final**report**

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Strategic management of weedy Sporobolus grasses

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Abstract

Weedy Sporobolus grasses including the unpalatable giant rats tail grass and giant Parramatta grass have invaded approximately 450,000ha of grazing land in coastal and sub coastal Queensland and New South Wales. Due to the strengths in the life cycle of these pasture weeds they are continuing to invade new areas and are increasing in dominance on currently infested properties. Control techniques are available, however the challenge has been to apply these efficiently and economically in extensive grazing areas due to the high financial and time requirements of some of the techniques.

This project focused on managing the weedy Sporobolus grasses at the property and catchment scale in central Queensland and northern New South Wales. Methodology for aerial application of flupropanate herbicide was designed and tested demonstrating good results. A grazing trial was conducted in New South Wales to test strategies incorporating livestock supplementation, fertiliser, rotational grazing and herbicides to best manage giant Parramatta grass infested country. Land manager participation and action on their own properties was encouraged and supported throughout the project. The outcomes of the project and the experience of land managers and researchers has been incorporated into a booklet “Weedy Sporobolus grasses best practice manual” and into an economic analysis of management strategies from the perspective of the land manager and the regional community.

Executive Summary

Weedy Sporobolus grasses including the unpalatable giant rats tail grass and giant Parramatta grass have invaded approximately 450,000ha of grazing land in coastal and sub coastal Queensland and New South Wales. Due to the strengths in the life cycle of these pasture weeds they are continuing to invade new areas and are increasing in dominance on currently infested properties. Control techniques are available however the challenge has been to apply these as part of efficient and economic control/management strategies on extensive grazing properties. The significant challenge is the high financial cost and ongoing time requirement and commitment to ensure the initial investment has been worthwhile.

This project focused on managing the weedy Sporobolus grasses at the property and catchment scale in central Queensland and northern New South Wales. Specific activities included:

- Development and testing of a methodology for aerial application of flupropanate herbicide on extensive paddocks with rough country and trees. Trials showed that each application kills around 83-99% of weedy Sporobolus grass plants. The control under tree canopies was at the lower end of the range but is still regarded as being effective. Post application grazing management is important to allow the good pasture species to replace the killed weed plants and follow-up herbicide treatments will be required to kill surviving plants and new seedlings emerging from the soil seed bank.
- A grazing trial was conducted in northern New South Wales to test strategies incorporating livestock supplementation, fertiliser, rotational grazing and herbicides to best manage giant Parramatta grass infested country.
- Land manager participation and action on their own properties was encouraged and supported throughout the project with a number of land managers assessing their own situation and undertaking a control strategy on their own property with their experience reported back to the advisory group.
- The outcomes of the project have been incorporated into a booklet “Weedy Sporobolus grasses best practice manual”. The manual incorporates the experience and knowledge of land managers and researchers. The manual contains a new 3 point planning process for tackling a Weedy Sporobolus grass infestation at the property scale, and a case study to demonstrate the application of the planning process. The manual also contains a new section on the use of flupropanate herbicide to control weedy Sporobolus grasses. Manuals have been sent to regional NRM bodies, shire councils, key agribusinesses in central Queensland, biosecurity officers and all land holders who participated in field and information days. The free manual is available by calling the DPI&F Business Information Centre 13 25 23 which has been widely publicised in newspaper articles and newsletters.
- An economic analysis of management strategies from the perspective of the land manager and the regional community was conducted. The analysis showed that the high cost of control may not be economic for the land holder with the infestation, but the control may be highly beneficial for other neighbours in the catchment indicating a case for regional investment to ensure the control strategies are undertaken.
- An internal DPI&F cost-benefit analysis was conducted using conservative assumptions on the per hectare benefits and uptake of research. This analysis indicated the research and development activities in Queensland produced benefits that were significantly greater than the costs of the research (includes DPI&F and MLA investment). At a discount rate of 5%, the project generated net benefits of more than $2.28 million with a Benefit Cost Ratio (BCR) of 5 to 1.
- The project team also worked with regional NRM bodies and land holders to develop projects and strategies to tackle high priority infestations particularly at the head of catchments in isolated areas. Five landholders have received financial support to manage weedy Sporobolus grass infestations on their property, protecting thousands of hectares of land downstream.

The “Weedy Sporobolus grasses best practice manual” is the key communication product from the project incorporating the experience and knowledge of land managers and researchers. This manual will be benefit to industry, land managers regional bodies and advisers to ensure that investment in weedy Sporobolus grass control has a high likelihood of success and a good return on investment.

Contents

1 Background (extracted from the updated Weedy Sporobolus grasses best practise manual)

1.1 What are weedy Sporobolus grasses?

Weedy Sporobolus grasses are a group of related weeds that include giant rat’s tail grass, American rat’s tail grass, Parramatta grass and giant Parramatta grass.

Weedy Sporobolus grasses:
- Are robust, tufted, well-rooted perennial tussocks, with tougher leaf blades than most other grasses.
- Are exotic to Australia (non-native) and extremely aggressive.
- Produce large quantities of seed that disperse readily, increase in numbers quickly and remain viable for a long time.
- Produce mature leaf blades that are tough and difficult for cattle to graze leading to reduced feed intake, in turn leading to reduced animal production.

Weedy Sporobolus grasses now infest an estimated 450 000 ha of grazing land in eastern Queensland and New South Wales. Weedy Sporobolus grasses grow in lower rainfall (600 mm average annual rainfall) areas, but are most common in areas with an average annual rainfall above 700 mm. Significant infestations occur in coastal and sub-coastal areas from the New South Wales border to Rockhampton, and areas near Moura, Mackay, Townsville, Ingham and Mareeba. Significant infestations also occur in the north coast region of New South Wales with smaller areas found south to the Victorian border.

Weedy Sporobolus grasses are adapted to a wide range of soils and climatic conditions in Australia, and have the potential to establish in areas receiving as little as 500 mm of annual rainfall, putting more than 60% of Queensland (108 million ha), and 30% of Australia (223 million ha), at risk.

1.2 Why do we need to control WEEDY SPOROBOLUS GRASSES?

Weedy Sporobolus grasses infestations have, in some cases, dramatically decreased producers’ economic viability and lowered land values. Current infestations are collectively costing the pastoral industry in the vicinity of $60 million per year in lost production and control costs.

Invasive weeds such as weedy Sporobolus grasses and parthenium now dominate large areas of Australia’s sown pastures and native grazing land, posing a serious threat to the viability of many rural industries. Weeds such as fireweed, creeping lantana, Paterson's curse and serrated tussock have also gained a significant foothold in areas of eastern Australia.

Cattle grazing weedy Sporobolus grasses dominated pastures can take up to 12 months longer to reach equivalent weights and stocking rates on these pastures need to be halved to maintain normal rates of production per animal.

A change in land management culture is required to effectively deal with weedy Sporobolus grasses infestation. Experience has shown that herbicide control alone cannot stop the relentless progress of these invaders.

Improved land management practices are needed, both to control the current infestations and to prevent the spread of weeds to clean areas.

Long periods of poor ground cover or exposed soil provide the ideal environment for introduced weed seeds to germinate and establish. These conditions are frequent occurrences during the yearly dry season, during the droughts that characterise our climate, or as a result of fire or overgrazing.

Managing pastures to keep them in good health is therefore of key importance to managing weeds and preventing new infestations in clean areas.

In Queensland, weedy Sporobolus grasses are a declared Class 2 pest which means they are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Landholders must, by law, take reasonable steps to keep their land free of Class 2 pests.

In some areas of New South Wales, weedy Sporobolus grasses have been declared noxious. Giant rat's tail grass is considered a Class 3 weed in areas where it is found, and must by law be fully and continuously suppressed and destroyed. Giant Parramatta grass has been declared in some areas as a Class 3 pest and in others as a Class 4 pest. By law, the growth and spread of Class 4 pests must be controlled according to measures set out by the local control authority.

1.3 How to identify WEEDY SPOROBOLUS GRASSES

Weedy Sporobolus grasses are similar in appearance to some native Sporobolus grasses. However, the weedy Sporobolus grasses species generally have hairless leaf margins at the join between the leaf blade and leaf sheath while native Sporobolus species often have obvious hairs. Native Sporobolus grasses also tend to be shorter than weedy Sporobolus grasses, their seed heads are often less dense, and their leaves aren't as tough. Positive identification of small plants within a pasture is difficult until they produce a seed head.

Giant rat's tail grass commonly grows to 1.7 m tall when seeding. The seed heads are generally a 'rat's tail' spike when young, but may branch to an elongated pyramidal shape when mature. The seed head can range from 25 to 80 cm long and the side branches from 3 to 8 cm long.

American rat's tail grass looks like a short version of giant rat's tail grass, growing to 1.0 m tall.

Giant Parramatta grass grows up to 1.5 m tall when seeding and the seed heads are always a 'rat's tail' spike. Sooty spike disease sometimes develops on its seed heads.

Parramatta grass is similar to giant Parramatta grass, but only grows to 1.0 m tall.

1.4 The weedy Sporobolus grasses infestation cycle

Understanding the weedy Sporobolus grass infestation cycle (Figure 1) allows producers and land managers to target the plants' weaknesses and bypass their strengths.

1.4.1 Introduction of seed

A new weedy Sporobolus grasses infestation begins when seed spreads from an existing infestation into clean land. Weedy Sporobolus grass seed coats become sticky when wet, allowing the seeds to stick to animals, vehicles and machinery. Animals grazing on weedy Sporobolus grasses can also excrete viable weedy Sporobolus grass seed in their dung.

Preventing the spread of weedy Sporobolus grass seed into clean land is the single most effective action you can take to stop the infestation cycle.

1.4.2 Germination and establishment

If seed transported into clean country germinates, the infestation moves to its next stage. Germination of weedy Sporobolus grass seed is stimulated by daily fluctuations of temperature and exposure to light. A good plant cover reduces these fluctuations, and helps prevent germination. Removing plant cover and exposing bare ground, increases seed germination.

Seedlings can emerge at any time of the year when soil moisture and temperature conditions are suitable. Generally most seedlings emerge in spring and summer. Newly-emerged seedlings require an area of low pasture competition to survive.

By the time seedlings reach approximately 5 cm in height they are tough. They can survive longer periods of moisture stress than most other pasture seedlings and are resistant to competition from surrounding plants.

In well managed, competitive pastures weedy Sporobolus grass seedlings may remain small and will not seed for years; a highly competitive pasture may even kill some small weedy Sporobolus grass seedlings, but usually many will survive.

Cattle will graze weedy Sporobolus grasses (particularly giant Parramatta grass) early in the growing season when the regrowth is young and leafy. However, as plants mature, their leaves become tougher and less palatable to stock. This sets up a vicious cycle. Overgrazing of the more desirable grasses allows established weedy Sporobolus grass plants to increase in size and more weedy Sporobolus grass seedlings to establish.

Mature weedy Sporobolus grass plants are long lived (more than 10 years), and resistant to competition from the surrounding pasture; they are not usually killed by fire, slashing or grazing.

Mature weedy Sporobolus grass leaves are tough, resulting in livestock eating less forage, directly impacting on livestock production.

1.4.3 Development of a soil seed bank

Weedy Sporobolus grass plants can quickly grow, flower and set seed whenever the pasture becomes less competitive through drought, overgrazing, fire or mechanical disturbance. Under the right conditions weedy Sporobolus grass plants can set seed within three months of emergence. Sub-lethal herbicide application may reduce seed production even if it does not kill the plant. High pasture competition also tends to reduce seed production.

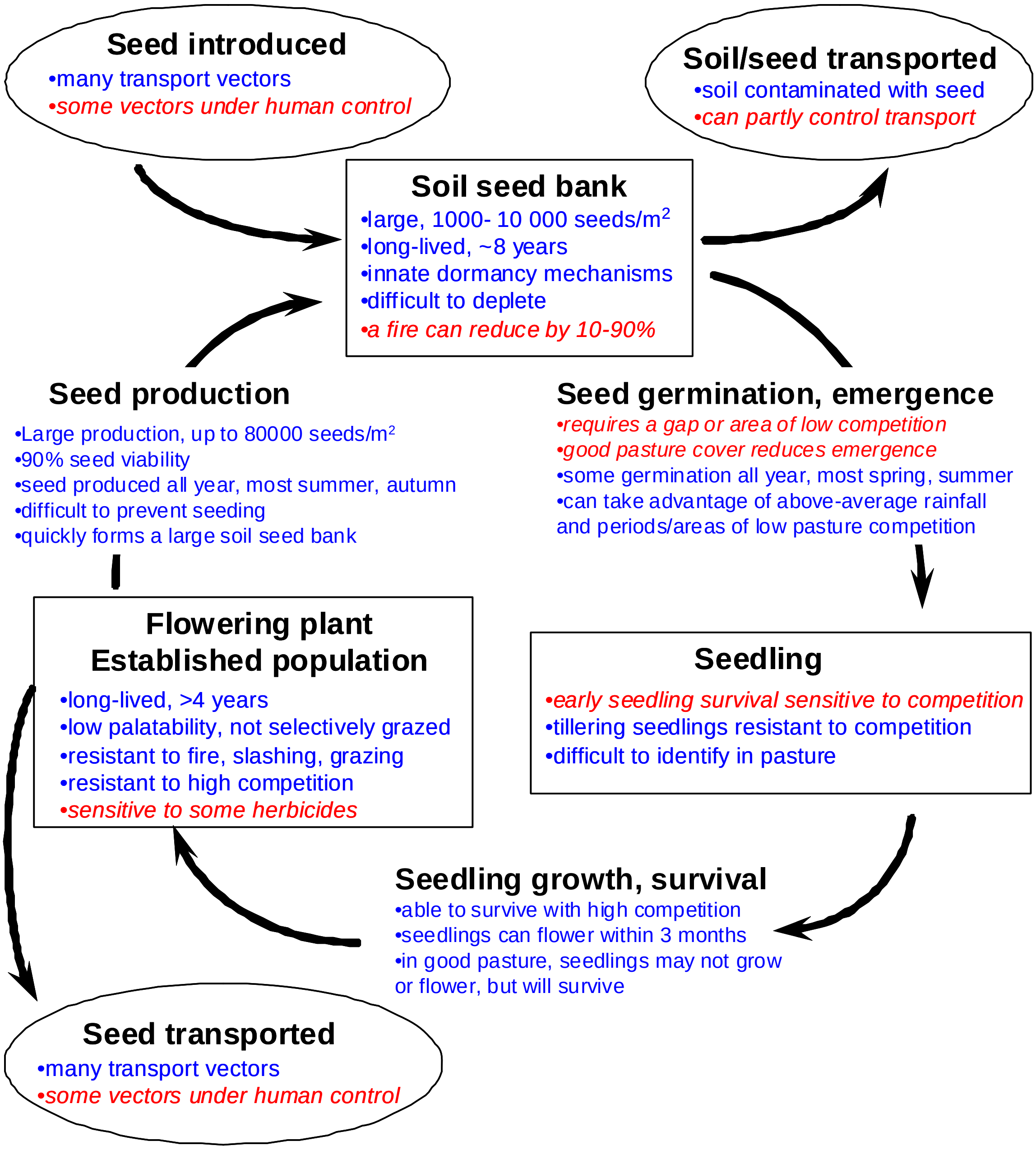


Figure 1 Life cycle of Weedy Sporobolus grasses. *Weaknesses* in the life cycle are highlighted in red italics. Strengths in the life cycle are in blue normal font.

Seed can be set throughout the year but most are produced during the warm season. Seed production is high with up to 80 000 seeds/m^2 produced per year, and most seed that falls is viable and can remain viable in soil for up to 10 years. A soil seed ‘bank’ quickly develops and up to 20 000 seeds/m^2 (or 2 seeds/cm^2) can be present in the soil.

