tank, boom, filters and hoses with clean water for a minimum of 10 minutes.
2. Fill the tank with clean water and add 300 ml chlorine bleach (containing 4% chlorine) per 100 L water. Flush through boom, filters and hoses, then allow to sit for 15 minutes with agitation engaged then drain.
3. Repeat Step 2.
4. Nozzles and screens should be removed and cleaned separately. To remove traces of chlorine bleach, rinse the tank thoroughly with clean water and flush through boom, filters and hoses.
CAUTION: DO NOT use chlorine bleach with ammonia.

RESISTANT WEEDS WARNING

GROUP	B C	HERBICIDE

This product is a member of the uracil and sulfonylurea group of herbicides. This product has the inhibitors of acetolactate synthase and inhibitors of photosynthesis at Photosystem II mode of action. For weed resistance management this product is a Group B C herbicide.
Some naturally occurring weed biotypes resistant to this product and Group BC herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by this product or other Group BC herbicides. Since the occurrence of resistant weeds is difficult to detect prior to use, Macspred Pty Ltd accepts no responsibility for any losses that may result from the failure of this product to control resistant weeds.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

- Macspred Trimac™ Industrial Herbicide can affect desirable plants if not correctly applied. Follow the instructions given.
- This product can be safely used within the root zone of established *Eucalyptus spp.* & *Corymbia spp* See tree tolerance.
- When applying to fence lines, it should be noted that some desirable species may be damaged or controlled where their root systems extend into the area treated. It is advisable to notify and consult with neighbours before treating boundary fences.
- When applying this product to yards and gravel areas leave a 1m buffer on the boundaries to avoid damage.
- Use the lower rate when applying this with a boom spray **or** as a spot or strip treatment to hard/compacted surfaces and to roadsides where run-off is likely to occur into sensitive areas.
- As soil organic matter increases, the rate of herbicide breakdown increases. Thus, the longest residual control is obtained in soils with low organic matter.
- Use lower rates in soils with low organic matter.
- Band spray or strip spray in soils low in organic matter.
- Apply a 5m buffer to areas where a surface flow of water could wash the chemical into drains.
- Only apply Trimac™ to fence lines where some damage to adjacent pasture species is acceptable.
- As Trimac™ needs moist soils for incorporation, best results are achieved by applying to moist soil. Avoid water logged or soils near to saturation.
- Avoid application in extreme / extended dry periods prior to intense rainfall adjacent to sensitive areas as surface run off may occur.
- **DO NOT** drain or flush equipment on or near desirable trees or other plants, or on areas where their roots may extend. As guidance, this is twice their height or more depending on the species and other conditions.
- **DO NOT** spray foliage or use on eroded areas, where sub-soil or tree roots are exposed, as injury to trees may result.
- **DO NOT** apply under meteorological conditions or from equipment which could be expected to cause drift of this product or spray mix into adjacent areas, particularly wetlands, water bodies or water courses.
- **DO NOT** apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures. See Tree tolerance.
- DO NOT apply in intense rainfall.
- DO NOT broad acre apply to bare ground on slopes exceeding 30% (~15°).
- For further information contact our nearest Macspred representative.

TREE TOLERANCE

- Field trials and use experience have indicated that the major forestry tree species are tolerant to Macspred Trimac^{TM} when applied at label rates. For further tree tolerance information, contact your Macspred representative or conduct a small-scale tolerance test.
- In some instances when Trimac^{TM} is applied near small trees, stunting may occur. This is usually short lived and a full recovery is expected in the next growing season.
- This stunting can be attributed to a prolonged dry period, pH, organic matter and rate selection.
- Therefore rate selection should suit soil and other conditions.
- Avoid overspray all tree species as damage to growth tip dominance/damage may occur.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

- If required Establish spray buffers zones. Review State regulation and statutory requirements. Eg. General Buffers 20 m- Permanent Streams 10 m, Temporary Stream and Drainage Line 10 m.
- DO NOT use in irrigation channels or in drains including roadside ditches and table drains or in areas where water is likely to flow.
- DO NOT empty equipment in the above situations.
- DO NOT use on leached, sandy soils, low in organic matter.
- Dangerous to aquatic life. DO NOT contaminate streams, rivers or waterways with the chemical or used containers.
- DO NOT apply to water-logged or saturated soil.

