MEAT & LIVESTOCK
AUSTRALIA

on farm

Weeds of Significance to the Grazing Industries of Australia

Project number COMP.045

Final Report prepared for MLA by:
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Feedbase and pastures

Table of Contents

SUMMARY 3

Weeds of significance to the grazing industries of Australia 4

Weeds of significance to the grazing industries of northern Queensland 7

Weeds of Significance to the Grazing Industries of the Northern Territory 32

Weed of significance to the grazing industries of northern Western Australia 34

Weed of significance to the grazing industries of Victoria 48

Weeds of Significance to the Grazing Industries of the New South Wales Tablelands, Slopes and Plains 70

Weeds of significance to grazing industries of coastal NSW 79

Weeds of importance to the grazing industry in southern Queensland 86

Weeds of Significance to the Australian Agricultural Company - an economic and management case study 94

Outcomes of Workshop 100

LIST OF ATTENDEES 114

SUMMARY

119 weed species were listed as relevant to Australian grazing lands. This list includes annual and perennial grasses and forbs, shrubs, trees and aquatic plants.

Together these weeds seriously affect a very large though undetermined proportion of Australian grazing lands in a variety of ways. Many are **unpalatable** or **toxic** to livestock. Others compete with more desirable pasture species and so **reduce livestock carrying capacities**. Some **inhibit effective animal husbandry**. Many of the species relevant to grazing industries are also significant **environmental weeds**.

Forty-eight species or species groups are listed being especially significant to Australian grazing lands. The species of greatest significance vary between bioclimatic zones.

In the **monsoon tropics** the greatest need is to develop and promote systems approaches to the management of the unpalatable perennial grasses **gamba grass**, **mission grass** and **giant rat's tail grass** and the perennial forbs **calotrope**, **sida** and **hyptis**.

In the **tropical rangelands** invasive exotic trees and shrubs are the highest priorities. Research is most needed for **parkinsonia**, **lantana** and **bellyache bush** to cover critical aspects of their ecology and control, including biological control. Further work on biological control of **mesquite** and **prickly acacia** is also required. The **rat's tail grasses** and other **unpalatable perennial grasses** are also high priority and management strategies are required for noogoora burr in regions where current biological control measures are ineffective. Approaches to the sustainable management of proliferating **native trees and shrubs** are also important in the tropical rangelands.

High priorities **in tropical and sub-tropical east coast** grazing lands are the **rat's tail grasses**, **lantana** and **creeping lantana. Parkinsonia** is of medium priority in this zone, as are **lippia**, **tobacco weed** and **sicklepod**.

In the **temperate rangelands**, **African boxthorn** is the highest priority exotic woody weed. Biological control may be a viable option for the management of this species. Two perennial forbs, **lippia** and **mother-of-millions**, should be given high priority, requiring effective management techniques and strategies. The annual forbs **onion weed** and **saffron thistle** also warrant research.

In the **cropping/pasture zone** the greatest need is for the development of **systems approaches** to the management of a **complex of weeds** that includes annual grasses and annual and perennial forbs. **Silverleaf nightshade** and **prairie ground cherry** are high priorities at the species level.

The situation on the **perennial pasture zone** is similar to that in the cropping/pasture zone with a complex of annual and perennial grasses and forbs being high priority weeds and the greatest need being for systems approaches and improved management and extension material. **African lovegrass, Chilean needlegrass, browntop bent, Parramatta grass, serrated tussock, silverleaf nightshade** and **prairie ground cherry** are the most significant species.

Measures to counter **emerging weed problems** should be high priority.

WEEDS OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF AUSTRALIA

INTRODUCTION

This is a report on a joint effort between Meat and Livestock Australia (MLA) and the Co-operative Research Centre for Australian Weed Management to evaluate weeds that are significant to Australian grazing industries.

The MLA provided the following terms of reference:

1. To provide a list of weeds of significance to Australian grazing industries;
2. To provide an assessment of the economic impacts of these weeds;
3. To identify opportunities and priorities for research and development on these weeds on the basis of the significance and the feasibility of success.

These terms of reference were addressed during a workshop held in Sydney in April 2002. The objectives of the workshop were to:

I. identify the weeds that are currently significant for Australian grazing industries;
II. identify plant species that could become a problem in the future;
III. provide an assessment of the impacts of these species including economic costs;
IV. identify other weed issues that are not species-specific;
V. propose and prioritize research and development needs in relation to weeds

APPROACH

This evaluation of the weeds of significance to Australian grazing industries involved review of current knowledge and determination of future needs.

First, regional reviews were prepared. These were commissioned to address seven questions with respect to specific regions of Australia:

1. Which weeds are currently important to grazing industries within the region?
2. In what ways are these weeds a problem to grazing industries?
3. Where are these species a problem?
4. Are there species present within the region that could become problems in the future?
5. What are the impacts of currently significant weeds on animal production, grazing land sustainability and economic viability of grazing enterprises?
6. Are there other weeds-related issues that do not relate to specific weeds but which threaten grazing enterprises and industries?
7. What are the research and development needs in relation to weeds within the region? Where you consider it appropriate, prioritise these needs.

The regions themselves were defined as far as practicable on bioclimatic grounds though, for logistic reasons there was also an alignment with state and territory boundaries (Figure 1).

Regional reviews were prepared for:

I. northern Queensland
II. The Northern Territory
III. northern Western Australia
IV. southern Western Australia
V. Victoria
VI. the tablelands, slopes and plains of New South Wales
VII. coastal New South Wales
VIII. southern Queensland

The regional reviews did not cover Tasmania or South Australia.

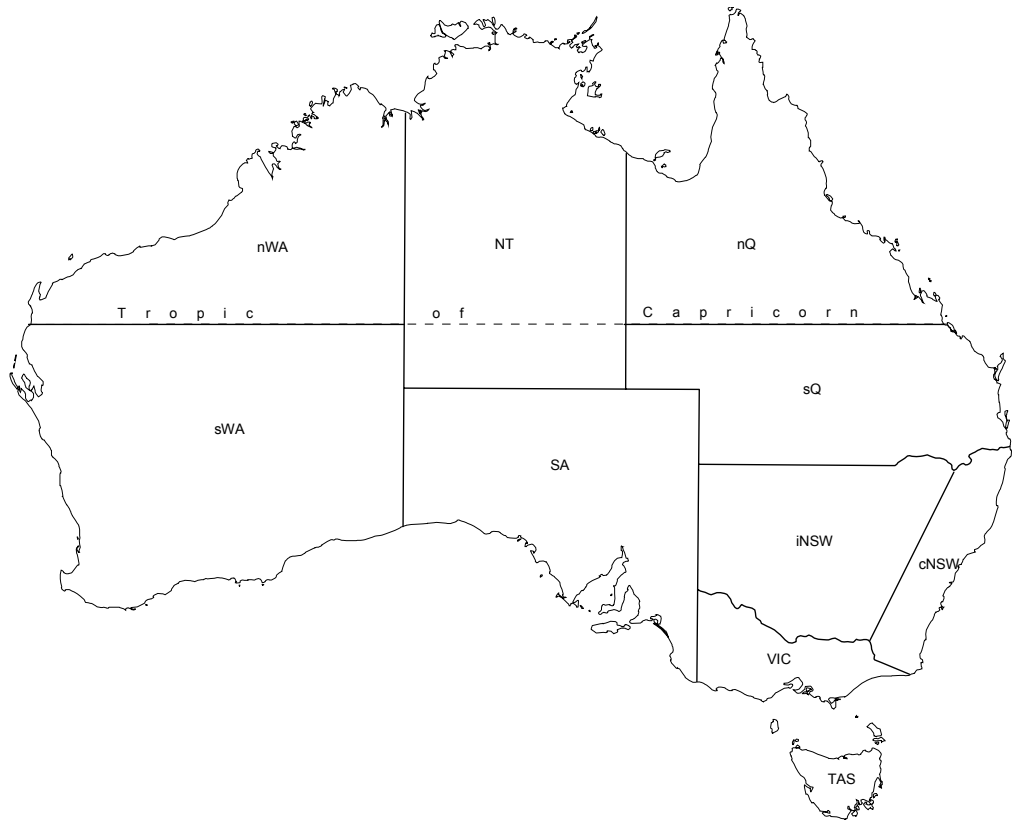


Figure 1. Regions of Australia used in this review. nQ northern Queensland; sQ southern Queensland; cNSW coastal New South Wales; iNSW tablelands, slopes and plains of New South Wales; VIC Victoria; NT Northern Territory; nWA northern Western Australia; sWA southern Western Australia.

Second, a workshop was held in Sydney on April 17-18 2002. The workshop was attended by 19 weed researchers, extension specialists and producers. Together they provided near national coverage, as well as regional perspectives, and expertise in various aspects of weed biology and management.

A list was compiled of all weeds identified in the regional reviews and during discussion at the workshop. Species or species groups on this list were prioritized on the basis of the regional reviews and subsequent discussion using criteria identified during the workshop.

Seven “growth form” categories of weeds were defined.

The eight regions provided a basis for identifying regional priorities for research and development. Information was subsequently presented in terms of six zones that were defined along bioclimatic lines:

A. Monsoon tropics
B. Tropical rangelands
C. Tropical and subtropical east coast
D. Temperate rangelands
E. Cropping/pasture zone
F. Perennial pasture zone

Overall research and development needs were identified by developing a matrix of weed categories against bioclimatic zones. It was not possible in the time available to provide a detailed analysis of R&D needs for each species or category of weed. Rather, needs in three areas – ecology, biological control and management strategies – were identified as **low, medium** or **high** priority.

Third, a draft report was prepared. Feedback on this draft was obtained from those attending the workshop and from a broader group of stakeholders. This Final Report is the outcome of that process. It presents the regional reviews, the outcomes of discussion and analysis at the workshop and responses to post-workshop feedback.

WEEDS OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF NORTHERN QUEENSLAND

J.S. Vitelli, Queensland Natural Resources and Mines

The Tropic of Capricorn makes a convenient division line between Northern and Southern Queensland. Broadly speaking, the line used to define Northern Queensland runs between Rockhampton and Longreach. The northern area of Queensland consists of approximately 937,000 square kilometres. The weed list is restricted to invasive species that pose threats to the grazing industries, particularly its pastures.

The short-listing of weeds significant to the grazing industry of Northern Queensland were based on two ranking systems available in the literature (Thorp and Lynch 2000, Bebawi *et al.* 2002) and on personal communications with Land Protection Officers and Extension Officers of the Queensland Department of Natural Resources and Mines. Inevitably there will be omissions or a difference of opinion as to the order of importance, but at least the list can serve as a start for decision-making.

Rankings used in this report are based on a series of criteria and weightings that have been used to prioritise weeds. The Weeds of National Significance list included 71 weeds submitted from all states and territories. The WONS ranking system looked predominantly at four criteria: invasiveness, impact, potential for spread, and socio-economic and environmental values (Thorp and Lynch 2000). The second ranking used is that of the Tropical Weeds Research Centre in Charters Towers, which was developed to help prioritise weed research activities at the centre. The original list of 246 weeds was derived from pest management plans of 47 shires and cities in Northern Queensland. The list was condensed to 53 weeds after feedback from stakeholders and divided into wet tropics and dry tropics weeds. Twelve criteria were then used to run the weeds in QDNRM MODSS (Queensland Department of Natural Resources and Mines Multiple Objectives Decision Support System) (Bebawi *et al.* 2002). The 12 criteria were based on economic, environmental and social impacts and current research knowledge with higher scores for greater impact and greater amount of needed research.

The list of weeds significant to the grazing industries in Northern Queensland have been further divided into exotic weeds (Table 1), potential weeds (Table 2), aquatic weeds (Table 3), and productive and palatable plants perceived as potential weeds outside the grazing industry (Table 4). A few troublesome native plants have also been included in this report (Table 5). The weed species listed in Tables 1-5 include information on whether the weed is toxic, impedes mustering, reduces pasture, or is a contaminant of produce. A monoculture index, an invasiveness index and a potential for spread index are also listed, with a value of 1 being high, and 0 being low (Thorp and Lynch 2000, Bebawi *et al.* 2002).

The author has not placed dollar values when defining the economic losses caused by each of the weeds in Tables 1-5, instead has opted for categories (low, medium and high). Economic values often quoted in past literature are based on limited information and in some cases the figures are only best guesses based on no or little qualitative data. Collecting useful economic data is seen as an important step when assessing weed prioritises for the grazing industry.

Figure 2 shows the current and potential distributions for each weed, where available. For exotic species the current distribution maps of exotic species were derived from Thorp and Lynch (2000) and potential distribution maps were prepared from Rod Randall (Western Australia Department of Agriculture). Current distribution maps of native plants were modified from Anderson (1993).

Tables 6-8 list the weed species and the areas where research is still needed to assist control measures and devise integrated weed management plans for each weed. Apart from specific control needs and basic biology for individual weeds, the area requiring attention is extension/adoption of

control information for a lot of the major weeds. This problem relates to a lack of basic weed biology known by land managers, lack of awareness on the impacts of exotic weeds and the timing of control options. A need also exists to develop an awareness of the dangers of accidental introduction of new weeds species to an area. For example through the movement of machines or produce from weed infested areas to new or weed-free areas.

REFERENCES

Anderson, E.R (1993) *Plants of Central Queensland: their identification and uses*. Queensland Dept. of Primary Industries, Brisbane.

Bebawi, F.F., Campbell, S.D., and Stanley, T.D. (2002) Priority lists for weed research in the wet- and dry-tropics of north Queensland. *Plant Protection Quarterly* 17:67-73.

Thorp, J.R and Lynch, R. (2000) *The Determination of Weeds of National Significance.* National Weeds Strategy Executive Committee, Launceston.

Table 1. The 20 exotic weeds that are most significant to the grazing industries of north Queensland. Values in the Table were generated from Thorp and Lynch (2000) and Bebawi *et al.* (2002). NB: (i) rankings in this Table relate only to weeds relevant to north Queensland; (ii) non-pastoral weeds were included in the overall analysis though they are not shown here; (iii) these data do NOT cover many of the species mentioned in this report. TWRC = Tropical Weeds Research Centre (Qld Dept Natural Resources and Mines, Charters Towers).

Weed species	Toxic	Impedes mustering	Reduces pasture	Monoculture index	Invasiveness index	Economic loss	Potential for spread	Contaminant of Produce	WONS ranking	TWRC ranking
Mesquite	No	Yes	Yes	0.6174	0.7954	High	0.6666	No	2	3
Parkinsonia	No	Yes	Yes	0.6174	0.8219	High	0.755	No	1	13
Rubber vine	Yes	Yes	Yes	0.6174	0.6275	Medium[1]	0.4157	No	5	9
Prickly acacia	No	Yes	Yes	0.6174	0.5917	High	0.2924	No	7	10
Lantana	Yes	Yes	Yes	0.6175	0.7336	High	0.1739	No	4	22
Parthenium	No	No	Yes	0.6174	0.6540	High	0.2940	Yes	16	4
Bellyache bush	Yes	Yes	Yes	0.6174	0.6010	High	0.2669	No	21	7
Giant rats tail grass	No	No	Yes	0.4914	0.3447	Medium	0.0626	Yes	48	17
Hyptis	No	No	Yes	0.6174	0.6275	Medium	0.3342	Yes	22	34
Chinee apple	No	Yes	Yes	0.6174	0.4595	Low	0.2657	No	35	12
Sicklepod	Yes	Yes	Yes	0.6174	0.4330	Medium	0.1373	Yes	30	20
Grader grass	No	No	Yes	0.6174	0.4065	Medium	0.1445	Yes	34	43
Tobacco weed	No	No	Yes	0.6174	0.4065	Medium	0.0041	Yes	44	25
Mother of millions	Yes	No	Yes	0.4914	0.2651	Medium	0.4980	No	54	30
Giant sensitive plant	No	Yes	Yes	0.5	0.5	Medium	0.7	Yes		5
Snake weed	No	No	Yes	0.6174	0.1344	Medium	0.1392	Yes	68	19
Calotrope	Yes	Yes	Yes	0.6174	0.0707	Medium	0.3165	No	70	35
Sida	No	No	Yes	0.6174	0.2651	Medium	0.5797	Yes	45	
Mimosa bush	No	Yes	Yes					No		
Noogoora burr	No	Yes	Yes	0.6174	0.6060	Low	0.8864	No	28	45

[1] Economic losses due to rubber vine have decreased from high to medium due to the successful introduction of the rubber vine rust (*Maravalia cryptostegiae*).

Table 2. List of potential weeds significant to the grazing industry in north Queensland. Values in table generated from Thorp and Lynch 2000, and Bebawi *et al.* 2002.

Weed species	Toxic	Impedes mustering	Reduces pasture	Monoculture index	Invasiveness index	Economic loss	Potential for spread	Contaminant of produce	WONS ranking	TWRC ranking
Captain Cook Bush	Yes	Yes	Yes	0.2	0.2	Low	0.2	No		13
Praxelis	No	No	Yes	0.6	0.7	High	0.6	Yes		4
Mission grass	No	No	Yes (reduces palatable & productive grasses)	0.6174	0.4330	Medium	0.0275	Yes	46	
Neem tree	No?	Yes	Yes			Medium		No		
Sisal hemp	No	Yes	Yes	0.1	0.1	Low	0.1	No		18

Table 3. List of aquatic weeds significant to the grazing industry in north Queensland. Values in table generated from Thorp and Lynch 2000, and Bebawi *et al.* 2002.

Weed species	Toxic	Impedes mustering	Reduces pasture	Monoculture index	Invasiveness index	Economic loss	Potential for spread	Contaminant of produce	WONS ranking	TWRC ranking
Cumbungi	No	No	No					No		
Salvinia	No	No	No	0.5994	0.9015	Low	0.2124	No	9	31
Water hyacinth	No	No	No	0.4914	0.4595	Low	0.2716	No	25	29
Cabomba	No	No	No	0.6174	0.7954	High	0.0262	No	11	11

Table 4. Productive and palatable plants perceived as potential weeds outside the grazing industry. Values in table generated from Thorp and Lynch 2000, and Bebawi *et al.* 2002.

Weed species	Toxic	Impedes mustering	Reduces pasture	Monoculture index	Invasiveness index	Economic loss	Potential for spread	Contaminant of Produce	WONS ranking	TWRC ranking
Hymenachne	No	No	No	0.6174	0.8484	High	0.0589	No	8	9
Leucaena										
Gamba grass	No	No		0.5	0.4	Medium	0.4	Yes		10
Aleman grass										

Table 5. Troublesome native species that are significant to the grazing industry in north Queensland.

Weed species	Toxic	Impedes mustering	Reduces pasture	Contaminant of Produce
Currant bush	No	Yes	Yes	No
Heart-leaf Poison Bush	Yes	No	Yes	No
Black wattle	No	Yes	Yes	No
Cocky apple	No?	Yes	Yes	No
Whitewood[1]	No	Yes	Yes	No
Guttapercha[1]	No?	Yes	Yes	No
Bauhinia	No	Yes	Yes	No

[1] Whitewood (*Atalaya hemiglauca*) and Guttapercha (*Excoecaria parvifolia*) are listed as 'Of concern' under the Vegetation Management Act 1999.

Table 6. Research and development needs for exotic weeds within northern Queensland.

Weed species	Research Needs						
	Biological	**Mechanical**	**Ecology**	**Pasture competition**	**Fire**	**Extension/ Adoption**	**Chemical**
Mesquite	√	X[2]	X[2]	X[2]	X[2]	√	X[2]
Parkinsonia	√	√	√	√	√	√	
Rubber vine						√	
Prickly acacia						√	
Lantana			√	√		√	
Parthenium				√		√	atrazine replacement
Bellyache bush	√	√	√	√	√	√	aerial
Giant rats tail grass	√		√	√	√	√	aerial
Hyptis	√	√		√	√		
Chinee apple		√ (Adaptive work)	√ [3]				
Sicklepod	√		√	√	√	√	
Grader grass	√[1]			√	√	√	
Tobacco weed	√	slashing	√	√	√	√	aerial
Mother of millions	√		√	√	√	√	
Giant sensitive plant		slashing		√	√	√	
Snake weed	√	slashing	√	√	√	√	
Calotrope	√	√	√	√	√	√	aerial
Sida		slashing		√	√	√	
Mimosa bush			√			√	
Noogoora burr						√	

[1] The potential for finding successful biological control agents may be complicated due to the occurrence of kangaroo grass (*Themeda australis*)
[2] Applies to *Prosopis pallida* only, other Prosopis species would require research
[3] Chinee apple ecology research is currently in progress by Tony Grice, CSIRO. Adaptive research utilising machinery as the primary treatment and chemicals as the secondary treatment is required.

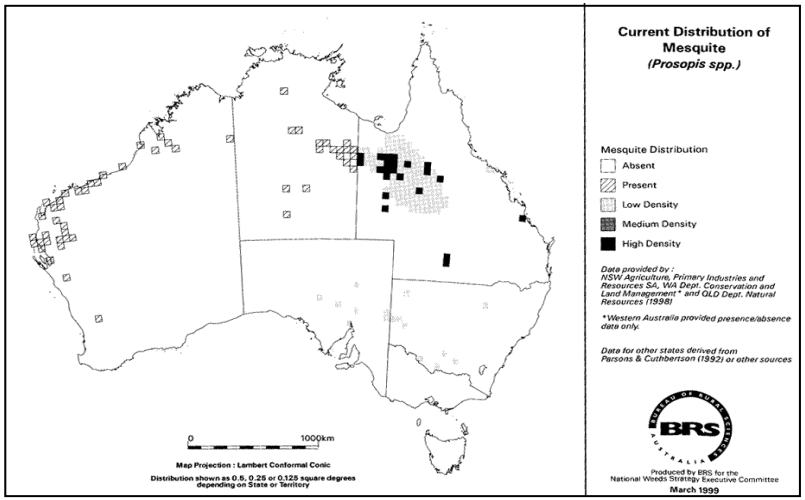
Table 7. Research and development needs for potential weeds within northern Queensland.

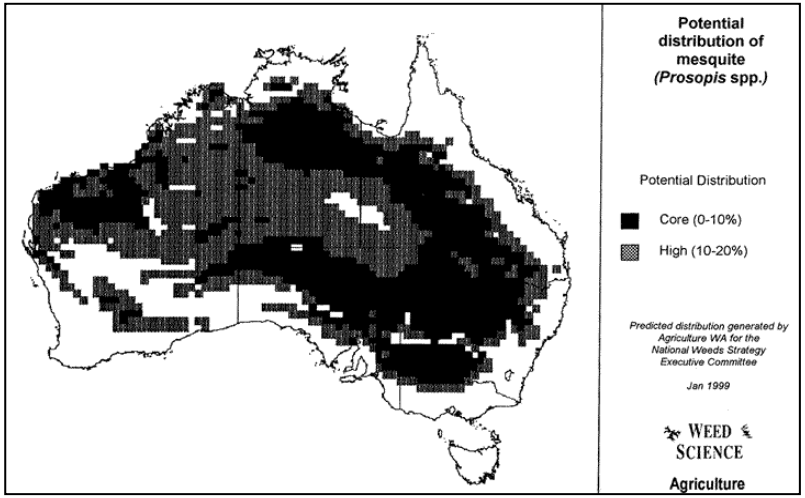
Weed species	Research Needs						
	Biological	Mechanical	Ecology	Pasture competition	Fire	Adaptive	Chemical
Captain Cook Bush	√	√	√	√	√	√	√
Praxelis	√	slashing	√	√	√	√	√
Mission grass	√		√	√	√	√	√
Neem tree	√	√	√	√	√	√	√
Sisal hemp	√		√	√	√	√	

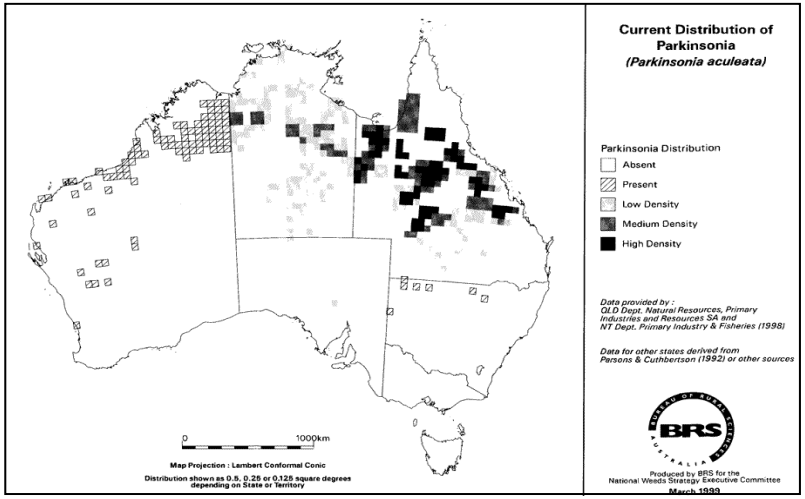
Table 8. Research and development needs for aquatic weeds within northern Queensland.

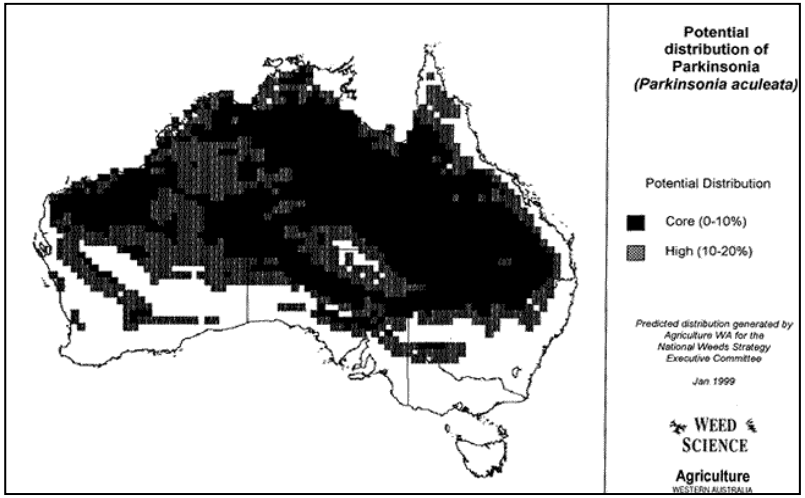
Weed species	Research Needs						
	Biological	Mechanical	Ecology	Pasture competition	Fire	Adaptive management	Chemical
Cumbungi		√		n/a	√	√	
Salvinia		√		n/a	N/a	√	
Water hyacinth		√		n/a	N/a	√	
Cabomba		√	√	n/a	N/a		√

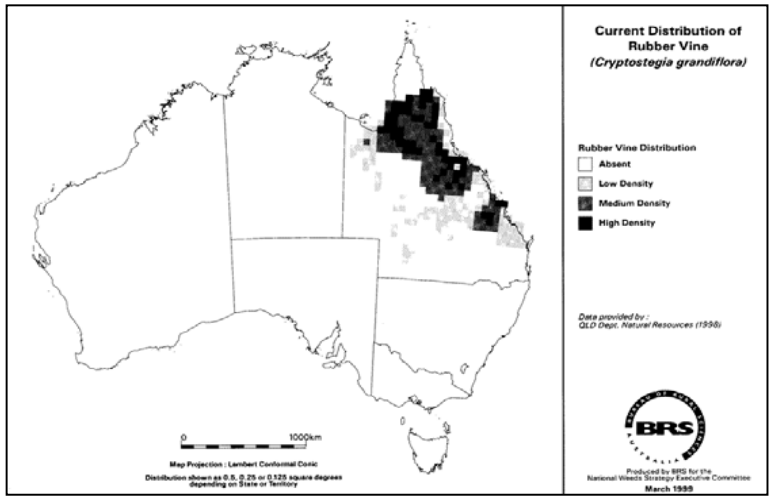
Figure 2 (Pages 16-32). National current and potential distributions of weeds relevant to the grazing industries of north Queensland. For exotic species the current distribution maps of exotic species were derived from Thorp and Lynch (2000) and potential distribution maps were prepared from Rod Randall (Western Australia Department of Agriculture). Current distribution maps of native plants were modified from Anderson (1993).