Once a soil seed bank has developed, management is more difficult. It is difficult to force the germination of all seeds contained in a soil seed bank. Although cultivation encourages seeds to germinate, seedlings will still emerge even after two years of continuous cultivation. Pre-emergent herbicides only kill germinating seed, and have no effect on dormant seed still in the soil. Seedlings can emerge from a maximum soil depth of 20 mm. Seed deeper than this can remain alive but dormant for extended periods.

1.5 Preventing the establishment of weedy Sporobolus grasses

Controlling established weedy Sporobolus grass infestations is expensive and time-consuming. Measures to prevent the initial establishment of weedy Sporobolus grasses should be put in place by all producers. Maintaining healthy, competitive pastures is essential to preventing the establishment of weedy Sporobolus grasses. Careful grazing management is required for pastures to achieve or remain in good condition, and high in perennial, productive and palatable species. A balance must be maintained between the needs of the pasture and the needs of the grazing animals. The following four principles are key to management:

1. Manage ground cover: Minimise the creation of bare and disturbed areas, as these areas are likely to be suitable for the establishment of weedy Sporobolus grasses and other weeds. Living plants compete with weedy Sporobolus grass seedlings for soil moisture and reduce the seedlings' chance of survival. Litter (dead plant parts on the ground) is not waste. It covers bare soil and reduces the light that reaches the soil, thus limiting the germination of weedy Sporobolus grasses. Litter also helps the soil retain moisture, improving pasture growth. Litter also encourages soil organisms which are essential for maintaining healthy soils.

2. Rest pasture periodically: Continuous grazing weakens plants, reducing their competitiveness within the pasture. Pasture plants require periodic rest to build-up reserves and produce seed. Current pasture condition determines the amount of rest required to achieve good condition. Some pastures may require other inputs (such as fertiliser, a selective weedicide, or re-sowing) before they can be considered to be in good condition.

3. Match forage production to animal consumption: Overgrazing weakens a pasture's competitive ability and its resistance to weed invasion. Therefore it is important to match forage production and animal consumption (forage budgeting). Forage budgeting tools such as the Stocktake package in Queensland (www2.dpi.qld.gov.au/stocktake) can be useful.

4. Remain vigilant: Keep a look out for invading weeds and quickly control before they become established.

2 Project Objectives

1. Develop practical paddock and property scale weedy Sporobolus grass control strategies for extensive grazing land

2. Propagate successful management strategies to key stakeholders, land managers and advisers

3. Develop and incorporate economic analysis into recommended management strategies for weedy Sporobolus grasses.

3 Methodology, results and discussion

3.1 Methodology overview

The project was a collaboration between NSW DPI in the Grafton region and QLD DPI&F in central Queensland. Two weedy Sporobolus grasses were the focus of the project, giant Parramatta grass in NSW and giant rats tail grass in central Queensland. Two advisory groups (NSW and QLD) decided on the focus and structure of work conducted in each region. In NSW a small grazing trial (South Park) was undertaken to assess impact of grazing management, livestock supplements, herbicide application and fertiliser application on maximising livestock productivity on pastures infested with giant Parramatta grass. In Queensland a different approach was taken where strategies were developed and trialled in large extensive grazing paddocks (core sites) with the advisory group landholders encouraged to assess their individual situation and trial strategies on their own properties (landholder sites) and report back to the group. Two key herbicide assessments were also undertaken in Queensland to assess aerial application of flupropanate herbicide and to assess a granular herbicide formulation.

To improve communication outside the advisory groups, the Giant rats tail grass best practice manual was modified and updated to incorporate all weedy Sporobolus grasses in Queensland and New South Wales. The “Weedy Sporobolus grasses best practice manual” is the key communication product from the project. The project team presented at field and information days and provided technical advice and support for regional NRM bodies to conduct targeted control projects. Weedy Sporobolus grass was also incorporated as the example weed into the central Queensland and coastal versions of the grazing land management (GLM) packages in Queensland. Economic analyses was also undertaken to assess weedy Sporobolus grass control options at the property-scale and a cost-benefit analysis on the research in Queensland.

3.2 Weedy Sporobolus Grass Best Practice Manual

The ‘Weedy Sporobolus Grass - best practice manual’ will be the key legacy of the project. This manual is a modification and update of the ‘Giant rats tail grass - best practice manual’ and incorporates giant Parramatta grass and other weedy Sporobolus grass species focussing on Queensland and northern New South Wales.

The format of the new manual has been redesigned (Figure 2). The manual contains a new planning section and includes a case study demonstrating the application of principles discussed in the manual.

The planning section has three key steps:
Step 1: Accurately identify where weedy Sporobolus grass is located on the property.
Step 2: Stop or minimize the spread of weed seed into clean country.
Step 3: Identify where the biggest long-term impact per dollar spent on weedy Sporobolus grass management can be achieved.

The case study is based on a hypothetical property and will assist producers to understand how best to plan and manage their weedy Sporobolus grass infestation across their whole property. The cases study demonstrates the application of:
1) Planning for eradication and control
2) Principles for good grazing and pasture management

A new section on the use of flupropanate herbicide has also been developed.

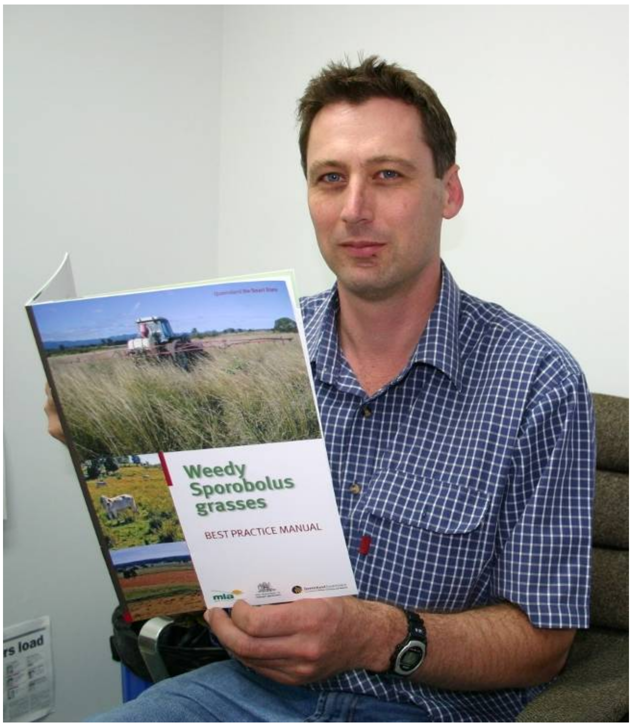


Figure 2 Weedy Sporobolus grasses best practice manual

The manual was launched by the Queensland Minister for Primary Industries and Fisheries, Tim Mulherin at the Nebo Agforce meeting in 2007. The manual has been distributed to all landholders who have been involved in the project and attended fields days or meetings. A copy of the manual and details on how to acquire more copies have been distributed to regional NRM bodies, local councils, biosecurity, key agribusinesses in Central Queensland and participants undertaking the more coastal versions of the Grazing Land Management program. The availability of the manual has also been advertised in newspapers and newsletters. Copies are available free of charge from DPI&F Business Information Centre on 13 25 23.

3.3 Management of extensive paddocks Queensland

Three core sites were established in central Queensland (Figure 3) on different land types, soils and climate. The three sites have in common a significant problem with weedy Sporobolus grass, with no easy solution for management and control.

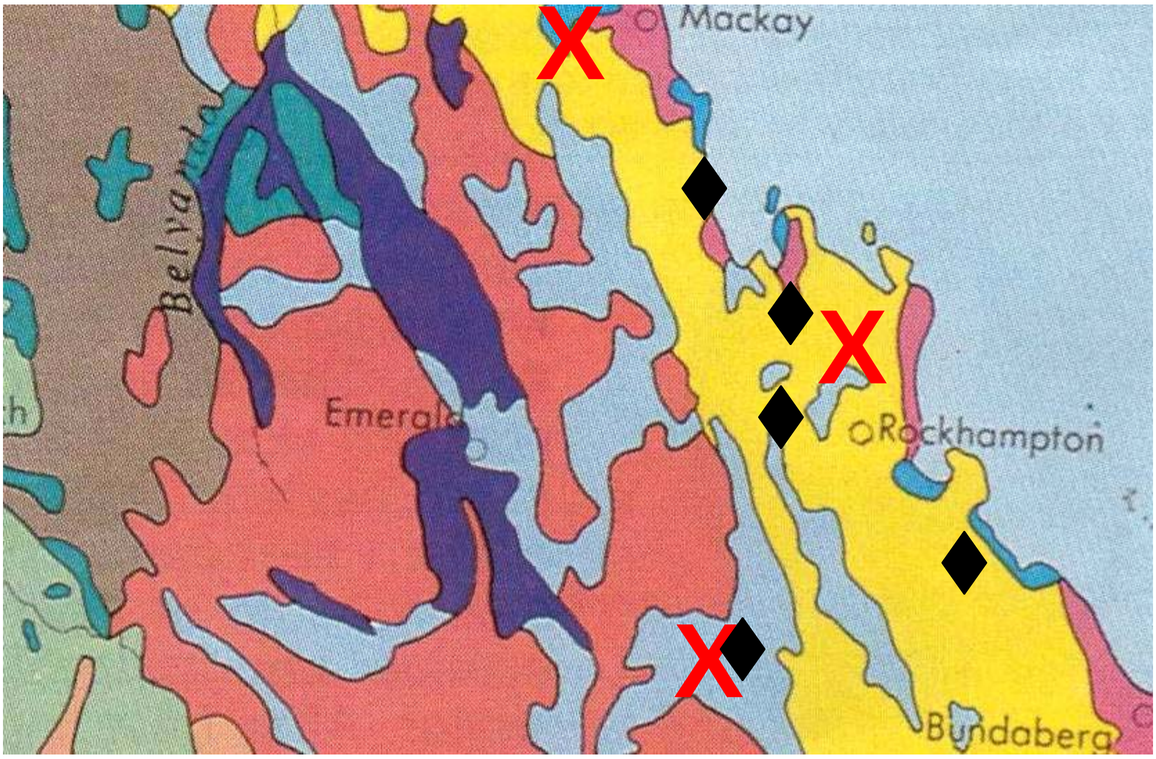


Figure 3 Site distribution in central Queensland for the Weedy Sporobolus Grasses project. Site locations are approximate only. A red cross is a core site, black diamonds are landholders sites. The background map is the Native Pasture Communities map (Weston and Harbison, 1980) Yellow – Black spear grass; Light blue – Brigalow pastures; Pink – Blady grass – coastal; Orange – Aristida/Bothriochloa

3.3.1 Moura site

The Moura site is located 2hr SW of Rockhampton. The site is a commercial cattle grazing property.
The initial weedy Sporobolus grass infestation appears to have developed along a power-line easement. The weed has spread to cover approximately 600ha of mostly arable land with adjacent infestations in forest (timbered) country and along gullies. The weedy Sporobolus grass has spread through the fence into the neighbours, particularly downstream along the gullies. The neighbours had been battling to eradicate the weed. Generally other pasture species were growing amongst the giant rats tail grass tussocks (mainly *Cenchrus ciliaris* - buffel grass, *Chloris gayana* - rhodes grass, *Bothriochloa bladhii* - forest bluegrass, *Heteropogon contortus* - black speargrass and *Arundinella nepalensis* - canegrass), even in the dense giant rats tail grass patches. Soil types range from heavy brigalow clay to sandy surfaced soils and lighter forest country. Our site was located in one paddock approximately 200 ha (Figure 4). Most of the paddock is reasonably arable (soil fairly erodable and would need to be reverted to pasture after a few years). The paddock was classified into three land zones:
1. 'brigalow' (cleared brigalow/blackbutt country planted to buffel grass)(Figure 5),
2. 'gully' (complex of gullies) (Figure 6), and
3. 'tree' (clumps of eucalypt forest and patches of trees in the gully) (Figure 6).

Outside the trial paddock was treated as a 'control' with no treatment applied.

The aim at this site was to control the weedy Sporobolus grass addressing all land types within the paddock.

Figure 4 Aerial photo of the Moura site. The white line mark the paddock fence. The blue dashed line on the western end of the paddock is where the aerial application trial was conducted.

Figure 5 Photos of the land type zone designated as 'brigalow'.

Figure 6 Photo of the land type zone designated as 'gully' (left) and 'trees' (right).

A plan was developed consisting of:
1. Planting the majority of the eastern end of the paddock to oats (forage crop) over 3 seasons and successive cultivations before sowing back to pasture.
2. Trialling aerial application of flupropanate herbicide on the forest area, complex gully area and associated open country on the western end of the paddock (left side of paddock-Figure 4).

Why chose aerial application of herbicide? Often the extensive paddocks are characterised by rough, uneven terrain and contain trees and shrubs. The size of the paddocks mean that spot spraying at the paddock-scale is not effective and expensive, while boom spraying is difficult due to the uneven terrain and having to operate within and around trees. Ground application in these circumstances generally leads to uneven herbicide distribution with some areas being overlapped (receive double the herbicide reducing selectivity) while other patches are missed.

Our work concentrated on the western end of the paddock. The landholder managed the rest of the paddock. Due to dry weather conditions, 2006 was the first season that oats was planted across the majority of the paddock.

Aerial application of flupropanate herbicide
The aim of this experiment was to test the efficacy of aerial applied flupropanate herbicide in the control of giant rats tail grass in the three land type zones.

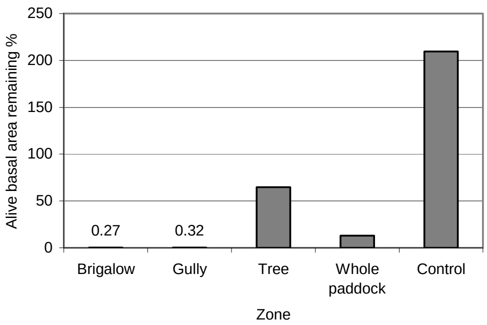
’Rats tail grasses’ are not listed on the flupropanate herbicide label for aerial application in Queensland. A research permit was acquired from the APVMA (NRA Permit Number PER6047). Aerial herbicide application can alleviate access problems and improve herbicide distribution efficiency in extensive pastoral areas. One difficulty with aerial application in uneven, timbered paddocks is that the aircraft are forced to fly at higher altitudes compared to spraying a cropping paddock. Higher aircraft altitudes cause a significant problem as there is greater opportunity for the spray droplets to evaporate before reaching the ground, potentially resulting in drift and unevenness of application. A second issue in timbered paddocks is that the herbicide can be captured on tree canopies preventing the herbicide from evenly reaching the target. Spraycheck Pty Ltd was contracted to test and recommend an aircraft setup for these conditions. To alleviate these problems it is recommended that high water volumes (50L/ha is regarded as optimum) and large droplet sizes are used. However, the high water volumes reduce the cost effectiveness of aerial application and therefore landholders need to be confident they will achieve a good result.

Experimental design and sampling
Four sampling sites were randomly selected using a geographical information system in each of the three land type zones (brigalow, gully, trees) and four sampling sites were located outside the target paddock (control – no treatment). At each sampling location two steel pickets were installed at either end of a 5 m transect (running south to north) ensuring that giant rats tail plants were present along the transect. Plants of giant rats tail grass and other species were located along the transect (distance along transect, right or left of transect and distance out). The basal diameter of located plants was measured in one direction. Plant basal area was calculated using the basal diameter and assuming a circle. The ‘brigalow’ zone had 155 weedy Sporobolus grass plants assessed, ‘gully’ zone 77 weedy Sporobolus grass plants assessed, ‘tree’ zone 48 weedy Sporobolus grass plants assessed and ‘control’ 152 weedy Sporobolus grass plants assessed. Approximately 560 plants of other species were also monitored. The initial sampling was in September 2003 prior to herbicide application in March 2004. Final sampling was conducted in July 2005, 16 months after herbicide application.