PROTECTION OF LIVESTOCK

- Keep stock away from treated areas. As some noxious weeds may become palatable.

STORAGE AND DISPOSAL AND PROTECTION OF OTHERS

During storage keep from contact with fertilisers, other pesticides and seeds.
Store in the closed original container in a well ventilated area, as cool as possible but out of direct sunlight.
Do not dispose of undiluted chemicals on site. Product should not be burnt. Outer cardboard carton may be recycled.

RECOMENDED MIXING ORDER.

1. DF, WG Dry Glyphosate and Macspred Clomac. (Dry products)
2. Allow some mixing time.
3. Add Trimac.
4. Add antifoaming agent if required.
5. Top up with water.
6. Add other liquids.
7. Add surfactants last.

COMPATIBILITY

Compatibility and spray tests have be conducted on the following products. Trimac product may be mixed with the following products only:

Companion Products

- *Glyphosate formulations.* (Macspred Glymac 450 Glyphosate, Glyphosate 450 and 360 Formulations, Ripper 480 Glyphosate, Macspred Glymac Dri 700 Glyphosate, Macpherson's Bi Dri 700 Glyphosate, Macspred Bi Dri 700 Glyphosate only)
- *Metsulfuron Methyl* (DuPont Brush Off ® and Macspred Metmac)
- *Clopyralid* (Macspred Clomac)
- *Surfactants and additives SST Brushwet, DuPont Input ®, Miller NuFilm P, Exit, Miller Foam Fighter Anti Foam -K, Miller Mist* Controller and Uptake Oil only

Non Companion Products

- *540 Glyphosate formulations, Roundup Powermax*

For an updated list of compatible products with Trimac^{TM}. Contact your nearest Macspred Australian representative or conduct a small jar test for compatibility.

SAFETY DIRECTIONS

Avoid contact with eyes and skin. Do not inhale dust. When preparing spray, wear face shield or goggles. Wash hands after use.

FIRST AID
If poisoning occurs, contact a doctor or Poisons Information Centre (TEL 131126).

MATERIAL SAFETY DATA SHEET
Additional information is listed in the Material Safety Data Sheet (MSDS) which can be obtained from the supplier.

NOTICE TO BUYER
To the extent permitted by law, all conditions and warranties and statutory or other rights or action which buyer or any other user may have against Macspred or Seller are hereby excluded. Macspred hereby gives Notice to Buyer and other users that it will not accept responsibility for any indirect or consequential loss arising from reliance on product information or advice provided by Macspred or on its behalf unless it is established that such information or advice was provided negligently and that the product has been used strictly as directed. Macspred's liability shall, in all circumstances, be limited to replacement of the product or a refund of the purchase price paid therefor.

DIRECTIONS FOR USE

Restraints - DO NOT use on leached sandy soils, low in organic matter.
DO NOT use when intense rainfall is likely or on soils saturated with water as off target movement may occur.
DO NOT store the mixed product overnight as settling out may occur.

METHOD OF APPLICATION – HANDGUN APPLICATION
FOR ALL STATES

CROP AND SITUATION	WEEDS CONTROLLED	RATE Per 100L water	CRITICAL COMMENTS
Commercial and Industrial areas including around building lines, rights of way, roadsides, guideposts, powerlines and substations, aerodromes, public utilities and fencelines.	ANNUALS Capeweed (*Arctotheca calendula*), Annual Ryegrass (*Lolium rigidum*), White Clover (*Trifolium repens*) Geranium (*Geranium sp.*) Milk Thistle (*Sow*) (*Sonchus oleraceus L.*) HARD TO KILL PERENNIALS Fog grass (*Holcus lanatus*)	1 x 100 g "water soluble" bag	Apply to weeds less than 10cm in height or diameter. Use with Glyphosate (in accordance with its label recommendations), for dense weed infestations and where weeds are greater than 10 cm in height and diameter. Apply this product with a water volume of approximately 1000 litres per hectare.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