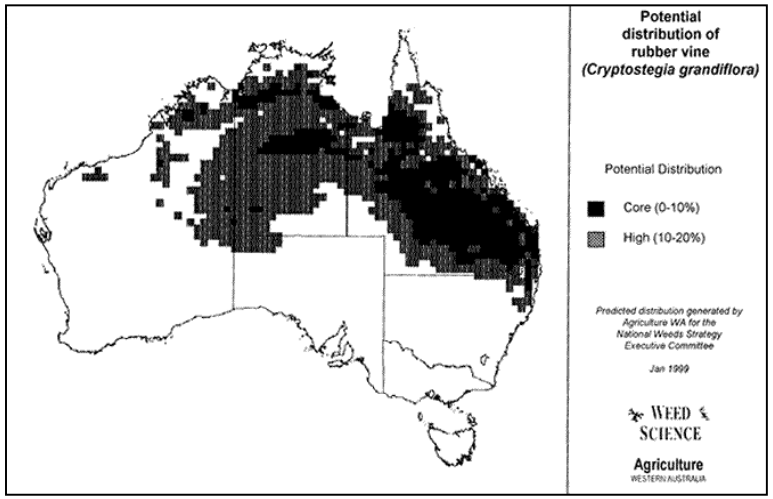

Current Distribution of Mesquite
(Prosopis spp.)
Mesquite Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by : NSW Agriculture, Primary Industries and Resources SA, WA Dept. Conservation and Land Management * and QLD Dept. Natural Resources (1998)
*Western Australia provided presence/absence data only.
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
0 1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999

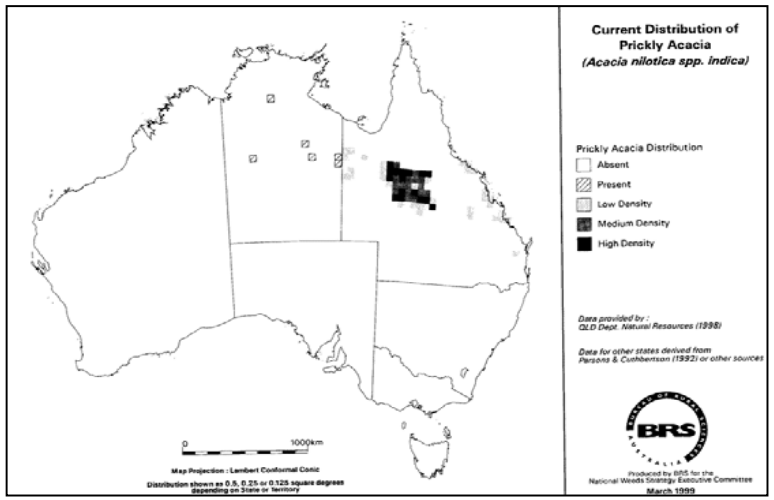

Potential distribution of mesquite
(Prosopis spp.)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture

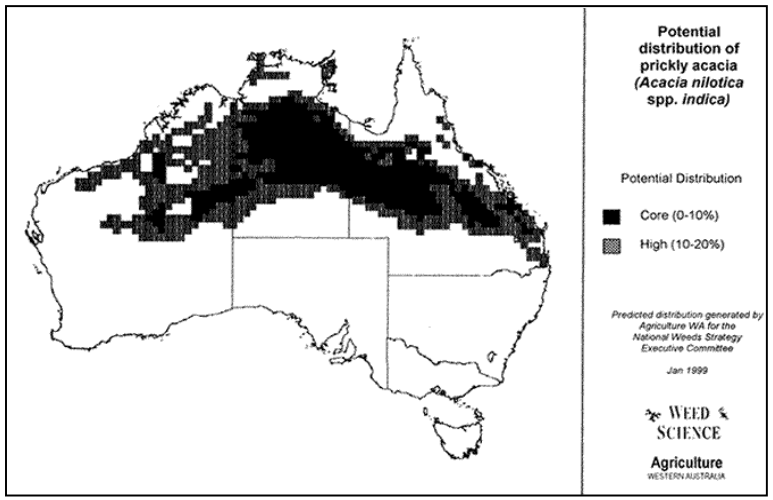

Current Distribution of Parkinsonia
(Parkinsonia aculeata)
Parkinsonia Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by : QLD Dept. Natural Resources, Primary Industries and Resources SA and NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
0 1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999

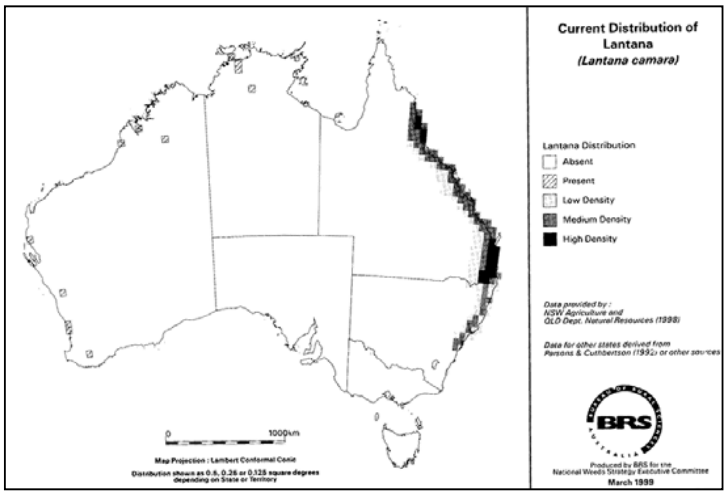

Potential distribution of Parkinsonia
(Parkinsonia aculeata)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA

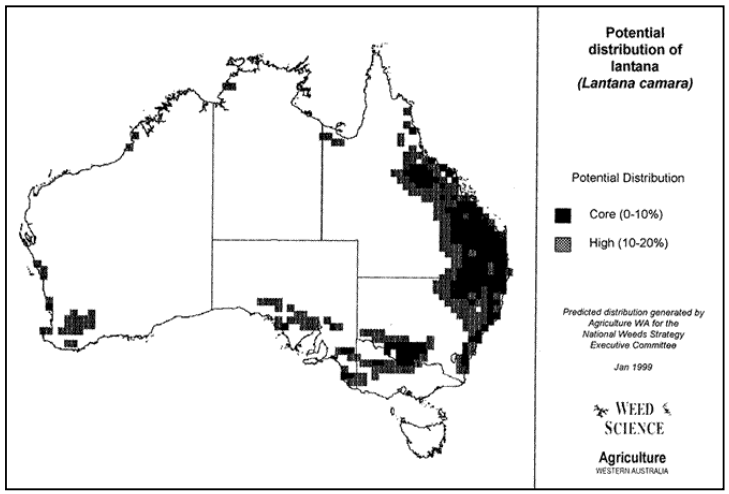

Current Distribution of
Rubber Vine
(Cryptostegia grandiflora)
Rubber Vine Distribution
Absent
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1996)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
rubber vine
(Cryptostegia grandiflora)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of
Prickly Acacia
(Acacia nilotica spp. indica)
Prickly Acacia Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
Data for other states derived from
Persons & Cumbertsson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
prickly acacia
(Acacia nilotica
spp. indica)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of Lantana
(Lantana camara)
Lantana Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
NSW Agriculture and
QLD Dept. Natural Resources (1998)
Data for other states derived from
Parsons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential distribution of lantana
(Lantana camara)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
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WEED SCIENCE
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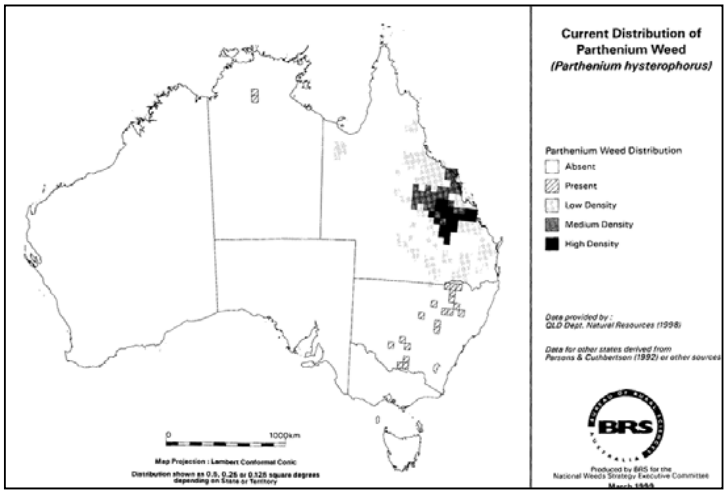
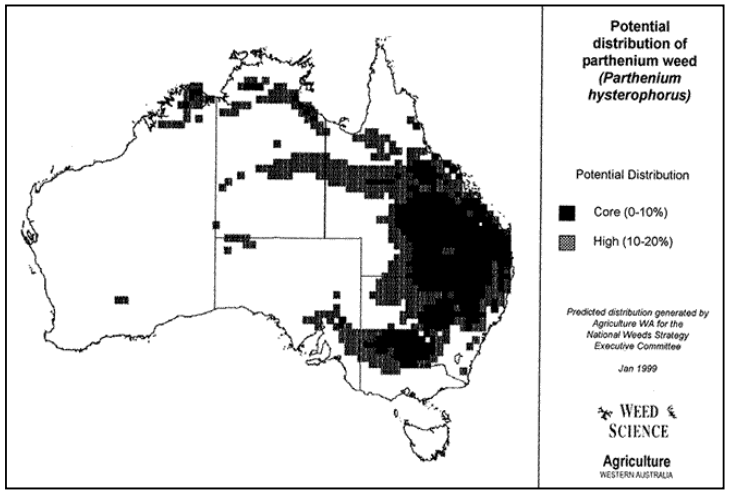

Current Distribution of Parthenium Weed
(Parthenium hysterophorus)
Parthenium Weed Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
Data for other states derived from
Parsons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee


Potential distribution of parthenium weed
(Parthenium hysterophorus)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
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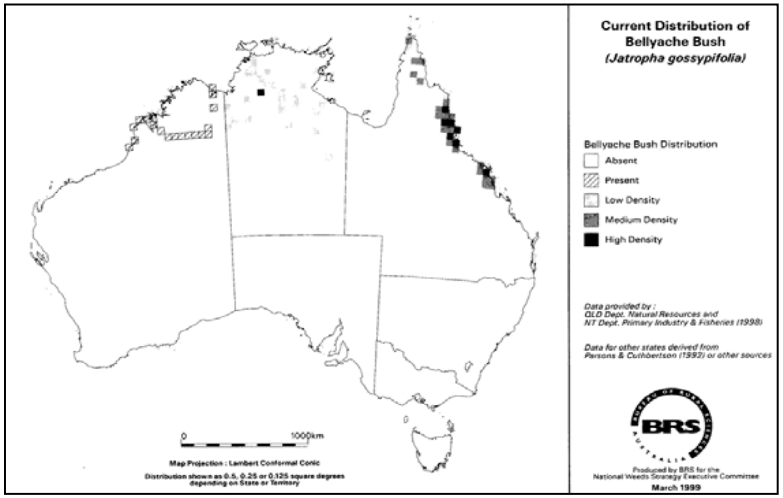
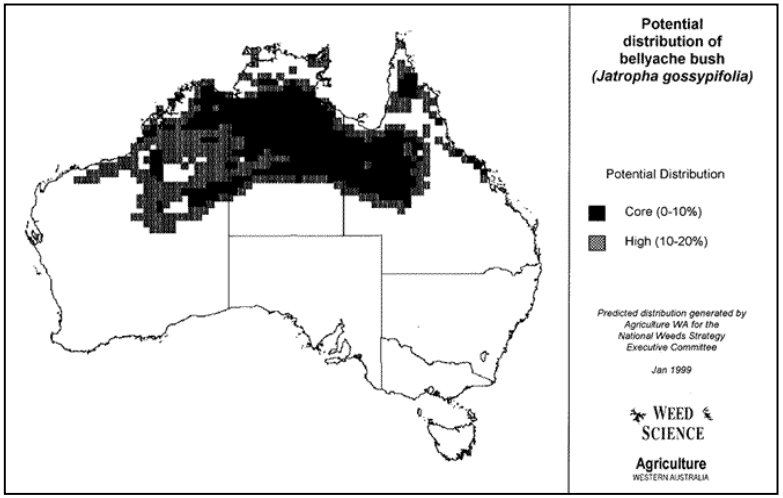

Current Distribution of
Bellyache Bush
(Jatropha gossypifolia)
Bellyache Bush Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources and
NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from
Persons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
bellyache bush
(Jatropha gossypifolia)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
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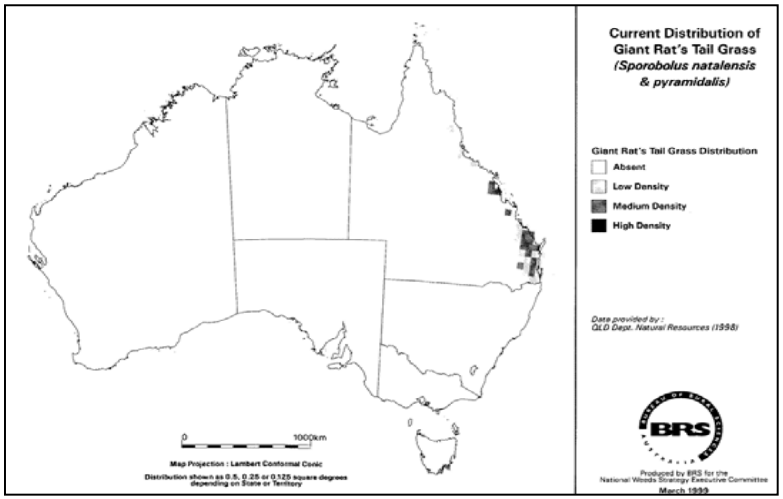
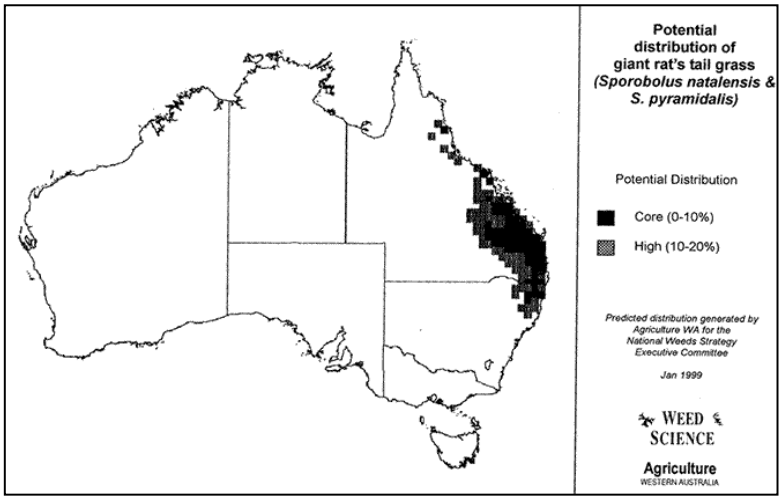

Current Distribution of
Giant Rat's Tail Grass
(Sporobolus natalensis
& pyramidalis)
Giant Rat's Tail Grass Distribution
Absent
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
giant rat's tail grass
(Sporobolus natalensis &
S. pyramidalis)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
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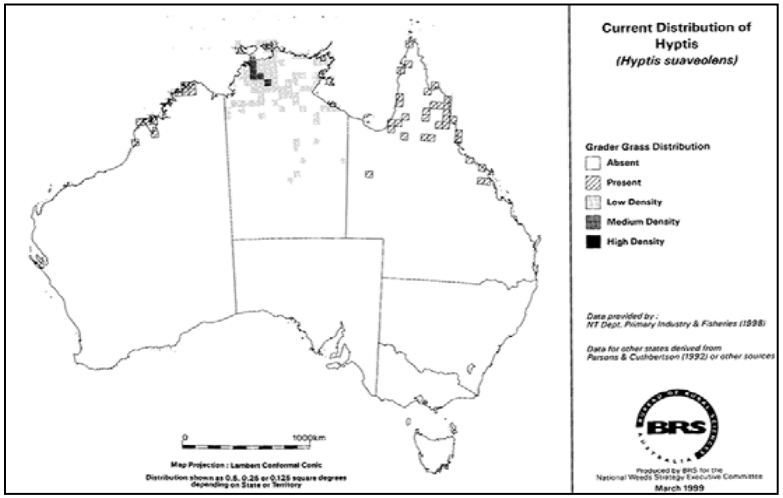
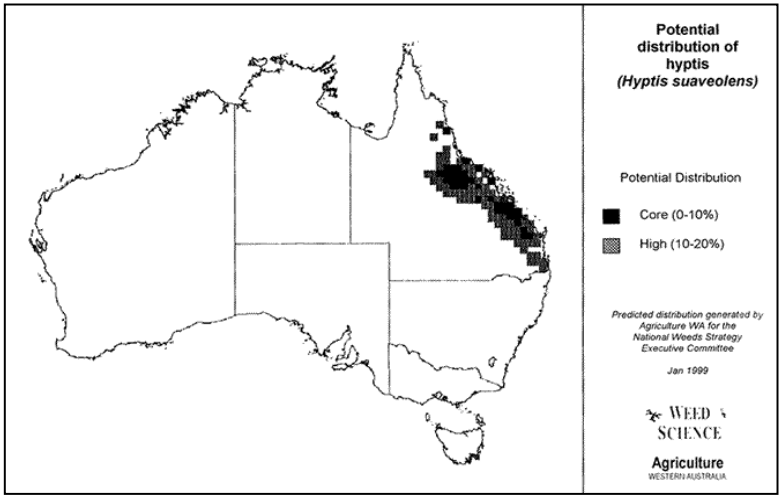

Current Distribution of Hyptis
(Hyptis suaveolens)
Grader Grass Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999


Potential distribution of hyptis
(Hyptis suaveolens)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
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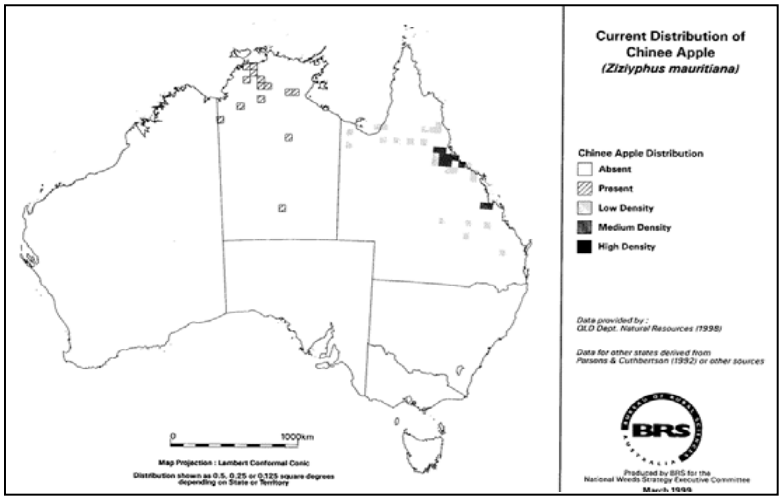
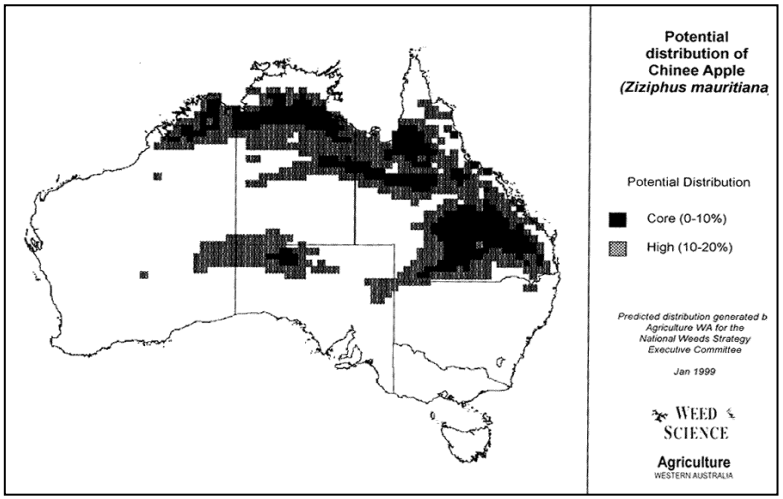
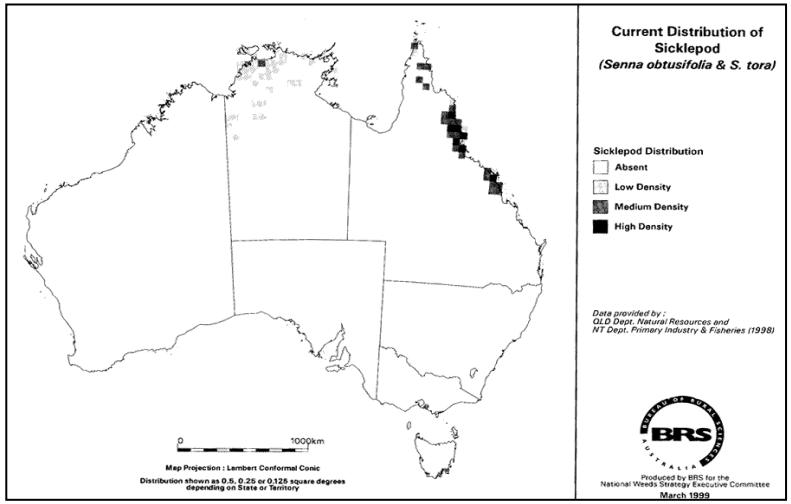
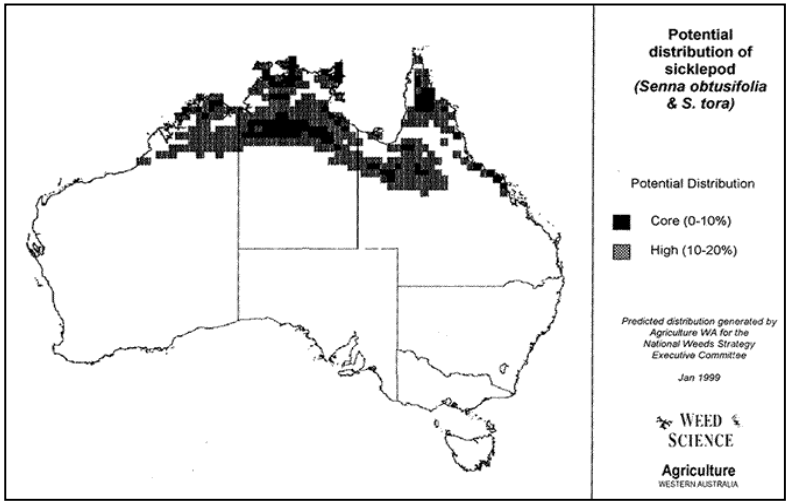

Current Distribution of Chinee Apple
(Ziziyphus mauritiana)
Chinee Apple Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the National Weeds Strategy Executive Committee


Potential distribution of Chinee Apple
(Ziziphus mauritiana
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated b Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of Sicklepod
(Senna obtusifolia & S. tora)
Sicklepod Distribution
Absent
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources and
NT Dept. Primary Industry & Fisheries (1998)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential distribution of sicklepod
(Senna obtusifolia & S. tora)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
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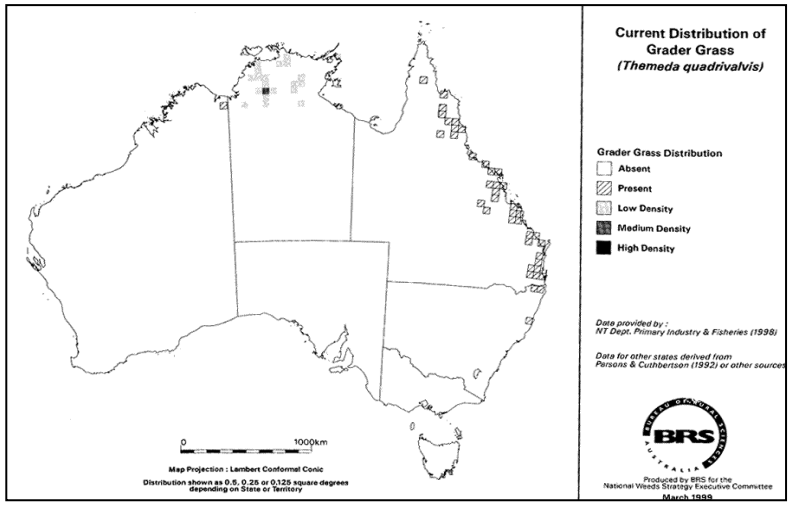
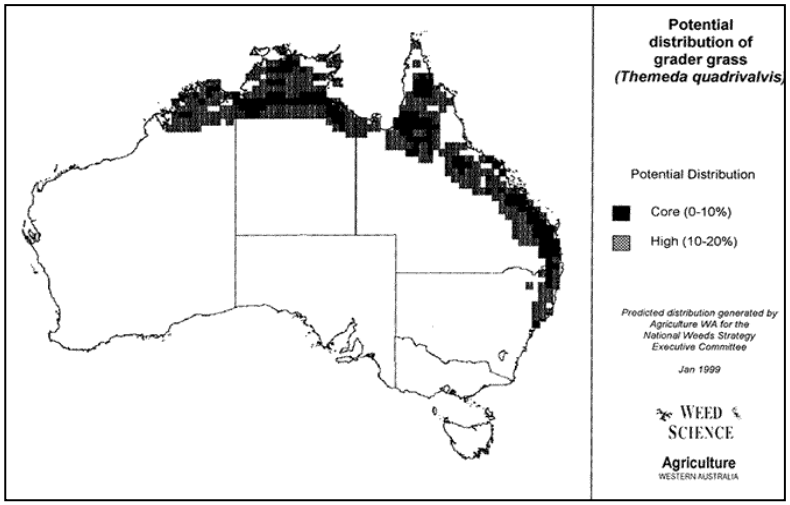

Current Distribution of Grader Grass
(Themeda quadrivalvis)
Grader Grass Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from
Persons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential distribution of grader grass
(Themeda quadrivalvis)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
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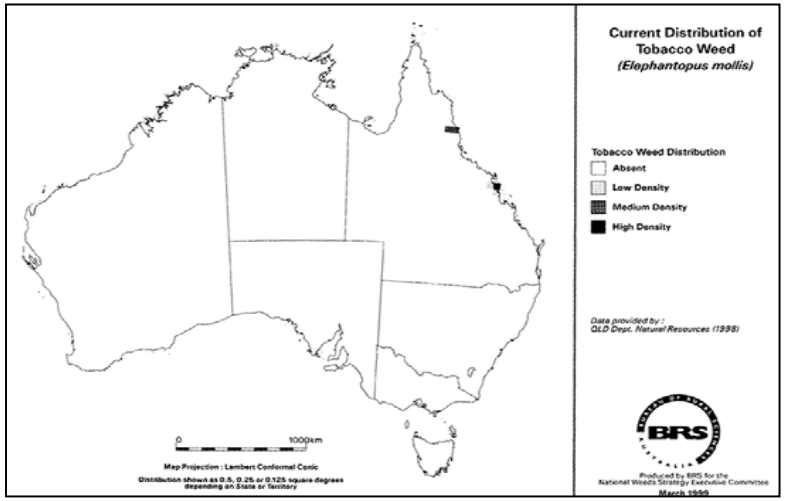
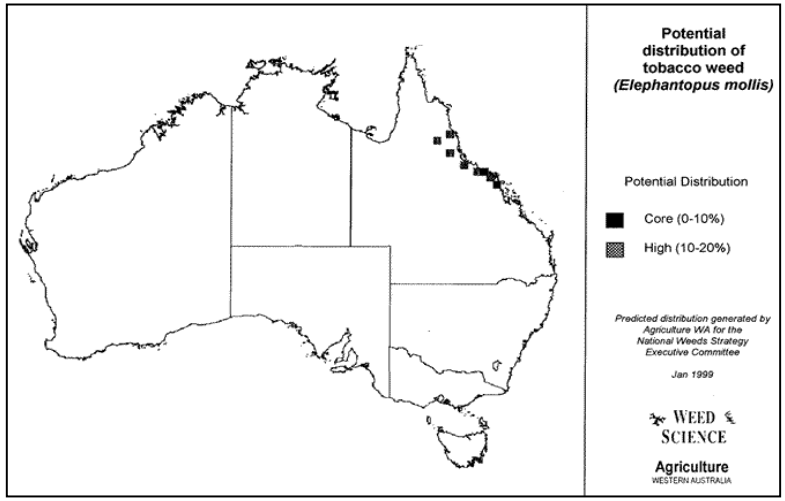