Two litres per hectare of flupropanate (Taskforce) herbicide (1490 g active per ha) were applied by aerial application to 80 ha at the western end of the infested paddock. The herbicide was applied with a total application volume of 50 L/ha, using narrow swaths widths (14m) and JARBA FF 4020 nozzles which produce ~300 VMD droplets.

The flupropanate herbicide was applied to 80ha on the 11 March 2004. Direct costs were $67/ha for the herbicide and $20/ha application costs (total $87/ha).

Experimental results and discussion
Ninety-three percent of giant rats tail grass plants died after an aerial application of flupropanate herbicide (
Figure 7a; Table 1; Figure 8), while only 11% of giant rats tail grass plants died when no treatment was applied. As expected, plant death in the tree zone was slightly lower (83%) than in the open ‘brigalow’ (92%) and ‘gully’ (99%) land type zones. One transect in the ‘tree’ zone appeared unaffected by the herbicide application indicating it was missed or shadowed from the herbicide application. The missed transect contained a four large plants (11.5 to 21 cm basal diameter) which had grown substantially during the trial resulting in a high alive basal area remaining (65%) at the final sampling (
Figure 7b). This response was similar to the ‘control’ zone where the live basal area of giant rats tail grass doubled without herbicide application. Little live basal area remained in the ‘brigalow’ and ‘gully’ land type zones.

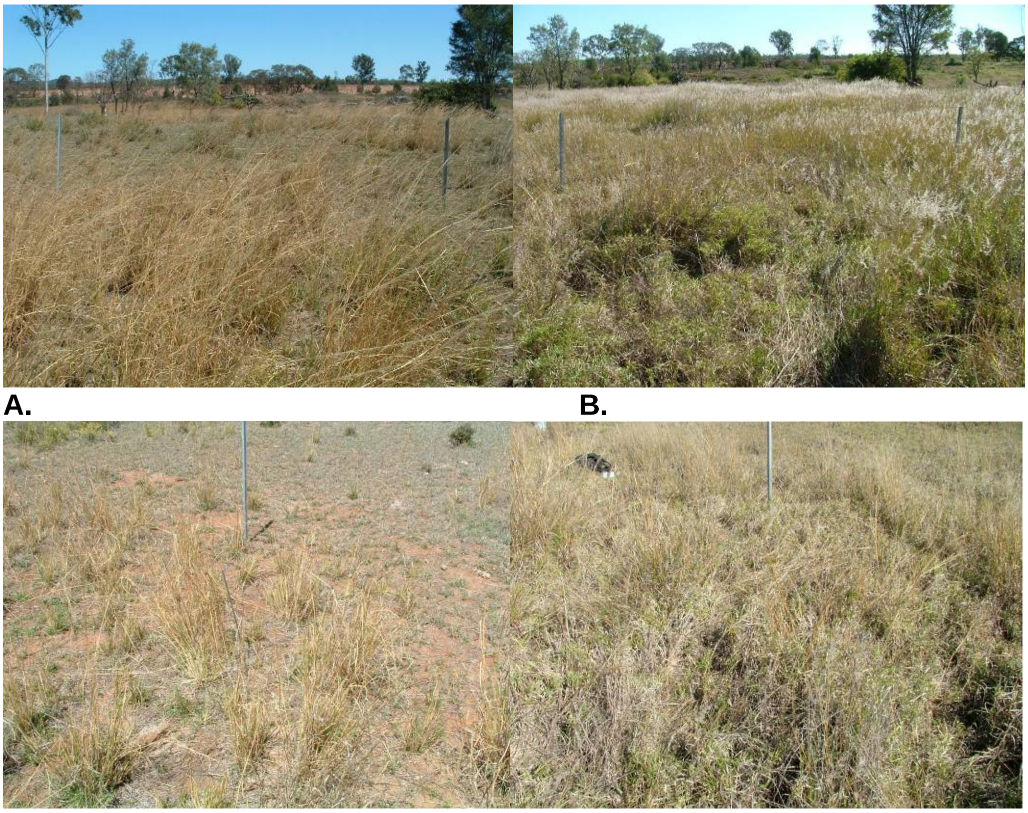


A. **B.**

Figure 7 Impact of an aerial application of flupropanate herbicide on A) plant death and B) live basal area remaining for giant rats tail grass.

Error! Reference source not found. presents the results of plant death for a number of different pasture species present in the pasture. Most pasture species other than giant rats tail grass (*Sporobolus pyramidalis*) demonstrated no substantial impact from the application of flupropanate herbicide. The pasture species designated as impact uncertain (eg. *Eriochloa spp.*) were generally short-lived perennial species and had low numbers of plants assessed in the control area.

Although not sampled, visual assessment indicated that the only areas where giant rats tail grass plants appeared to obviously survive was within the gully channel or on the margins of ‘melon-holes’, where the root systems of the giant rats tail grass plants would have been inundated for short periods following rainfall events. These plants would require follow-up treatment.



A. B.

A. B.

Figure 8 Two photo pairs showing the impact of flupropanate application. Photo A was taken prior to herbicide application in March 2004, Photo B was taken in July 2005, 16 months later. The giant rats rat grass has been killed and the buffel grass has recovered. Note the 'white' flowering grass (red natal grass). This grass is generally regarded as a pioneer grass indicating there are 'ecological gaps' in the pasture. Hopefully the buffel grass will be able to increase in competitiveness to fill these gaps and prevent GRT seedling establishment from the soil seed bank

Table 1 Plant death for a number of pasture species following an aerial application of flupropanate herbicide relative to the control (no treatment). An assessment of the impact of herbicide application is based on expected plant traits and number of plants assessed.

Species	Number of plants assessed in sprayed area	Plant death in sprayed area %	Number of plants assessed in control area	Plant death in control area %	Impact of herbicide and cautionary notes
Aristida ramosa	18	11	7	0	No impact
Arundinella nepalensis	37	11	11	0	No impact
Bothriochloa bladii	26	19	8	13	No Impact
Bothriochloa dicipiens	20	10	24	13	No impact
Cenchrus ciliaris	96	5	33	6	No Impact
Chloris divaricata	3	0	3	0	No impact, low plant numbers
Chloris gayana	29	14	-	-	No impact
Dicanthium sericeum	8	25	1	0	No impact, low plant numbers
Eragrostis spp.	4	25	2	50	No impact, low plant numbers
Eriochloa spp.	13	69	-	-	Impact uncertain, short lived species, no plants measured in control

Heteropogon contortus	55	11	18	11	No impact
Lomandra spp.	6	0	-	-	No impact, low plant numbers
Melinis repens	5	40	-	-	No impact expected, low plant numbers, short lived species, no plants measured in control
Panicum maximum	49	20	-	-	No impact expected, no plants measured in control
Sida spp.	18	61	8	88	No impact, short lived forb species
Sporobolus pyramidalis	280	93	152	11	Substantial impact
Sporobolus elongatus or S. creber	6	33	3	100	Impact uncertain, low plant numbers
Themeda triandra	10	60	4	0	Impact uncertain, low plant numbers, can be short-lived species
Urochloa spp.	20	40	-	-	No impact expected, short-lived species, no plants measured in control

Summary

This experiment successfully demonstrated the efficacy of an aerial application of flupropanate herbicide for the control of giant rats tail grass in extensive pasture situations. Giant rats tail grass plant death was reduced in heavily timbered areas compared to more open areas, however plant death was still high (83%). Technology that may increase the efficacy of flupropanate herbicide in timbered areas should be evaluated (eg. granular formulations of flupropanate herbicide).

3.3.2 Rossmoya site

The Rossmoya site is located 40 minutes NNE of Rockhampton. Weedy Sporobolus grass was introduced to this property by the previous property owners via contaminated grass seed. The seed was aerially sown onto steep, low productivity country prone to woody regrowth problems. Weedy Sporobolus grass has become widely established and is spreading across the property, down the waterways and across the flood plain country. Soil type is a coastal white loam on the flats and toe slopes, leading up to an infertile stony soil on the ridges (Figure 10). A wallaby and cattle proof fence has been erected along top of a ridge to limit seed transport into “clean” rough country further back (bottom left of Figure 9). Wallabies appear to be a major problem in this area. Country that could be ploughed (marginal cultivation country) has been sown to forage sorghum for 5 years and sown to rhodes grass. Weedy Sporobolus grass has not been controlled in the steep, rough, regrowth country. This country has low productivity and low commercial value, but weedy Sporobolus grass seeds have potential to move down the slope re-infesting the cultivated areas (contour banks have been constructed along top of cultivation to limit water transport). As part of a property-scale weedy Sporobolus grass control strategy, weedy Sporobolus grass control in the steep regrowth country is crucial, not because of lost production, but because of the continual and inevitable threat of weedy Sporobolus grass seed re-infesting the cleaned (cultivated) country.

Figure 9 Aerial photo of the Rossmoya core site. Giant rats tail grass had established throughout the paddock area enclosed in white and was spreading to the top right and top left outside the paddock. The bottom left corner is relatively free of giant rats tail grass and a wallaby proof fence has been erected along the majority of the ridge line marked by the white paddock border.

The aim at this property was to control weedy Sporobolus grass on a sub-catchment scale (paddock scale), addressing all land types within the catchment. A plan was developed consisting of:
a) Aerially spray hills and regrowth areas with flupropanate
b) Replant the cultivation area to pasture as part of the owners ongoing control strategy
c) Aerially spray gullies with flupropanate
d) Continue wallaby proof fencing to limit spread of infestation
e) Before apply broadacre aerial flupropanate conduct a simple flupropanate rate trials to assess the impact on native grasses in the steep stony hills.

Figure 10 Rossmoya core site. Landscape photos demonstrating the lie of the land. Weedy Sporobolus grasses are scattered throughout the steep hills covered in tree suckers.

The landholder planted the cultivation to rhodes grass following five years of forage cropping. The project conducted a simple herbicide rate trial to ensure that an application of flupropanate herbicide would not kill the native grasses in the poor stint hills. An important part of the flupropanate herbicide strategy is that competitive pasture species tolerant of flupropanate herbicide must be present to replace the dead weedy Sporobolus grass and obtain effective long term control. The reason we conducted this trial was because all the native grass species had been killed during a previous control attempt along a track using handgun application. It was suspected that the handgun application may have applied too much herbicide resulting in death of most grass species.

However, results from the herbicide rate trial Figure 11 showed that most of the grass species growing in this location were sensitive to the standard rate of the herbicide. The planned aerial application of flupropanate was abandoned due to environmental concerns (eg. soil erosion with removal of grasses) and that a major aspect of successful control (presence of a good competitive pasture) would not be met. The only option left was to establish flupropanate tolerant grasses across this area. As discussed in earlier this country is poor quality and not profitable, which has major implications for spending large amounts of money on control. However if this area is not controlled it will continue to infest the better quality country below.

To address these serious limitations, we worked with the landholder and the regional natural resource management group to acquire funding to mediate the cost of pasture seed and stick raking. The hills were stick raked and sown with pasture seed (Spring 2005)(Figure 12) and later aerially sprayed with flupropanate herbicide. The herbicide application appeared to "set-back" the sown grasses possibly due to the poor seasons impeding pasture establishment, however the sown pasture appears to have subsequently recovered.

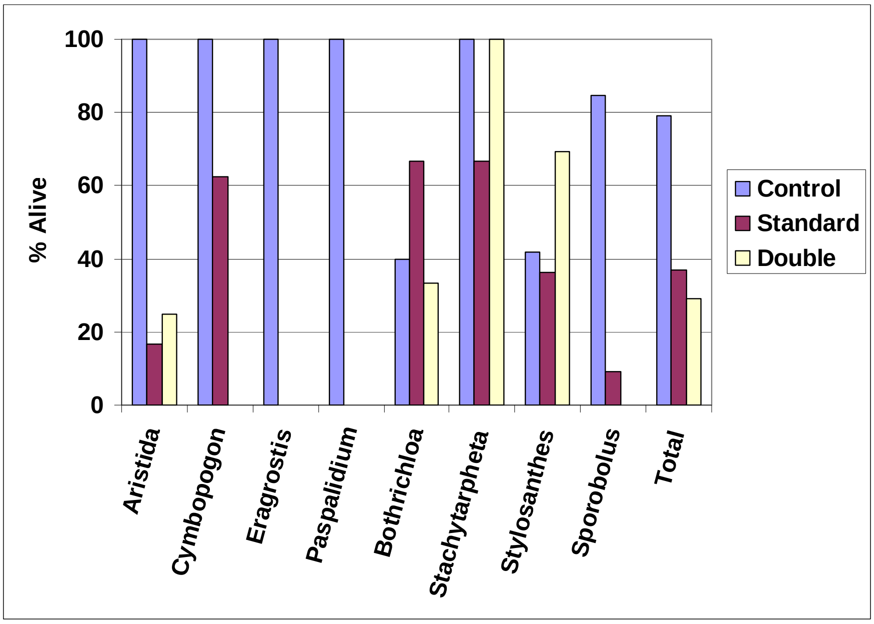


Figure 11 Results of a simple herbicide rate trial in the hill land type at Rossmoya. Stachytarpheta is blue snake weed, Stylosanthes is stylo, Sporobolus is giant rats tail grass, the rest are native grasses. Most grasses were killed or severely knocked back by the standard rate (2L/ha) of flupropanate herbicide on this land type. Control = no herbicide applied, Double = 4L/ha.

Having to sow pasture severely increased the cost of control in this low economic potential land type. However if control is not achieved in this area, it will continue to be a source of infestation for the better country further down the catchment.

A. **B.**

Figure 12 Photo A shows the establishing rhodes grass pasture on the footslopes as the final stage of the fodder crop and pasture replant control option. Photo B shows the stickraking in the hills prior to pasture seed sowing.

The landholders control strategy of forage cropping and sowing to rhodes grass on the better country (Figure 12) appears to have achieved good success at reducing the soil seed bank. Only 1 seedling has emerged from soil samples collected in the forage crop area, while hundreds of seedlings have emerged from soil samples in the uncultivated area.

3.3.3 Pioneer Valley - Mackay

The Pioneer Valley - Mackay site was located 30 minutes west of Mackay. The property is largely undulating hills containing sown pastures with areas of native pasture and patches of trees, scrub and lantana. Six monitoring sites were established in two paddocks in July 2005 (154 giant rats tail plants were monitored) to assess the impact of the herbicide application by individually identifying and measuring the diameter of plants between two steel pickets. Two sites were situated in tree clumps. Flupropanate herbicide was aerially (helicopter) applied at 2L/ha in November 2005. Conditions were generally dry after application. The final assessment was in November 2006, twelve months after the herbicide application (Figure 13).

The flupropanate herbicide application resulted in the death of 84% of the weedy Sporobolus grass plants and a 92.1% reduction in live basal area across all monitoring sites. Plant death at individual monitoring sites ranged from 100% kill to 64% kill. There was no clear reason for the reduced plant death where only 64% were killed, except that possibly the nearby lantana clump may have captured the herbicide. The weedy Sporobolus grass kill in the tree clumps was good (91 and 100% kill). The weedy Sporobolus grass plants that survived were generally observed to have greatly reduced basal area indicating they had been impacted by the herbicide.