WITHHOLDING PERIOD – DO NOT CUT OR GRAZE FOR STOCK FOOD ANY TREATED VEGETATION

CROP AND SITUATION	WEEDS CONTROLLED	RATE Per ha	CRITICAL COMMENTS
Commercial and Industrial areas, including around building lines, rights of way, roadsides, guideposts, powerlines and substations, aerodromes, public utilities, fence lines	ANNUALS Capeweed (*Arctotheca calendula*), Annual Ryegrass (*Lolium rigidum*), White Clover (*Trifolium repens*) Geranium (*Geranium sp.*) Milk Thistle (*Sow*) (*Sonchus oleraceus L.*) HARD TO KILL PERENNIALS Fog grass (*Holcus lanatus*)	500 g or 1kg/ha	Apply to weeds less than 10cm in height or diameter. Use with Glyphosate (in accordance with its label recommendations), for dense weed infestations and where weeds are greater than 10 cm in height and diameter. Apply this product with a water volume of 100 litres per hectare. Use the higher rate for dense weed infestation. Use the lower rate when retreat areas with minimal regrowth. Buffer areas from 1 to 5m where Chemical creep is not acceptable.

APVMA Approval No: 54812/51865
Date of Manufacture:
Batch No:
8th June 2011 *Page 7 of 9*

CAUTION CAUTION
KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

MACSPRED
TRIMAC™ INDUSTRIAL HERBICIDE

ACTIVE CONSTITUENTS:
880 g/kg TERBACIL
40 g/kg SULFOMETURON METHYL

NET: 100g

APVMA APPROVAL NO: 54812/51865

NOT TO BE SOLD SEPARATELY

BEFORE USE READ ALL DIRECTIONS ON THE OUTER PACK

WATER SOLUBLE PACKAGING. KEEP DRY.

™Macspred Trademark

8th June 2011 *Page 8 of 9*

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

MACSPRED
TRIMAC™ INDUSTRIAL HERBICIDE

ACTIVE CONSTITUENTS:
880 g/kg TERBACIL
40 g/kg SULFOMETURON METHYL

NET: 1 kg

NRA APPROVAL NO: 54812/51865

NOT TO BE SOLD SEPARATELY

BEFORE USE READ ALL DIRECTIONS ON THE OUTER PACK

WATER SOLUBLE PACKAGING. KEEP DRY.

™Macspred Trademark

8th June 2011 *Page 9 of 9*

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Uragan® WG Herbicide

ACTIVE CONSTITUENT: 800 g/kg BROMACIL

GROUP **C** HERBICIDE

For the control of certain annual broadleaved weeds and grasses in Citrus, Pineapples, Asparagus and in Commercial and Industrial areas, Rights of Way and around Agricultural Buildings as specified in the Directions for Use table.

ADAMA

adama.com

CONTENTS: 2kg, 5kg

DIRECTIONS FOR USE

RESTRAINTS: DO NOT allow spray to contact foliage or fruit of desirable plants.
For best results sufficient moisture, either by rainfall or irrigation, is required within 3-4 days of treatment to carry the product into the soil.

CROP	WEEDS CONTROLLED	STATE	RATE/HA**	CRITICAL COMMENTS
Asparagus (older than 1 year)	**Annual Weeds:** Annual Ryegrass, Barley Grass, Bathurst Burr, Brome Grass, Caltrop, Capeweed, Cobbler's-pegs, Doublegee (Spiny Emex, Threecornered Jack), Fat-hen, Khaki Weed (seedling), Noogoora Burr, Paterson's Curse, Prairie Grass, Annual Ragweed, Saffron Thistle, Summer Grass, Thornapple, Wild Mustard, Wild Oats, Wild Radish, Wild Turnip, Winter Grass	All States	1.1 to 2.5 kg	Apply after cultivation to established plantings only as damage may occur to young plantings. Apply 3-4 weeks prior to spear emergence in Spring or before the early cutting period. If cultivation occurs during cutting period apply immediately after last cultivation. If needed, apply a second spray after harvest to keep fields weed-free. Irrigate before or as soon as possible after spraying. (See Crop Safety Section). **Note:** For Wild Oat control, use no less than 2.5 kg/ha.
Citrus Established groves only			1 kg/500 L water	**Spot Spray:** Wet weeds thoroughly to point of run-off. (See Crop Safety Section).
			2.2 to 4.5 kg	* Apply to weed-free ground in Autumn and Spring. After 1-2 years of application, once per year may be adequate. DO NOT apply more than 9 kg/ha/year. (See Crop Safety Section). **Note:** For Wild Oat and Caltrop control, use no less than 3 kg.
				*** Spot Treatment:** Spray to point of run-off. (See Crop Safety Section).
Pineapples	Barnyard Grass, Billygoat Weed/Bluetop, Cobbler's-pegs, Crowsfoot, Guinea Grass, Red Natal Grass, Sourgrass, Stinking Roger, Summer Grass, Thickhead	Qld, NT only		Apply as a blanket spray prior to weed emergence immediately after planting or before planting material begins to grow.
			2.2 kg	* If needed apply as a direct inter-row spray prior to flower differentiation. DO NOT spray over top of plants. DO NOT apply more than 9 kg/ha/year.