Current Distribution of
Tobacco Weed
(Elephantopus mollis)
Tobacco Weed Distribution
Absent
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
tobacco weed
(Elephantopus mollis)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
Jan 1999
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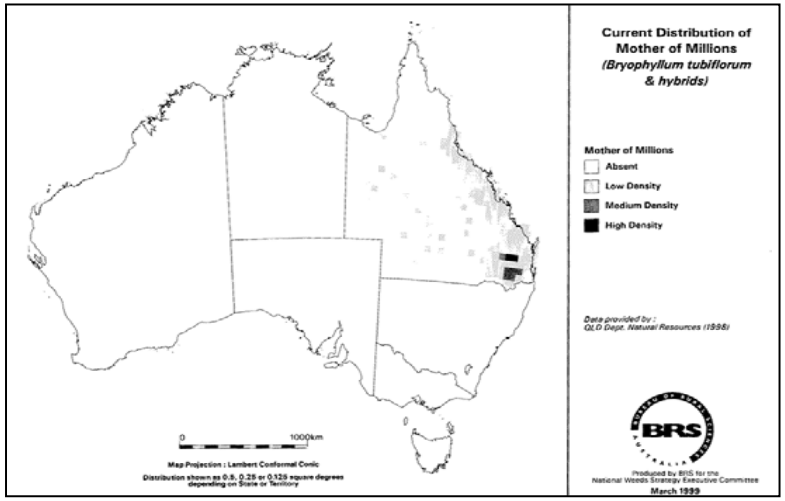
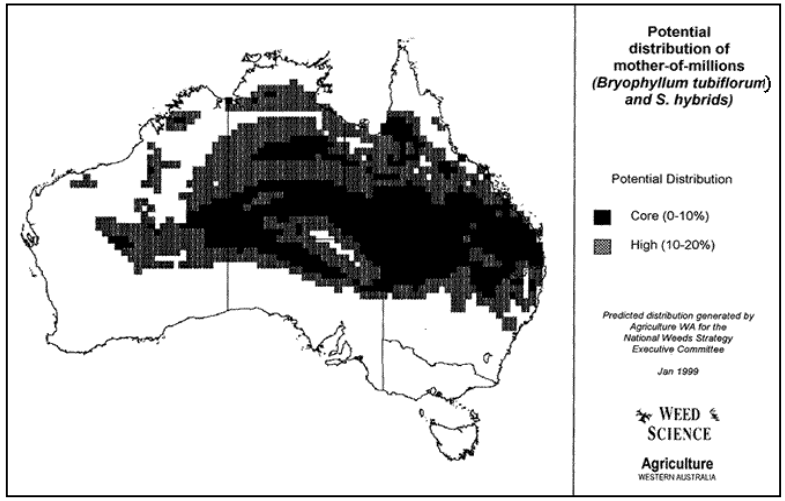

Current Distribution of
Mother of Millions
(Bryophyllum tubiflorum
& hybrids)
Mother of Millions
Absent
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential
distribution of
mother-of-millions
(Bryophyllum tubiflorum)
and S. hybrids)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by
Agriculture WA for the
National Weeds Strategy
Executive Committee
Jan 1999
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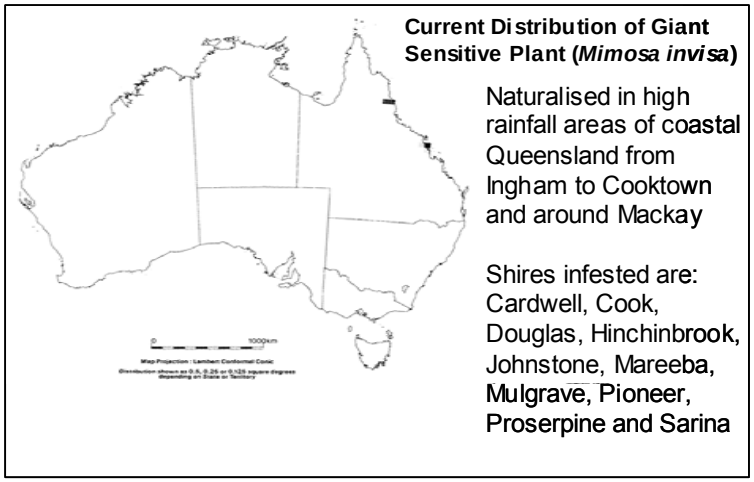
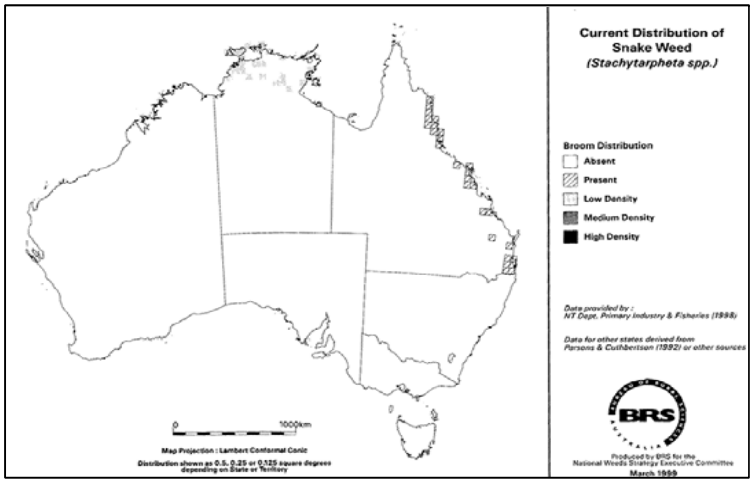
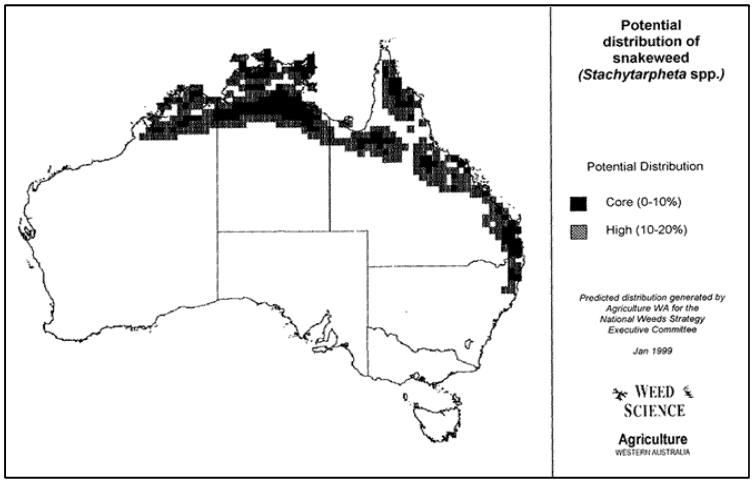
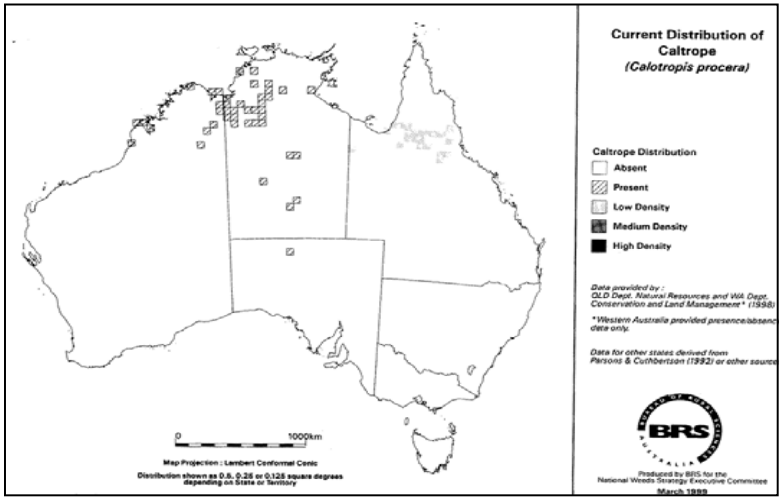

Current Distribution of Giant Sensitive Plant (*Mimosa invisa*)
Naturalised in high rainfall areas of coastal Queensland from Ingham to Cooktown and around Mackay
Shires infested are: Cardwell, Cook, Douglas, Hinchinbrook, Johnstone, Mareeba, Mulgrave, Pioneer, Proserpine and Sarina


Current Distribution of Snake Weed
(Stachytarpheta spp.)
Broom Distribution
Absent
Present
Low Density
Medium Density
High Density
BRS


Potential distribution of snakeweed
(Stachytarpheta spp.)
Potential Distribution
Core (0-10%)
High (10-20%)
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of Caltrope
(Calotropis procera)
Caltrope Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources and WA Dept. Conservation and Land Management * (1998)
*Western Australia provided presence/absence data only.
Data for other states derived from Persons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
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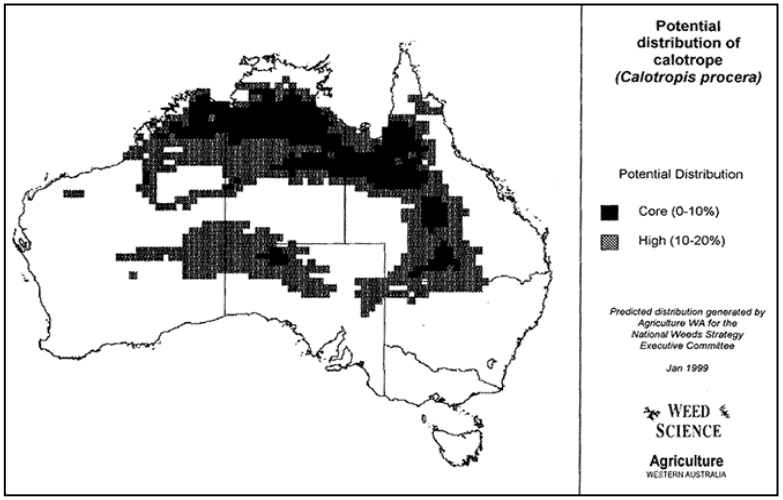
March 1999


Potential distribution of calotrope
(Calotropis procera)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
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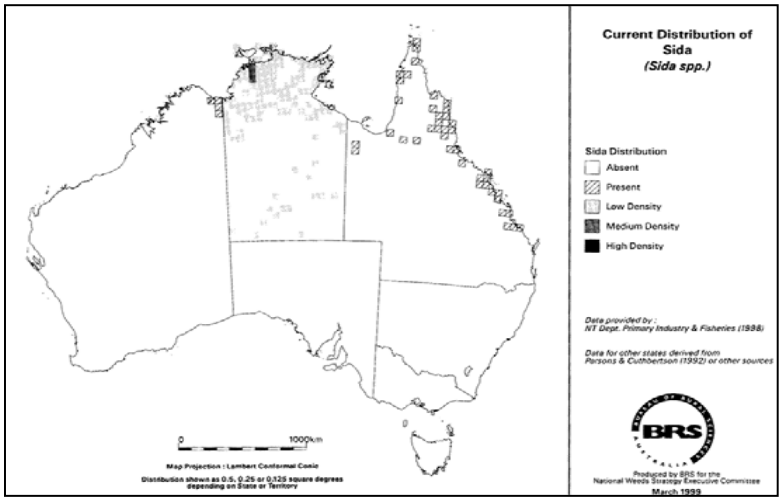
Current Distribution of Sida
(Sida spp.)
Sida Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from Persons & Cuthbertson (1992) or other sources
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
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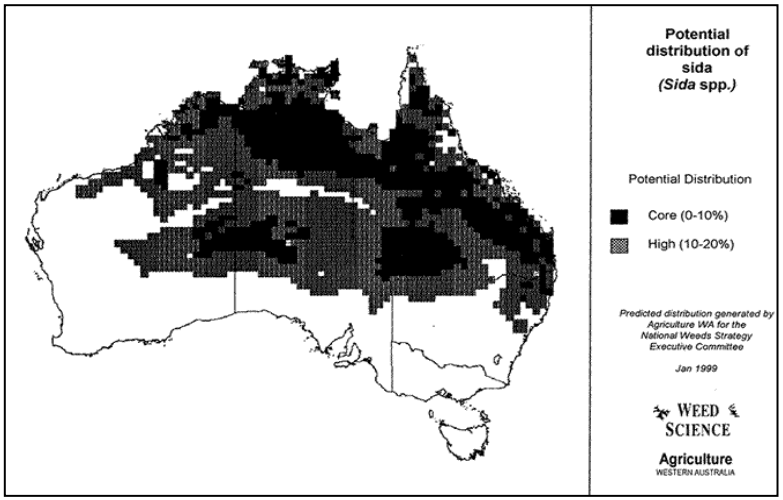
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999


Potential distribution of sida
(Sida spp.)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
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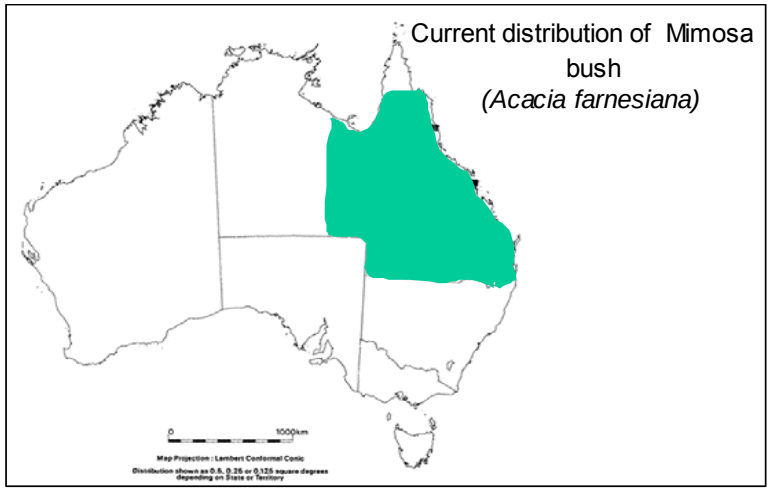
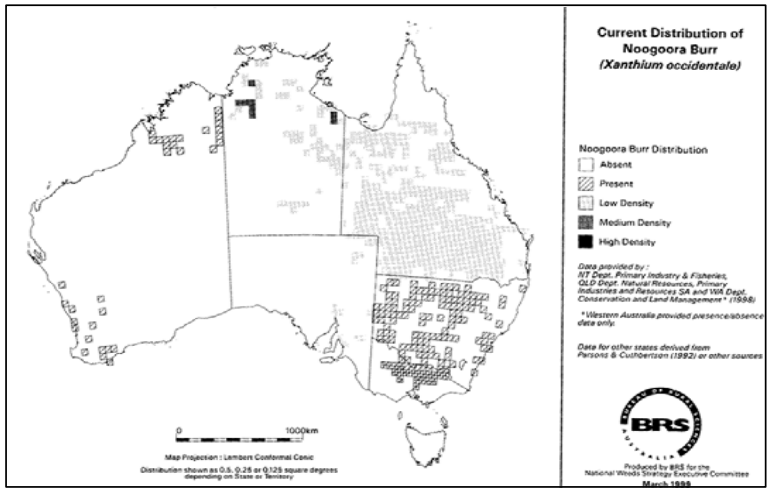
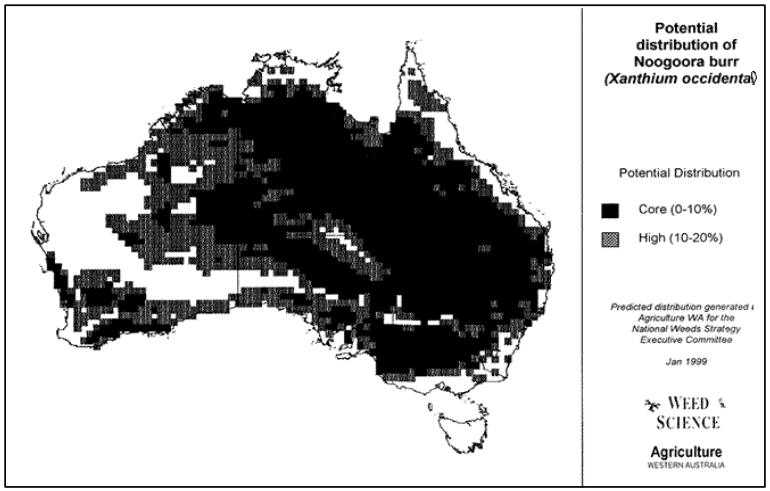

Current distribution of Mimosa bush
(Acacia farnesiana)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Current Distribution of Noogoora Burr
(Xanthium occidentale)
Noogoora Burr Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by :
NT Dept. Primary Industry & Fisheries,
QLD Dept. Natural Resources, Primary Industries and Resources SA and WA Dept. Conservation and Land Management * (1998)
*Western Australia provided presence/absence data only.
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Potential distribution of Noogoora burr
(Xanthium occidentale)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated
Agriculture WA for the
National Weeds Strategy
Executive Committee
Jan 1999
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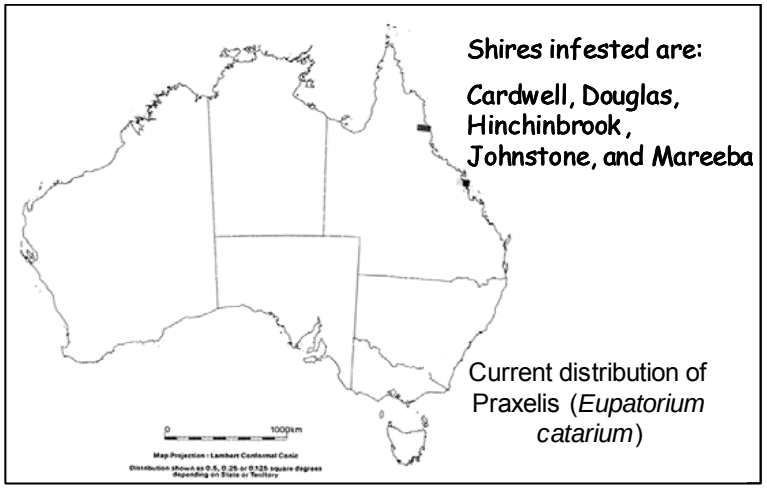
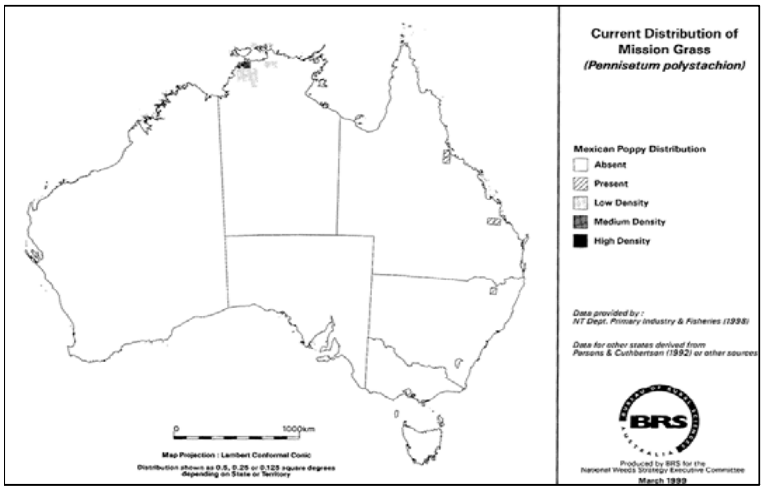
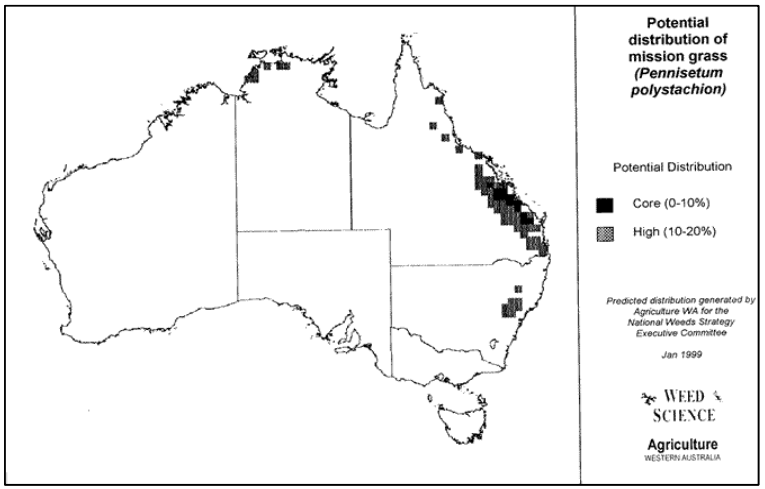

Shires infested are:
Cardwell, Douglas, Hinchinbrook, Johnstone, and Mareeba
Current distribution of Praxelis (*Eupatorium catarium*)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Current Distribution of Mission Grass
(Pennisetum polystachion)
Mexican Poppy Distribution
Absent
Present
Low Density
Medium Density
High Density
Data provided by : NT Dept. Primary Industry & Fisheries (1998)
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Potential distribution of mission grass
(Pennisetum polystachion)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
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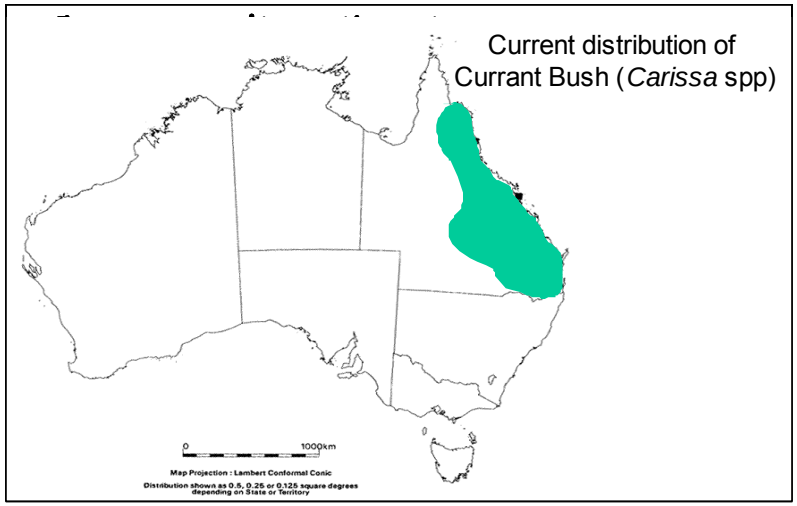
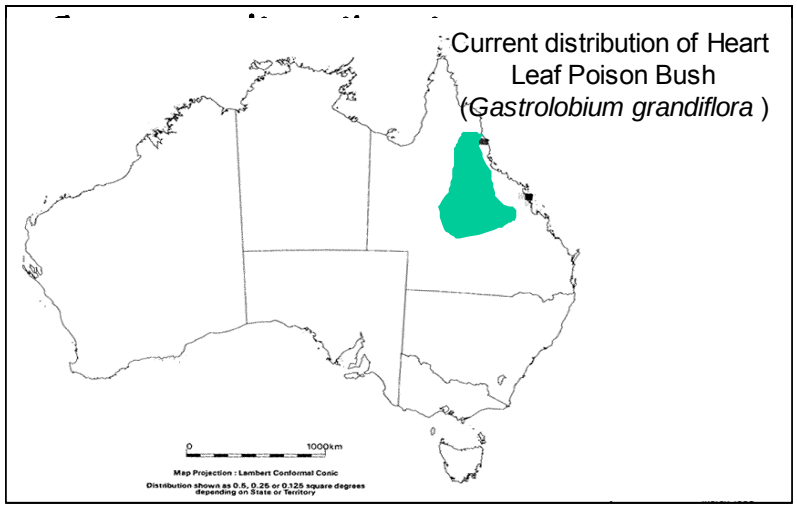
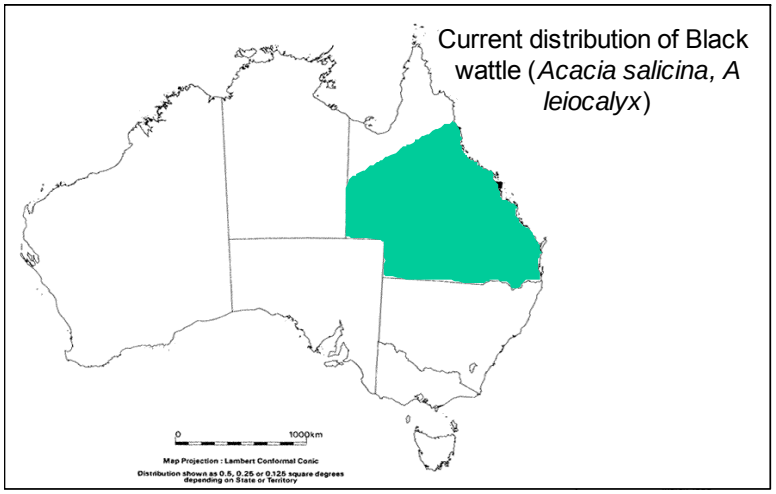

Current distribution of
Currant Bush (*Carissa* spp)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory


Current distribution of Heart
Leaf Poison Bush
(*Gastrolobium grandiflora*)
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees
depending on State or Territory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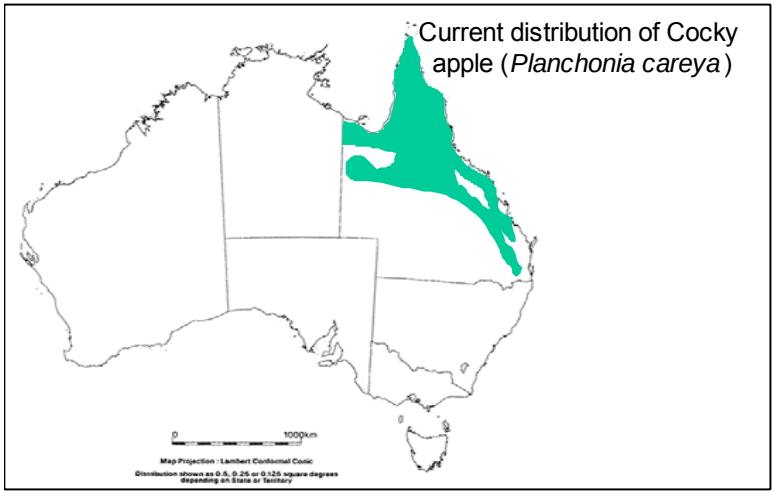
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory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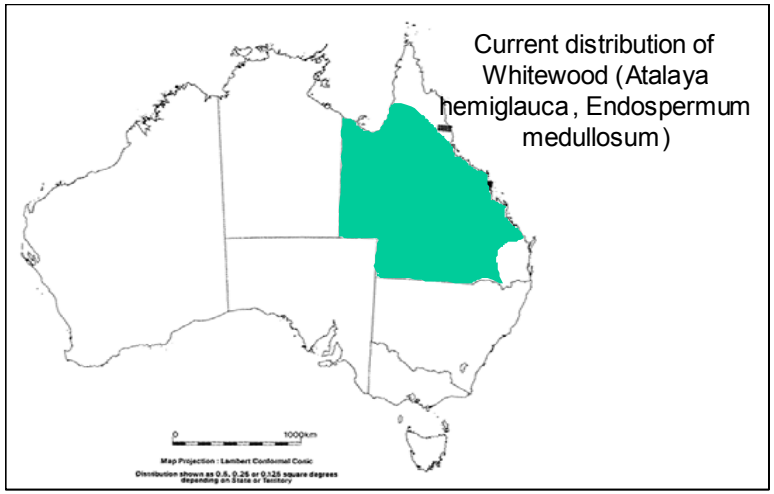
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Current distribution of Whitewood (Atalaya hemiglauca, Endospermum medullosum)
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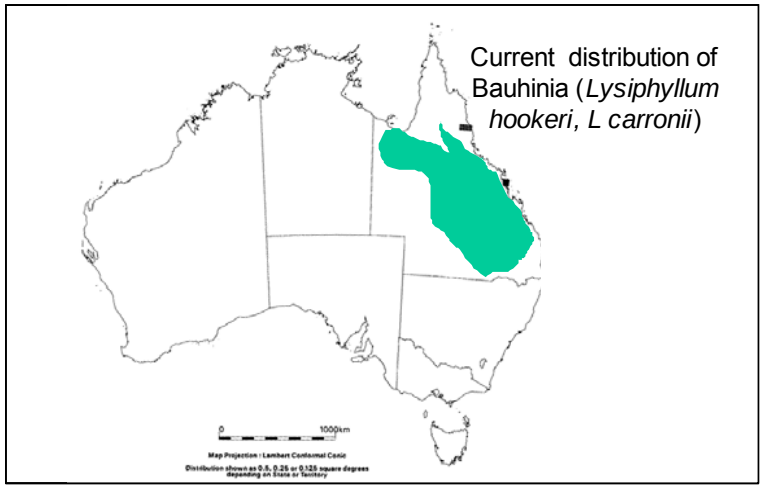
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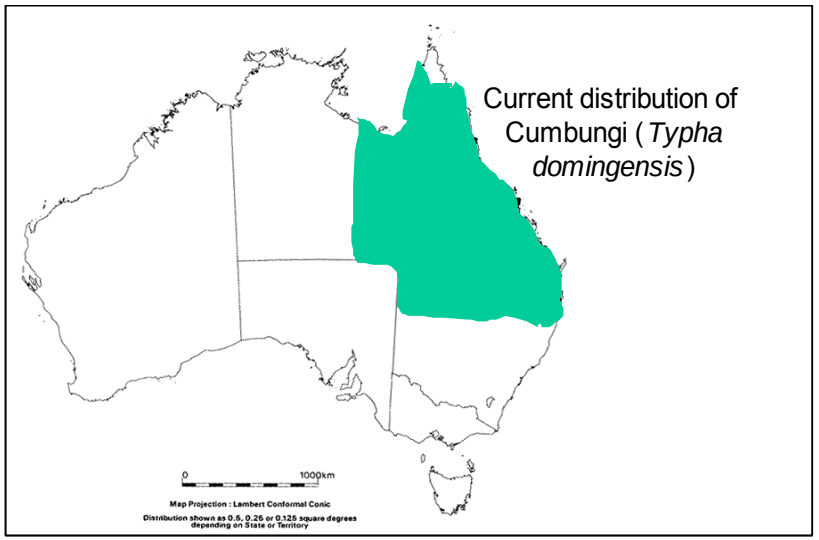
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory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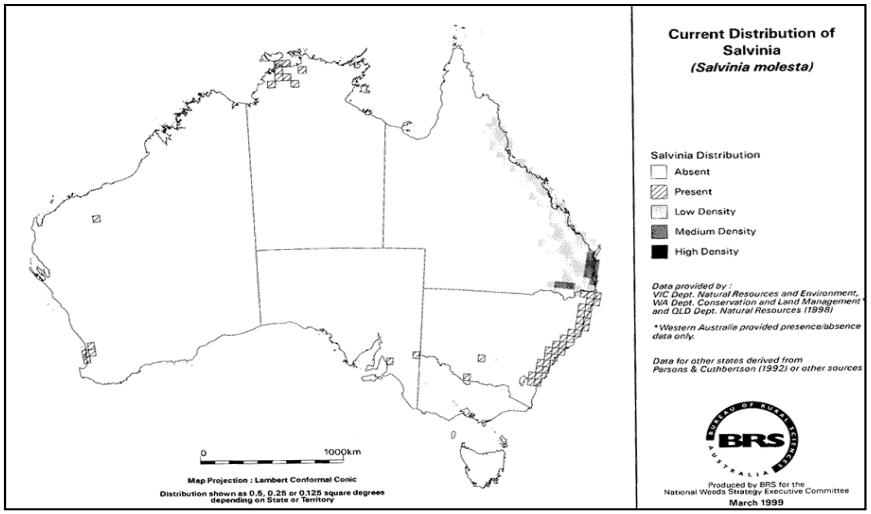
Current Distribution of Salvinia
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Salvinia Distribution
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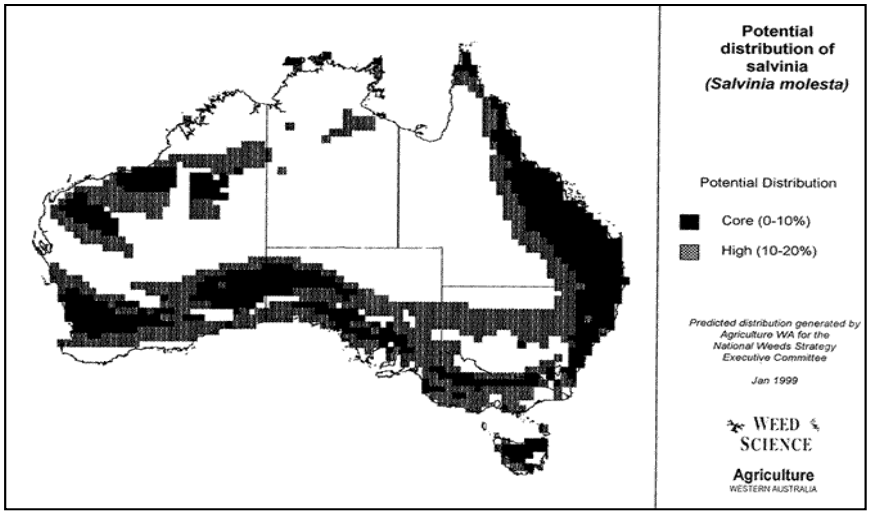
Present
Low Density
Medium Density
High Density
Data provided by : VIC Dept. Natural Resources and Environment, WA Dept. Conservation and Land Management* and QLD Dept. Natural Resources (1998)
*Western Australia provided presence/absence data only.
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999
0
1000km
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory


Potential distribution of salvinia
(Salvinia molesta)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
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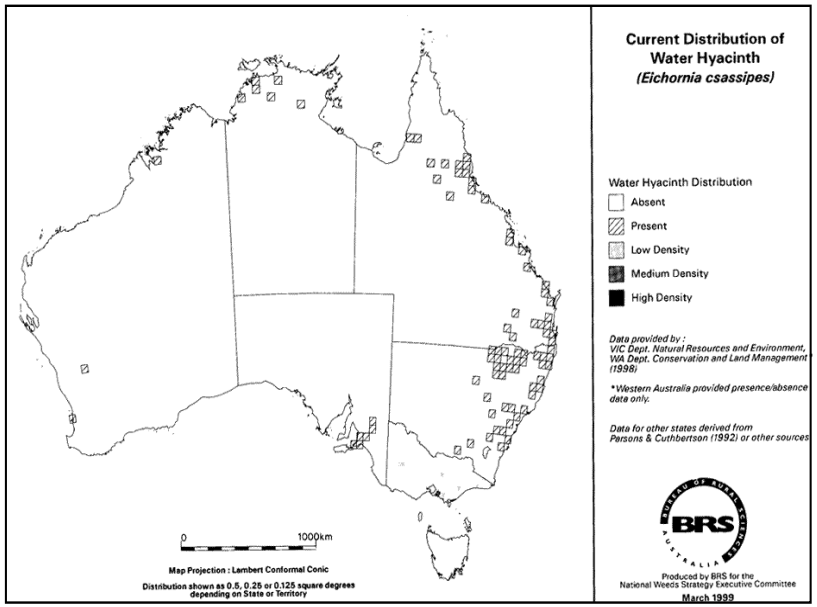
WESTERN AUSTRALIA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Water Hyacinth Distribution
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Low Density
Medium Density
High Density
Data provided by :
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WA Dept. Conservation and Land Management (1998)
*Western Australia provided presence/absence data only.
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
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Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
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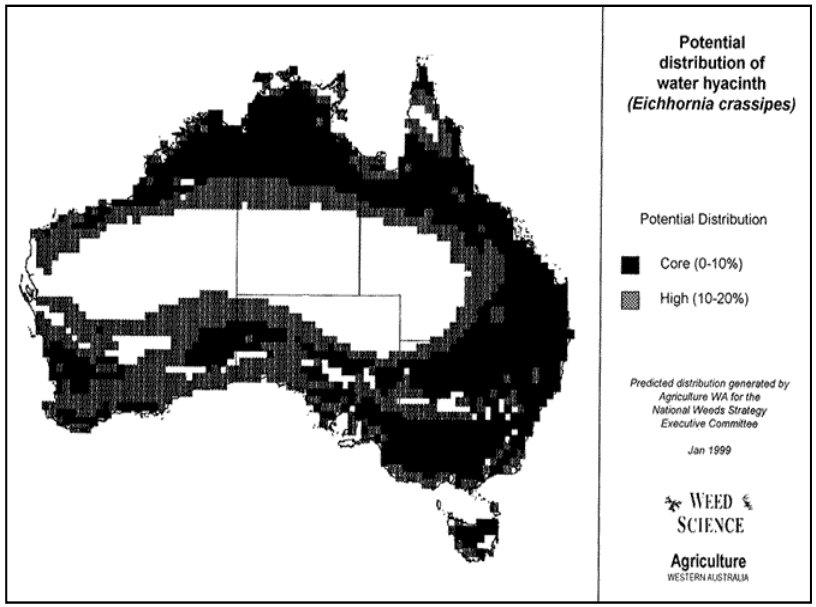
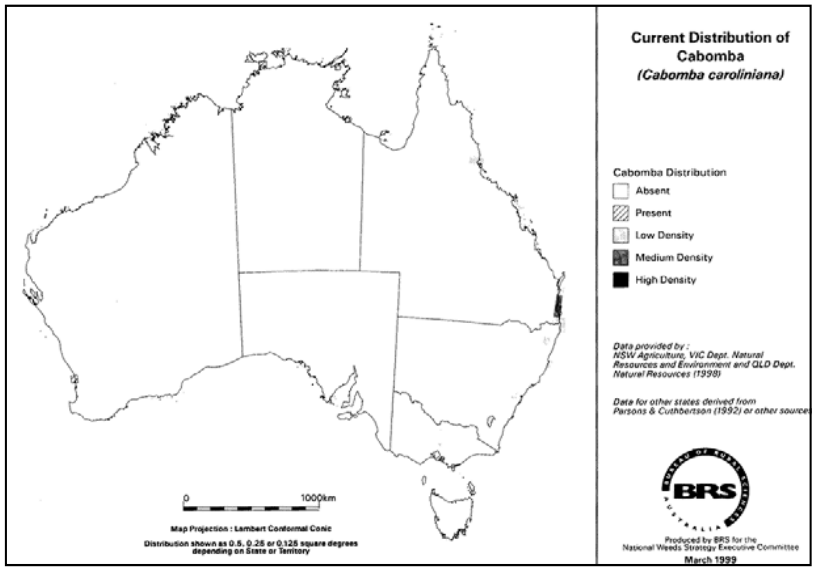
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999


Potential distribution of water hyacinth
(Eichhornia crassipes)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of Cabomba
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Cabomba Distribution
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Present
Low Density
Medium Density
High Density
Data provided by :
NSW Agriculture, VIC Dept. Natural Resources and Environment and QLD Dept. Natural Resources (1998)
Data for other states derived from Parsons & Cuthbertson (1992) or other sources
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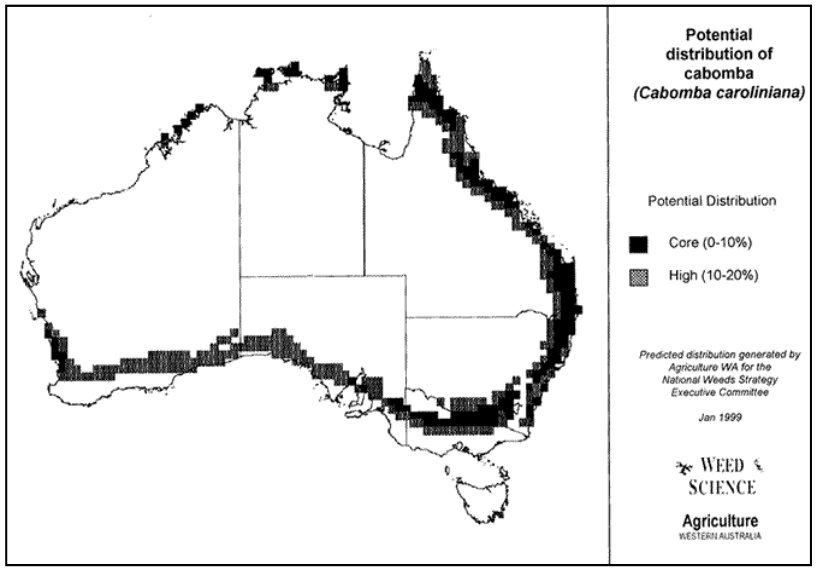
Map Projection : Lambert Conformal Conic
Distribution shown as 0.5, 0.25 or 0.125 square degrees depending on State or Territory
BRS
Produced by BRS for the National Weeds Strategy Executive Committee
March 1999


Potential distribution of cabomba
(Cabomba caroliniana)
Potential Distribution
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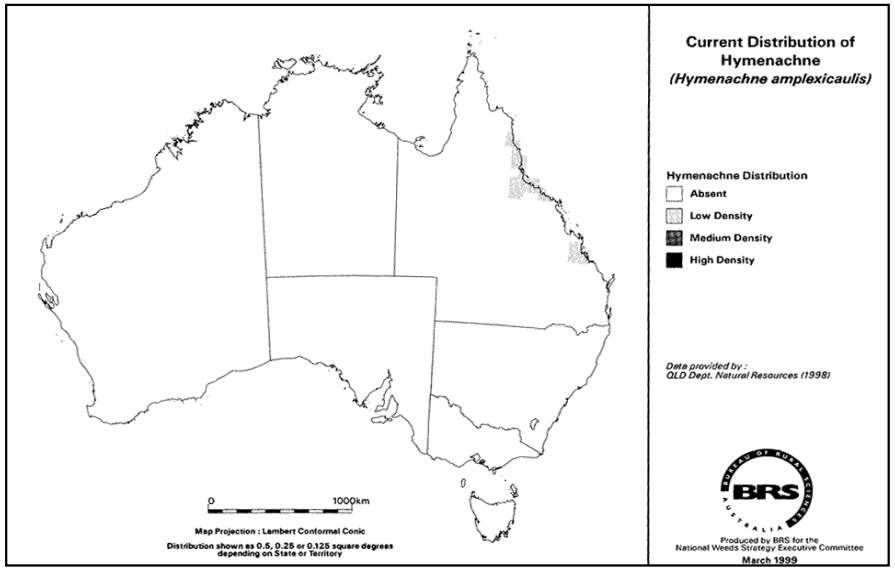
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA


Current Distribution of Hymenachne
(Hymenachne amplexicaulis)
Hymenachne Distribution
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Low Density
Medium Density
High Density
Data provided by :
QLD Dept. Natural Resources (1998)
0
1000km
Map Projection : Lambert Conformal Conic
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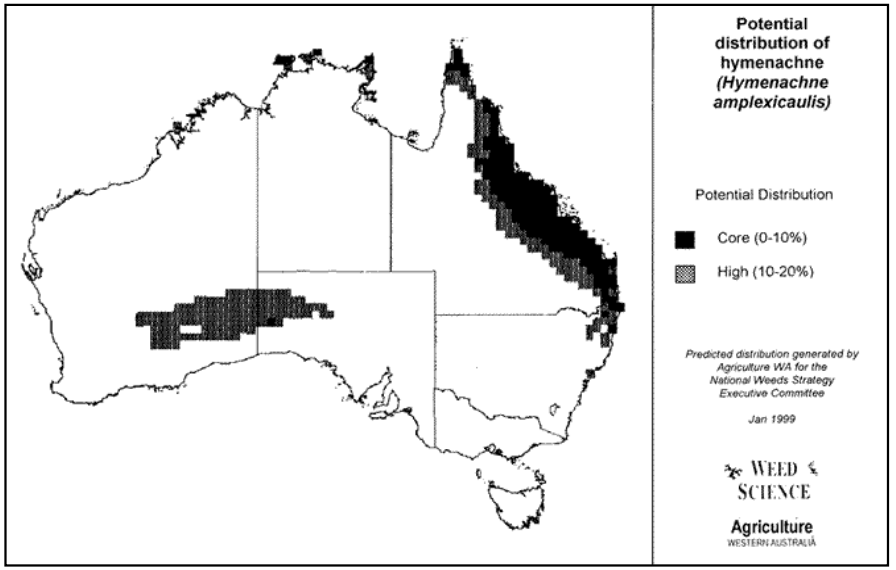
BRS
Produced by BRS for the
National Weeds Strategy Executive Committee
March 1999


Potential distribution of hymenachne
(Hymenachne amplexicaulis)
Potential Distribution
Core (0-10%)
High (10-20%)
Predicted distribution generated by Agriculture WA for the National Weeds Strategy Executive Committee
Jan 1999
WEED SCIENCE
Agriculture
WESTERN AUSTRALIA

WEEDS OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF THE NORTHERN TERRITORY

Steve Wingrave, NT Dept of Business, Industry and Resource Development

INTRODUCTION

The Northern Territory occupies an area of 1,348,021 square kilometres of which 674,529 square kilometres is occupied by the pastoral industry. The pastoral industry, based primarily on cattle production (harvest of feral camel and buffalo forms minor industries) is comprised of 215 properties with an average size of 314,000 ha. Currently cattle number 410,000 head with a value of $170,000,000 coming from live export to Asia and interstate movement through Queensland and South Australia.

Arid/semi arid rangelands

The pastoral industry in the central Australian arid/semi arid rangelands is primarily based on grazing of native plant species. These species include annual grasses such as *Enneapogon spp* and *Aristida spp*, a range of perennial native species, chenopod shrublands and also a range of native woody species. More recently Buffel grass (*Cenchrus ciliarus*) has been introduced to the industry in this region.

There is a number of introduced weed species impacting on the pastoral industry in the arid/semi arid rangelands. These species include athel pine (*Tamarix aphylla*), noogoora burr (*Xanthium occidentale*), bathurst burr (*Xanthium spinosum*), saffron thistle (*Carthamus lanatus*), parkinsonia (*Parkinsonia aculeata*), rubberbush (*Calotropis procera*), mesquite (*Prosopis pallida*). It is very difficult to accurately determine the impacts of these species due to the very low stocking rates of the region, the restricted areas of infestation and the ecological niches occupied by the weed species themselves. Interestingly the weeds with the most significant impact in the region are native “increaser” species which are emerging as a problem most likely due to a response to the changing fire regime and the removal of rabbits as a mechanism controlling the recruitment of juvenile woody plant species. Researchers in this region indicate the major group of concern includes mulga (*Acacia anuera*), ironwood (*Acacia estrophiolata*) witchetty (*Acacia kempana*), needlebush (*A.farnesiana*) and broombush (*Senna artemisoides*).

Barkly Tablelands

The pastoral industry in the Barkly Tableland region which occupies an area extending east from Tennant Creek to the Queensland border is based primarily on native grass species. These species include the Mitchell grasses (*Astrebla spp*.) and Flinders grass (*Iseilema membranaceum*) which occur across the cracking clay soils of the region.

There are a number of introduced weed species present in this region including parkinsonia (*Parkinsonia aculeata*), rubberbush (*Calotropis procera*), mesquite (*Prosopis pallida),* prickly acacia (*Acacia nilotica*), noogoora burr (*Xanthium spinosum*) with minor outbreaks of *Senna spp*, *Sida spp* and *Hyptis suaveolens* occasionally occurring.

Prickly acacia and mesquite which are in very early stages of invasion represent a major threat to the ecological integrity and pastoral industry based in this region and as such are currently under programs aimed at achieving eradication.

Parkinsonia which is well established throughout the region is centred mainly around the drainage lines and associated floodouts and in some areas has formed extensive infestations covering hundreds of hectares. Cooperative programs involving the WONS program, NT Government and landholders have developed in the region and are currently implementing strategic control programs to manage this species.

Rubberbush (*Calotropis procera*) occurs over extensive areas within the Barkly tableland and represents the most significant weed in terms of impact on the pastoral industry. In this area rubberbush forms dense thickets on richer soils associated with alluvial floodouts and from these areas can spread into adjacent rundown pastures further reducing the pasture production potential of these sites.

Tropical Savannas

Pastoral production in the tropical savannas particularly in the eastern and northern area of this region is based primarily on native species which include the annual and perennial sorghum species while in the south west pastures change to *Astrebla spp* and *Iseilema membranaceum* communities while further southwest with increasing aridity spinfex communities occur.

In this region a wide variety of introduced weed species occur including perennial woody species such as bellyache bush (*Jatropha gossypifolia*) rubberbush (*Calotropis procera*), mesquite (*Prosopis pallida*), chinee apple (*Ziziphus mauritiana*), parkinsonia (*Parkinsonia aculeata*) and mimosa (=giant sensitive plant) (*Mimosa pigra*) annual species such as devil's claw (*Martynia annua*), *Sida* spp, *Senna* spp., hyptis (*Hyptis suaveolens*), parthenium (*Parthenium hysterophorus*) and an increasing number of grass species such as grader grass (*Themeda quadrivalvus*), gamba grass (*Andropogon gayanus*), the mission grasses (*P. polystachion* and *P. pedicelatum*) and *Sporobolus* species. Of this wide range of weeds the bulk of these are "indicator" species with occurrence more limited to isolated sites and also disturbed and overgrazed sites. Of the woody species which are all limited in their impacts and areas of infestation bellyache bush (*Jatropha gossypifolia*) represents the only weed of major significance. This species, that occurs at a number of sites, is invading areas of pasture with significant impacts on mustering costs and pasture production losses particularly in riparian systems.

Northern Pastoral Zone

The northern tropical pastoral zone is basically dominated by the alluvial floodplain systems of the major rivers and the uplands in the immediate surrounds.

Floodplain production in this area is based on a mix of introduced pasture species which include olive hymenachne, aleman grass and para grass as well as the native species which include native hymenachne, wild rice and a number of other species. The major weed of this region is clearly mimosa (*Mimosa pigra*) that currently occupies approximately 85,000 hectares of floodplain. Mimosa infestation completely prevents pasture production and greatly increases mustering costs while also having significant environmental impacts.

In the adjoining upland areas again pasture production is based on a mix of introduced species which include 'Cavalcade', Tully grass, sabi grass, buffel grass, gamba grass, Jarrah grass, verano, seca stylo and wynne cassia and the native species which comprise primarily of the annual and perennial sorghum species. In the uplands the major weed species include a range of "indicator" species such as hyptis (*Hyptis suaveolens*), *Sida* spp. and *Senna* spp. while there is currently a rapid expansion of weedy grass species including the mission grasses, grader grass and the weedy sporobolus group which will increase in impact over time.

WEED OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF NORTHERN WESTERN AUSTRALIA

Mic Julien and Rieks van Klinken, CSIRO Entomology

The following is largely extracted from van Klinken and Julien (2000) "A review of biological control opportunities for rangeland weeds in Western Australia". This report was prepared for Agriculture WA, and assesses the relative importance of weeds in rangeland areas through correspondence with all Agriculture WA weed officers in rangeland WA. The report also outlines histories of biological control of the important weeds and makes suggestions for future weed management activities.

EXISTING SERIOUS WEEDS

Five weeds were identified as being of highest priority to the grazing industry (Table 9).

Table 9. Weeds prioritised on the basis of discussions with Agriculture WA.

Scientific name	Common name
Xanthium occidentale	Noogoora burr
Jatropha gossypiifolia	Bellyache bush
Parkinsonia aculeata	Parkinsonia, Jerusalem thorn
Prosopis spp.	Mesquite
Carthamus lanatus	Saffron thistle

Noogoora burr

In the Kimberley Noogoora burr occupies at least 53, 364 ha on 16 properties (Roberts *et al.* 1988), including along the Ord and Fitzroy Rivers and on Gordon Downs and Nicholson Station. The most extensive infestation is on the Fitzroy River. Noogoora burr is still spreading and increasing in density in the Kimberley. Climate-based modelling for Western Australia predicts that much of the Pilbara region, the Goldfields and the Agricultural region in the south-west will be suitable for Noogoora burr (Roberts *et al.* 1988). At least $200,000/yr was spent on containment in the 1980's (Roberts *et al.* 1988), and up to $700,000/yr by 1996 when eradication was the aim. Control is now limited to containment of existing infestations and eradication of some infestations including those on Nicholson Station and Sturt Creek.

Bellyache bush

Bellyache bush is widespread in the Kimberley. Infestations include the Bo River, Turkey Creek, Ord River, Wyndham Town site and the Hall Creek area. Although infestations are still quite light in many areas, large thickets on one lease south of Lake Argyle restricts mustering. Indications are that bellyache bush will become a serious weed in the Kimberley in the relatively near future. Options for the control of bellyache bush include herbicide application, mechanical destruction, burning and cultivation (cropping) of soil (Csurhes 1999). Repeated treatment is generally necessary to deal with regrowth, seedlings (which can emerge more than four years after the death of the parent plant) and reinvasion from other areas. Available control options are prohibitively expensive for widespread application.

Parkinsonia

Parkinsonia has been identified as one of the most serious weeds in northern Australia, and Agriculture WA considers it to be one of the two most serious weeds in the Kimberley. Hundreds of kilometres of watercourses are infested, including along the banks of Lake Argyle, Christmas Creek and the Ord, De Grey, Maitland, Ashburton, Robe, Harding and Fortescue Rivers. Although mainly riparian, some infestations are beginning to spread onto floodplains. It forms dense, thorny thickets that become virtually impenetrable. There is currently no cost-effective means for containing and managing parkinsonia.

Mesquite

Mesquite forms impenetrable thorn forests in upland habitats, and is adapted to a large proportion of semi-arid and arid Australia. In Western Australia the most extensive infestation is on Mardie station and surrounds where there is an estimated 30,000 ha of dense “hybrid” mesquite and a further 120,000 ha of scattered mesquite. In the Murchison and Gascoyne Junction Districts over 200 km of watercourses have patches of “hybrid” mesquite, and isolated plants have been found throughout. Mesquite infestations are also present around Onslow (*P. pallida*) and in the Kimberley (“hybrid” mesquite and *P. glandulosa*). “Hybrid” infestations in the Pilbara and Gascoyne Regions are beyond any realistic attempts of eradication, and very little mechanical or chemical control work has been done since the early 1990’s. There is currently no method for sustainable containing and managing mesquite.

Saffron thistle

Saffron thistle is an important winter growing annual weed of cropping and pastoral areas throughout the wheat belt of Australia (Crump *et al.* 1996), often growing on disturbed sites of low fertility in areas receiving 300 to 600 mm of annual rainfall (Parsons and Cuthbertson 1992). It occurs over nearly 400,000 hectares in Western Australia.

POTENTIALLY SERIOUS WEEDS

Some of the most serious weeds of the future are likely to be introduced grasses. Several species are highly aggressive, forming virtual monocultures. Although some can be palatable, others are of limited pasture value. Besides effects on biodiversity through displacement, grasses can also significantly alter fire regimes (through increased biomass, and delayed drying off), and may have longterm negative effects on soil quality. A risk analysis has not yet been done, but some of the potentially most serious species already present in Western Australia include gamba grass (*Andropogon gayanus*) and mission grass (*Pennisetum polystachion*).

OTHER WEED-RELATED PROBLEMS

More general weed-related problems directly affecting the pastoral industry are the weed-syndromes on highly disturbed land. Highly disturbed areas (in heavily grazed uplands and/or riparian zones) often have a diverse and dominant weed flora. Most of these weeds are unpalatable, and many are annuals. This degraded country has low productivity and it serves as an important source from which the more aggressive weeds can spread into less disturbed country. These include noogoora burr, hyptis, bellyache bush, coffee-bush (*Senna occidentalis*), *Sida acutifolia* and stinking passion flower (*Passiflora foetida*).

RESEARCH AND DEVELOPMENT NEEDS

Current research

Parkinsonia

Research is funded until end June 2003 by NHT, CSIRO, QDNRM, AgWA and NT DBIRD. This is a collaborative research program across northern Australia focussing on predicting what landscapes are most at risk from parkinsonia invasion, developing methods for sustainable managing parkinsonia (including the use of fire etc), and conducting native-range surveys to identify potential biological control agents. Research will need to continue over a number of years, especially the biological control work, before new agents can be released.

Mesquite

Research is funded until end Sep 2003 by NHT, AgWA, the Pilbara Mesquite Management Committee and landholders. Funding is required until mid 2005 (a four year program) to develop and implement a strategic plan for mesquite management in the Pilbara region. Results will be relevant to the rest of northern Australia.

Bellyache bush

Research is funded by QDNRM, NT DBIRD and CSIRO. This collaborative project aims to develop integrated management strategies including biological control.

Hyptis

Research is funded by NT DBIRD to search for potential biological control agents.

New research areas

Grasses

Grasses present a rapidly emerging threat that requires urgent attention. Perceived conflicts of interests need to be resolved between conservation and pastoral sectors. The most threatening species need to be identified and their potential threat described. Containment and management strategies are urgently required.

Weed syndromes in highly disturbed rangelands (heavy grazing and/or riparian)

Work is required to determine the best ways for highly disturbed, weed-infested, country to be rehabilitated, an how to prevent further degradation and weed spread from occurring.

Noogoora burr

Biological control appears to be the only possible means of reducing large infestations of Noogoora burr in northern Australia. Biological control is effective in controlling Noogoora burr in eastern Australia, but agents that are better adapted to conditions in northern Australia are required. Much of the native range of Noogoora burr, including areas with climates similar to northern Australia, remain unexplored for biological control agents, suggesting that potentially suitable agents might exist.

WEEDS OF SIGNIFICANCE TO GRAZING INDUSTRIES OF SOUTHERN WESTERN AUSTRALIA

Clinton Revell, Department of Agriculture, Western Australia

(with contributions from J. Moore, J. Peirce, A. Douglas, R. Butler and J. Allen)

BACKGROUND

This paper outlines weed issues of significance to grazing industries of the southern agricultural region of Western Australia. This region occupies some 16 million ha and supports a diverse range of farming systems. Annual average rainfall extends from 250 mm in the east to over 1200 mm in the far south-west (Figure 3). The region is dominated by the sheep/wheat zone (some 10-12 million ha), where grain crops are grown in rotation with pastures that are mostly annual species. The zone covers average annual rainfall ranging from 250 mm to 650 mm. In rainfall regions greater than 650 mm, farming systems are predominantly focussed on animal industries (sheep and cattle) and are based on permanent pastures (Figure 3). These pastures are largely comprised of annual species but low levels of perennial species are sometimes present. Irrigated pastures for dairy industries are a feature of the south-west coastal regions but occupy a relatively small proportion of the landscape.