Before **After**

Figure 13 Before and after flupropanate application at one monitoring site at the Pioneer Valley - Mackay site. 79% kill and a 97% reduction in live basal area of weedy Sporobolus grass in an open area. A tape is stretched between the two pegs and individual plants are identified in a belt transect along the tape. This technique allows accurate relocation of plants to assess their survival following herbicide treatment**.**

Aerial flupropanate application at Mackay resulted in a good kill and reduction of live basal area of weedy Sporobolus grass plants. However some plants survived and a significant soil seed bank will still be present, therefore careful pasture management will be required to minimise re-establishment of weedy Sporobolus grass and a follow-up herbicide application will be required.

3.4 Landholder managed satellite sites - Queensland

All the landholders involved in the Queensland part of the project were encouraged to assess their situation and undertake a control/management strategy and report back to the project advisory group. A brief report of the experience of two of the land managers is provided below.

3.4.1 Raglan – Situation 1

American rats tail grass was established throughout the occasionally flooded pasture with a bluegum over-storey and wattle mid-storey (Figure 14). There were difficulties locating and accessing the American rats tail grass plants for control, which was complicated by the dense wattles mid-storey. This ecosystem including the wattles is classified as endangered under the current vegetation legislation and therefore could not be cleared.

Site management history:

- Up until December 2002 occasional spot spray with glyphosate. Permission had been sort to clear wattles (leaving the bluegums) but permission was refused.
- February 2003 major flood (underwater for 4 days) which appeared to kill much of the grass. The grass slowly came back with lots of American rats tail grass present.
- August 2003 obtained permission to put some tracks through the wattles from which to work from to target the American rats tail grass.
- Summer 2003/04 sprayed heavily with handgun using glyphosate
- March 2004 spot sprayed on foot with glyphosate.

- September 2004. American rats tail grass still present but density greatly reduced. Other grass species have come back after spraying in Summer 2003/04. Wattles are still increasing.
- Future plans. Continued regular spot spraying to keep the American rats tail grass at a low level.

Figure 14 American rats tail grass under bluegums December 2002 (left) and September 2004 (right).

3.4.2 Raglan - Situation 2

American rats tail grass was scattered throughout an ironbark woodland with predominately native pasture. The American rats tail grass came in with the powerline (Figure 15). There were difficulties with this site locating and accessing the American rats tail grass plants across a wide area. Complicated by trees. Pasture mostly poor native grasses. The electricity company was eventually convinced to accept some responsibility for the problem.

Site management history:

- Summer 2001/02, dense patches of American rats tail grass were sprayed heavily with glyphosate.
- ~April 2002 boom sprayed with flupropanate. Figure 15 taken December 2002 showing dying tussocks.
- February 2004 boom sprayed with flupropanate. The paddock was later ripped and sown with pasture grass seeds (rhodes, buffel and bisset). Sown from a homemade roller drum mounted on the rippers.
- September 2004 American rats tail grass greatly reduced.
- Future plans, continue monitoring and control of re-infestations. Maintain relationships with and accountability of the electricity company.

Figure 15 American rats tail grass under powerline in December 2002 (left) and September 2004 (right). The tussocks in December 2002 had been boom sprayed with flupropanate in February 2002.

3.4.3 Clairview

Debil-Debil country infested with scattered weedy Sporobolus grass plants at Clairview, central Queensland. Debil-debil country is characterised by mounds or lumps across the paddock which makes machinery operations difficult (Figure 16). Parallel strips were ploughed across the paddock to create smooth tracks from which a spot spray vehicle can operate. The property has since been sold and become a eucalyptus plantation. The selling of properties with a weedy Sporobolus grass problem appears common in central Queensland. Unfortunately although probably a wise (economic) decision on the part of the landholder, it does not address the weedy Sporobolus grass issue from a regional perspective. See the economic assessment section for more discussion on the economic issues associated with managing weedy Sporobolus grass infestations from a landholder and community perspective.

A. **B.**

Figure 16 Debil-Debil country (A) infested with scattered weedy Sporobolus grass plants at Clairview, central Queensland. Debil-debil country is characterised by mounds or lumps across the paddock which make traversing with machinery difficult. Strips were ploughed across the paddock to create smooth tracks from which to operate a spot spray vehicle. The property has since been sold and tree plantations established (B).

3.5 Economic analysis of control options

3.5.1 Overview

Various management interventions are available to manage and/or control weedy Sporobolus grass infestations depending on land type and infestation density. These management interventions manipulate the level of weedy Sporobolus grass in a pasture and therefore change the productive pasture potential. However, the costs of these interventions are generally high, relative to the return from livestock. Therefore we need to decipher what is economically possible for the landholder and whether 'external support' may be required to enable appropriate weedy Sporobolus grass management. External support may be relevant not only to the landholder with the weedy Sporobolus grass infested property but also for others outside the infested property (eg. neighbours downstream) at risk of being infested.

Using a hypothetical case study property, fifty year scenarios were developed for alternative future paths (options) starting from the same initial situation (eg. level of infestation).

A livestock carrying capacity calculator (a modified version of Stocktake) was utilised to estimate the annual number of livestock that can be carried at four defined weed infestation levels (paddock-scale). The annual cost of weed management treatments was subtracted from the annual gross margin for the grazing enterprise (property-scale). Differences in land value (based on carrying capacity) at the end of the scenario were also considered. At the end of 50 years, the Net Present Value (NPV), Annualised Return, Internal Rate of Return (IRR), payback period, annual cash flow and cumulative cash flow were calculated for option 2 relative to option 1 in the scenario. This process allows comparison of weed management options, but also highlights that control which may be highly worthwhile for the neighbours, but may not be financially feasible for the landholder with the infestation. Results indicate that at current prices many control options are probably outside the financial capability of many landholders, particularly on poor quality country.

A paper was presented at a Resource Economics Workshop in Rockhampton, 28 Oct 2005 and a paper has been submitted to The Rangeland Journal.

3.5.2 Our approach

A hypothetical case study property was generated (eg. Figure 17 **Map of hypothetical case study property 'Brig Plains'. The stylised green plants represent weedy Sporobolus grass infestation.**Figure 17) where weedy Sporobolus grasses are currently or potentially a major issue. The property was designed to be a 'typical' commercial cattle property in size, land types, paddock number and livestock carrying capacity for the region.

Our hypothetical property 'Brig Plains' was generated for the central Queensland brigalow-belt. The property is 5390 ha and has a livestock carrying capacity of 1800 adult equivalents (AE) when in good condition. The property is divided into eight paddocks and two land types. Seven paddocks are brigalow-blackbutt country (range in size from 550 to 850ha with a smaller paddock of 90ha -Table 2), and one large paddock (1200ha) of ironbark forest country. The enterprise breeds weaners, which are grown through to bullocks. One paddock is densely infested with weedy Sporobolus grasses (Rats paddock - Figure 17), one paddock (Tails) has weed clumps and scattered plants, two paddocks (Giants and House) have widely scattered weed plants. The other paddocks are not infested.

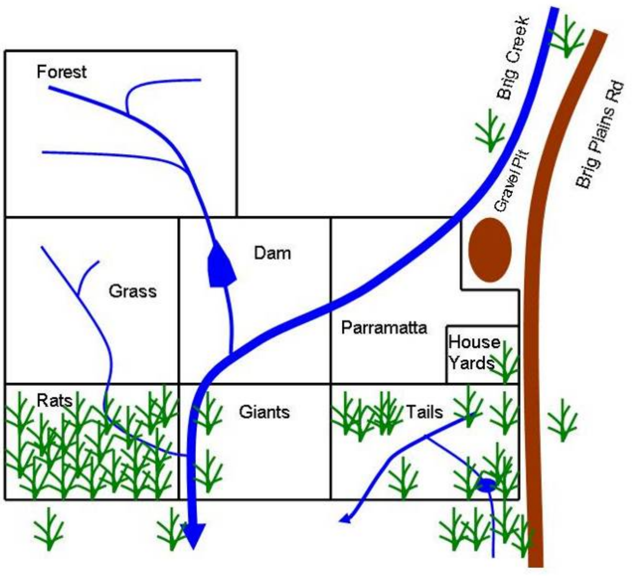


Figure 17 Map of hypothetical case study property 'Brig Plains'. The stylised green plants represent weedy Sporobolus grass infestation.

To assess the economic consequences of various weed management options, we developed scenarios that compared two different future paths (options). For example in Scenario 1, we compare the expected change over the next 50 years with no weed management, relative to an alternative 'future', in this case, the broadacre herbicide control strategy. Both options within a scenario start with the same initial (Year 0) situation (eg. level of infestation) and the different management options begin the following year (Year 1). Parameters used in the analysis are listed in Table 2.

The Stocktake livestock carrying capacity calculator, was used to calculate the number of livestock (adult equivalents - AEs) that can be carried at various levels of weedy Sporobolus grass infestation in each paddock. The calculator discounted livestock carrying capacity based on four infestation conditions (Clean, Scattered, Clump or Dense; **Error! Reference source not found.**). Property livestock carrying capacity was modified during fifty-year scenarios depending on the expected change in weedy Sporobolus grass infestation density in each paddock, based on pre-determined rules and assumptions (eg. **Error! Reference source not found.**; **Error! Reference source not found.**). These rules were formulated based on research data and expert opinion for each weed management option.

Table 2 Parameter values used in the analyses

Parameter	Unit values
Gross margin per adult equivalent AE	\$205
Capital value of one adult equivalent AE	\$600
Interest rate for discounting	6%
Land value/adult equivalent AE	\$1500
Broadacre herbicide application cost	\$85/ha
Containment costs for infested properties. Spot spray (limited by landholder time), quarantine (cattle) and containment costs (washdown facilities, buffer strips, vehicle track control etc.).	\$10,000 per year
Containment costs for clean properties. Quarantine (cattle), property inspection (riparian areas, fencelines), washdown facilities.	\$10,000 in year 1 and thereafter \$5,000 per year
Property size total	5390 ha
Tails paddock	650 ha
Grass paddock	850 ha
Parramatta paddock	700 ha
Dam paddock	750 ha
Forest paddock	1200 ha
House paddock	90 ha
Giants paddock	550 ha
Rats paddock	600 ha

The gross margin (GM) per adult equivalent (AE) was estimated for the case study region using Breedcow/Dynama software (Holmes, 2005). The GM per AE will vary depending on the type of country, animal growth rate, branding rate, type of animals, husbandry costs and sale prices. As mentioned above, livestock carrying capacity will change with the level of weedy Sporobolus grass infestation, however individual animal growth rates may also be affected (NRM 2001). We have based our analyses on changes in livestock carrying capacity with changes in weed infestation. We did not modify the GM per AE based on the density of an infestation.

Table 3 Infestation condition description based on the density of weedy Sporobolus grass infestation and the discount relative to the potential livestock carrying capacity when not infested.

Condition class	Description	Proportion of potential carrying capacity
Clean	No weedy Sporobolus grass present. Viable weed seed needs to enter the pasture followed by germination and weed establishment before progression to Scattered condition. To transfer from Scattered to Clean condition, all weed plants and soil seed bank have to be eliminated.	1
Scattered	Initial invasion, scattered weedy Sporobolus grass plants, little impact on carrying capacity, but inevitable increase to Clump condition without management intervention. Potential for spot-spray control.	0.95
Clump	Weedy Sporobolus grass clumps and plants across the paddock. Moderate impact on carrying capacity and inevitable increase to Dense condition without management intervention.	0.8
Dense	Dense weedy Sporobolus grass across the paddock. Substantial impact on carrying capacity. Major management intervention required to reduce density.	0.4

Table 4 Rules and assumptions for change in weedy Sporobolus grass density when applying the broadacre herbicide control strategy (Scenario 1).

Rule or assumption	Details
Pasture condition	Assume good pasture species are across the infested paddocks which can replace killed weedy Sporobolus grasses.
Carrying capacity in year of herbicide application	In the year of broadacre herbicide application, livestock carrying capacity is 50% of previous year due to the herbicide withholding period and to enable pasture recovery.
Carrying capacity in year following herbicide application	In the year following broadacre application livestock carrying capacity is 80% of Scattered condition to enable pasture recovery.
Livestock destocking rules when applying broadacre herbicide	Clean condition paddocks are able to carry up to 10% higher stock numbers for two years in ten years, enabling the destocking of sprayed paddocks to be mitigated. Excess livestock are sold.
Broadacre herbicide control of Clump condition paddocks	Two herbicide applications are applied two years apart. Clump condition paddocks become Scattered condition in the second year following the herbicide applications and can progress to Clean condition with spot-spraying over the following 10 years.
Broadacre herbicide control of Dense condition paddocks	Two herbicide applications are applied two years apart, followed by a third application ten years later (Year 14) to control widely scattered plants not controlled with spot-spraying (important in extensive paddocks). Dense condition paddocks (substantial soil seed bank) become equivalent to Scattered condition in the second year following the first two herbicide applications and require spot-spraying to maintain Scattered condition. Following the third herbicide application the paddock can progress to Clean condition over the next 10 years with spot-spraying. Dense condition paddocks can not progress to Clean condition during the 20 year scenario.

An Excel spreadsheet was used to conduct a discounted cash flow analysis. Annual gross margin was estimated for the grazing enterprise by multiplying the number of AEs by the GM per AE, then subtracting the weed management costs. The difference in land and livestock value was incorporated at the end of the scenario. Land value was based on property livestock carrying capacity. Net Present Value (NPV), Annualised Return, Internal Rate of Return (IRR), payback period, annual cash flow and cumulative cash flow were calculated for Option 2 relative to Option 1 covering 50 years of projected outcomes.

3.5.3 The analysis

We analysed three scenarios. Two scenarios compare two different weed management options against the same ‘no weed management’ option based on the infested case study property described above (Figure 17). The third scenario uses the same case study property but assumes it is **not** initially infested and compares the option of applying strategies that prevent weed invasion, against the option of no weed management resulting in infestation of the property.

Scenario 1 Broadacre herbicide control strategy verus no weed management
The option of applying the broadacre herbicide control strategy and containment strategies was compared to the option of conducting no weed management.

In the broadacre herbicide control strategy option, both Rats and Tails paddocks are sprayed with a broadacre selective herbicide (flupropanate) in Year 1 and Year 3 substantially reducing annual cash flow (
Figure 18). Rats paddock has another broadacre application in Year 14. Giants and House paddocks are spot-sprayed as are Rats and Tails paddocks following the second broadacre herbicide application. Quarantine and weed seed movement containment measures are also established. The rules and assumptions for the option are detailed in

Table 5.

The no weed management option steadily increases in density of weedy Sporobolus grasses. The rules and assumptions for this option are detailed in Table 6.

The predicted NPV over 50 years for the broadacre herbicide control strategy for weedy Sporobolus grass relative to no weed management was $1.155m with an IRR of 16.0%, annualised return (profit) $73,270, payback period of 14 years and a peak deficit of $362,300 in year 5 (

Table 7; Figure 20).

If cattle purchases are excluded from the analysis, cattle being a "liquid" (near cash) asset, payback period would be 10 years and the peak deficit $228,700 in year 3.

This analysis does not include the benefits to neighbouring non-infested landholders from the removal of a weed seed source. Infested landholders may be deterred from this investment by the relatively large peak deficit or the relatively long payback period. There are however additional spillover benefits to non-infested landholders for which they do not currently pay. This infers a justification for non-infested landholders (or government acting on their behalf) to contribute to weed control costs on infested properties to protect productivity and land values of the so-far-uninfested areas.

Table 5 Rules and assumptions for change in weedy Sporobolus grass density with no weed management (Scenario 1 and 2).