APVMA Approval No: 62760/61185
Uragan WG Herbicide PAGE 1 OF 3

ADAMA

CROP	WEEDS CONTROLLED	STATE	RATE/HA**	CRITICAL COMMENTS
Industrial Weed Control Commercial & Industrial Areas; Rights of Way, Fencelines; Around Agricultural Buildings.	**Annual Weeds:** Annual Ryegrass, Barley Grass, Bathurst Burr, Brome Grass, Caltrop, Capeweed, Cobbler's-pegs, Doublegee (Spiny Emex, Threecornered Jack), Fat-hen, Khaki Weed (seedling), Noogoora Burr, Paterson's Curse, Prairie grass, Annual Ragweed, Saffron Thistle, Summer Grass, Thornapple, Wild Mustard, Wild Oats, Wild Radish, Wild Turnip, Winter Grass	All States	3.5 to 6.5 kg	* The lowest rate will provide control in low rainfall areas (250 mm or less).
	Retreatment: All of the above weeds		2 to 6.5 kg	* Apply when weeds and grasses re-appear on sites where growth has been controlled.
	Small Areas: Annual and Perennial Weeds		20 g/10 m^2 (20 kg/ha)	*

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

* If weeds are present add non-ionic surfactant at 100 mL/100L (0.1% v/v) of spray solution.
** Use lower rates on lighter soils low in clay or organic matter and higher rates on heavier soils high in clay or organic matter.

WITHHOLDING PERIODS: NOT REQUIRED WHEN USED AS DIRECTED.

APVMA Approval No: 62760/61185
Uragan WG Herbicide PAGE 2 OF 3

ADAMA

GENERAL INSTRUCTIONS

For best results apply shortly before weed growth occurs to moist well prepared trash and clod free soil. Well established weeds should be removed before applying the product.
Actively growing weeds up to about 10 cm in height may be controlled, but a wetting agent must be used.
DO NOT cultivate soil surface after application as efficacy may be reduced and/or crop injury may result.
For best results sufficient moisture, either by rainfall or irrigation, is required within 3-4 days of treatment to carry the product into the soil. With irrigation thoroughly wet the entire area. Where rainfall is limited during the growth period, control of deep-rooted hard-to-kill weeds will not be satisfactory.

RESISTANT WEEDS WARNING

URAGAN® WG Herbicide is a member of the Uracils group of herbicides. URAGAN WG has the inhibitors of photosynthesis at photosystem II mode of action. For weed resistance management URAGAN WG is a Group C herbicide. Some naturally occurring weed biotypes resistant to URAGAN WG and other Group C herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by URAGAN WG or other Group C herbicides, thus resulting in a reduction in efficacy and possible yield loss.

GROUP **C** HERBICIDE

Since the occurrence of resistant weeds is difficult to detect prior to use, Adama Australia Pty. Ltd. accepts no liability for any losses that may result from the failure of this product to control resistant weeds.
Advice as to strategies and alternative treatments that can be used should be obtained from your local supplier, consultant, local Department of Agriculture, Primary Industries Department or a Adama representative.

RE-ENTRY PERIODS

After treating asparagus or pineapple, do not allow entry into treated areas for 14 days, unless wearing cotton overalls buttoned to the neck and wrist over normal clothing and chemical resistant gloves. Clothing must be laundered after each days use.
After treating citrus, do not allow entry into treated areas for 3 days, unless wearing cotton overalls buttoned to the neck and wrist over normal clothing and chemical resistant gloves. Clothing must be laundered after each days use.