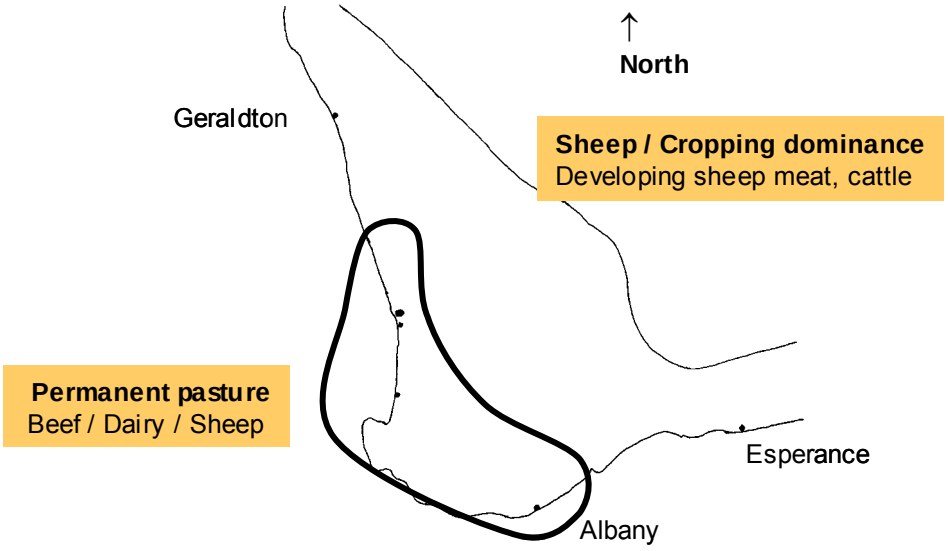


Figure 3. Southern agricultural region of Western Australia. The zone of permanent pasture is circled.

This paper:

1. Outlines general weed issues for grazing industries.

2. Details weed species of greatest concern for each of the sheep/cropping and permanent pasture zones and highlights new weed threats. A useful reference for weed descriptions is Western Weeds by Hussey *et al*., 1997.

3. Discusses potential directions for Research and Development in weeds of pastures.

General issues concerning weeds of pasture

There are a number of general weed issues that relate to grazing industries and which are particularly pertinent for agriculture in southern Australia.

1. There are no clear boundaries to distinguish whether a particular plant species is considered a weed of pasture. This problem of definition needs to be recognised when determining priorities for weed research. For many species 'weediness' depends on whether there are desirable alternatives present (Madin, 1993). For example, capeweed (*Arctotheca calendula*) is often considered a weed of legume based pastures but if there is little legume present, capeweed becomes an important feed source.

2. Weeds are generally present in pasture as a complex of species. Hence any one species cannot be managed without regard for the response of remaining species. Gaps arising from the removal of one species are often found to be filled with another weed species. For example, eradication of broadleaf weeds in legume pasture can result in an increase in the proportion of beneficial annual ryegrass (*Lolium rigidum)* or wool contaminating barley grass (*Hordeum leporinum)*.

3. The importance of weeds differs according to land use. This is clearly illustrated in the significance attached to weeds of newly sown pasture compared to that for well-established pasture. Newly sown pastures generally have much lower plant densities and are generally less competitive. This feature, combined with the need to ensure adequate seed production invariably means weeds of newly sown pasture have greater significance. In farming systems with Mediterranean climates, there is also a need to consider weeds of the dry phase (eg in crop and pasture stubbles) as well as weeds of the green feed period.

4. Many crop weeds need to be controlled in a pasture phase even though they may be of only minor significance in the pasture. For example, wild radish (*Raphanus raphanistrum*) is an important crop weed but has less impact in established pastures and can be controlled through grazing management. Pasture weeds may also be a reservoir of crop diseases and pests (such as annual grasses that can host cereal root and leaf pathogens eg the take-all fungus and rusts) and insects (eg. Desiantha in cereals, vegetable weevil in canola).

5. Tillage practices in the crop phase can have an impact on the weed flora. For example, reducing the extent of cultivation fro crop establishement has led to an increased occurrence of small flowered mallo (*Malva parviflora)* and sand fescue (*Vulpia fasciculata)*.

6. Weeds in pasture are often a symptom of poor pasture management such as through intensification of cropping, poor nutrition or poor grazing practices. For example, storksbill (*Erodium botrys*) can quickly invade infertile sandy soils.

7. Seasonality has a significant influence on weed populations and their impact on pastures. This is particularly notable for summer weeds in mediterranean farming systems but also applies to weeds of the winter growing season such as a capacity to survive false breaks of season. Such variability needs to be understood in order to predict and manage weed incursion.

8. In the last ten years there has been a rapid increase in the number of new pasture legume species and cultivars. There is considerable variation in herbicide tolerance between species and many species have few herbicide options that can be used with safety. This adds to the complexity of weed management in legume-based pasture.

9. Many farmers only have a limited understanding of pasture dynamics, it is poorly presented in the extension literature and it differs significantly between regions.

Weeds of significance

Weeds of significance are outlined for each of the sheep/cropping and permanent pasture zones. They are categorised according to criteria outlined by Taylor and Sindel (2000) in the Pasture Weed Management Kit (CRC Weed Management Systems). These criteria describe attributes that confer 'weediness' in plants and include;

- Low palatability and digestibility
- Competition with more desirable species
- Cause vegetable fault in skins and wool
- Impede livestock movement and cause injury
- Poisonous to livestock

Weed species within each category are listed in an approximate order of decreasing importance. Reputed allelopathic effects of some species are noted where appropriate.

Sheep / Cropping Zone

Low palatability and digestibility

- Fescues (*Vulpia* spp. especially silver grass *V. myuros*)

  Widely distributed with limited options for herbicide control in legume pasture. The species *V. fasiculata* appears to be increasing in reduced tillage cropping systems.

- African lovegrass (*Eragrostis curvula*)
  Appears to be increasing in abundance as a consequence of reduced tillage cropping practices.

- Guildford (onion) grass (*Romulea rosea*)
  Generally confined to medium and high rainfall regions, particularly in undisturbed areas. Few control options in legume based pasture.
  Summer weed complex; Afghan melon (*Citrullus lanatus*), paddy melon (*Cucumis myriocarpus*), Afghan thistle (*Solanum hoplopetalum*), goosefoot – small crumbweed (*Chenopodium pumilio*), tumbleweed (*Amaranthus albus*).
  Mainly a problem following wet summers and often associated with grazing crop stubbles. Goosefoot is reputed to be allelopathic and can restrict crop and pasture regeneration. Tumbleweed can damage fencelines.

- Thistles (*Carduus, Cirsium, Silybum*)
  These are generally of minor significance, typically confined to non-arable hill tops. Saffron thistle (*Carthamus lanatus*) can be a problem in grazed crop stubbles.

Competition with more desirable species

- Capeweed (*Arctotheca calendula*)
  Widely distributed with a range of ecotypes and well adapted to seasons with early germination. Difficult to control in newly sown pasture.

- Ryegrass (*Lolium rigidum*)
  Widely distributed and has developed resistance to multiple herbicide groups. Ryegrass is a major crop weed but can be an important feed source in pasture.

- Wild radish (*Raphanus raphanistrum*)
  Distributed mainly in central and northern regions and is a major crop weed. Difficult to control in newly sown pasture. Wild turnip (*Rapistrum rugosum*) and wild mustard (*Sisymbrium orientale*) often occur in association with wild radish but are of much less concern.

- Storksbill (*Erodium botrys* and other sub-species)
  Generally associated with infertile, sandy soils and favoured by seasons with early germination.

- Paterson's curse (*Echium plantagineum*)
  Appears to be increasing in abundance and is spreading eastwards from the Avon Valley (central west) and northern coastal areas. Still a major focus for biological control with several agents released (Ian Dadour, Department of Agriculture WA *pers. comm.*)

- Sorrel (*Rumex acetosella*)
  Generally associated with wetlands and granitic soils with poor nutrition. The introduction of glyphosate has slowly reduced the significance of this weed.

- Lesser swinecress (*Coronopus didymus*)
  Increasing in the central and western regions.

- Species increasing as a consequence of reduced tillage practices in crop establishment. Small flowered mallow (*Malva parviflora*), blackberry nightshade *Solanum nigrum*), windmill grass (*Chloris truncata*).

Vegetable fault in wool, skins

- Annual grasses
  - Barley grass (*Hordeum leporinum*) Mainly associated with fine textured loam soils but widely distributed.
  - Brome grass (*Bromus diandrus*) Prominent in northern regions.
  - Silver grass (*Vulpia* spp.)

- Storksbill (*Erodium botrys* and other species)

- Naturalised medics (eg *M. minima*)
  Generally confined to alkaline fine textured loam soils but are of relatively minor significance.

Impede livestock movement, injury

- Doublegee (*Emex australis*)

  Widespread, predominantly found on fine textured loam soils and with long lived seed banks. Difficult to control in legume based pastures. Biological control with the red apion beetle (Woodburn and Yeoh, 2000) yet to be realised.

- Caltrop (*Tribulus terrestris*)

  Mainly a problem following wet summers and often associated with grazing crop stubbles.

Poisonous to livestock

- Ryegrass / ARGT complex (Annual Ryegrass Toxicity)

Infection of ryegrass with the nematode *Anguina funesta* and an associated bacterium *Rathayibacter toxicus* can result in the formation of toxic galls which replace the seed. Stock losses have been considerable since its development in the 1970's. Estimated stock losses in 2000 were 80,000 sheep and in 2001 were 30,000 sheep. Initial outbreaks were located in the southern agricultural region but these areas are now essentially free of the disease, perhaps as a consequence of the increased incidence of the endemic twist fungus *(Dilophospora alopecuri*) that competes for seed head occupancy. Current outbreaks tend to be located in the central region with some movement into northern regions. Twist fungus inoculum is now being produced commercially for use as an on-farm control measure. The recently developed cultivar Safeguard, which has resistance to ARGT, should be evaluated for its productivity and persistence in Western Australia (Figure 4).

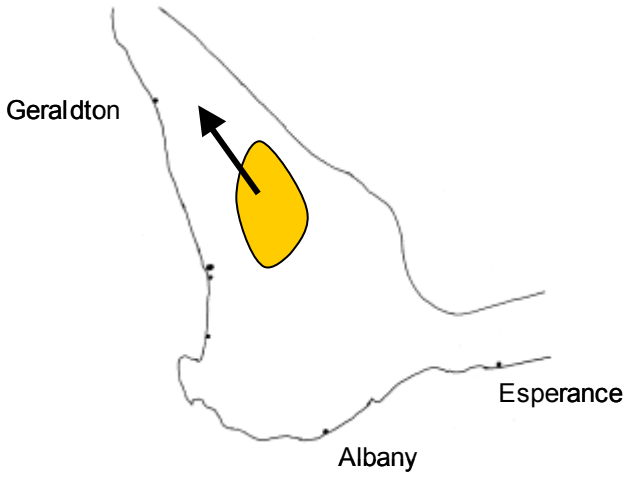


Figure 4. Incidence and spread of ARGT

- Annual ryegrass ergot is a minor problem of the south coastal area.
- Ice-plant (*Mesembryanthemum crystallinum*)

  Mainly a problem in non-arable areas and in grazed stubbles, particularly on fine textured clay soils and mildly saline areas.
- Common heliotrope (*Heliotropium europaeum*)

  Summer growing annual, increasing in abundance in the central and southern region. British breeds of sheep and cattle more susceptible than merino sheep.
- Paterson's curse (*Echium plantagineum*)
- Caltrop (*Tribulus terrestris*)

  Mainly a problem following wet summers and often associated with grazing crop stubbles. Notable in sheep, it causes liver damage and so results in jaundice and photosensitisation.
- Cape tulip (*Homeria breyniana/miniata*)

  Still a declared weed in Western Australia and mostly located in medium to high rainfall areas.
- Box poisons (*Gastrolobium* spp., *Oxylobium* spp.)

  Native plant species with problems arising from grazing remnant vegetation; generally of minor significance.
- Goosefoot – small crumbweed (*Chenopodium pumilio*)

  Often associated with nitrate and oxalate poisoning in wet summers.

High Rainfall Zone

Many of the listed weed species are common to the sheep/cropping zone. Their specific details are described in the previous section.

Low palatability and digestibility

- Fescues (*Vulpia* spp.)
- Guildford (Onion) grass (*Romulea rosea*)
- Parramatta grass (*Sporobulus* sp.)
- A summer weed that is significant in the dairy irrigation areas of the west coast.
- Thistles (*Carduus, Cirsium, Silybum*)

Competition with more desirable species

- Flatweed (*Hypochaeris glabra/radicata*)

  Increasing in significance and a particular concern for cattle producers.

- Capeweed (*Arctotheca calendula*)

- Cotula (*Cotula* sp)

  Increasing in abundance particularly in hard grazing production systems.

- Paterson's curse (*Echium plantagineum*)

  A particular concern for beef producers.

- Storksbill (*Erodium botrys* and other species)

- Dock / Sorrel (*Rumex* sp.)

  A particular concern for cattle producers. Some research into biocontrol agents.

- Pennyroyal (*Mentha pulegium*)

  Significant in winter wet/waterlogged environments and a particular concern for cattle producers.

- Yorkshire fog (*Holcus lanatus*)

  Significant in winter wet/waterlogged environments and a particular concern for cattle producers. Also noted for its poor palatability and digestibility.

- Mouse-eared chickweed (*Cerastium glomeratum*)

  Increasing in the higher rainfall areas.

- Stinkwort (*Dittrichia graveolens*)

- Toxic, allelopathic and can dominate in low phosphorus soils especially in wetter areas.

Vegetable fault in wool

- Barley grass (*Hordeum leporinum*)

- Fescues (*Vulpia* spp.)

- Brome grass (*Bromus* spp.)

- Storksbill (*Erodium botrys* and other species)

- Thistles (*Carduus pycnocephalus, C. tenuiflorus, Cirsium arvense, Carthamus lanatus, Silybum marianum)*

Poisonous to livestock

- Bracken (*Pteridium esculentum*) is decreasing in importance as it can be controlled with metsulfuron (Ally®). Main issue is extension and adoption of the management package.
- Arum lily (*Zantedeschia aethiopica*) is mainly a problem in the dairy irrigation areas of the west coast.
- Paterson's curse (*Echium plantagineum*)
- Cape tulip (*Homeria breyniana/miniata*)
- Oestrogenic subterranean clovers. Some of the older cultivars have high levels of oestrogenic substances which have a negative impact on lambing percentages and some association with lower palatability. These cultivars are often very persistent and difficult to replace with new cultivars.
- Stinkwort (*Dittrichia graveolens*)

Species with a watching brief

A number of weed species are being monitored for potential incursion into agricultural areas including,

- Branched broomrape (*Orobanche* sp.)
- Small-seeded dodder (*Cuscuta planifolia*)
- Three-horned bedstraw (*Galium tricornutum*)
- Chincherinchee (*Ornithogalum thyrsoides*)
- Lincoln weed (*Diplotaxis tenuifolia*)

Priorities for weed research and development

Arriving at a list of priorities for weed research and development should be based, in part, on economic impact. However, there is a severe deficiency of this information (Madin 1993) and some resources should be directed towards this need. Implications for the whole farm system need to be considered as well as social impacts.

Any assessment of the economic impact of a particular weed species will be aided by a better understanding of weed distribution. Weed surveys need to be conducted on a regular basis (5-10 years) and require specific resource allocation. Remote sensing technology maybe appropriate in some situations (eg. summer weeds) but is unlikely to replace manual surveys for some years.

Panetta *et al*. (1993) reviewed some of the issues relating to weed ecology in Australian sheep pastures and many of their recommendations are still appropriate today. Research to date has defined the physiological and morphological features that allow weeds to invade a variety of pasture types, often away from the pasture environment. This has contributed to a lack of understanding of the pasture characteristics that allow invasion, both originally and recurrently. Future research into pasture weed ecology should examine the dynamics of pasture gap formation and the complementary

processes leading to gap closure. This will be critical as increasing attention is given to the development of new perennial pasture species for farming systems that seek to address hydrological imbalance.

Management of resident weed populations should aim to maintain the abundance of weeds below levels at which significant losses to pasture production occur (Panetta *et al*. 1993). These authors suggest that while there is some understanding of the factors which selectively favour germination and establishment of certain species, there is little known about the individual (or combined) effects of competition and grazing on the growth and seed production of annual pasture weeds. There is also a particular need to assess the impact of herbicidal and biological control measures on seed output. Such information is essential to develop weed control packages that impact on the key drivers of seed production and seed bank decline. For example, it may be possible to exploit differences in the relative acceptability to grazing animals of weeds and desirable pasture plants that will confer better weed control (Revell *et al*., 2002). Continual advances in herbicide technology should also be evaluated.

The choice of strategy for weed control largely depends on the behaviour of weed seed populations (Panetta *et al*. 1993). More information is required about the half-lives of seed populations and how these might be modified. For example, a better understanding of the effects of cropping practices on seed banks of weeds and other pasture species is required, particularly with the increased adoption of reduced tillage systems.

Encouraging the adoption of weed management packages is also an important area in which to direct resources. Increased support is required for farming systems research, which utilises a combination of basic research and on-farm participatory research with graziers.

Summary

There is a considerable number of significant weeds for grazing industries of southern Western Australia and any ranking of importance is difficult. However, there is general consensus on the top group of weeds in each of the sheep/cropping and permanent pasture zones. Allocation of species to functional groups can simplify the process but particular species of note can be overlooked.

In the sheep/cropping zone, we suggest that the annual grasses particularly *Vulpia* spp. along with doublegee, storksbill and capeweed are currently the weed species of greatest significance. In the permanent pasture zone these species, with the exception of doublegee, are also of major significance along with flatweed, onion grass and Paterson's curse.

Weed species requiring either ecological research or further research into management include silvergrass, onion grass, flatweed, doublegee, dock, African lovegrass and Parramatta grass.

Weed species requiring refinement of management packages through participatory research include capeweed, storksbill, bracken, wild radish, Paterson's curse and common heliotrope.

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WEED OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF VICTORIA

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INTRODUCTION

It has been estimated that weeds cost Australia in excess of $2,096 million every year (Combellack 1987) and that this figure would be more like $3,300 million on present day figures (National Weeds Strategy, 1995). Weeds cost the Australian wool industry nearly $600 million/year or approximately 10% of the value of the total woolclip (Sloane *et al.* 1988). More than $500 million is spent annually on herbicides alone which is more than double the amount spent on insecticides and fungicides. Herbicide usage can also cause significant losses to the community in terms of:

- Environmental contamination affecting non-target plants, fauna, soil and water.
- Reduced income from crops and pasture caused by herbicide damage.
- Development of herbicide resistance in weeds.

This is only part of the story, as there are significant flow-on effects to the community. A farmer losing productivity because of weed infestations will not provide as much input into the local community. New cars, machinery, groceries and other goods resulting in less input to local rural businesses. These will therefore reduce their orders from large city manufacturers. There will also be less primary production for export resulting in higher unemployment and a larger balance of payments debt to the community as a whole. These sorts of indirect costs are more difficult to estimate.

To date the cost of environmental weeds impacting on natural ecosystems has not been adequately evaluated in Australia. However, they can create significant economic costs in many ways:

- damage to human health (asthma, allergies, poisonings, etc.)
- damage to water resources (flow restrictions, eutrophication, etc.)
- fire hazards
- shelter for vermin
- hosts for plant pests and plant diseases
- tourism (reduced value of recreational areas, aesthetically unpleasant etc.)
- biodiversity (may threaten native flora and fauna)

Some biologists have placed the monetary value of environmental weeds in the same order of magnitude as that of weeds of primary production (National Weeds Strategy 1995).

Weighing up the costs and benefits at any spatio-temoral scale is the central issue in determining whether control measures for any pest are justified. Estimating these costs and benefits may be very difficult even in the short term. The uncertainties about future costs and benefits and the rate of discount that should be applied in a cost/benefit analysis are magnified when dealing with pest plants

and animals. This is because of a large number of individual economic units of widely different types are involved in the management and dispersal of the pest and because we are less able to predict outcomes with naturally evolving systems.

The spread of weeds is partly the result of externalities, unintended consequences of rational economic decision-making. For example, a load of cheap, supposedly clean fodder brought from interstate during a drought year may contain enough seed to establish a weed in an area for the first time with such a wide dispersal that it is uneconomic to treat the infestations. Similar problems can result from the use of cheap, uncertified seed. The market may fail because the buyer has imperfect knowledge, the product is not homogeneous, or the public greed, rather than the public good, is at risk. An economy that encourages mobility of goods and services has resulted in weeds that are also mobile. National quarantine measures fail to cope and intra-national quarantine is almost totally ineffective. Weeds continue to evolve to take advantage of the opportunities provided by human cultures.

An externality arises when the behaviour of one person creates a cost to another person who is not compensated, or creates a benefit for another person without recieving any reward. The externalities asociated with weeds are analagous to those of pollution and have thus been regulated initially by legal restrictions. These legal restraints tend to avoid the more complex questions involving dispersal of the weed and the equitable distribution of costs and benefits associated with weed management.

The cost of weeds has been estimated to be approximately $3,300 million on present day figures without considering losses to biodiversity (Agriculture & Resource Management Council of Australia & New Zealand, Australia & New Zealand Environment & Conservation Council and Forestry Ministers 1997). In contrast, estimates of the cost of salinity to Australia are in the range $250-330 million per annum, one tenth that of weeds. 47% of farmers consider weeds to be their greatest problem as compared to 21% for salinity (Australian Bureau of Statistics 2001). Salinity was a priority environmental issue at the Australian Federal Government 2002 election with budget allocations in the order of $700 million to salinity and water quality (Senator Hill Media release 2001).

Victoria's Vascular Plant 2000 Census listed 4331 species of plants of which 1110 species (25.6%) are naturalised introduced species. At present there are 97 noxious weeds in Victoria and Carr *et al.* (1992) have listed 354 species of environmental weeds. Approximately 8-10 new plants invade Victoria each year. How do we rank or prioritise work on these species? The CRC for Australian Weed Management is developing a weed risk assessment system that should address this issue.

Some weeds are termed "new and emerging" weeds because the have only just arrived in Australia and often go through what is known as a "lag phase" or "sleeper phase" before expanding rapidly and becoming serious problems (Figure 5). In the past, Governments and Industry have waited until a weed has become a problem before acting to control them. It is far more economical and feasible to control weeds in the "lag phase" than in the "expansion phase.

To help determine which weeds are more important than others, the CRC for Australian Weed Management, Program 1 are developing a national weed risk assessment methodology.

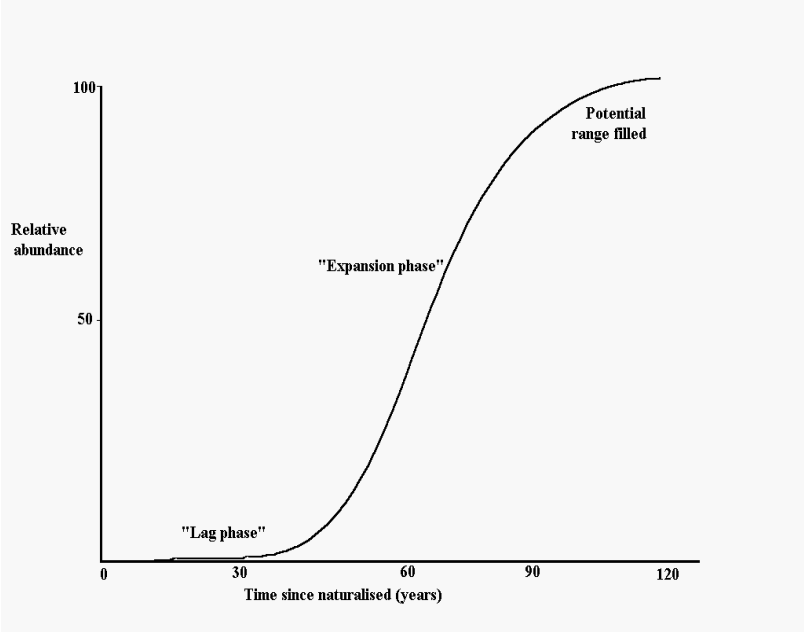

Figure 5. A hypothetical pattern of colonisation by a new weed species entering Australia.

Weed Risk Assessment (WRA) has predominantly concentrated on the biological properties of a weed that make it invasive. However the invasive component of a weed is only one component of a WRA. If we want to determine or prioritise weeds an assessment must take into account the impact of the weed on social, environmental and agricultural values (or resource conditions). As these values change depending upon the land managers involved, the scale of the assessment (national, state, catchment or local level) has to be adaptable to account for these differences. The major components in predicting weed status are:

- Assessing the plant's invasiveness,
- Its current and potential distribution and
- Impacts of the plant on land use and ecosystems.
- The decision making process may also include;
- The value of threatened ecosystems and
- The feasibility of successful control.

Victoria has developed a risk assessment process that can work independently or utilise a GIS based system to determine resource conditions and then the risk or threat that weeds pose to these values. This is a paradigm shift in thinking. Rather than looking at the weed and its biological attributes it focuses on the threat that it has on resources.

This Decision Support System (DSS) is an Expert System relying on multi-criteria analysis/analytical hierarchical process (AHP) that enables complex issues to be broken down into a set of related criteria. The AHP is a method that assists with decisions about priorities using qualitative and/or

quantitative information. AHP facilitates effective decisions on complex issues by simplifying and expediting the intuitive decision making process.

Basically, the AHP is a method of breaking down a complex unstructured situation into its component parts; arranging these parts into a hierarchical order; assigning numerical values to subjective judgements on the relative importance of each variable; and synthesising the judgements to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation. AHP also provides an effective structure for group decision making by imposing a discipline on the group's thought processes.

Because there is a dearth of specific information on land/resource value and the impact of any particular weed on social, environment and agriculture resources, there is a need for a methodology to mix both qualitative and quantitative information. The DSS allows for this integration.

Potential distribution is a major factor in comparing the threats posed by weed species (Panetta and Dodd 1987). The greater the potential distribution of a weed species, the greater the potential impact and management costs. Knowledge of potential distribution is also important for devising management programs. Landholders can be alerted to the risk of weed invasion and measures can be enforced to prevent the introduction of weed propagules into such areas. Low priority can be given to areas where the weed might fail to persist, or be of little economic importance (Panetta and Dodd 1995).

This Victorian Pest Plant Prioritisation process is a system that allows for a visible and documented weighting to be applied to more important criteria or resources to indicate their importance (Tables 10-12).

Table 10. Grass Weeds of Importance to Grazing Industies. (Invasiness Scores: Very Highly Invasive, >0.68; Highly Invasive, >0.60 <0.68; Invasive, > 0.50 <0.60; Less Invasive, < 0.49)

Common Name	**Scientific Name**	**Distribution (ha)**	**Invasiveness score** (scale 0-1).
Serrated tussock	*Nassella trichotoma*	130,000 ha	0.74
Chilean needle-grass	*Nassella neesiana*	Widespread and Spreading	0.72
Lobed needle-grass	*Nassella charruana*	20 ha	0.65
Mexican feather grass	*Nassella tenuissima*	None	0.74
Espartillo or Puna grass	*Achnatherum caudatum*	Spreading	0.64
Bent grass	*Agrostis capillaris*	Widespread	0.65
Silver grass	*Vulpia bromoides*	Widespread	0.67
	Vulpia fasciculata		
	Vulpia myuros		
African love grass	*Eragrostis curvula*	Spreading	0.50
Parramatta grass	*Sporobolus africanus*	Spreading	0.71
Tambookie grass	*Hyparrhenia hirta*	Spreading	NA

Table 11. Broadleaf Weeds of Importance to Grazing Industries. (Invasiness Scores: Very Highly Invasive, >0.68; Highly Invasive, >0.60 <0.68; Invasive, > 0.50 <0.60; Less Invasive, < 0.49)

Common Name	***Scientific Name***	**Distribution/Cost**	**Invasiveness Score**
Blackberry	*Rubus fruticosus*	3,040,000 ha $42 million/year (Aust)	0.77
Branched broomrape	*Orobanche ramosa*	Not in Vic yet	0.71
Capeweed	*Artotheca calendula*	Widespread	0.51
Caltrop	*Tribulus terrestis*	1,430,00 ha	0.61
Dock	*Rumex* sp.	Widespread	
Heliotrope	*Heliotropium europaeum*	Widespread	
Horehound	*Marrubium vulgare*	5,980,000 ha	0.60
Gorse	*Ulex europaeus*	948,000 ha	0.54
Paterson's curse	*Echium plantagineum*	918,000 ha $3.2 Vic, $31 Aust	0.66
Prairie ground cherry	*Physalis viscosa*	96,000 ha	0.73
Ragwort	*Senecia jacobaea*	820,000 ha	0.60
Silverleaf nightshade	*Solanum elaeagnifolium*	38,000 ha	0.67
St Johns wort	*Hypericum perforatum*	900,000 ha	0.66
Spear thistle	*Cirsium vulgare*	9,700,000 ha	0.69
Variegated thistle	*Silybum marianum*	4,760,000 ha	0.76
Slender thistle	*Carduus pycnocephalus* *Carduus tenuiflorus*	8,250,000 ha	0.72
Artichoke thistle	*Cynara cardunculus*	248,500 ha	0.66
Californian thistle	*Cirsium arvenese*	327,000 ha	0.70
Ox-eye daisy	*Leucanthemum vulgare*	27,000 ha	0.51

Table 12. Bulb Weeds. (Invasiness Scores: Very Highly Invasive, >0.68; Highly Invasive, >0.60 <0.68; Invasive, > 0.50 <0.60; Less Invasive, < 0.49)

BULBOUS WEEDS			
Onion grass	*Romulea rosea*	Widespread	0.54
Cape tulip - one leaf	*Homeria flaccida*	227,000 ha	0.48
Cape tulip - two leaf	*Homeria miniata*	133,000 ha	
JUNCUS WEEDS			
Rushes	*Juncus sp.*	Widespread	0.52

Information on Specific Weeds

Unpalatable Grasses Complex

Serrated tussock *Nassella trichotoma*

Nassella trichotoma is a perennial, drought resistant species that is native to the pampas grasslands of Argentina, Uruguay, Chile and Peru (Parodi 1930, Rosengurtt *et al.* 1970) and it has been reported from Bolivia (Walsh and Entwisle 1994). *Nassella trichotoma* is a proclaimed noxious weed in the Australian Capital Territory, New South Wales, Victoria, South Australia and Tasmania and has been described as potentially causing greater reductions in carrying capacity than any other plant in Australia (Parsons and Cuthbertson 1992). It has also naturalised in New Zealand and South Africa while small infestations also occur in England, France, Italy, Scotland (Campbell 1982, Stace 1997) and in the United States (Westbrooks 1991, Westbrooks and Cross 1993).