Rule or assumption	Details
Manipulating infestation levels between Scattered, Clump and Dense condition.	Once a paddock is infested (eg. Scattered condition) it takes 10 years to drop down an infestation level eg. Scattered to Clump, or Clump to Dense. Adult equivalent numbers decline evenly over the 10 year period (eg. 5 AE reduction per year, to drop 50 AEs changing from Clump to Dense condition).
Infestation rule for Clean condition paddocks.	All Clean condition paddocks become infested over a 10 year period (ie. go from Clean to Scattered condition). The year in which a particular paddock becomes infested (Scattered condition) is spread evenly over the 10 year period (eg. 1 of the 4 uninfested paddocks becomes infested every 2-3 years).

Scenario 2 Containing spread on an infested property verus no weed management

The option of containing the spread of weedy Sporobolus grasses was compared to the option of conducting no weed management. This scenario utilises the same case study property as Scenario 1 (Figure 17). The no weed management option is the same as Scenario 1 (

Table 5).

Containment strategies (quarantine, vehicle washdown, buffer strips etc) cost $10,000 each year. In year 1, an additional $10,000 is required (total $20,000) to control the weedy Sporobolus grass in the riparian areas in the infested Rats and Tail paddocks and in the Scattered condition paddocks (Table 6).

The predicted NPV over 50 years for containing the spread of weedy Sporobolus grasses versus no weed management was $648,300 with an IRR of 19.7%, annualised return (profit) $46,900, payback period of 14 years (9 years with cattle excluded) and peak deficit of $84,600 in year 7 ($30,000 in year 4 with cattle excluded) (

Table 7; Figure 20).

This analysis does not include the benefits to neighbouring non-infested landholders from the containment of a weed seed source. One negative aspect of the containment of spread option is that although the infestation is reasonably contained, it is still a potential source of seed contamination for clean areas on the property and other properties (eg. downstream), particularly during major flood events, feral animal movement or if containment strategies are not maintained.

Table 6 Rules and assumptions for change in weedy Sporobolus grass density when containment strategies are applied (Scenario 2).

Rule or assumption	Details
Weed seed spread to clean paddocks can be contained.	Implementing a package of buffer strips, quarantine paddocks, wash down areas, vehicle and livestock movement controls and weed control in riparian areas will stop the spread of the weed to Clean paddocks.
Clump and Dense condition paddocks.	Clump condition paddocks will progress to Dense condition over 10 years and Dense condition paddocks will remain Dense condition. Weed control is conducted in riparian areas in Clump and Dense condition paddocks.
Scattered condition paddocks	Scattered condition paddocks can become Clean condition with concerted spot-spraying over 10 years.

Table 7 Economic indices for comparison of weedy Sporobolus grass management scenarios.

Economic indices	**Scenario 1** Broadacre herbicide control strategy versus no weed management	**Scenario 2** Containment strategy versus no weed management	**Scenario 3** Preventing invasion strategy for a clean property versus no weed management
NPV (annual cash flows)	$1,031,063	$648,252	$1,139,773
NPV (extra livestock at end of 50 years)	$35,374	$25,993	$35,407
NPV (extra carrying capacity at end of 50 years)	$88,436	$64,983	$88,517
Total NPV	$1,154,873	$739,229	$1,263,698
Annualised return	$73,270	$46,900	$80,174
IRR	15.95%	19.66%	31.18%
Payback period (years)	14	14	9
Peak deficit	$362,260 in year 5	$84,599 in year 7	$43,035 in year 5
Payback period excluding investment in extra cattle (years)	10	9	4
Peak deficit excluding investment in extra cattle	$228,653 in year 3	$30,044 in year 4	$7,335 in year 1

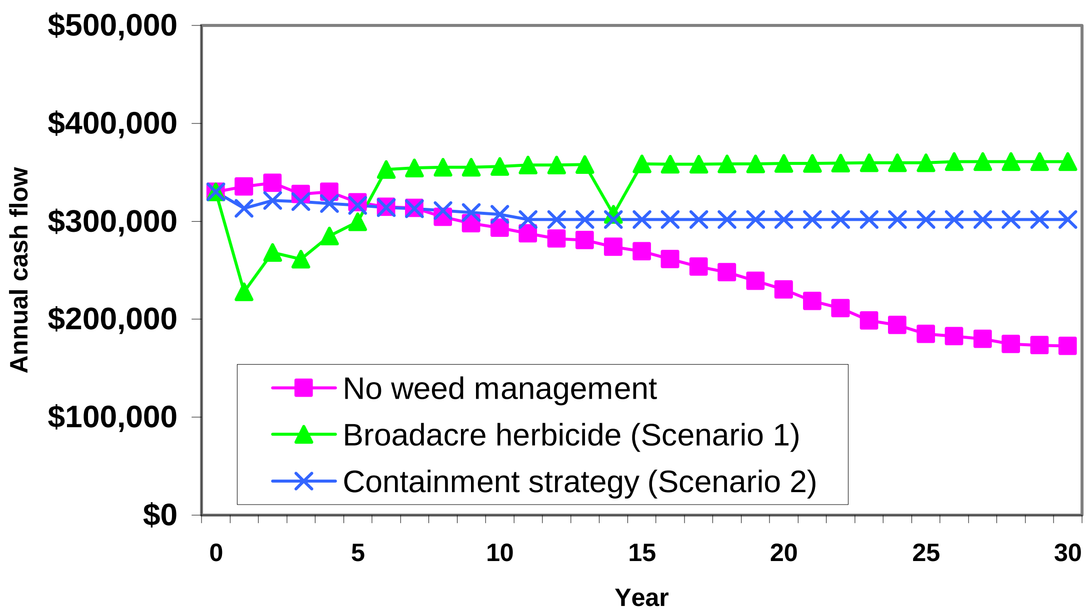


Figure 18 Annual cash flow for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management.

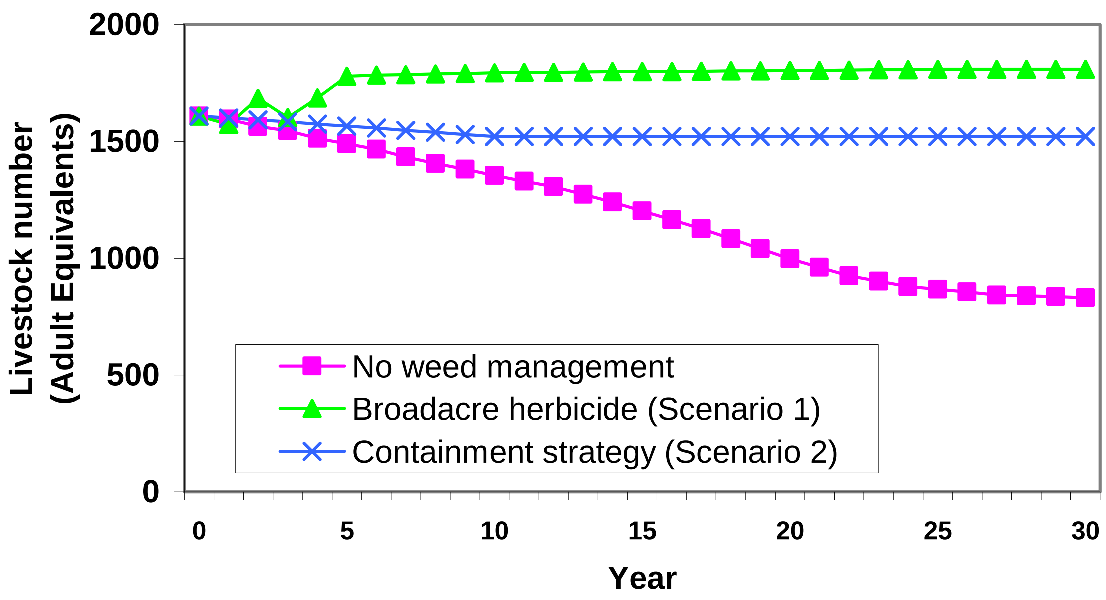


Figure 19 Comparison of livestock numbers (adult equivalents) over time for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management. Final land value was based on livestock numbers.

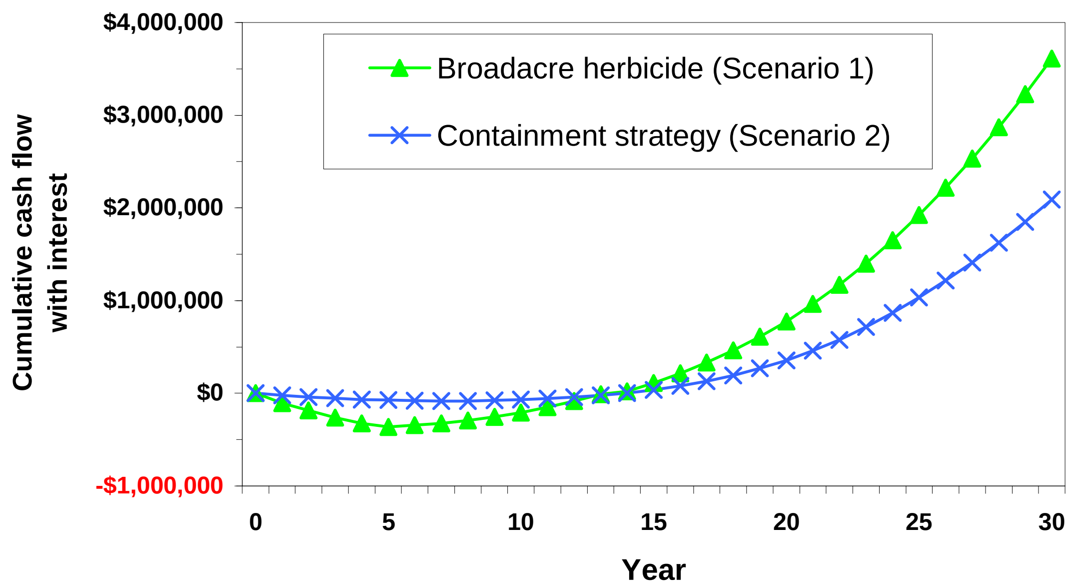


Figure 20 Cumulative cash flow with interest including sale or purchase of livestock for the broadacre herbicide control strategy (Scenario 1) and the containment strategy (Scenario 2) relative to no weed management.

Scenario 3 Preventing invasion of a clean property verus no weed management

The preventing invasion scenario assumes the case study property was initially **not** infested with weedy Sporobolus grass and therefore the case study property differs from the other two scenarios. However, infestations are nearby (eg. the neighbours, upstream, purchased cattle of unknown history) and therefore the property is likely to be infested. This scenario tests the option of investing in strategies to prevent weed invasion verus the option of no weed management. The prevention of weed invasion option maintains the paddocks in Clean condition throughout the scenario with a $10,000 cost in year 1 to establish strategies to prevent weed invasion (eg.

wash down areas, a quarantine paddock etc) with an annual cost of $5000 per year thereafter. The no weed management option follows the rules and assumptions in **Error! Reference source not found.**.

The predicted NPV over 50 years for prevention of invasion of weedy Sporobolus grasses was $1.264m with an IRR of 31.2%, annualised return $80,200 (profit), payback period of 9 years (4 years with cattle excluded) and peak deficit of $43,000 in year 5 ($7,300 in year 1 with cattle excluded) (

Table 7; Figure 21).

This option appears highly worthwhile for landholders who are currently not infested with weedy Sporobolus grass but are likely to become infested over time. This analysis prescribes some containment strategies in which to invest (eg. wash down facilities, livestock quarantine), however some of the investment may be better spent off-property controlling a potential seed source (eg. an infestation on a neighbours property upstream or a buffer strip inside the neighbours fence). The positive aspect of Scenario 3 is that invasion is prevented for a minor investment, relative to the substantial financial and productivity penalty of having to manage weedy Sporobolus grass infested pastures.

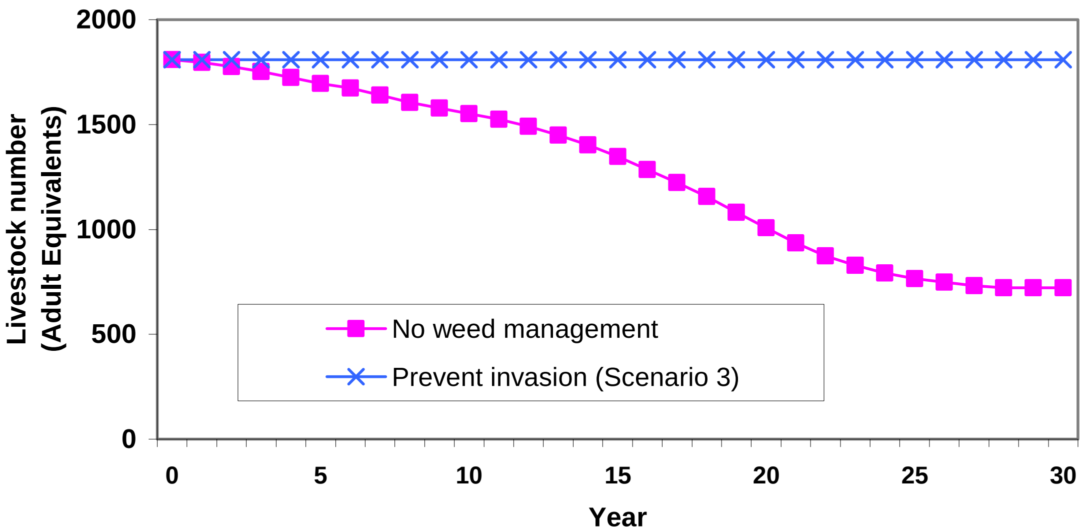


Figure 21 Comparison of livestock numbers (adult equivalents) over time for the prevention of invasion strategy (Scenario 3) relative to no weed management.

Implications for natural resource management bodies
Comparing the two infested scenarios (Scenario 1 and 2), the containment scenario (20% IRR, peak deficit $84,600, payback period 14 years) would be a more attractive investment to an infested landholder than the broadacre herbicide control strategy with a lower IRR (16%), much higher peak deficit ($362,000) but the same payback period (14 years). However, the broadacre herbicide control scenario would be a worthy case for subsidisation as it eliminates the seed source rather than suppressing the seed source with the ongoing risk of seed movement from the 'contained' infestations particularly during floods and uncontrolled feral and native animal movement. In order for the broadacre herbicide control scenario to achieve a comparable IRR to the containment scenario, the herbicide costs in the first three years would need to be subsidised by 40%, increasing the IRR to 20% and reducing the peak deficit to $246,500 (still worse than the containment scenario) and the payback period to 11 years.

Preventing invasion (Scenario 3) with an IRR of 31%, peak deficit of $43,000 and payback period of 9 years is clearly preferable to allowing an infestation to occur and then dealing with an established weed infestation. The preventing invasion option should be highly encouraged across regions, not only for weedy Sporobolus grass management but also for the management of other weeds.

The investment scenarios also have a benefit for neighbouring landholders, and indeed for the region as a whole through reduced potential for weed seed spread. Had the regional benefits been included in the analysis, the NPV and IRR would be higher, perhaps much higher, particularly where a property is a seed source 'hot-spot' (eg. at the head of a catchment). An indication of the regional benefits is provided by Scenario 3, where the most efficient investment to prevent invasion may have been to help control the weed in the neighbours riparian zone.

These analyses highlight the substantial financial cost of managing weedy Sporobolus grass infestations and suggests there is a case for a public financial contribution to infested landholders to "sweeten" the investment in control strategies on behalf of other landholders who will benefit from weedy Sporobolus grass management on the infested properties.

References

Holmes, W.E. 2005. Breedcow and Dynama Herd Budgeting Software Package, Version 5.04 for Windows 95, 98, Me, NT, 2000 and XP. Training Series QE99002, Queensland Department of Primary Industries and Fisheries, Townsville.

NRM 2001. Weedy Sporobolus Grasses Strategy 2001-2006. Natural Resources and Mines, Queensland.