EQUIPMENT AND APPLICATION

Fill spray tank no more than 50% full with clean water. Before adding URAGAN WG begin agitating vigorously and continue agitation during the entire mixing and spraying operation. Pour required amount of product steadily into the spray tank. Allow vigorous bypass agitation to completely disperse product.
DO NOT dump product into spray tank all at once.
After adding required quantity of product and obtaining complete dispersion, continue to fill tank to desired level for spraying. Thorough agitation of the spray liquid should continue during the entire spraying operation. Spray solution should not be left standing in the tank overnight.

Large areas

Use a fixed boom sprayer or handgun. To prevent nozzle blockage, strainer and nozzle screens should be 50 mesh or coarser. Always agitate in spray tank to keep material in suspension.

(a) Fixed Boom Sprayer

Use 1000-2000 L/ha water for industrial weed control. For selective weed control use 250-450 L/ha at 200-300 kPa pressure.

(b) Handgun

Use 1000-2000 L/ha and 60-800 kPa pressure.

Small areas

Use a knapsack or pressurised hand sprayer or water can. Shake or stir frequently.

SPRAYER CLEANUP

Thoroughly clean all traces of URAGAN WG from application equipment immediately after use. Flush tank, pump, hoses and boom with several changes of water after removing spray nozzles and screen (clean these parts separately).

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

DO NOT apply or drain or flush equipment on or near desirable trees or other plants or where their roots may extend.
Movement of soil from treated areas should be avoided because damage to off-target species may occur.
DO NOT spray under weather conditions or from sprayer equipment that may cause spray to drift over nearby susceptible plants or crops, cropping lands or pastures.

Asparagus: DO NOT apply to newly seeded asparagus, or to young plants during the first growing season after setting or to plants whose roots are exposed.

Citrus: Use with caution on light sandy soils as yellowing may occur.
Treated area for asparagus and citrus – DO NOT replant any crops within three (3) years of last application as injury may occur.

Pineapples: Only pineapples can be replanted into the same area within the 3 year plan.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

DO NOT contaminate streams, rivers or waterways with the chemical or used containers.

STORAGE AND DISPOSAL

Store in the closed original container in a dry, well-ventilated area, as cool as possible, out of direct sunlight. Store in a locked room or place away from children, animals, food, feedstuffs, seed and fertilisers. Single rinse before disposal. Add rinsings to spray tank. DO NOT dispose of undiluted chemicals on-site. Break, crush, or puncture and deliver empty packaging to an approved waste management facility. If an approved waste management facility is not available bury the empty packaging 500 mm below the surface in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots, in compliance with relevant Local, State or Territory government regulations. DO NOT burn empty containers or product.

SAFETY DIRECTIONS

Harmful if swallowed. Will irritate the eyes and skin. Avoid contact with eyes and skin. When opening the container, mixing and loading, wear cotton overalls, over normal clothing, buttoned to the neck and wrist, chemical resistant gloves and goggles or safety glasses. Wash hands after use. After each day's use wash gloves, goggles or safety glasses and contaminated clothing.

FIRST AID

If poisoning occurs, contact a doctor or Poisons Information Centre. Phone Australia 131126.

MSDS

Additional information is listed in the material safety data sheet (MSDS). A material safety data sheet for URAGAN WG is available from Adama on request. Call Customer Service on (02) 9431 7800.

CONDITIONS OF SALE: The use of URAGAN WG Herbicide being beyond the control of the manufacturer, no warranty expressed or implied is given by Adama Australia Pty. Ltd. regarding its suitability, fitness or efficiency for any purpose for which it is used by the buyer, whether in accordance with the directions or not and Adama Australia Pty. Ltd. accepts no responsibility for any consequence whatsoever resulting from the use of this product.

NOT A DANGEROUS GOOD ACCORDING TO THE AUSTRALIAN DANGEROUS GOODS (ADG) CODE.

Adama Australia Pty. Ltd. ABN 55 050 328 973
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207 Pacific Highway
St Leonards NSW 2065 Australia
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APVMA Approval No: 62760/61185

Batch No.