Nassella trichotoma was probably introduced into Australia in the early 1900s but was not recorded in Australia until 1935 when a collection was made at Yass (55 km NE of Canberra) (Campbell and Vere 1995) (Figure 6). However, the earliest lodged collection is based on a specimen collected at Yass on 7/2/1936 (NSW Herbarium, specimen No 115759) and a further two collections were made later that year, also at Yass. In 1977 it occupied 680,000 ha (Campbell 1977) and now occupies more than 870,000 ha in New South Wales with an estimated 2,000,000 ha at risk of infestation (McGowan, personal communication, see Figure 7). In Victoria *N. trichotoma* was first collected on 19/12/1954 at Broadmeadows (15 km NNW of Melbourne). By 1979 it had spread to occupy approximately 30,000 ha (Lane *et al.* 1980) and by 1998 it occupied in excess of 130,000 ha (Pest Management Information System, Keith Turnbull Research Institute, Figure 6). *N. trichotoma* is also found in Tasmania where it was is was first recorded in 1956 (Parsons and Cuthbertson 1992) and is currently spread in scattered populations over an area of approximately 1000 ha (C. Goninon personal communication).

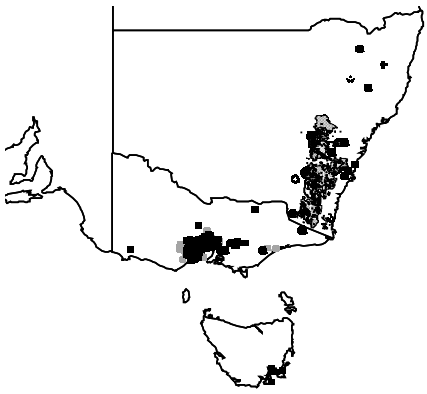

Figure 6. Distribution of serrated tussock in Australia.

By using a climate matching program called CLIMATE, the potential distribution of *N. trichotoma* in Australia has been estimated at 32 million ha (best prediction from Australian sites only, Figure 7) with substantial areas of New South Wales, Victoria and Tasmania at risk of invasion.

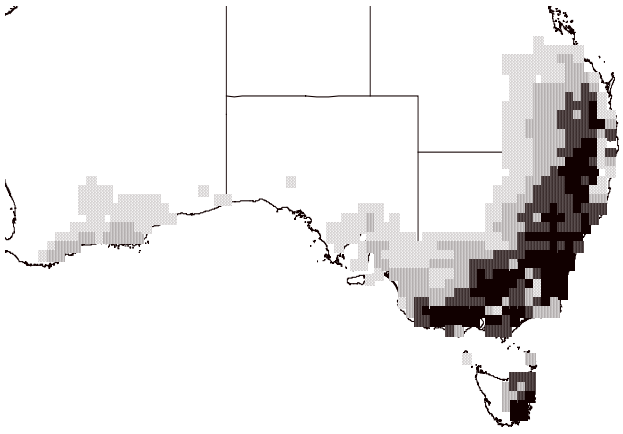

Figure 7. Potential distribution of serrated tussock in Australia.

In 1988, *N. trichotoma* was estimated to cost the Australian Wool Industry approximately $12.9 million annually (Sloane *et al.* 1988). A recent report produced by Inland Agriculture (1995) stated that Victoria could save approximately $35 million/year if it restricted the distribution of *N. trichotoma* to 200000 ha (Abadeen 1995). A conservative figure for the cost of *N. trichotoma* in Victoria is $5 million per year (Nicholson *et al.* 1997) and for New South Wales $40 million per year (Jones 1998).

In contrast to the vast literature on the impacts of *N. trichotoma* on agricultural productivity, there is a remarkable paucity of literature on its environmental impacts. Carr *et al.* (1992) classified *N. trichotoma* as a very serious environmental weed that invades dry coastal vegetation, lowland grassland, grassy woodland, sclerophyll forest and woodland and rocky outcrop vegetation.

Chilean needle grass *Nassella neesiana* (Syn. *Stipa neesiana* Trin. & Rupr.)

Nassella neesiana is a tufted perennial that is becoming a serious pasture and environmental weed in south eastern Australia. It is indigenous to Argentina, Bolivia, Chile, Ecuador, Southern Brazil and

Uruguay (Rosengurrt *et al*., 1970). This species is a serious weed in New Zealand (Bourdot and Hurrell 1989). It has also been recorded in south east England (Stace 1997) and has been found on ballast dumps such as in Mobile, Alabama (U.S. Department of Agriculture1953) in the United States but there have been no recent records according to Barkworth (1993).

The earliest known collection *of N. neesiana* in Australia was made in October 1934 in Northcote, an inner northern suburb of Melbourne (MELU specimen) but was "originally identified as *Stipa elatior* (*S. scabra* var elatior)" i.e. *Austrostipa flavescens*. In New South Wales, the earliest known collection was made in 1944 at Glen Innes on the New England Tablelands (284 km SW of Brisbane) (Figure 8). *N. neesiana* is also naturalised in South Australia where it was first recorded from Lucindale (265 km SE of Adelaide) on 18/11/1988 and " it does not seem at this stage that it is causing any trouble"(J.P Jessop., AD Herbarium, personal communication). In New South Wales the species is declared as a category W3 noxious weed in the New England and Seven County Shires of New South Wales, while it has yet to be declared in Victoria or South Australia (J. Fisher personal communication).

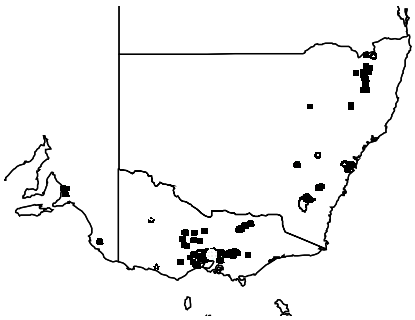

Figure 8. Distribution of Chilean needle-grass in Australia

A national mail survey of 1000 land managers shows that Chilean needle-grass (*Nassella neesiana* (Trin. & Rupr.) Barkworth) has spread widely throughout Victoria, NSW and the ACT (McLaren *et al.* 2002). Frrom the survey, only 5% of respondents considered *N. neesiana* a beneficial plant while 79% believed it would be financially detrimental to them in the future. On average, *N. neesiana* costs from \$64.50 ha^{-1} to \$118.75 ha^{-1} to control on grazing lands, depending on whether the infestation is scattered or dense. The survey has highlighted support for a biological control program and the need to control this Weed of National Significance (McLaren *et al.* 2002).

Currently there are no published estimates of the area infested with *N. neesiana* from any of the three states where it occurs. By using CLIMATE, the potential distribution of *N. neesiana* has been estimated at 41 million ha (best prediction from Australian sites only, Figure 9) with substantial areas of Victoria and New South Wales at risk. Likewise there have been no estimates or reports of the economic losses incurred by *N. neesiana.*

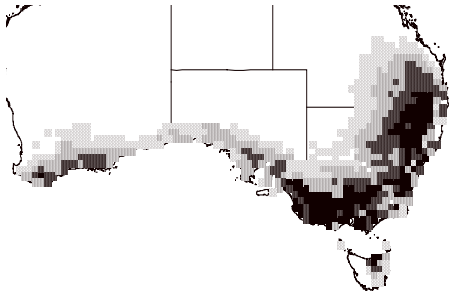

Figure 9. Potential distribution of Chilean needle-grass in Australia.

The competitive ability and efficient reproductive mechanisms of *N. neesiana* have enabled it to dominate large areas of highly productive pastures on the Northern Tablelands of New South Wales and on the Volcanic Plain of Victoria (Gardener 1998). During warmer months it produces large numbers of unpalatable flower stalks and very little leaf material, resulting in a severe reduction in summer stock carrying capacity. Conversely, a reasonable quantity of good feed is produced during the winter months on the New England Tablelands (Gardener 1998).

N. neesiana has been described as being potentially the worst environmental weed of indigenous grasslands in Victoria (C. Hocking personal communication). Carr *et al.* (1992) classified *N. neesiana* as a very serious environmental weed that invades lowland grassland, grassy woodland and rocky outcrop vegetation.

It tolerates drought and heavy grazing, and at least in Victoria, it also tolerates soils or sites that are subject to seasonal water-logging such as at Derrimut and the Laverton North grassland reserves (V. Stajsic personal observation) and the Tarnagulla (160 km NW of Melbourne) flora reserve (Liebert, 1996). It has also been found on the alluvial flats that are subject to seasonal waterlogging at the Wattle Park (12 km E of Melbourne) (G. Carr personal communication). Liebert (1996) comments that *N. neesiana* often establishes in damp depressions such as drainage lines and roadsides and then radiates out into the drier grassland. Its apparent drought tolerance and ability to tolerate seasonal waterlogging gives this species a wide ecological amplitude and potential to spread and overrun existing indigenous vegetation.

The presence of cleistogenes hidden at the base of the tillers (Gardener 1998) allows this species to reproduce after most of the plant itself has been destroyed in a fire. The cleistogenes represent approximately 50% of the total annual seed production (R. Parsons personal communication) and in New Zealand it has been observed that frequent burning of sites promotes *N. neesiana* and assists it in forming a monoculture (Bourdot personal communication).

Nassella neesiana is much more invasive in *Themeda triandra* dominated grasslands than is *N. trichotoma.* (M. Trengove personal communication). In trial plots, *N. neesiana* has not only invaded areas of *T. triandra* but has also choked out *N. trichotoma* (Hunt 1996).

Nassella neesiana is frequently associated with watercourses, growing along the banks of streams or even on islands that are subject to temporary flooding. Floodwaters play a significant role in the dispersal of seeds (Liebert 1996).

Lobed Needle Grass *Nassella charruana* (Syn. *Stipa charruana* Arech.)

Nassella charruana is indigenous to Uruguay, Argentina and south east Brazil (Rosengurrt *et al.* 1970). It is a perennial that has a very distinctive seed with large apical lemma lobes (Rosengurrt *et al.* 1970). It forms dense competitive infestations in Australia (D. McLaren, V. Stajsic personal observation) and Argentina (M. Gardener personal observation). It provides productive winter fodder but its seeds can penetrate the fur and skin of stock (Rosengurrt *et al.* (1970). In Argentina *N. charruana* was regarded as very poor fodder and unlike *N. trichotoma* and *N. neesiana* it was considered an extremely damaging noxious weed due to its invasiveness, competitiveness, unpalatability and very sharp and clinging seeds (M. Gardener personal observation).

To date it has only naturalised in Victoria and it was first collected and determined in 1995 at Thomastown (G. Carr personal communication). It has also been recorded at Janefield Reserve (C. Beardsal, personal communication, V. Stajsic personal observation) and near Cooper St. Epping where it has been reportedly growing for more than 40 years (P. Haberfield, personal communication) (Figure 10, Table 10). It was found growing primarily in direct sunlight or light shade and appears to prefer wet depressions but was also found growing on stoney rises. It was discovered on clay (grey/black cracking) which Rosengurrt *et al.* (1970) comments is the preferred soil type in South America.

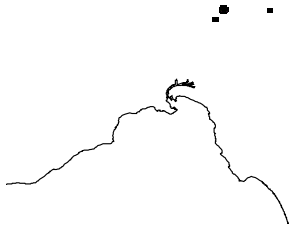

Figure 10. Distribution of lobed needle-grass in Victoria.

The Department of Natural Resources and Environment has recently begun a program to eradicate this weed. At the Thomastown site, the infestation occurs directly in line with road works for the Western ring road. The infestation was sprayed prior to commencement of road works and contaminated soil was stockpiled at a known location to enable control of re-growth. The road works contractor was instructed to implement a vehicle hygiene program to reduce spread of the weed. At Janefield Reserve, a population of 105 *N. charruana* plants including seedlings and adult plants were sprayed with Glyphosate on 24/12/97 (V. Stajsic personal observation). A large infestation (10-15 ha) at Cooper St. is currently being assessed for an extermination program over the next few months. A detailed survey and community awareness campaign will be implemented next spring when it is in flower and is easily identified. Young cattle will not eat

By using CLIMATE, the potential distribution of *N. charruana* in Australia has been estimated at 0.6 million ha (best prediction from Australian sites only) with a substantial area of Victoria at risk (Figure 11).

Figure 11. Potential distribution of lobed needle-grass in Australia.

Mexican feather grass *Nassella tenuissima*

Nassella tenuissima (Synonym - *Stipa tenuissima*) is native to Argentina, Chile, New Mexico and Texas (Jacobs *et al.* 1998). *N. tenuissima* is commonly called Mexican feather grass, Texas tussock, white tussock, ponytail grass and tussock grass. In Argentina, *N. tenuissima* is regarded as an unpalatable grass (Moretto and Distel 1998) and has been classified as a non-preferred species that can become dominant under continual heavy grazing pressure with a low frequency of high intensity fire (Distel and Boo 1995). Similarly, it is regarded as a species that is rarely eaten by deer in Texas (Simons 1996).

N. tenuissima is climatically very well matched to Australian conditions and its taxonomic similarity to *N. trichotoma* makes this species a potential disaster for the Australian environment. Mexican feather-grass can potentially occupy 6 times the area serrated tussock could occupy in Australia (Figure 12).

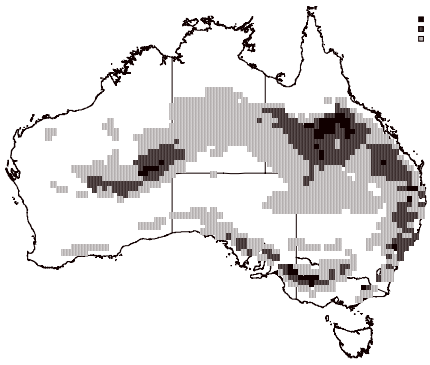

Figure 12. Potential distribution of Mexican feather -grass in Australia predicted from its distributions in its countries of origin.

In Argentina, Mexican feather-grass is less palatable than serrated tussock (Figure 13).

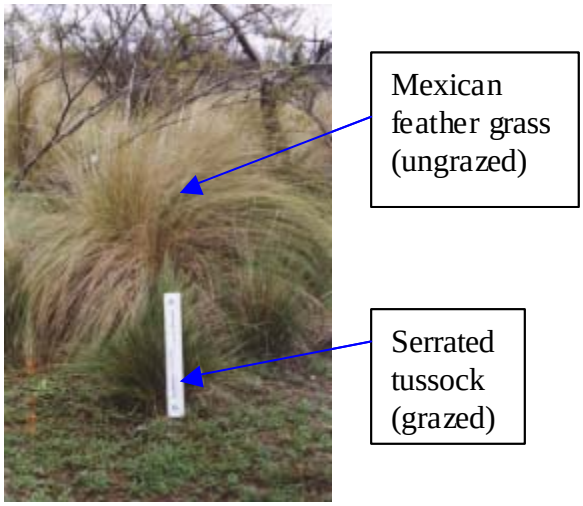

Figure 13. Comparison of Mexican feather-grass and serrated tussock in Argentina.

N. tenuissima's availability via the internet and other plant purchasing situations makes its entry and naturalisation in Australia almost inevitable. The AQIS system for screening new plant introductions for weed potential is possibly the best process of its type in the world. However, the system is founded on a dynamic list of permitted taxa that includes many genera such as *Stipa* spp. For grater confidence that potential new weeds will be excluded, gernera on the permitted list should ultimately be replaced with appropriate species.

Broad-kernel espartillo *Achnatherum caudatum* (syn. *Stipa caudata* Trin.)

Achnatherum caudatum is a perennial densely tufted grass indigenous to Chile and Argentina (Rosengurtt 1970, Caro and Sanchez 1971). *Achnatherum caudatum*, like the very closely related species *A. brachychaetum*, has been identified as a problem weed in lucerne crops in both Argentina and California (Parsons and Cuthbertson 1992). In Chile and Argentina A. caudatum is regarded of being of little to no fodder value, inhabits fertile areas but its seeds are not harmful to stock. It is considered an aggressive plant on fallow lands of calcareous soils (Rosengurrt et al. 1970).

The earliest known collection in Australia was made in the Cootamundra district of New South Wales on 5/11/1959 and has since spread to the Deniliquin area in New South Wales (Parsons and Cuthbertson 1992) (Figure 14). In Victoria it was first observed near Dunnolly on 30/11/1984. It has also been collected from Cambells Creek near Castlemaine. According to McPhee and May (1992) A. caudatum was first introduced to Clunes in gravel, possibly during the 1970s. It has recently been found invading riparian vegetation along Edgars Creek, Coburg.

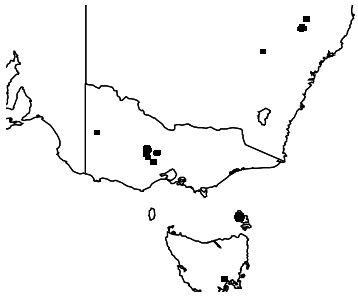

Figure 14. Distribution of broad kernel espartillo in Australia.

This species also occurs in Tasmania. It was recorded on Flinders Island in 1979 (Parsons and Cuthbertson 1992) and on mainland Tasmania at Bridgewater and is declared as a noxious prohibited species. It has yet to be declared in New South Wales and Victoria.

In New South Wales, A. caudatum is becoming a serious weed invading pasture, particularly after cultivation. It invades re-sown pasture and becomes prominent by the third year. In native pasture it is limited to areas of disturbance and along fence lines. Near Clunes in Victoria, A. caudatum poses a serious threat to grazing production and an unknown threat to cropping and horticulture. It is a poor fodder plant but starving will feed on young plants that were still vigorous under heavy grazing pressure (McPhee and May 1992). At Maryborough, cattle were observed to feed on it where little or no other pasture species remained (V. Stajsic, E. Bruzzese personal observation).

Achnatherum caudatum is reportedly spread by water, particularly after flooding and by stock along stock routes (J. Cherry personal communication, McPhee and May 1992). It is also spread by slashing, mowing and soil disturbance by machinery along roadsides in the Maryborough, Talbot and Clunes areas (V. Stajsic personal observation, McPhee and May 1992).

The species produces abundant hard awnless “nut-like” cleistogenes at the base of the leaf sheaths. The tussocks are spiny at the crown which may serve to protect the basal sheaths containing the cleistogenes (McPhee and May 1992).

In Victoria, *A. caudatum* has been observed invading riparian vegetation in central Victoria and in Melbourne.

By using CLIMATE, the potential distribution of *A. caudatum* in Australia has been estimated at 12.9 million ha (best prediction using Australian sites only) with a substantial area of Victoria, New South Wales and Tasmania at risk (Figure 15).

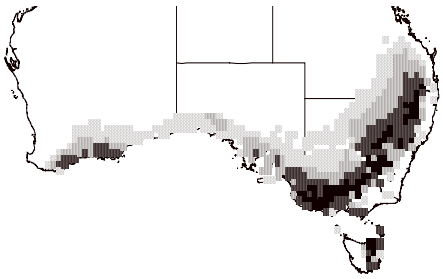

Figure 15. Potential distribution of large kernal espartillo.

Parramatta Grass *Sporobolus africanus*

Parramatta grass, *Sporobolus africanus* is becoming a serious threat to grazing industries in Australia. Parramatta grass is a tough unpalatable C_4 perennial tussock grass that originates from South Africa and was first recorded in Victoria in 1964. Sporobolus species occur in several forms, the most common being:

- Parramatta grass or rats tail grass, *S. africanus* (NSW and Victoria)
- Giant Parramatta grass, *S. fertilis* (Queensland and NSW)
- Giant rats tail grass, *S. pyramidalis* and *S. natalensis* (Queensland and NSW)

Parramatta grass is particularly aggressive in wet swampy soils, competing readily with paspalm-white clover pastures, often becoming dominant in open sunny situations and seriously reduces pasture productivity. Weedy *Sporobolus* spp. have many traits within their life cycle which make them highly adapted to Australian conditions:

- long plant life span,
- seedlings and plants are unpalatable and difficult to kill,
- high seed production,
- large seed banks,
- drought tolerance, and
- effective seed dispersal.

S. africanus is spreading rapidly in Victoria. It is becoming a serious weed around Melbourne where it is being spreading rapidly along arterial roads such as the Mulgrave freeway. It is also becoming a particular problem in the northern irrigation area of Victoria where it is invading high input irrigated pasture and severely reducing milk production on heavily infested properties (Figure 16). A survey conducted in this region during 2001 shows an alarming increase of infestations occurring since 1994 (Figure 17).

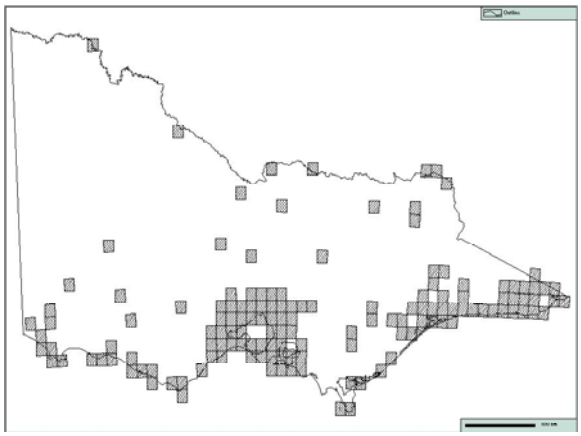

Figure 16. Distribution of Parramatta grass in Victoria. (from Flora Information System database, DNRE)

The Queensland Department of Natural Resources & Mines and the Meat & Livestock Association of Australia have funded a project to investigate the feasibility of a biological control program for Parramatta grass.

The Queensland Department of Natural Resources & Mines has recently developed a “national” Weedy Sporobolus Grasses Strategy. The four goals of the strategy are:

- Alert the community to the impact and seriousness of weedy Sporobolus grasses and ensure ongoing education on their management.
- Minimise the risk of spread of weedy sporobolus grasses.
- Infestations of weedy Sporobolus grasses are managed to reduce impacts.
- Coordinated management.

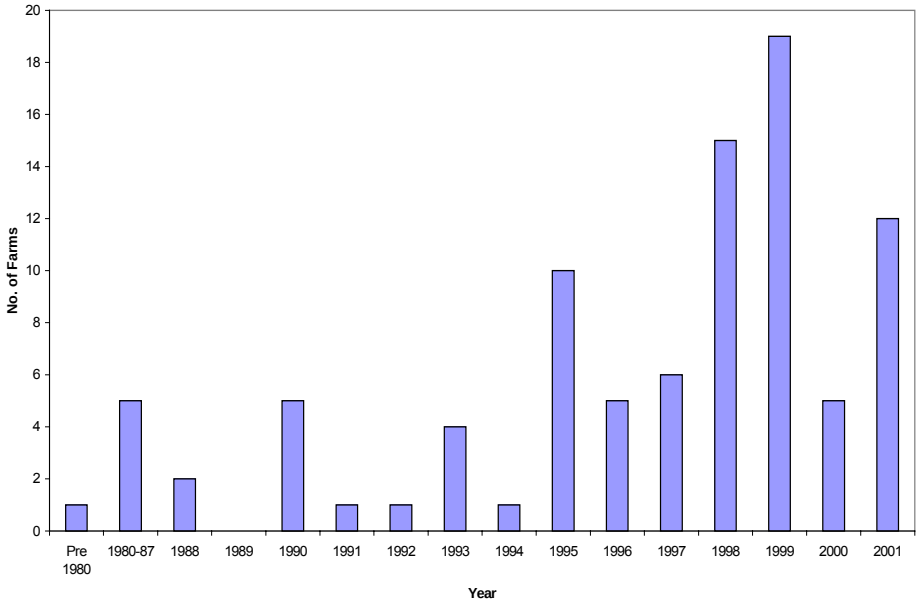

Figure 17. Survey results from Northern irrigation region of Victoria.

NRE is currently considering the relevance of the goals listed in the "National" strategy to Victoria, taking into consideration the weed's impacts to industries utilising irrigated pastures and possible impacts on natural ecosystems.

NRE has held a workshop with affected farmers in Northern Irrigation Region to establish current best practice in the management of Parramatta grass by landholders. The most effective herbicide for Parramatta grass control is flupropanate but withholding periods prevents its use on dairy farms. The other registered herbicides are glyphosate and 2,2 DPA. Glyphosate is non-selective and can result in additional bare ground leading to re-infestation. 2,2 DPA has only recently come back onto the market and its effectiveness against *S. africanus* is still being assessed.

Parramatta grass is spreading rapidly along roadsides, particularly in the Port Phillip region and it is likely that this weed's impacts will increase dramatically over the next decade. Figure 18 shows the potential distribution of Parramatta grass in Victoria.

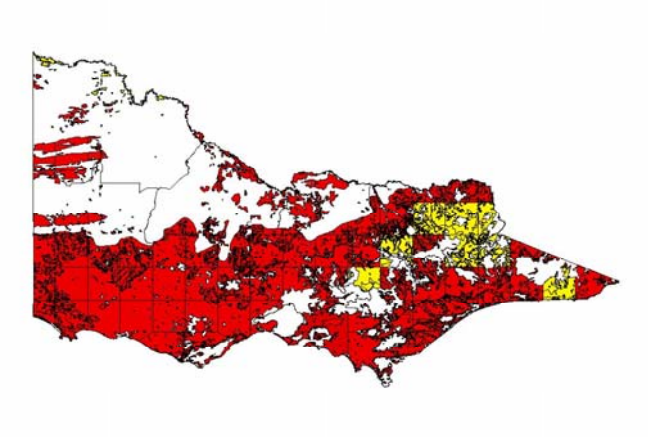

Figure 18. Potential distribution of Parramatta grass in Victoria.

Bent Grass *Agrostis capillaris*

Agrostis capillaris, (although some plants may be *A. stolonifera* and there are suggestions that we may have A. castellana) is known as creeping bent, bent grass, browntop or couch. *A. capillaris* is a native of Europe that has spread throughout much of the temperate world.

Bent grass is a perennial plant which spreads by stolons (horizontal above ground stems), rhizomes (underground stems) and seeds. It has been accidentally introduced in seed but also deliberately imported into Australia as a turf species, roadside stabiliser and as a pasture species for very infertile soils. Although it performs this role well, other species are much more productive and there is enormous potential to increase carrying capacity by improving fertility and replacing bent grass. *A. capillaris* makes an ideal lawn and is widely used in lawn seed mixtures, although *A. capillaris* is not as good as A. stolonifera. It dominates at least 1 million ha of high rainfall Victoria and reduces carrying capacity by at least 3 to 4 dse, costing Victoria $30 to $40m p.a., $16 to $20m in the Ballarat District alone (Figure 19). It rarely occurs as a pure stand and the most common weeds associated with bent grass in the Ballarat District are; Sweet Vernal, flatweed, fog grass and silver grass in most situations with species such as moss, scirpus, sedge, danthonia and dogstail being present in very infertile soil. In fertile soils it may coexist with barley grass, capeweed and wild radish etc.