3.6 Assessment of the cost benefit ratio of research in Queensland

An internal DPI&F cost-benefit analysis was conducted using conservative assumptions on the per hectare benefits and uptake of research. This analysis indicated the research and development activities in Queensland produced benefits that were significantly greater than the costs of the research (includes DPI&F and MLA investment).

Over the life of the Queensland part of the project funds invested in the project were:

- MLA $100,000 for operating costs
- DPI&F $485,000 for salaries, on-costs and corporate support and overheads.

The project developed weedy Sporobolus grass management strategies which provide effective solutions for extensive grazing properties, however economic analyses indicate that the cost of control will be a major impediment to effective management strategy adoption.

Demonstrating the cost of control has been a major factor in encouraging regional natural resource bodies to get involved and co-funded management strategies in key high priority locations.

Estimation of benefits

The project has the capacity to impact on the current area of infestation in northern Australia.
It also has a capacity to help limit the spread of weedy Sporobolus grasses into new areas of infestation. The project funding has made the research available for immediate adoption. It is estimated that the findings could benefit all of the producers currently infested or at significant risk of being infested. Benefits accrue through minimising the impact of a current infestation or through applying strategies that prevent weed invasion. The project has provided proven scenarios for use in developing funding applications by landholders for support from regional natural resource management bodies.

Implementation costs
Costs include broadacre herbicide for infested areas (up to $85 per hectare), containment costs (wash down facilities, buffer strips, cattle quarantine, spot spraying) and income foregone from reduction in carrying capacity during the treatment and restoration period.

Evaluation of benefits
Key data was extracted from the economic assessment of control options described earlier. The estimate of farm level benefits is derived from the calculating the net impact of applying management strategies at different levels to an integrated beef property that breeds and fattens beef cattle. Size of the property is 1800 adult equivalents.

Three scenarios for weed management were analysed by project staff. Two scenarios considered treatments for a property that was currently infested. The third scenario considers treatment for a property not currently infested but at significant risk of infestation.

All treatments or prevention scenarios were compared to a scenario where the weed infestation was allowed to progress without significant management.

Key assumptions in the Benefit Cost Analysis (BCA)
1. Total area of infestation in Queensland is 200,000 hectares. 40% of this area is densely infested, 40% is infested with clumps and 20% has a scattered infestation.
2. Annual benefit of treatment is assessed as $10 per hectare across all levels of infestation. The calculated range is between $7 and $12 per hectare per annum.
3. The current level of adoption in 2005-06 is 5% of the infested area.
4. The project impact is to increase adoption to 10% of the infested area over the next decade.
5. Adoption is limited by the risky nature of the management scenarios and is unlikely to increase above 10% at the current level of extension activities and community co-funding.
6. The benefits of applying containment strategies to currently clean areas close by infested areas are not calculated.

Results
The research and development activities produced benefits that are significantly greater than the costs of the research. At a discount rate of 5%, the project generates net benefits of more than $2.28 million with a Benefit Cost Ratio (BCR) of 5 to 1.

3.7 Contribution to GLM package in Queensland

The Grazing Land Management (GLM) package is a primary extension tool of MLA and DPI&F promoting sustainable and profitable grazing management. By working with the GLM team we contributed to the development of a weed management/control scenario based on giant rats tail grass as the main example weed in the Fitzroy, Burnett and Mackay/Whitsunday versions of the package.

3.8 Refinement and testing of herbicide application technology

3.8.1 Aircraft setup testing

Aerial application of herbicides is currently an effective and integral part of many agricultural systems. However most grazing paddocks contain uneven terrain and have some timber remaining, therefore the aircraft are forced to fly at higher altitudes compared to spraying a cropping paddock. Higher aircraft altitudes cause a significant problem as there is greater opportunity for the spray droplets to evaporate before reaching the ground, potentially resulting in drift and unevenness of application. A second issue in timbered paddocks is that the herbicide can be captured on tree canopies preventing the herbicide from evenly reaching the target. Spraycheck Pty Ltd was contracted to test a range of aircraft setups and advise on the most effective setup for our purposes. The aircraft testing occurred over an open and timbered area (Figure 22). Treatments assessed included water rates, droplet sizes and nozzle configuration.

Figure 22 Site where the aircraft testing occurred. The plane flew in transects between the open grassland and forested country.

To alleviate these problems associated with aerial application, it is recommended that high water volumes (50L/ha is regarded as optimum), large droplet sizes and narrow swath widths are used. However, the high water volumes and narrow swath widths reduce the cost effectiveness of aerial application but ensure more even coverage which is especially important with flupropanate herbicide as it is generally only selective at the recommended and ineffective if the rate is too low. The recommendations were applied at the Moura and Rossmoya sites.

The report suggested that a granular formulation of the herbicide may be more effective for aerial application. A granular formulation was subsequently trialled for efficacy.

3.8.2 Effectiveness of granular formulations of flupropanate herbicide in the control of weedy Sporobolus grasses

A liquid form of flupropanate herbicide is currently registered for the control of weedy Sporobolus grasses in Queensland. To control weedy Sporobolus grass in extensive grazing areas it is necessary to improve efficiency through aerial application of the herbicide. However most grazing paddocks contain uneven terrain and have some timber remaining, therefore the aircraft are forced to fly at higher altitudes compared to spraying a cropping paddock. Higher aircraft altitudes cause a significant problem as there is greater opportunity for the spray droplets to evaporate before reaching the ground, potentially resulting in drift and unevenness of application. A second issue in timbered paddocks is that the herbicide can be captured on tree canopies preventing the herbicide from evenly reaching the target. To alleviate these problems it is recommended that high water volumes (50L/ha is regarded as optimum) and large droplet sizes are used. The high water volumes reduce the cost effectiveness of aerial application.

Granular forms of herbicides can minimise the impact of higher aircraft heights. In addition, there can be significant cost savings with granular herbicides through not using high water volumes, therefore the aircraft can carry more herbicide and cover a greater area per load.

A granular version of flupropanate herbicide was manufactured by Granular Products Pty Ltd. Testing was required to assess the impact of the granulation process on the herbicide efficacy and the impact of a reduced number of granules/droplets per area.

A small-plot experiment was conducted to test the efficacy of the granular form of herbicide at different rates and formulations. Two comparisons were conducted. The first comparison was a herbicide rate trial using the expected 'best-bet' granule formulation (size and herbicide concentration). The second comparison tests for differences between granule formulations.

The trial was conducted under APVMA Permit No: TPM0001A by the Queensland Department of Primary Industries and Fisheries in consultation with Granular Products Pty Ltd.

The experimental site was located at Kunwarara approximately 70km north of Rockhampton in Central Queensland. The site had been fenced to exclude stock for a number of years. The plots were located on areas of dense giant rats tail grass (*Sporobolus pyramidalis*) to ensure there were plenty of weed plants to evaluate. There were minimal numbers of other plant species in the plots, therefore herbicide selectivity was not tested.

Experimental design

The experimental design was a randomised block design with 4 blocks, 10 treatments and a square plot size of 5 x 5m. Sampling consisted of running a measuring tape diagonally across the plot. Starting approximately 1.5m along the tape (~1 m from the sides of the plot) plants were individually located (distance along tape, left or right of tape, distance out from tape). The basal diameter of located plants was measured in two directions. Plant basal area was calculated from the diameter measurements using the formula for an oval. Measurements were taken prior to the application of herbicide (15 December 2004) and 14 months later (9 February 2006). Approximately 20 plants were individually identified and measured per plot.

Although all ten treatments were combined in the same experimental design, there were two groups of treatments for comparison (Table 8 and

Table 9). The first comparison assessed five herbicide application rates using a single ‘best-bet’ granular formulation (medium sized granule and 10% herbicide concentration). The second comparison assessed four different granular formulations (two granule sizes and two herbicide concentrations) at the same herbicide active ingredient application rate. Treatment 3 (medium sized granule and 10% herbicide concentration, 100% rate) was common to both comparisons. All treatments were compared to the liquid herbicide control (currently available herbicide formulation - 100% recommended rate) and applying no treatment (untreated control). All treatments were statistically analysed together.

Table 8 Comparison 1 – Assessment of the efficacy of varying rates of flupropanate granular herbicide compared to the recommended liquid formulation rate (100%). The medium-sized granule formulation with a 10% herbicide concentration was used for all the granule treatments.

Treatment number	Treatment name	Herbicide rate (g active per ha)	Granule number per m^2
1	Granules 50% rate	745	44.7
2	Granules 80% rate	1192	71.5
3	Granules 100% rate	1490	89.4
4	Granules 150% rate	2235	134.1
5	Granules 200% rate	2980	178.8
9	Liquid Control 100% rate	1490	-
10	Untreated control	0	-

Table 9 Comparison 2 – Assessment of efficacy of different flupropanate granule formulations. Two granule sizes and two herbicide concentrations (4 combinations) were trialled which modify the granule number per area. All granule treatments and the liquid control were applied at the recommended 100% rate.

Treatment number	Treatment name	Herbicide rate (g active per ha)	Granule number per m^2
3	Granules, Medium size, 10% conc.	1490	89.40
6	Granules, Large size, 5% conc.	1490	119.20
7	Granules, Large size, 10% conc.	1490	59.60
8	Granule, Medium size, 5% conc.	1490	178.80
9	Liquid Control	1490	-
10	Untreated control	0	-

Herbicide application

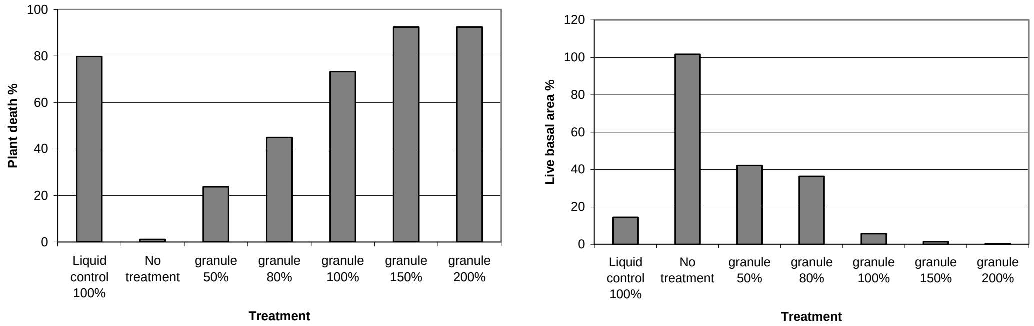
The granular herbicide was weighed for each plot and mixed with approximately 2.5 L of sand. The mixture was hand-spread across the plot, crossing the plot in two directions. A ‘dummy’ plot was erected prior to herbicide application to practice hand-spreading the sand. The liquid herbicide was applied with a backpack sprayer and 0.9 m boom. The rate was calibrated by measuring the spray volume required to spray a ‘dummy’ plot in two directions. Prior to herbicide application, the plots were clearly outlined by running tape along the plot borders.

Weather conditions at time of application were hot (38^{o}C) and humid. The 14 months following herbicide application was generally dry for the region.

Experimental results and discussion

Comparison 1: Efficacy of varying rates of granular flupropanate herbicide compared to liquid flupropanate herbicide

Plant death increased with flupropanate herbicide application rate (A.
B.
Figure 23a). There was no significant difference between the 100% rate granular formulation (medium size, 10% concentration) on plant death (73.3%) compared to the liquid formulation (79.8%). Increasing the granular herbicide application rate to 150% increased plant death to 92.5%, which suggests the efficacy may be slightly improved at a rate greater than 100% rate. Few plants died when no herbicide treatment was applied. There was also no significant difference on the alive basal area remaining after 14 months between the 100% rate granular formulation (5.7%) compared to the liquid formulation (14.3%) (**Figure 23**b).

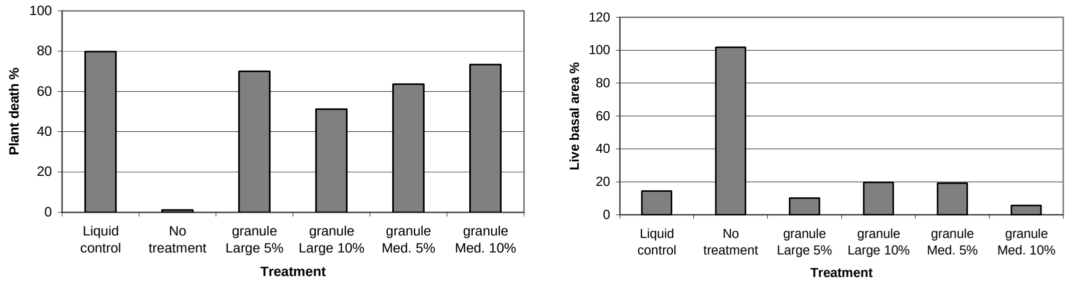


A. **B.**

Figure 23 Impact of granular flupropanate herbicide rate (granule formulation - medium size, 10% concentration) on A) Plant death (LSD 5% is 29.1), and B) Live basal area (LSD 5% is 11.8), of giant rats tail grass 14 months after herbicide application (Comparison 1).

Comparison 2: Efficacy of different granular flupropanate herbicide formulations

There was no significant difference between flupropanate granular formulations on plant death and the alive basal area remaining after 14 months (Figure 24 a and b), however the medium size 10% concentration formulation and the large size 5% concentration formulation had the greatest plant death and least alive basal area remaining after 14 months.



A. **B.**

Figure 24 Impact of different granular flupropanate formulations (using the same active ingredient application rate) on A) Plant death (LSD 5% is 29.1), and B) Live basal area (LSD 5% is 11.8), 14 months after herbicide application (Comparison 2).

There was no consistent link between granule number and plant death, although the treatment with the least granule number (large granule, 10% concentration treatment – 60 granules per m^2) had the lowest plant death.

Summary

In this experiment, there was no significant difference between the granular and the liquid flupropanate herbicide formulations in efficacy for giant rats tail grass (*Sporobolus pyramidalis*) control when applied at the recommended active ingredient rate (1490 g active per ha).

3.9 Field days and technical expertise provision to regional natural resource bodies

3.9.1 Field days

Project staff contributed to 5 field/information days in central Queensland in partnership with the regional natural resource bodies, the Capricorn pest management group, Landcare groups and shire council weeds officers. Field days were held at Moura, Rossmoya, Nebo, Ridgelands (west of Rockhampton) and Ubobo/Calliope. The outcomes of the NSW grazing trial have been presented at a regional meeting of NSW Farmers and the Landcare group at Gressford.

Names and addresses of participates were collected and the 'Weedy Sporobolus Grass best practice manual' was posted out following publication.

3.9.2 Technical expertise provision to regional natural resource bodies

Weeds and in particular weedy Sporobolus grasses have been identified as a high priority issue in regional NRM plans being developed by natural resource bodies. This has led to requests for funding to control weedy Sporobolus grass in key areas. The project has provided technical expertise in the development of 8 project proposals/assessments in central Queensland, Kilcoy and Boonah.

Five landholders have received funding and the others are in negotiation.

3.10 Giant Parramatta Grass Grazing trial Grafton NSW (Jan 2004-Aug 2005)

The advisory group on NSW took a different approach to the Queensland advisory group and supported the establishment of a grazing trial to manage and 'live-with' giant Parramatta grass at "SouthPark" Grafton. The trial evaluated grazing and supplementation strategies in association with other control/management techniques with a focus on maximising livestock productivity for giant Parramatta grass infested pastures.

Trial treatment included:
1. Set stock grazing
2. Flupropanate application and set stock grazing
3. Rotational grazing
4. Flupropanate application and rotational grazing
5. Supplementation block and set stock grazing
6. Fertiliser application and rotation grazing
7. BMP (Best management Practise) – moderate P
8. BMP (Best management Practise) – high P

The below preliminary results are after 20 months (Jan 2004 to August 2005).