Date of Manufacture

ADAMA

Appendix 4: Herbicide options for gamba grass control

Category	Herbicide	Type	Control	Notes/observations	Field trial	Pot trial
M	Glyphosate	Broad spectrum herbicide for annual and perennial plants.	Foliar application	Non-selective Aerial trials at Batchelor – straight glyphosate with different surfactants Pot trials – RioTinto. Most effective.	Yes	
J	Flupropanate (Liquid)	Selective, soil-active, residual herbicide for grasses	Direct hand spray of tussocks Requires rainfall (15-20mm) to enter the soil and be absorbed through the roots	Foliar applied is a problem in high fire risk areas Application after fire seems OK – doesn't seem to be affected by ash Minimal off-targets at label rate (but low mortality for gamba) Vogler & Carlos 2017	Yes	Yes
J	Flupropanate (Granular)	Selective, soil-active, residual herbicide for grasses	Spot application in tussock – not requiring water Better for aerial application than liquid	2.5 times more expensive then liquid Minimal off-targets if applied by hand to tussock Vogler & Carlos 2017	Yes	
B	Sulfometuron	Broad spectrum for the control of annual and perennial grasses and broadleaf weeds	Root and some foliar uptake, rapid upward translocation – inhibits cell division and disrupts growth. Applied after a knockdown directly to the surrounding soil/ground layer	Significant off-target effects – will kill all grasses. Eucalypts are reasonably tolerant (Herbiguide) Being trialled NT Weeds Branch - Macspred	Yes	Yes

Category	Herbicide	Type	Control	Notes/observations	Field trial	Pot trial
			Trimac and Eucmix granular – Terbacil with Sulfometuron			
C	Terbacil	Mainly root absorbed herbicide that controls a wide range of grasses and broad leaved plants	Trimac and Eucmix granular – Terbacil with Sulfometuron	Effect on Native Plants: Low levels due to drift are not expected to have long-term effects. Most native plants with roots under treated areas are likely to be damaged. Water flows from treated areas may cause damage. Being trialled NT Weeds Branch – Macspred	Yes	Yes
B	Imazapyr	Broad spectrum for the control of annual and perennial grasses and broadleaf weeds		Unknown		Yes
G	Flumioxazin	Broad-spectrum, foliar and root absorbed, residual, used as a mixing partner with knockdown herbicides	Spray treatment – soil applied pre-emergent On relatively bare soil Could be applied after fire?	Unknown		
G	Oxyfluorfen	Selective pre and post emergent for annual broadleaf and some grasses	Liquid or granular	Unknown		Yes
C	Bromacil	Residual for grass and broadleaf - root absorbed		Do not use it near trees; kills most native plants		Yes
O	Indaziflam	Selective pre and post		Unknown		Yes

Category	Herbicide	Type	Control	Notes/observations	Field trial	Pot trial
		emergent for annual broadleaf and some grasses				
F	Clomazone	Soil applied for annual weeds		Unknown		Yes
G	Oxyfluorfen	Soil or seedling applied – non selective		Unknown		Yes
A	Haloxyfop	Post-emergent grass selective herbicide for most annual grasses	Spray treatment	Off-target grasses Pot trials – RioTinto OK but weak compared with DIMS		
A	Fluazifop-p-butyl	Foliar; control of grasses in bushland and broadleaf crops		Pot trials – RioTinto Weak		
N	Glufosinate	Foliar, non-residual control of broadleaf and grass weeds in various situations.		Pot trials – RioTinto OK – recommended as alternate for glyphosate		
A	Clethodim	Foliar. Grass selective herbicide		Pot trials – RioTinto. Quite good success on very young plants in pots.		
A	Butroxydim	Foliar. Grass selective.		Pot trials – RioTinto. Quite good success on very young plants in pots.		
A	Fenoxaprop	Foliar.		Unknown		
A	Clodinafop	Foliar.		Unknown		
A	Propaquizafop	Foliar. Post emergent selective for		Unknown		

Category	Herbicide	Type	Control	Notes/observations	Field trial	Pot trial
		annual grasses				
C	Diuron	Broad spectrum residual		Huge off-target effects – aquatic systems particularly at risk. Not approved for use in non-agricultural settings Kills trees		
R	Asulam	Broad spectrum		Pot trials – RioTinto Not effective		
H	Isoxaflutole	A pre-emergent or early post emergence, soil residual, root absorbed and translocated herbicide for the control of emerging broad-leaved weed		Pot trials – RioTinto Not effective		