Figure 19. The distribution of bent grass in Victoria.

Total annual production is very low, supporting 6 to 8 dse in environments which should be able to carry twice that. Winter production is extremely poor and carry-over summer feed is of negligible feed value. Late spring/ early summer production can be quite good, particularly in wet summers, but stocking rates are normally too low (because of the stocking rate ceiling established by the poor winter growth) to utilise it. Under utilised bent grass rapidly becomes rank and is unable to maintain sheep after mid-January unless it is topped to encourage fresh foliage growth. Carry-over dry feed resulting from wet summers leads to a dense mat which locks up nutrients, prevents clover germination and chokes out other perennial grasses. A self-perpetuating vicious cycle develops with carryover dry feed leading to poor winter production, low stocking rates and production of more carry-over unpalatable dry feed.

Bent grass is listed as one of the worlds worst weeds. Bent grass conservatively costs Victoria $30-40 million per year in control costs and lost production. Reg Hill (NRE Ballarat) has developed a spray topping technique using low rates of glyphosate that has enabled farmers to manage bent grass, improving profitability and substantially reducing its cost to Victoria. It is interesting to note that Monsanto PTY LTD has been investigating development of a glyphosate resistant form of bent grass for the Turf industry. DNRE has requested Monsanto to end this research.

African Lovegrass *Eragrostis curvula*

Eragrostis curvula is a perennial C_4 tussock grass that originates form southern Africa. It is believed to have been introduced by accident prior to 1900's but has also been specifically imported for agronomic assessment resulting in naturalisation of four different forms (Parson's and Cuthbertson, 1992). It is a highly persistent, summer-growing grass and most forms are unpalatable. It reproduces

copious amounts of seed that is spread by wind, animals, footwear, vehicles, machinery and through contaminated soil (Parson's and Cuthbertson 1992).

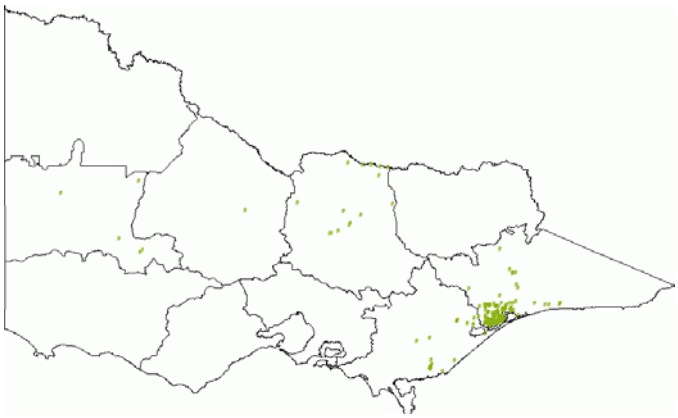

Figure 20. Current distribution of African lovegrass in Victoria

Populations of *E. curvula* continue to spread in the Bainsdale-Statford area of Victoria despite a concerted management program (Figure 20). Figure 21 shows the potential distribution of E. curvula in Victoria.

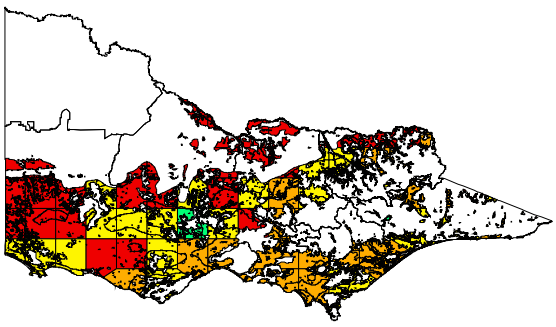

Figure 21. Potential distribution of African lovegrass in Victoria

Silver grass *Vulpia bromoides*

V. bromoides is a slender, tufted annual grass that originates from the western Mediterranean, south western and central Europe. It was first recorded in Victoria in 1852 and has now spread throughout large areas of Victoria's grazing pastures (Figure 22). *V. bromoides* reproduces by producing large numbers of small seeds that readily attach to animals and clothing. The seeds are a major cause of vegetable fault in wool and may also work their way into the skin of livestock, causing hide damage (Whittet 1969). Figure 23 shows the potential distribution of *Vulpia bromides* in Victoria.

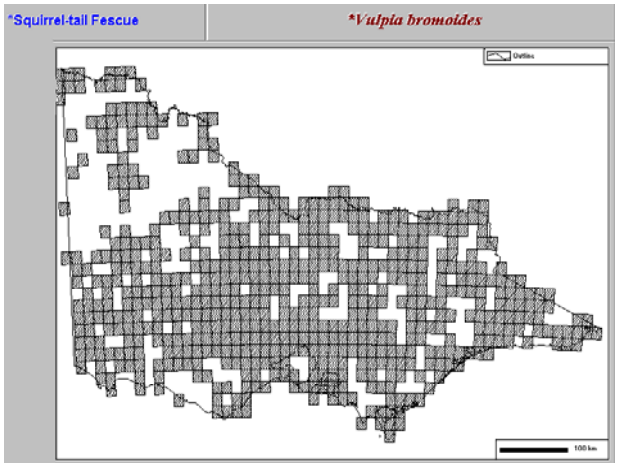

Figure 22. Current distribution of silver grass in Victoria (from Flora Information System database, DNRE)

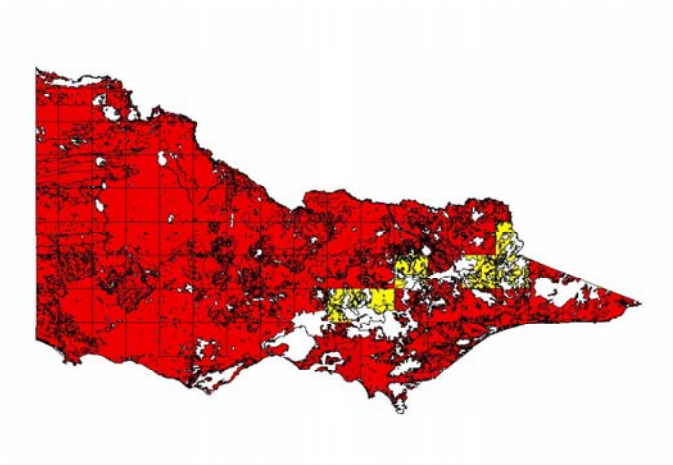

Figure 23. Potential distribution of silver grass in Victoria.

Coolatai grass/Tambookie grass *Hyparrhenia hirta*

Hyparrhenia species are important components of natural pastures in Africa, especially where there is a long dry season, and their foliage has been used for roof thatching in many countries. There are four species in Australia, three of which are naturalised. They are classified in the grass tribe Anthristriinae, along with *Themeda* (kangaroo grass).

*H. hirt*a, also known as Coolatai grass, is native to Africa, south west Asia and a large part of the Mediterranean region. It was introduced to and spread in Australia as a summer-growing pasture grass and was first recognised as naturalised in Victoria in the early 1990s. It is now spreading widely in the Northern Irrigation region with rapidly increasing populations e.g. in irrigated areas near Piangil (Swan Hill area), Kyabram, Numurkah and Springhurst. Tambookie grass is potentially a very serious weed of roadsides, urban areas, pastures, grassland and bushland.

H. hirta is an economically important plant that was promoted for pasture use in Western Australia from the 1960s onwards. At least ten races, sourced from Iraq to Portugal and South Africa, were introduced by CSIRO and used for trials in the 1960s. Studies indicated that Tambookie grass monocultures could double carrying capacity in Western Australian sheep pastures, but the potential of the grass could be limited by low seed yields. It is believed that seed from South Africa was first sown in the Coolatai district of NSW in the 1940s and the plant now occurs widely in northern NSW and southern Queensland. In northern NSW *H. hirta* is generally regarded as an invasive, weedy species and as undesirable where it has invaded roadsides, travelling stock routes and pastures.

The plant has spread rapidly in WA over the last five years, along road and rail verges and into adjacent bushland, throughout the whole of the south-west, from Dongara to Ravensthorpe. In South Australia it is considered a grassland invader on the outskirts of Adelaide. It has spread very quickly with the aid of council mowing in the north of the city and has been seen (and controlled) on roadsides to the south.

A similar species, the rhizomatous *H. filipendula*, also known as Tambookie grass, from Africa and tropical Asia, is grown in NSW and Queensland as a useful winter and drought forage.

Hyparrhenia hirta is extremely deep-rooted for a grass (at least 3 m). It has a growth cycle characteristic of subtropical grasses, with maximum growth usually in late spring but highest in mid summer after good rain. It is sensitive to low temperatures (<15°C) during germination and as a seedling. It produces large amounts of dry herbage and the prolific summer biomass production increases fire risks and requires more frequent mowing. Opinions differ on the fodder value of the species, with some authors considering that it is a useful species, others that it is avoided by stock and has little forage value. In general, in each particular area there will be better, less invasive pasture grasses that are easier to manage. No herbicides are registered for control of Tambookie grass in Victoria.

Broadleaf Weeds

Branched broomrape *Orobanche ramosa.*

The broomrapes, *Orobanche* spp., are parasitic plants that attack the roots of crops including pulses, pasture legumes, oilseeds and a wide range of vegetables. Orobanche are highly advanced plants with no green parts and can only survive by parasitising a host. Of the numerous broomrapes worldwide, five are particularly weedy and cause heavy damage in Europe, Asia and America. *O. ramosa* is one of these species.

A single *O. ramosa* plant can produce up to 20,000 seeds, with dormancy of 10 or more years being common. Seeds are extremely small and can be dispersed by wind and water (including irrigation water/sprinklers), animal manure, contaminated soil, produce, machinery, livestock and clothing. Overseas, *O. ramosa* has been recognised as a serious parasitic weed on tobacco, cannabis/fibre hemp, canola, tomatoes, cabbage and eggplant. It has been found attacking canola and peas in South Australia.

Establishment of *O. ramosa* in Australia, even in small areas, can affect Australian export markets because many of our trading partners prohibit all *Orobanche* spp.

O. ramosa was first recorded in the Murray Bridge area of South Australia in 1992 and has been subject to an on-going eradication program.

A survey conducted in 2000/2001 in South Australia has detected O. ramosa over a total area of approximately 4,000 ha within an area of approximately 70 km by 70 km.

O. ramosa is palatable and will not be a direct issue to grazing industries. However, its impacts on pulse, grains and vegetable industries would result in full quarantine being impored on graziers in

Victoria if found. Approximately 300 landowners are under quarantine restrictions in South Australia. As such, *O. ramosa* represents a serious threat to grazing industries in Victoria.

An NRE Branched Broomrape response team "Operation Rapid Response" was set up in August 2000 and has overseen monitoring of sites in Victoria linked to infested sites in South Australia.

Paterson's curse *Echium plantagineum*

E. plantagineum is an annual herb that originates from the Mediterranean region and Western Europe. It was first recorded in Australia in 1843 and is now widely distributed as the dominant species over large areas of grazing land in southern Australia. In Victoria, *E. plantagineum* is a serious weed in northern Victoria and is continuing to spread into the Port Phillip, Gippsland and South West regions (Figure 24). Figure 25 shows the potential distribution of *E. plantagineum* in Victoria.

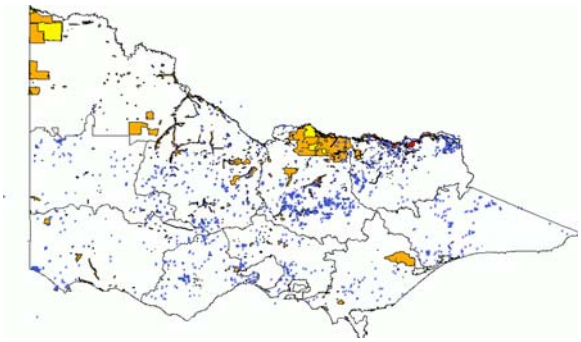

Figure 24. Distribution of Paterson's curse in Victoria.

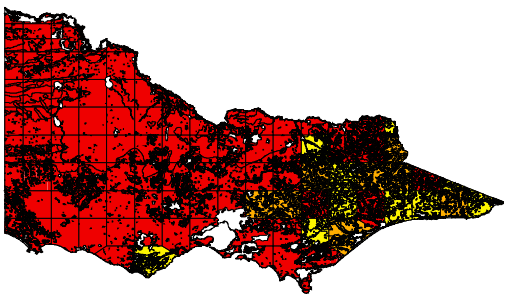

Figure 25. Potential distribution of Paterson's curse in Victoria.

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WEEDS OF SIGNIFICANCE TO THE GRAZING INDUSTRIES OF THE NEW SOUTH WALES TABLELANDS, SLOPES AND PLAINS

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INTRODUCTION

In spring 1999 a region-wide survey designed to obtain objective weed incidence data was conducted in New South Wales for the first time (Dellow *et al.* 2002). Although confined to the temperate perennial pasture zone (PPZ - comprised mostly of the Northern, Central, Southern Tablelands and near slopes) of New South Wales, this 7 million hectare area yields nearly half of the sheep and cattle production of New South Wales. The most abundant weeds were annual grasses, especially *Vulpia* spp. and *Bromus molliformis*. As a group, annual grasses comprised more than a quarter of the total average pasture biomass. In contrast, broadleaf weeds only accounted for around 8% of the biomass. At these levels of infestation, production losses are estimated at $230 million per year

There are well-established management techniques that have been developed to limit the abundance of annual grass weeds. It would appear from the relatively poor condition of much of the tablelands pastures, however, that their extension and adoption needs to be much more effective.

The objective data generated in this survey may be contrasted with grazier perception of weed importance. In a weed survey of the Northern Tablelands (Sindel 1996), graziers ranked thistles, blackberry and Bathurst burr as the major troublesome weeds. Out of the forty-six weeds nominated, *Vulpia* spp. ranked eleventh. These results are quite different from those in Dellow *et al.* (2002). It is possible that the pastures had substantially changed in species composition between 1996 and 1999, but it is more likely that annual grass weeds are underestimated because of identification difficulties. It further underlines the point that good objective survey data is required in order to determine weed management priorities.

Dellow *et al.* (2002) provides only a single 'snapshot' in time of the state of NSW Tablelands pastures and further periodic surveys are highly desirable. To that end, follow-up summer and spring surveys of a limited number of the sites surveyed above have been done, although the results are yet to be fully analysed.

Excluding this perennial pasture zone, the remainder of the State has not been surveyed in any systematic fashion. Individual weeds have been surveyed; however, they have been done on an individual species basis and usually only conducted by questionnaires sent to regional agronomists (Table 13). As a result, the figures are subject to the different perceptions of weed importance by different respondents and, although some estimates of the area and severity of infestation can be made, region-wide quantitative data is difficult to derive and subject to considerable error. Nevertheless, numerous surveys have been conducted and are summarised below (maps appended). Well in excess of fifty percent of the State remains completely unsurveyed and this includes the wheat/sheep/cropping belt, the very extensive Western Division and the coastal divisions.

The weeds considered in this paper pose livestock grazing problems in relation to production, carcass and product damage and poisoning.

It should also be noted that surveying annual weeds may yield atypical results, depending on the year. The distribution and abundance of weeds such as *Echium plantagineum* are a direct result of preceding and prevailing weather conditions, often resulting in huge seasonal variations in distribution and density of infestation. For development of the most effective management strategies, survey data

needs to be used in conjunction with knowledge of the biology of the plant, the potential for spread, economic and environmental impact and the ease and cost of control.

Table 13. Weed surveys conducted in New South Wales

Weed	Total Area infested (ha)	Reference
Serrated tussock	740,000 (1994)	Campbell (1977), Jones & Vere (1998)
African lovegrass	45,000 (1982)	Campbell (1983)
Paterson's curse	50% LGA	Dellow & Seaman (1985)
Blue heliotrope	100,000 (1984)	Dellow & Seaman (1987)
Common heliotrope	10,000,000 Aust (1988)	Dellow & Seaman (1987)
Silverleaf nightshade	134,000 (1992)	Dellow (1993)
Blackberry	5,700,000 (1983)	Vere & Dellow (1984)
Sifton bush	616,000 (1988)	Campbell (1990)
Lippia	800,000 (2001)	Dellow *et al.* (2001)
St John's wort	250,000 (2001)	Campbell *et al.* (2001)
Scotch thistles (*Onopordum* spp.)	1,000,000 (1989)	Dellow & Holtkamp (1994)
Thistles -		
Black	46,000,000 (1978)	
Variegated	36,000,000 (1978)	
Slender	18,000,000 (1978)	Medd (1981)
Nodding	5,000,000 (1978)	
Onopordum spp.	20,000,000 (1978)	NSW = 7M km^2

DISCUSSION

Grasses

Annual Grasses

For the PPZ, annual grasses (Table 14) form 26% of the pasture biomass (Dellow *et al.* 2002) with an estimated opportunity cost of $33 per hectare per year. *Vulpia* spp. was the dominant annual grass. Unlike many other weed species, techniques for the reduction of annual grasses are quite well established. The relatively poor condition of the NSW Tablelands pastures, however, indicates that more effective promotion of this technology within an integrated pasture management strategy is required.

Perennial Grasses

Considerable effort has been spent in determining the distribution and impact of perennial grass weeds on the tablelands and slopes of New South Wales (Table 14).

Nassella spp. in New South Wales have for a long time been targeted as serious production and environmental weeds. Vere *et al.* (2002) and Jones *et al.* (2000) have estimated that widespread control of *N. trichotoma* would generate potential annual benefits of $40.3 million. *N. trichotoma* is perhaps the most studied weed in Australia. Current technology needs to be promoted and extended to specific situations.

Eragrostis curvula has made rapid spread in the last 20 years (Campbell 1983) and unlike the *Nassella* spp. has the potential to spread throughout the whole of the cropping and pastoral zones of the State. The high incidence of *Eragrostis curvula* as a roadside weed is indicative of its continuing threat. *E. curvula* control has been researched in central and southern NSW; the weed can be selectively removed from perennial pastures such as *Phalaris aquatica* (Campbell *et al.* 1985) and *Pennisetum clandestinum* (Campbell *et al.* 1987).

Two perennial grass species which have been generally overlooked as current and potential weeds are *Agrostis capillaris* (browntop bent) and *Hyparrhenia hirta* (Coolatai grass). *A. capillaris* is widespread along the tablelands; its distribution has been attributed to it being a contaminant of perennial ryegrass (*Lolium perenne*) seed (Dellow *et al.* 2002). *A. capillaris* is highly unpalatable and difficult to control. Where *A. capillaris* dominates pastures carrying capacity may be reduced by at least 3-4 dse. *H. hirta* is perhaps one of the major 'sleeper' weeds. The PPZ survey (Dellow *et al.* 2002) found *H. hirta* present in several locations; within these locations the species was dominant making up 81% of the pasture biomass. *H. hirta* is widespread throughout the state (Dellow personal observation) being present throughout all the cropping and pastoral lands. *H. hirta* has traditionally been a weed of northern NSW. Lodge *et al.* (1994) and McCormick and Lodge (1991) found *H. hirta* to be widely distributed in northern NSW, mostly on lighter-textured soils and also in southern Queensland, producing large amounts of unpalatable herbage from the rapidly growing summer forage.

Aristida ramosa (three-awned speargrass) is a native grass species of very low forage value. Besides the poor feed quality the three-awned seed causes major production and carcase and wool contamination. In areas of the tablelands and slopes carcase contamination causes losses of up to 50 percent of their retail value (Dadd *et al.* 1989).

Broadleaf weeds

Tables 13 and 14 list the nominated species and their distribution. For the PPZ the most widespread broadleaf weed is *Hypochaeris radicata* (Dellow *et al*. 2002). *H. radicata* poses the vexed question; weed or beneficial pastoral species?

The broadleaf weeds with the greatest weed potential (Dellow personal observation) are:

Hypericum perforatum

This species is continuing to make major incursions on the tablelands, slopes and near plains. Campbell and Dellow (1984) demonstrated that *H. perforatum* can be controlled by insects (biological control agents) and grazing livestock. Further perennial pasture establishment and grazing management research by Campbell (Arnott 1997) in 1975 (Coolah) demonstrated successful control techniques (Campbell and Nicholl 1997). The success of grazing can be dependent on the type of grazing livestock used. Bourke (Campbell *et al.* 2001) has demonstrated that different strains of sheep have varying susceptibilities to *H. perforatum*. Campbell *et al.* 2001 also demonstrated differing strains of *H. perforatum* have varying levels of hypericin (poison) content. Coupling herbicides with perennial pasture establishment (Campbell and Nicol 1997) have demonstrated effective long term control of *H. perforatum*. A vast amount of research has been conducted on *H. perforatum* and it is suggested a review of the considerable literature would be the obvious first step in the process of extending this knowledge as well as acknowledging the "gaps". Graziers have for many years controlled *H. perforatum* in the New South Wales tablelands managing sheep with inputs of subterranean clover and superphosphate (Dellow personal observation and experience).

Phyla canescens

This species already infests 800,000 hectares of valuable flood plain country of the plains of NSW. *P. canescens* is one of the major agricultural and environmental weeds of western New South Wales (Dellow *et al.* 2001). In the Moree area, an estimated 500 000 ha are infested with reductions in productivity on some properties of up to 75% ($40 000 per year – The Land, May 2, 2002, p15)

Onopordum spp.

Onopordum spp. are long lived perennial thistles with long lived seeds. The weed at present infests one million hectares of south-eastern Australia (Dellow and Holtkamp 1994) and unfortunately are continuing to spread.

Brassica spp.

These weeds are conspicuous throughout the cropping belt (Table 14). Their impact on grazing industries is little documented. The main species are: *Rapistrum rugosum*, *Brassica tournefortii* and *Sisymbrium* spp.

Echium plantagineum and *Heliotropium europeaum*

These weeds are extremely widespread annual weeds, occurring throughout south-eastern Australia (Table 14). Although continuing to spread the density of infestation varies greatly from season to season. Both species are high in alkaloids causing chronic livestock poisoning problems as well as general grazing production losses. Where both species co-exist the exposure to associated alkaloid poisoning is enhanced (Dellow & Seaman 1985). *E. plantagineum* grows through autumn to spring while *H. europeaum* grows through summer months.

'Sleeper' broadleaf weeds

The authors consider the following weed species of major potential risk to the grazing industries. Although recorded in few locations, these weeds have demonstrated major problems in other countries:

- *Centaurea maculosa* and *Centaurea nigra* are only present in isolated locations.

- *C. maculosa* is a major pastoral weed of North America - (USA 3M hectares, Montana $4.5M)and is at present known from only one location in the ACT.

- *C. nigra* is currently a major weed in the cropping belt of Victoria. The *Centaurea* species of thistles are major weeds throughout the world (600 species in *Centaurea* genus).

- *Hieracium* spp. (Hawkweeds) are capable of invading the tablelands of south-eastern Australia (Groves 1996). *Hieracium* spp. has been collected from one horticultural nursery in New South Wales. *Hieracium murorum* has naturalized at Katoomba and attempts are being made to eradicate this species.

Woody Weeds

Blackberry has been estimated to cost New South Wales $25M per year (Vere and Dellow 1984). No survey information is available for other woody weeds.

Olea spp. (olives) are already a major weed of the County of Cumberland (central coast). Dellow *et al.* (1987) considered *Olea* spp. potentially one of the major threatening pastoral and environmental woody weeds. The recent proliferation of olive groves throughout south-eastern Australia exposes the area to rapid incursion of this difficult to kill and adaptive weed. Table 14 lists the nominated woody species.

Graziers consider a number of inedible native shrubs to be a problem for the grazing industry in rangelands. Some of these species are listed in Table 14. Some species increase under various forms of grazing.

Table 14. Weed species nominated (not in order of importance). * "Sleeper weeds"

Grasses		**Broadleaf Plants**		**Trees and Shrubs**	
Common name	Scientific name	Common name	Scientific name	Common name	Scientific name
Annual Grasses		Silverleaf nightshade	*Solanum elaeagnifolium*	African olive	*Olea europaea* spp. *cuspidata*
Vulpia	*Vulpia* spp.	St John's wort	*Hypericum perforatum*	Blackberry	*Rubus fruticosus* agg.
Annual ryegrass	*Lolium rigidum*	Scotch thistles	*Onopordum spp.*	Sweet briar	*Rosa rubiginosa*
Brome grasses	*Bromus* spp.	Paterson's curse	*Echium plantagineum*	Broom	*Cytisus scoparius*
Barley grasses	*Hordeum* spp.	Parthenium weed	*Parthenium hysterophorus*	Sifton bush	*Cassinia arcuata*
		Blue Heliotrope	*Heliotropium amplexicaule*	Boxthorn	*Lycium ferocissimum*
Perennial grasses		Common heliotrope	*Heliotropiueuropaeum*	Native trees and shrubs	Various species. e.g. *Cassinia* ssp.
Serrated tussock	*Nassella trichotoma*	Lippia	*Phyla canescens*		*Olearia* spp.
Chilean needlegrass	*Nassella neesiana*	Saffron thistle	*Carthamus lanatus*		*Dodonaea* spp.
					Eremophila spp.
African lovegrass	*Eragrostis curvula*	Thistle species	*Cirsium vulgare*		*Solanum* spp.
Browntop bent	*Agrostis capillaris*		*Silybum marianum*		*Acacia* spp.
Coolatai grass	*Hyparrhenia hirta*	Catsear	*Hypochaeris radicata*		
*	*Nassella* spp.	Sorrel	*Acetosella vulgaris*		
Three-awned speargrass	*Aristida ramosa*	Brassicaceae	*Rapistrum rugosum*		
			Sisymbrium spp.		
			Brassica tournefortii		
		* Centaurea thistles	*Centaurea nigra*		
		*	*Centaurea maculosa*		
		* Hawkweeds	*Hieracium spp.*		
		Salvinia	*Salvinia molesta*		
		Alligator weed	*Alternanthera philoxeroides*		
		Water hyacinth	*Eichhornia crassipes*		

Western Rangeland weeds

Table 15 lists the weedy species for this region (Peter Milthorpe pers. comm). *Prosopis* spp. and *Lycium ferocissimum* have the potential to invade the entire watercourse country of the Western Division. *Prosopis* spp. are confined to a relatively small area in the far North West Plains of NSW (Packsaddle Station). A small amount of resolve by the Western Lands Commission and NSW Agriculture could solve this potentially disastrous threat to the whole of the Western Division.

Asphodelus fistulosus is well adapted to arid regions and poses huge pastoral and environmental threats. Herbicide control is effective but would be only appropriate on small colonising sites.

Carrichtera annua is the major annual brassica weed of the Western Division. It is highly competitive and has a large seed. It occupies more than 500 000 ha in an area bounded by Hillston, Deniliquin and Wentworth (P. Milthorpe, pers. comm.). It is also considered a major environmental weed.

Ixiolaena brevicompta (billy buttons) is present in periods of local flooding. Major livestock losses occasionally occur during these incidences (Cunningham *et al.* 1981).

Table 15. Western rangeland weeds (native western woody weeds not included) (P.Milthorpe, pers. comm.)

Common name	Scientific name
Mesquite	*Prosopis* spp.
Onion weed	*Asphodelus fistulosus*
Boxthorn	*Lycium ferocissimum*
Lippia	*Phyla canescens*
Noogoora burrs	*Xanthium* spp.
Ward's weed	*Carrichtera annua*
Billy buttons	*Ixiolaena brevicompta*

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WEEDS OF SIGNIFICANCE TO GRAZING INDUSTRIES OF COASTAL NSW

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INTRODUCTION

Coastal NSW is home to a wide variety of weeds of which 61 are currently declared noxious (Table 16). Not all these weeds are declared in all coastal council areas and many weeds vary in the type of declaration from one council area. Those weeds that are of significance to the production of grazing animals are discussed.

The area reviewed covers the coastal plain and eastern escarpment between the Queensland and Victorian borders (excluding metropolitan Sydney and Newcastle), an area of 4.6 million hectares.

The area boasts high annual rainfall (900-2000mm) and climate that varies from sub-tropical in the north to temperate in the south. Mean maximum and minimum temperatures are listed in Table 17. The eastern escarpment of the Great Dividing Range reaches 1000m above sea level and mean maximum and minimum temperatures decline by approximately 0.6^{o}C for every 100m increase in elevation.

Weeds have a significant impact on animal welfare on the NSW coast. It has been estimated that approximately 40% of coastal stock deaths from the Hunter Valley to the Queensland border are the result of plant poisoning (Ian Harradine RLPB Grafton, personal communication). In the Grafton Rural Lands Protection Board area most stock poisoning deaths are due to native bracken fern, *Pteridium esculentum* (600-1000/annum) and red lantana, *Lantana camara* (5-600/annum) and green cestrum, *Cestrum parqui* (200/annum) (Ian Harradine RLPB Grafton, personal communication). Only introduced species have been discussed in this review.