Set Stock Treatments (1, 2 and 5)
As per protocol 2 steers are keep in each 1.5ha set stock paddock year round. Steers are removed from the paddock if dry matter/ha falls below 2500 kg/ha and are returned to their paddock once pasture dry matter exceeds this minimum. Whilst steers are off their experimental paddocks they are kept on similar quality pasture to the paddock they have left.

The average weight gain for steers on the set stock (SS) treatment for 20 months was 141 kg or 184g/steer/day (Table 10). Feed quality and not quantity remains the limiting factor in these animals ability to grow. Despite there being 6.62 t/ha dry matter in June 2005 the set stock steers have lost weight over winter 2005. One of the four set stock paddocks was de-stocked for a period of 84 days between March and July. The two steers removed from this paddock were put in two other set stock paddocks which had plenty of standing feed.

Table 10 Effect of treatment on steer weight gain from Jan 2004 to Aug 2005 (574 d)

	Jan 05-Aug 05 (kg)	[1] kg/ha	% increase	Jan 04–Aug 05 kg/ha	% increase
Set Stock	22	29		141	
Flupropanate	33	44	51	176	25
Block	61	81	279	205	45

[1]208 days Jan 05 to Aug 05

Flupropanate:*(GPG removed, paspalum, Bothriochloa decipiens & carpet grass left)*
In 2005 (Jan–Aug) steers on the flupropanate treatment have grown faster than those on the set stock paddocks by 15 kg/ha. This is a modest weight gain increase compared to those animals given blocks. One of the flupropanate paddocks will be de-stocked over winter and spring as there is insufficient feed.

Block: *(10% urea molasses block given year round to steers grazing GPG pasture)*
The steers on the block treatment increased weight gain by 52 kg/ha compared with the un-supplemented set stock animals during Jan-Aug 2005 (Table 10). During Jan-May 2004 cattle in the set stock and set stock plus block treatments were grazing paddocks that had been locked up for between three and four months prior the start of the experiment. The lack of improvement in weight gain in 2004 can be put down to the fact that animals in both treatments had plenty of green feed (Table 11). Due to drought conditions in 2003 neither of the treatments had much rank feed from the previous year at the start of 2004. By Jan 2005 most of the available feed in both treatments (set stock and block) was rank and unpalatable having been through the winter of 2004 and due to grazing management in 2004. Under these feed conditions the block supplemented animals out performed their set stock counterparts.

Table 11 Effect of 10% urea blocks on the weight gain of steers grazing GPG (STD)

	Jan-May (104 d)		Jan-Aug (208 d)	
	2004	**2005**	**2004**	**2005**
Eaten/steer kg	18.2 (2.84)	18.0 (7.88)	54.9 (18.59)	42.0 (16.94)
Cost/beast $	15.04 (2.34)	14.84 (6.50)	45.31 (15.34)	34.67 (13.97)
Gain kg	45.5 (8.89)	52.4 (6.06)	65.3 (18.61)	57.2 (8.37)
Block-SS kg	0.1	30.5	19.8	35.7
Cost $/kg gain	-	0.52 (0.29)	2.38 (2.86)	0.97 (0.26)

In 2004 it appeared that supplementation was financially warranted only over winter and spring. However, in 2005 supplementation has been economic from Jan-Aug and will likely be so throughout the whole year.

Pasture Composition
GPG: Analysis by estimated dry matter (Table 12 and Appendix 1): The proportion of GPG in the pasture (% of dry matter present) and frequency (% of observations containing GPG) has declined in control treatment (set stock) since Jan 2004 from 49.1 to 37.4 and 86.7 to 72.1% respectively. The decline has occurred between May 2004 and June 2005. During this period some die off of GPG plants has been observed in most paddocks. Further observations in the 12 months are planned and will confirm if the decline in GPG is likely to continue.

To date the cause of the GPG die off has not been identified despite numerous attempts to do so. Symptoms are most obvious over summer and autumn when the leaves of sick plants turn orange-yellow instead of light green. Eventually the crown below the sick leaves turns necrotic and dies. More work is required to identify the agent responsible for the GPG die-off.

Analysis by Frequency (

Table 13 and Appendix 1): Altering the grazing management from set stock to rotational (Jan 04 to Jun 05) has had no effect on the frequency with which GPG has been found in the pasture. In other words grazing management has not altered the amount of GPG plants in the pasture. Please note the survival of individual mature plants or emergence of new seedlings has not been measured specifically at “SouthPark”.

The frequency of GPG fell close to zero post spraying with flupropanate when measured in June 04. By May 05 (18 months post spray) the frequency of GPG in these sprayed treatments was on the increase (1.7-11.7%). It is still too early to tell if any of the management regimes are having an effect on the rate of re-infestation.

Two autumn applications (2004 and 2005) of super (20kg/ha P) have not altered the frequency of GPG compared with its’ unfertilised counterpart. Any additional grazing pressure applied to the set stock paddocks as a result of providing a urea molasses block has had no effect on GPG frequency.

Other pasture species: For those treatments where the proportion of GPG has fallen since Dec 03 (based on pasture dry matter) it has been replaced by carpet grass and native *B decipiens* and by paspalum in the sprayed paddocks (Table 12 and

Table 13).

Spraying with flupropanate opened up the pasture to invasion by annual broad-leafed weeds including fireweed. The frequency of fireweed had increased from 25% in unsprayed paddocks to 51% in sprayed paddocks when measured in May 04. By June 05 there was no difference in the frequency of fireweed between sprayed and unsprayed paddocks. However, the frequency of other broad-leafed weeds in June 05 is still higher in the sprayed paddocks compared with those that were not sprayed (average of sprayed 54% v not 37%).

The species composition of the improved pastures has remained relatively stable over the last 20 months. Autumn application of super has yet to have an effect on pasture composition.

Table 12 Trends for species based on pasture dry matter (Dec 2003 to Jun 2005)

Treatment	GPG	Paspalum	Carpet	Native[1]	Fireweed	Weeds
Set stock	down	down	increase	increase	same	same
Fluproponate - set stock	down	same[2]	increase	increase	variable[3]	variable[3]
Rotational	down	same	increase	same	same	same
Fluproponate - rotational	down	same[2]	increase	increase	variable	variable
Block - set stock	down	down	increase	same	same	same
Fertilizer - rotational	down	same	increase	same	same	same
BMP Mod P	same	same	same	same	same	same
BMP High P	same	same	same	same	same	same

[1] Native is predominately *Bothriochloa decipiens*
[2] Paspalum dry matter significantly higher on both flupropanate treatments than Set stock by Dec 03 due to Oct 03 spray
[3] Fireweed and weeds dry matter increased post spraying then declined to level Dec 03 by Jun 05.

Table 13 Trends for species based on frequency (Dec 2003 to Jun 2005)

Treatment	GPG	Paspalum	Carpet	Native[1]	Fireweed	Weeds
Set stock	down[2]	down	increase	increase	same	down
Fluproponate - set stock	down[3]	up/same[4]	down/up[5]	same	variable	same
Rotational	down	same	increase	same	same	down
Fluproponate - rotational	down[3]	up/same[4]	down/up[5]	increase	variable	down
Block - set stock	same	same	increase	same	same	down
Fertilizer - rotational	same	same	increase	same	same	down
BMP Mod P	down	down	same	same	same	down
BMP High P	down	same	same	same	variable	same

[1] Native is predominately *Bothriochloa decipiens*
[2] Fell by 14.5% from May 04 to Jun 05.
[3] Fell after spraying but has started to increase since May 04.
[4] Frequency increased from Dec 03-May 04 then returned to Dec 03 level by Jun 05.
[5] Fell post spraying; by June 05 was equal to or exceeded Dec 03 frequency.

Grazing management

The first year of rotational grazing reduced the amount of rank GPG in the paddocks compared with those that were set stocked. So far this year the grazing pressure on the rotationally grazed paddocks has been a lot lighter due to restrictions placed on the project team by the collaborator who wished to maintain livestock growth rates (see Table 14).

Table 14 Seasonal grazing pattern and annual stocking rate for 2004.

	Jan-Aug 2004	**GDs[1] 2004**	**Av No steers /ha/yr**	**Jan-Aug 2005**	**05/04 %**	**GDs/SS 2005**
Set Stock (SS)	416	713	1.3	416	100	.
Flupropanate (F)	412	597	1.1	416	101	.
Rotational (R)	698	846	1.6	342	49	82
RF	388	521	1.0	334	86	80
Block	416	693	1.3	416	100	.
Fertiliser	664	828	1.5	308	46	74
BMP mod P	604	861	1.6	365	60	88
BMP high P	634	878	1.6	447	71	107

[1]GDs = grazing days = No of animals x days grazing;
730 grazing days = 2 steers/day/annum

The cattle have been allowed to grazing each paddock for two days at one time and then only with cattle numbers that approach the 2 steers/paddock set stock ratio. As a consequence more of the GPG has been allowed to go rank and remain in the paddock uneaten.

NSW grazing trial summary

- The first 20 months of grazing has shown up some of the limitations of rotational grazing strategies to manage weedy sporobolus grasses. More work is required to refine the use of rotational grazing to manage these species.
- Flupropanate was effective in reducing GPG to less than 1% of the pasture. However, 22 months after spraying, the frequency of GPG in the sprayed pasture is increasing and has reached 11% in the rotationally grazed treatment. Management strategies need to take into account the speed with which GPG can recover post spraying.
- The 10% urea molasses blocks have continued to improve steer weight gain on GPG infested pasture.

- Analysis of changes in feed quality for different pasture species is currently being under taken.

4 Success in Achieving Objectives

4.1 Develop practical paddock and property scale weedy Sporobolus grass control strategies for extensive grazing land

The project was successful at developing and demonstrating practical, property scale weedy Sporobolus grass control strategies for extensive grazing land. Two separate approaches were undertaken by the central Queensland and New South Wales advisory groups to address this objective.

In Queensland strategies were developed and trialled on three extensive grazing properties (core sites) with different situations, climate and soil types. The advisory group landholders were also encouraged to assess their individual situation and trial strategies on their own properties (landholder sites) and report back to the advisory group. Two key herbicide assessments were undertaken in Queensland to assess aerial application of flupropanate herbicide and to assess a granular herbicide formulation.

In NSW a different approach was taken. A small grazing trial (South Park) was established to assess the impact of grazing management, livestock supplements, herbicide application and fertiliser application on maximising livestock productivity on pastures infested with giant Parramatta grass.

The experience and knowledge gained in the development of these control strategies by land managers and researchers has been incorporated into the “Weedy Sporobolus grasses best practice manual”.

4.2 Propagate successful management strategies to key stakeholders, land managers and advisers

The key communication product completed by the project is the ‘Weedy Sporobolus grasses Best practice manual’ (Figure 2). The manual contains a new three step planning section and includes a case study demonstrating the application of principles discussed in the manual. The case study is based on a hypothetical property and will assist producers to understand how best to plan and manage their weedy Sporobolus grass infestation across their whole property. The cases study demonstrates the application of:
1) Planning for eradication and control
2) Principles for good grazing and pasture management

A new section on the use of flupropanate herbicide has also been included.

The manual has been distributed to all landholders who have been involved in the project and attended field or information days. A copy of the manual and details on how to acquire more copies have been distributed to regional NRM bodies, local councils, biosecurity, key agribusinesses in Central Queensland and participants undertaking the more coastal versions of the Grazing Land Management program. The availability of the manual has also been advertised in newspapers and newsletters. Copies are available free of charge from DPI&F Business Information Centre on 13 25 23.

The project contributed to 5 field/information days in central Queensland in partnership with the regional natural resource bodies, the Capricorn pest management group, Landcare groups and shire council weeds officers. Field days were held at Moura, Rossmoya, Nebo, Ridgelands (west of Rockhampton) and Ubobo/Calliope. The outcomes of the NSW grazing trial have been presented at a regional meeting of NSW Farmers and the Landcare group at Gressford.

The Grazing Land Management (GLM) package is a primary extension tool of MLA and DPI&F promoting sustainable and profitable grazing management. By working with the GLM team we contributed to the development of a weed management/control scenario based on giant rats tail grass as the main example weed in the Fitzroy, Burnett and Mackay/Whitsunday versions of the package.

Weeds and in particular weedy Sporobolus grasses have been identified as a high priority issue in regional NRM plans being developed by natural resource bodies. This has led to requests for funding to control weedy Sporobolus grass in key areas such as isolated infestations at the head of catchments. The project has provided technical expertise in the development of 8 project proposals/assessments in central Queensland, Kilcoy and Boonah. Five landholders have received funding support and the others are in negotiation.

4.3 Develop and incorporate economic analysis into recommended management strategies for weedy Sporobolus grasses

An assessment on the economic consequences of weedy Sporobolus grass management options at the property scale has been conducted in collaboration with Bill Holmes. Using hypothetical case study properties, fifty year scenarios were developed for two alternative future paths (options) starting from the same initial situation (eg. level of infestation).

A livestock carrying capacity calculator (a modified version of Stocktake) was utilised to estimate the annual number of livestock that can be carried at four defined weed infestation levels (paddock-scale). The annual cost of weed management treatments was subtracted from the annual gross margin for the grazing enterprise (property-scale). Differences in land value (based on carrying capacity) at the end of the scenario were also considered.

At the end of 50 years, the Net Present Value (NPV), Annualised Return, Internal Rate of Return (IRR), payback period, annual cash flow and cumulative cash flow were calculated for option 2 relative to option 1 in the scenario. This process allows comparison of weed management options, but also highlights that control which may be highly worthwhile for the neighbours, may not be financially feasible for the landholder with the infestation. Results indicate that at current prices many control options are probably outside the financial capability of many landholders, particularly on poor quality country.

A paper was presented at a Resource Economics Workshop in Rockhampton, 28 Oct 2005 and a paper has been submitted to The Rangeland Journal.

An internal DPI&F cost-benefit analysis was also conducted using conservative assumptions on the per hectare benefits and uptake of research. This analysis indicated the research and development activities in Queensland produced benefits that were significantly greater than the costs of the research (includes DPI&F and MLA investment). At a discount rate of 5%, the project generated net benefits of more than $2.28 million with a Benefit Cost Ratio (BCR) of 5 to 1.

5 Impact on Meat and Livestock Industry – now & in five years time

The unpalatable weedy Sporobolus grasses including giant rats tail grass and giant Parramatta grass have invaded approximately 450,000ha of grazing land in coastal and sub coastal Queensland and New South Wales. Due to the strengths in the life cycle of these weeds they are continuing to invade new areas and increasing in dominance on properties already infested. This project developed and demonstrated efficient and economical control and management strategies for extensive grazing properties.

As outlined in the booklet “Weedy Sporobolus grasses best practice manual” which was published as part of this project, land managers need to understand the strengths and weaknesses of this problem weed and implement strategies to minimise the likelihood of their property becoming invaded by weedy Sporobolus grass or reduce the likelihood of the weed spreading to currently clean areas on their property. The manual outlines a three step planning process to maximise the likelihood of success in the control and management of weedy Sporobolus grasses at the property-scale. One-off control activities such as a single herbicide application are unlikely to result in medium term success and are generally a waste of financial and time resources.

The manual incorporates the experience and understanding of land managers and researchers in the control and management of weedy Sporobolus grasses. The manual is an excellent tool against which land managers can test their current control strategies and ensure their strategies have the highest likelihood of success over the next five years and beyond.

6 Conclusions and Recommendations

This project focused on managing the weedy Sporobolus grasses at the property and catchment scale in central Queensland and northern New South Wales. Methodology for aerial application of flupropanate herbicide was designed and tested, demonstrating good results. A grazing trial was conducted in New South Wales to test strategies incorporating livestock supplementation, fertiliser, rotational grazing and herbicides to best manage giant Parramatta grass infested country. Land manager participation and action on their own properties was encouraged and supported throughout the project. The outcomes of the project and the experience of land managers and researchers has been incorporated into a booklet “Weedy Sporobolus grasses best practice manual” and into an economic analysis of management strategies from the perspective of the land manager and the regional community.

Recommendations

1. Support the process of bringing a granular flupropanate herbicide product to market.

7 Appendices

7.1 NSW grazing trial treatments and 2004 weather data

Table 1 NSW grazing trial treatments

Treatment No	1	2	3	4	5	6	7	8
	Control	**Flupro-panate (F)**	**Rotational Grazing (RG)**	**F and RG**	**Block 10% urea year round**	**Fertiliser**	**BMP 20kg P**	**BMP 40kg P**
Pasture species	GPG + naturalised grass	GPG + naturalised grass	GPG + naturalised grass	GPG + naturalised grass	GPG + naturalised grass	GPG + naturalised grass	Sown grass + legume	Sown grass + legume
Flupro-panate	Nil	1.5 l/ha Year 1	Nil	1.5 l/ha Year 1	Nil	Nil	1.5 l/ha Year 1	1.5 l/ha Year 1
Fertiliser Program	Nil	Nil	Nil	Nil	Nil	20kg P/an applied in autumn	20kg P/an applied in autumn	40kg P/an applied in Aut & Spr
Grazing strategy	Set stocking	Set stocking	Rotational grazing	Rotational grazing	Set stocking	Rotational grazing	Rotational grazing	Rotational grazing

BMP = Best management practice; Fertiliser = single super; Flupropanate was applied in October 2003. Treatments 6, 7 and 8 had 2.5 t/ha of lime applied in December 2003 and the first super application occurred in March 2004. A legume mix containing 0.9 (kg/ha) Aztec Atro, 0.9 Burgundy bean, 1.5 Claret red clover, 1.5 Waverly white clover and 1 of Tonic plantain was sown on March 1 and resown on April 8 2004. The sown grass is setaria (3 of 4 replicates) and a mix of Rhodes grass, paspalum and bahia grass (replicate 4) in treatments 7 and 8.

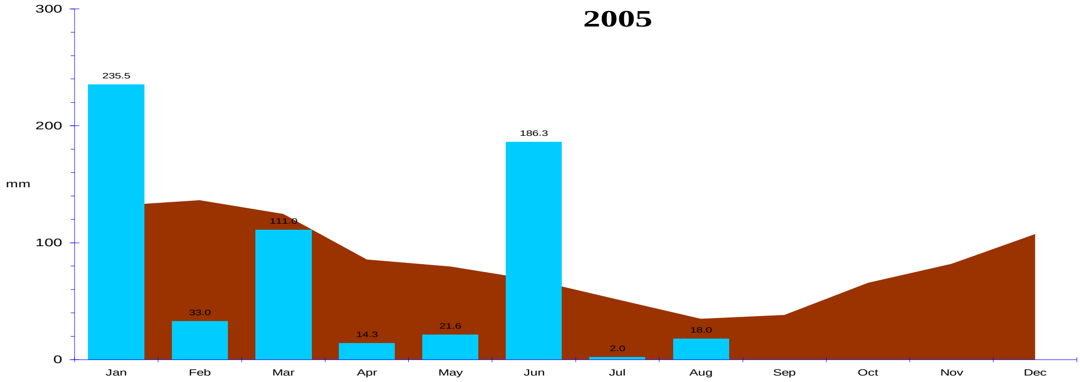


Figure 1. Grafton Research Station rainfall for 2005. The research station is approx 12 km from SouthPark. Note the mean monthly rainfall is shown as a shaded area.

Grafton Research Station mean daily max and minimum temperatures (^{o}C) and monthly rainfall (mm) for 2005.

Element	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Annual**
Max	31.2	30.6	28.4	27.4	24.1	21.7	22.1	22.5	
Min	19.6	19.9	16.8	15.5	11.3	9.8	9.6	8.2	
Rain	236	33	111	14	22	186	2	18	622

Rainfall in 2005 (Jan-Aug) has been patchy with 6 of the first eight months having below average rainfall. Only 2 of the first eight months of the year had rainfall that exceeded evaporation. Total evaporation (year to date) has exceed rainfall by 140mm. Monthly maximums and minimum temperatures have been above average all year. Winter has been warm with fewer frosts than average. The wet weather in June combined with the warmer than average temperatures were used to over sow white clover into the BMP paddocks. The white clover strike from this sowing has been patchy but is promising.

Table 2. Change in frequency of pastures species over time

Date	Treatment	Bahia	Carpet	Couch	Fireweed	GPG	Kikuyu	Legumes	Nat.Grass	OtherGrass	Paspalum	Q.B.Couch	Rhodes	Setaria	Weeds
Aug-03	Set stock	3.3	45	5	77.2	90.6	2.8	4.4	30.6	1.1	63.3	0	0.6	5	88.3
Dec-03	Set stock	5.8	33.8	7.9	22.1	86.7	3.8	3.8	22.1	0.4	72.9	0.8	0	12.9	60
May-04	Set stock	0.8	61.3	6.7	22.5	82.1	1.7	0	25.8	0	41.3	0	0.4	12.5	37.1
Jun-05	Set stock	3.8	62.5	5	24.6	72.1	2.1	2.9	44.2	2.1	54.2	0	0	2.1	42.9
Aug-03	Flupropanate - set stock	1.1	57.8	5	67.2	92.2	0.6	2.2	41.7	0	68.3	0	0	3.3	82.2
Dec-03	Flupropanate - set stock	6.7	43.8	7.9	24.6	81.3	1.3	3.3	30.8	0	82.5	0	0	12.1	66.7
May-04	Flupropanate - set stock	4.2	38.8	5	50	0	1.7	0	39.2	0.4	75.8	0	0	9.2	62.5
Jun-05	Flupropanate - set stock	5	56.3	12.9	24.2	2.1	2.5	2.1	43.8	2.1	83.8	0	0	13.8	60
Aug-03	Rotational	0.6	65.6	6.7	73.3	90.6	2.2	3.3	37.2	0	53.9	0	1.1	5.6	91.1
Dec-03	Rotational	0.8	53.8	11.7	20	85.8	3.3	1.7	23.8	0	66.3	0.4	0	24.6	59.6
May-04	Rotational	2.1	80	11.7	28.8	72.9	2.9	0	17.5	0.4	59.6	0.4	0	17.9	35.4
Jun-05	Rotational	2.1	86.7	11.3	28.3	70	3.8	1.3	13.8	0.4	60.8	0	0	9.2	32.5
Aug-03	Flupropanate - rotational	1.1	50	1.7	77.2	87.2	6.1	5.6	39.4	1.1	77.2	0	1.7	1.7	87.2
Dec-03	Flupropanate - rotational	2.5	25.4	5.4	26.3	73.8	6.7	2.9	36.3	2.5	81.3	0	0	7.5	62.9
May-04	Flupropanate - rotational	5	26.3	11.3	51.7	0.8	4.2	0.8	38.8	1.7	81.7	0.4	0.4	11.7	58.3
Jun-05	Flupropanate - rotational	2.9	50.4	12.1	34.2	11.7	5.8	0.4	56.3	1.7	80.8	0	0	6.7	47.9
Aug-03	Block - set stock	1.1	63.9	3.3	76.7	88.9	0	6.7	37.8	0.6	47.2	0	0.6	1.1	91.1
Dec-03	Block - set stock	2.1	55.8	9.2	18.3	81.7	3.3	0.4	28.8	2.1	63.3	0	0	11.7	62.5
May-04	Block - set stock	2.1	76.7	7.5	23.3	79.6	0.4	0	25.4	0	38.8	0	0	14.2	28.3
Jun-05	Block - set stock	0.8	77.9	12.9	15.4	70	0.4	1.3	35	1.3	52.9	0.4	0	3.3	35
Aug-03	Fertilizer - rotational	1.1	56.7	8.3	78.9	96.7	1.1	1.7	30	0	49.4	0	0	4.4	85
Dec-03	Fertilizer - rotational	5	53.3	10	30	82.9	1.7	0.8	15	0.4	66.7	0.4	0	12.9	54.2
May-04	Fertilizer - rotational	1.3	66.3	12.1	26.3	72.1	2.5	0	19.6	0	55.4	0	0	15	36.7
Jun-05	Fertilizer - rotational	1.7	85.8	14.6	25.8	79.6	4.6	1.3	24.6	1.3	56.3	0.8	0	7.5	36.7
Aug-03	BMP mod P	9.4	23.3	6.7	53.3	41.7	2.2	8.9	1.1	0	44.4	0	14.4	73.3	67.2
Dec-03	BMP mod P	13.8	14.2	5.4	16.3	21.3	3.3	1.3	0.8	0	44.2	0	17.9	75.8	22.5
May-04	BMP mod P	13.3	6.7	3.8	18.3	0.8	1.3	5	1.7	0.8	28.3	0	11.7	74.6	23.3
Jun-05	BMP mod P	7.9	11.3	2.5	8.3	1.7	3.3	15	1.3	0	29.6	0	14.2	74.6	5.8
Aug-03	BMP high P	11.1	18.3	11.7	52.8	50.6	10	7.2	1.1	0	55.6	0	15	71.1	57.2
Dec-03	BMP high P	12.1	11.7	4.6	9.6	20.4	5.4	1.3	5.4	0.4	45	0	15.4	70.4	14.2
May-04	BMP high P	12.1	9.6	5.5	21.1	0	6.3	6.3	1.7	0.6	33.4	0	16.3	68.3	13
Jun-05	BMP high P	6.7	10.4	5	4.2	2.9	5.4	8.8	1.3	0	46.7	0	15.8	69.2	7.1
LSD (treats)		**9.5**	**25.6**	**8.4**	**14.3**	**14.8**	**6.4**	**6.4**	**22.5**	**2.2**	**30.6**	**0.8**	**18.2**	**36.6**	**13.2**
LSD (times)		**4.1**	**14.9**	**6.4**	**14.1**	**12.4**	**4.1**	**6.2**	**14.1**	**1.8**	**12.8**	**0.8**	**3.6**	**8.5**	**12.6**

Table 3. Change in pasture species over time (percentage dry matter)

Date	Treatment	Bahia	Carpet	Couch	Fireweed	GPG	Kikuyu	Legumes	Nat.Grass	Others	Paspalum	QBCouch	Rhodes	Setaria	Weeds
Aug-03	Set stock	1.3	7.5	1.7	6	47.9	0.3	0	13.1	0.4	13.5	0	0	0.3	8
Dec-03	Set stock	2.5	8.8	1.1	0.1	49.1	0.9	0	5.8	0.1	26.9	0.1	0	2.2	2.2
May-04	Set stock	0.8	23.8	2.2	0.2	52.1	0.6	0	7.6	0	8	0	0	3.5	1.2
Jun-05	Set stock	2.3	23.3	0.7	0.2	37.4	0.3	0	22	0	13	0	0	0.5	0.4
Aug-03	Flupropionate - set stock	0.5	11.3	1.1	5.2	47.9	0.6	0	11.3	0	15.5	0	0	0.1	6.7
Dec-03	Flupropionate - set stock	4.6	7.7	1.6	0.2	39.6	0.2	0	6.8	0.1	34.3	0	0	3.1	1.9
May-04	Flupropionate - set stock	3.6	13.4	1.7	3.6	0	0.5	0	19.4	0	45	0	0	4.2	8.6
Jun-05	Flupropionate - set stock	3.8	20.6	2.3	0.1	0.3	0.5	0	24.1	0	41.8	0	0	5.8	0.8
Aug-03	Rotational	0.6	13.1	1.4	4.6	50.3	0.8	0	11.6	0	9.8	0	0	0.9	7
Dec-03	Rotational	0.1	12.2	4	0	47.9	1.2	0	4	0	22.9	0	0	6.1	1.6
May-04	Rotational	1.8	30.7	2.7	0.2	34.4	0.4	0	3.2	0.1	20.3	0	0	5.2	1
Jun-05	Rotational	0.8	35.4	2	0.2	33.2	0.5	0	6	0.3	18.4	0	0	3	0.2
Aug-03	Flupropionate - rotational	1.1	8.5	0.5	5.6	48.3	1.2	0	10.6	0.5	16.8	0	0	0.8	6.2
Dec-03	Flupropionate - rotational	1.5	2	1.6	0	40.7	1.8	0	8.7	1.6	37.1	0	0	2.9	2.1
May-04	Flupropionate - rotational	3.9	6	4	4.2	0.1	2.6	0	12.7	0.1	51.6	0.4	0.4	6.3	7.6
Jun-05	Flupropionate - rotational	1	15.7	2.8	1.1	0.6	2.1	0	32.5	0.3	39.7	0	0	3	1.2
Aug-03	Block - set stock	0.5	13.1	2.3	5.8	48.2	0	0	11.2	0.4	11.2	0	0	0.2	7.1
Dec-03	Block - set stock	1.5	12	3.3	0.3	44.8	1.5	0	8.5	1.2	22.4	0	0	3.4	1.2
May-04	Block - set stock	1.3	31.1	1.5	0.3	44.9	0	0	7.1	0	10.3	0	0	3.2	0.3
Jun-05	Block - set stock	0.8	31.8	2.9	0	32.5	0	0.1	19.1	0.6	11	0	0	0.6	0.4
Aug-03	Fertilizer - rotational	0.5	8.5	5.6	5.8	45	0.8	0	9.9	0	15.9	0	0	0	8
Dec-03	Fertilizer - rotational	2.4	14.6	2.2	1.2	46.8	0.5	0	2.6	0	25.4	0	0	3.4	1
May-04	Fertilizer - rotational	0.8	31.5	2.7	0.5	35	0.4	0	3.2	0	21.6	0	0	3.7	0.5
Jun-05	Fertilizer - rotational	1.1	41.7	1.2	0.2	31.6	0.5	0	6	0.1	16.5	0	0	1.1	0.1
Aug-03	BMP mod P	5.6	3.1	0.3	1.5	7	0.3	1.5	0	0	18.3	0	5.1	56.1	1.1
Dec-03	BMP mod P	7.1	1.5	1	0	3.2	2.2	0	0.1	0	16.9	0	6.5	61.4	0
May-04	BMP mod P	7.2	0.8	0.5	0.1	0	0.5	0	0.1	0	15.7	0	5	69.7	0.5
Jun-05	BMP mod P	5.1	1.5	0	0	0.3	0.3	0.4	0.5	0	13.5	0	8.1	70.4	0
Aug-03	BMP high P	5.7	1.9	1.6	0.8	7.5	4.9	0.2	0	0	18.3	0	5.4	51.5	2.2
Dec-03	BMP high P	5.9	1.8	1.4	0	2.8	1.7	0.3	0.8	0	20.8	0	6.2	58.3	0
May-04	BMP high P	7.5	1.5	0.3	0.1	0	2.6	0	0.1	0	20.9	0	5.3	61.5	0.2
Jun-05	BMP high P	4.6	3.7	0.9	0	0	2.5	0.1	0.1	0	17.1	0	9.1	61.9	0
LSD (treats)		**6.4**	**11.1**	**3.9**	**2.5**	**12.9**	**2.6**	**0.7**	**11.5**	**1**	**19.9**	**0.2**	**8.8**	**30.7**	**2.8**
LSD (times)		**2.4**	**6.5**	**3.3**	**2.5**	**11.2**	**2.2**	**0.7**	**8.5**	**0.8**	**10.6**	**0.2**	**2.7**	**4.8**	**2.9**