The weeds of significance to Coastal NSW have been grouped under the following headings:

- Unpalatable grasses
- Exotic woody shrubs and trees
- Weedy herbs
- Potential weeds

Table 16. Sixty-one weeds that are declared noxious weeds for parts of coastal NSW.

Common name	Scientific name	Common name	Scientific name
African love grass	*Eragrostis curvula*	Miconia	*Miconia spp.*
African boxthorn	*Lycium ferocissimum*	Mint Weed	*Salvia reflexa*
Alligator Weed	*Alternanthera philoxeroides*	Mistflower	*Ageratina riparia*
Bitou Bush	*Chrysanthemoides monilifera*	Mother-of-Millions	*Bryophyllum delagoense*
Blackberry	*Rubus fruticosus* (agg. spp.)	Mysore Thorn	*Caesalpinia decapetala*
Black Knapweed	*Centaurea nigra*	Nodding Thistle	*Carduus nutans*
Broomrape	*Orobanche* spp.		
Burrs - Bathurst, Cockle, Californian and Noogoora	*Xanthium* spp	Pampas Grass	*Cortaderia* spp.
Cabomba	*Cabomba* spp.	Parthenium Weed	*Parthenium hysterophorus*
Camphor Laurel	*Cinnamomum camphora*	Paterson's Curse, Vipers Bugloss	*Echium* spp.
Cape broom	Genista monspessulana	Perennial ragweed	Ambrosia psilostachya
Columbus Grass	*Sorghum x almum*	Prickly Pears (not *Ficus indica)*	*Opuntia* spp.
Crofton Weed	*Ageratina adenophora*	Privet - Broadleaf	*Ligustrum lucidum*
Dodder	*Cuscuta campestris*	Privet - Narrowleaf	*Ligustrum sinense*
Fireweed	*Senecio madagascariensis*	Rhus Tree	*Toxicodendron succedaneum*
Giant Parramatta Grass	*Sporobolus fertilis*	Salvinia	*Salvinia molesta*
Giant Rat's Tail Grass	*Sporobolus pyramidalis*	Scotch/English Broom	*Cytisus scoparius*
Green Cestrum	*Cestrum parqui*	Scotch Illyrian Stemless thistles	*Onopordum spp.*
Gorse	*Ulex europaeus*	Serrated Tussock	*Nassella trichotoma*
Groundsel Bush	*Baccharis halimifolia*	Senegal Tea Plant	*Gymnocoronis spilanthoides*
Harrisia Cactus	*Harrisia* spp.	Siam Weed	*Chromolaena odorata*
Hawkweeds	Hieracium spp.	Spiny Burrgrass	*Cenchrus incertus*
Hemlock	Conium maculatum	Spiny Burrgrass	*Cenchrus longispinus*
Horsetail	*Equisetum* spp.		
Johnson Grass	*Sorghum halepense*	Spotted Knapweed	*Centaurea maculosa*
Karroo Thorn	*Acacia karroo*	St John's Wort	*Hypericum perforatum*
Kochia (not ssp. *triophylla*)	*Kochia scoparia*	Tree of heaven	*Ailanthus altissima*
Lagarosiphon	*Lagarosiphon major*	Water Hyacinth	*Eichhornia crassipes*
Lantana – other than pink-flowered variety	*Lantana camara*	Water Lettuce	*Pistia stratiotes*
Mexican feather grass	*Nassella tenuissima* syn. *Stipa tenuissima*	Willow, Black	*Salix nigra*
		Willows (not *S. bablyonica*, *S. reichardtii* or *S. calodendron*)	*Salix* spp.

Table 17. Mean maximum and minimum temperatures for coastal NSW.

Region	Mean Maximum Temperature (^oC)	Mean Minimum Temperature (^oC)
Grafton to QLD border	24	12
Wollongong to Grafton	21	12
Wollongong to Vic border	18	9

Unpalatable grasses

Unpalatable grasses are generally avoided by livestock and are therefore able to set seed and spread rapidly making pasture less productive. The unpalatable grasses of concern to coastal graziers are the weedy sporobolus grasses (Sporobolus spp); African lovegrass (*Eragrostis curvula)*; serrated tussock (*Nassella trichotoma*) and Chilean needle grass (*Nassella neessiana*).

Weedy sporobolus (*Sporobolus* spp.)

The weedy sporobolus grasses present in Coastal NSW include giant parramatta grass (GPG) (*Sporobolus fertilis*; formerly *S indicus var. major*); giant rats tail grasses (GRT) (*S. pyramidalis* and *S. natalensis)* and parramatta grass (PG) (*S. africanus*). GPG is well established on the north, mid-north coast and Hunter and is rapidly increasing its' presence in almost all council areas south of the Hunter to the Victorian border. PG is also widespread but to date has caused less concern in coastal NSW than its taller cousin. In the dairying areas of Northern Victoria PG has recently been recognised as a significant emerging weed problem. GRT have established on less than 20 properties in NSW and doesn't appear to be as vigorous as GPG in the NSW coastal climate.

State of research:

The ecology of GPG and GRT are reasonably well understood thanks to MLA funding. One weakness in our current knowledge is in the area of the adaptability of the weedy *Sporobolus* spp. to various climates.

There is a need for on-going evaluation of current and potential herbicides. This would include, for example, the effect of flupropanate on native species and new cultivars.

The MLA has recently agreed to fund a project to evaluate various management strategies for weedy *Sporobolus* spp. where cropping is not possible. This project will look at strategies for both GPG and GRT in NSW and central Qld respectively.

Identification of weedy species from the less aggressive native species is difficult and somewhat unreliable. Further work is required to develop molecular techniques that can routinely and economically identify both weedy and native species of *Sporobolus*.

Currently a research program is under-way in Southern Africa to identify potential biocontrol agents for weedy *Sporobolus* spp. This program has been running less than 12 months. If potential agents are identified, it will be very important to fund further research into each agent's host specificity and efficacy. For this work to be reliable, identification of individual *Sporobolus* spp. via a reliable DNA identification method will be important.

Public understanding of the importance of weedy *Sporobolus* spp. is variable across the NSW coastal region. Awareness of weedy sporobolus (mainly GPG) is relatively good in the north of the state where it is most prevalent but quite poor in the south of the state. Any education program will need to be targeted to the needs of each coastal region.

African lovegrass (*Eragrostis curvula*)

African lovegrass is a densely tufted perennial (up to 120cm high) with a number of agronomic types. Like other unpalatable species, African lovegrass displaces more desirable pasture species and increases management costs. African love grass grows on a range of soil types but is well suited to light to medium acid soils. It has been used for erosion control and to prevent growth of spiny burr grasses (*Cenchrus* spp.). Unlike other biotypes, cultivar Consol is reputed to be of medium palatability.

Weedy biotypes are currently most abundant in tableand areas of NSW and Tenterfield and occur in parts of the coastal regions. This grass has the potential to spread rapidly (alongside roads initially) throughout much of NSW, Victoria and southern Queensland. This weed still requires research into its ecology and management and educational programs with respect to management.

Serrated Tussock (*Nassella trichotoma*)

A highly invasive wind dispersed grass weed that is not eaten by stock. Serrated tussock is currently prevalent in tableland areas of NSW and in Victoria but is also found on the NSW South Coast and in small pockets east of Glen Innes. A lot of ecological and management research has been conducted on serrated tussock. However gaps in our knowledge include managing pastures to prevent reinfestation with serrated tussock and improving wiping practice and technology. A program has commenced to identify and evaluate potential biological control agents for this weed. Given the diversity of plant communities in which this plant grows, extensive evaluation of species potentially affected by biocontrol agents will be required. On-going public education of control and management strategies is required.

Chilean Needle grass (*Nassella neesiana*)

A relative of serrated tussock, Chilean needle grass has only relatively recently been recognised as a serious weed. Chilean needle grass grows as dense clumps up to a height of 1m. It produces two types of seeds (panicle and cleistogene or stem seeds). The cleistogenes allow the plant to reproduce even when obvious flowering has been prevented. Chilean needle grass seed is hairy and is spread by attachment to machinery, clothing, livestock and water.

Much work is required to improve our understanding of the best methods to prevent, contain and rehabilitate Chilean needle grass infestations. Also, as a relatively newly recognised weed, research is required to map infestations, increase public awareness and develop comprehensive extension packages.

Exotic shrubs and trees

There are five weedy tree species of concern to graziers especially on the NSW north coast. These are camphor laurel *(Cinnamomum camphora*); small- and large-leaved privets (*Ligustrum sinense* and *L. lucidum*), broad-leaved pepper tree (*Schinus terebinthifolius*) and Chinese celtis (*Celtis sinensis*).

These weeds are escapees from gardens and are well adapted to our coastal climate. The five tree species are capable of producing thickets that impede stock movement and reduce productivity of grazing land. To date, Broad-leaved pepper tree is only known to be a pasture problem on one property near Mullumbimby (John Hosking, NSW Agricuture, Tamworth, personal communication).

Camphor laurel is widespread in paddocks, transport routes, stream banks and urban areas especially on the north coast of nsw. privets are also widespread in transport routes and streams especially on the eastern slopes of the great dividing range but only scattered plants are found **currently in paddocks and**

urban areas. Both Chinese celtis and broad-leaved pepper tree have been recognised as weeds only relatively recently and have much smaller distributions than camphor laurel and the privets.

The shrubs lantana (*Lantana camara*) and blackberry (*Rubus fruticosus* sp. agg.) are also problematic. Lantana is a dense twining shrub that is widely distributed over coastal NSW and continues to invade new habitats within the region. There are a number of types of lantana, which are identified by their flower colour. The genetic diversity of this species and its ability to drop its leaves when stressed have made many past and present attempts at biological control unsuccessful. Red flowered lantana is toxic to sheep and cattle as it causes photosensitization and eventual death. For example 150 out of 1700 beasts died at Doughboy Station after eating red lantana. These animals came from the Northern Territory to the NSW North Coast and had not previously encountered red lantana. Local stock tends to refrain from eating red lantana except during drought and therefore large numbers of deaths at one time are unusual.

Research is required to develop sterilisation techniques for these species to stop berry formation. Without the berries these trees will stay where they are planted. For plants that are causing problems more economical methods are required to control and remove unwanted trees. Large trees in sensitive areas are very expensive to kill and removal costs can be more than $1000 each.

Research into lantana should concentrate on:

- Integrated management using physical (hand or mechanical removal or fire), chemical, revegetation and biological control techniques.
- Ongoing attempts at biological control.
- Determine the critical factors in developing integrated weed management for bird-dispersed weeds.
- Ongoing education.

Further research is also required to determine the environmental impacts of exotic woody weeds on native fauna and flora. The effects for example of camphor laurel on soil microbiology, allelopathic effects on other plants, stream bank erosion and the potential toxic effects of this tree on native fauna require research. Research is required to develop ways to value add to camphor laurel. It may be possible to develop the market for camphor laurel products (oil, timber and timber products) to make removal of trees less costly.

Weedy herbs

There are a large range of herbaceous weeds. The most important of these are alligator weed (*Alternanthera philoxeroides*), fireweed (*Senecio madagascariensis*); green cestrum (*Cestrum parqui*) and St Johns wort (*Hypericum perforatum*). Other herbaceous weeds of currently of lesser importance to the grazing industry on the NSW Coast are crofton weed (*Ageratina adenophora*); groundsel bush (*Baccharis halmifolia*) and mother-of-millions (*Bryophyllum delagoense*).

Alligator weed (*Alternanthera philoxeroides*)

Alligator weed grows over summer both as a terrestrial herb and a floating aquatic. Currently Alligator weed is found in the lower Hunter Valley, Sydney basin and a small area in Byron Creek a tributary of the Richmond River on the NSW North Coast. In addition, backyard infestations have been found at Grafton, Newcastle and Wollongong. Alligator weed causes photosensitization of skin in light pigmented cattle. Production from land infested by Alligator weed can be quarantined due to its W1 status. The W1 status means its presence must be notified to the Local Council Authority and continuously suppressed and destroyed.

Research into Alligator weed needs to concentrate upon:

- The development of improved methods of herbicide control especially for infestations located near waterways.
- Development of biological control.
- Development of integrated management strategies.
- Continued education

Fireweed (*Senecio madagascariensis*)

Fireweed is an annual or short-lived perennial herb that can cause ill-thrift in cattle and horses. Sheep are 20 times more tolerant than cattle to the liver-damaging pyrrolizidine alkaloids in fireweed. Fireweed poisoning usually occurs when feed is in short supply or the infestation is so thick that stock cannot avoid eating it.

Fireweed seeds spread in the wind and can germinate over much of the year depending on rainfall and temperature (optimum temperatures for germination are 15-27^{0}C). The time from germination to flowering can be as short a six weeks. Therefore, because 90% of mature seed is immediately germinable a number of generations can occur in the one season. Fireweed is widespread in the Richmond, Clarence, Manning and Hunter Valleys and in Metropolitan areas plus in the region from Wollongong south to the Victorian border.

Research into Fireweed should concentrate on:

- Integrated management of the weed by combining grazing management, fertiliser, chemical, pasture improvement and mixing of ovine and bovine animals.
- Development of biological control with agents that don't attack the native *Senecio lautus* complex.
- Ongoing education to control infestations and avoid its' poisonous effects.

Green Cestrum (*Cestrum parqui*)

Green cestrum is a shrub that grows to 3m high. It has attractive, shiny, lanceolate leaves that give off an unpleasant smell when crushed. The greenish yellow tubular flowers of green cestrum produce black/purple berries. The plant spreads by birds eating and excreting viable seeds and by overland movement with water. Root fragments will also strike and form new plants. All parts of the plant are poisonous. Stock poisoning from this weed occurs rapidly and is common. Local councils have the responsibility to ensure this plant is removed from gardens, which remain a source of re-infestation for agricultural land. Green cestrum prefers alluvial soils and riparian areas but is found throughout coastal NSW. Physical removal is not always practical as the plant can regrow from remaining root fragments. Chemicals are available for its control. Research into green cestrum needs to concentrate upon extension and education programs for the general public as well as producers.

St John's wort (*Hypericum perforatum*).

St Johns wort is a garden escapee that causes photosensitization in sheep, cattle, horses and goats. It also adds vegetable fault to wool and competes with useful plants. It is currently found throughout the South Coast and Hunter. Biological control of St John's Wort commenced in 1914 and 5 of the 8 agents released have established. Research has made a significant contribution to the management of this weed. However, the spread of the weed to the north both inland and on the coast will necessitate the release of new biological agents adapted to the northerly environments.

Research into St Johns Wort should concentrate on:

- Biological control.
- Extension of integrated management techniques
- Potential weeds

A number of the weeds on the noxious weeds list for coastal NSW are not currently found in this region. Of these potential weeds, siam weed (*Chromolaena odorata*), parthenium (*Parthenium hysterophorus*) and lippia (*Phyla canescens*) are considered to pose the greatest threat to the coastal grazing industry.

Summary

The current major weeds of significance to the NSW coastal grazing industry are giant parramatta grass (*Sporobolus fertilis*; formerly *S. indicus* var. *major*); Fire weed (*Senecio madagascarensis*) and lantana (*Lantana camara*). These three weeds are wide spread and also have significant impacts on production and the environment. For almost all weeds discussed in this paper there is a need for increased adoption of integrated management techniques and extension or commencement of biological control programs.

WEEDS OF IMPORTANCE TO THE GRAZING INDUSTRY IN SOUTHERN QUEENSLAND

Steven Bray, Queensland Department of Primary Industries

INTRODUCTION

Weeds are a major problem for the grazing industries in southern Queensland. Weeds reduce production, are expensive to control in both time and money, hinder management and can poison stock. This presentation highlights weeds that invade significant areas of pasture land in southern Queensland and/or have potential to affect the livelihood of producers. Weeds that only infest small areas, environmental weeds of high value habitats with little grazing value, weeds of irrigated pastures and seasonal short-lived weeds (eg. many thistles and Sida spp.) have not been discussed.

The information contained in this presentation was gathered by talking to Department of Primary Industries officers and some producers scattered throughout the region and from printed material.

The southern Queensland region is defined as Rockhampton, west to Longreach and the Northern Territory border and south to the New South Wales border. Native pasture communities (Figure 26) will be used to describe the location of weed infestations. The major regions on this map heading from east to west are the black speargrass region, brigalow pastures, *Aristida/Bothriochloa* pastures, Mitchell grass, Mulga pastures and Channel pastures.

The weeds have been divided into 4 groups, based on plant type and origin:

- Unpalatable weedy grasses
- Exotic woody weeds
- Herbaceous weeds
- Native woody weeds

These weed groups will be addressed separately with the most important species within each group highlighted.

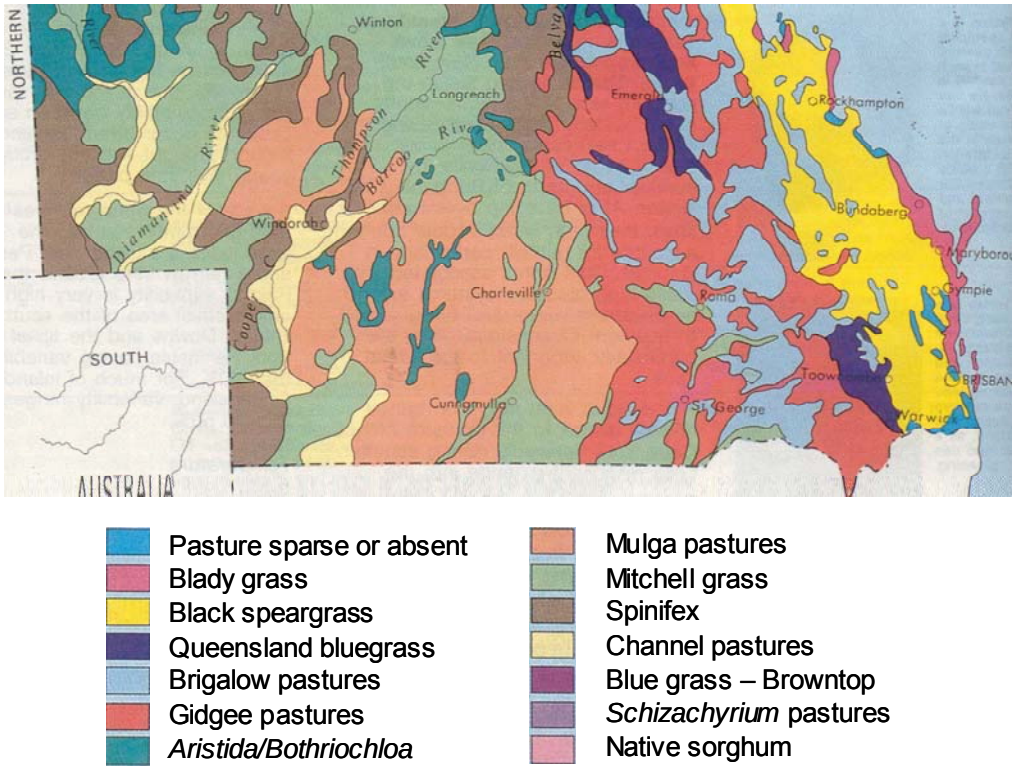

Figure 26. Native pasture communities map, adapted from Weston and Harbison (1985).

Unpalatable weedy grasses

Two exotic grass groups, weedy *sporobolus* grasses (*Sporobolus* spp.*)* and African lovegrass (*Eragrostis curvula*), currently infest significant areas and are spreading. They have potential to create massive problems in the region. Chilean needle grass (*Nassella neessiana*), Fountain grass (*Pennisetum setaceum*) and Bahia grass (*Paspalum notatum*) have established in localised areas and have potential to become a much larger problem. Native unpalatable grasses for example wiregrasses (*Aristida* spp.) are also increasing in many areas in the region.

These unpalatable weedy grasses are strongly competitive and have tough, difficult to eat leaf blades, resulting in stock selectively grazing more palatable species allowing the unpalatable grasses to increase and eventually dominate the pasture.

Weedy *Sporobolus* grasses

The weedy *Sporobolus* grasses of concern are:

- *S. pyramidalis/natalensis* Giant rats tail grass - GRT
- *S. fertilis* Giant parramatta grass - GPG
- *S. jacquemontii* American rats tail grass

- *S. africanus* Parramatta grass
- *S. indicus* Smutgrass – not yet in Australia

The potential distribution of the weedy Sporobolus grasses in Australia, extends right along the east coast, southern South Australia, south-west corner of Western Australia, the northern part of the Northern Territory and northern Western Australia. In southern Queensland current infestions are located in the speargrass zone with isolated outbreaks in the brigalow pastures, extending west to approximately the 600mm/year rainfall isohyte.

The problems caused by weedy Sporobolus grasses include:

- 10-80% reduction in carrying capacity
- cattle take 12 months longer to reach desired weights
- effective seed transport mechanisms
- expensive and difficult to control
- reduced cattle and property values (discounted because contaminated with seed)
- interferes with property management, eg. stock movement

Work required to address gaps in current knowledge and improve management of weedy Sporobolus grasses includes:

- herbicide research
- biochemical diagnostic tools for *Sporobolus* identification
- continue biological control work
- continue grazing management work
- continued education

African lovegrass

This unpalatable tussock grass is currently a weed in the black speargrass and *Aristida/Bothriochloa* zones, being particularly problematic in the Burnett region and western Darling Downs. African lovegrass is also a weed in many other parts of Australia.

African lovegrass causes similar problems as the weedy Sporobolus grasses. Up to 80% reduction in stock carrying capacity. In one example, a 20 000 acre property carried 1200hd, but now only carries 800hd.

Work required in improve control and management includes:

- Management trials
- Ecology work
- Education

Chilean Needle grass

This is an unpalatable tussock grass. This grass currently has a fairly restricted distribution but has potential to spread much further. Currently it is increasing in southern areas near the New South Wales border, north of Tenterfield (*Aristida/Bothriochloa* zone).

Fountain grass

This is an unpalatable tussock grass. This grass currently has a fairly restricted distribution but has potential to spread much further. Current outbreaks occur in the black speargrass zone, for example around Mount Morgan near Rockhampton. The control of this grass is hampered and its spread encouraged by being promoted by the nursery trade and is planted as a garden or roadside plant.

Bahia grass

This is an unpalatable stoloniferous grass that invades and dominates fertile riparian areas. The grass is increasing in fertile riparian areas in the black speargrass zone.

*Wiregrass (*Aristida *spp.)*

Unpalatable native grasses that often increase with grazing. In sheep areas can cause vegetable fault. Various species are distributed across southern Queensland. There is a reasonable understanding of their ecology and management, but extension is required to turn knowledge into practise amongst landholders.

Exotic woody plants

Many exotic woody plants are causing problems in southern Queensland, including:

- Lantana (*Lantana camara*)
- Creeping lantana (*Lantana montevidensis*)
- Rubber vine (*Cryptostegia grandiflora*)
- Prickly acacia (*Acacia nilotica*)
- Parkinsonia (*Parkinsonia aculeate*)
- Mesquite (*Prosopis pallida*)
- Chinese celtis (*Celtis sinensis*)
- Camphor laurel (*Cinnamomum camphora*)
- Cat's claw creeper (*Macfadyena unguis-cati*)
- Groundsel bush (*Baccharis halimifolia*)
- Many other current and potential garden escapees (eg. *Tecoma stans*)

Some of these plants are widespread pests of grazing land, while others are more environmental weeds, but can affect grazing land and management.

Lantana

Lantana has been recognised as a problem for a long time. Many biological control organisms have been released, but good control has not yet been achieved. As well as invading large areas of grazing land, some types of lantana are also poisonous to stock. Lantana is also a serious environmental weed.

Lantana is currently distributed throughout the black speargrass zone and predominately in riparian areas in the brigalow and *Aristida/Bothriochloa* zones.

More time and money is probably spent on controlling lantana than any other exotic weed in the grazing lands of southern Queensland.

Creeping Lantana

Creeping lantana is a prostrate shrub, which creates an almost complete ground cover, therefore reducing grass production. It is a major problem in national parks and grazing land, particularly in inaccessible hilly areas. An area of 150 000ha was infested in a 1997 survey. Currently distributed throughout the black speargrass zone, but is particularly troublesome in the Burnett region.

Rubber vine

Significant weed of riparian areas, but moves out onto grazing land. Reasonable understanding exists on its ecology and management and biological controls have been effective, but education and action is still required.

Weed of riparian areas in the northern part of the black speargrass zone extending west into the brigalow zone.

Prickly shrubs

- Prickly acacia (*Acacia nilotica*)
- Parkinsonia (*Parkinsonia aculeata*)
- Mesquite (*Prosopis pallida*)

The prickly shrubs are a problem extending down from northern Queensland (see appropriate section), particularly in the Mitchell pastures south and west of Longreach with potential to move into the Channel pastures. Other areas include riparian areas in the northern part of the southern Queensland region.

Herbaceous weeds

A large number of herbaceous weeds could be included in this list, but the most important have been highlighted. They include:

- Parthenium (*Parthenium hysterophorus*)
- Mother-of-millions (*Bryophyllum spp.)*
- Lippia (*Phyla canescens*)
- Fireweed (*Senecio madagascariensis*)
- Blue heliotrope (*Heliotropium amplexicaule*)

- Saffron thistle (*Carthamus lanatus*)
- Cactuses – eg. Harrissia (*Eriocereus martinii)*
- Burrs eg. Bathhurst, Noogoora
- Crofton weed (*Ageratina adenophora*)
- Mistflower (*Ageratina sericifera*)

Parthenium

Parthenium is an annual weed, which increases with disturbance such as overgrazing and floods. It is a problem or potentially a problem across most of southern Queensland, but is particularly a prevalent in the Central highlands (northern brigalow zone). Parthenium has some health concerns as it causes allergic reactions in some people.

Research has been effective, biological control has been released, but eduction is required on management and prevention of seed spread.

Mother-of-millions

This plant is poisonous, with many cattle deaths recorded. Over 10 000ha of land is infested (a conservative estimate). Mother-of-millions is a problem particularly along creek banks and alluvial plains.

There are many outbreaks throughout southern Queensland, often associated with town dumps, but the majority of the infestations are in the black speargrass and brigalow pasture zones.

Lippia

Lippia is a weed of flooded riparian areas and is particularly a problem in riparian areas in the southern Brigalow and *Aristida/Bothriochloa* zones. As well as dominating the pasture, streambank erosion is enhanced by the dominance of this weed.

Native woody plants

In southern Queensland, more time, money and energy would be spent controlling native woody weeds than all of the exotic weeds. Increases in native woody plants can lead to woodland thickening. Many photographic examples exist where the tree/shrub cover has increased substantially over the last 5 or 6 decades. Some of the most problematic native woody weeds are:

- Currant bush (*Carissa ovata*)
- *Eremophila* spp.
- Lime bush (*Eremocitris glauca*)
- *Eucalyptus* spp.
- *Acacia* spp. (mulga, gidgee, brigalow, black wattle)
- Cypress pine (*Callitris glaucophylla*)

Native woody weeds provide a large cost to industry through reduced pasture production and hindering stock management (eg. mustering). One conservative example, shows the expected increase in tree and shrub basal area would reduce pasture production by 30% over 40 years. This is a large drop in production for individual properties as well as affecting the viability of surrounding rural communities. If cattle numbers are not reduced in line with the reduced carrying capacity, serious environmental damage, such as erosion and loss of ground layer biodiversity is likely.

Property weed preparedness

Weed invasion requires a seed to be transported into the pasture as well as a gap in which to establish. There are three factors to stop or reduce the likelihood of weed invasion.

Stop seed transport, which relies on education and action, but many seed transport mechanisms cannot be controlled.

Pasture management to resist weed establishment. Grazing management that reduces pasture competitiveness involves the risk that weeds can establish more easily and may require expensive control measures.

Early control of weeds that do establish. Requires vigilance and continuous observation, which is very difficult on large properties.

More emphasis should be placed on promoting strategies leading to property weed preparedness, so the likelihood of major infestations establishing before they can be controlled relatively cheaply is reduced.

Summary

A large number of weeds impact on the grazing industry in southern Queensland. Some of the weeds mentioned and many not mentioned have significant impacts on grazing businesses, but currently have limited distribution. These weeds are often restricted as they have fairly specific climatic, environmental and management requirements. The weeds of "most" importance to the grazing industry across southern Queensland are adapted to a large range of conditions eg. rainfall, soil type and have efficient dispersal mechanisms, therefore have potential to invade large areas.

The weeds I believe are most important across southern Queensland requiring research and extension of current knowledge are:

- Weedy Sporobolus grasses
- African lovegrass and other unpalatable grasses
- Native woody plants
- *Lantana* species

Other species, for example parthenium and rubber vine, have good management strategies available, but require a concerted education campaign to capitalise on the good research that has been conducted and achieve effective on-ground management and control.

The issue of replacement of one weed by another should be addressed. Changed management is required. Emphasis and investment needs to be directed by funding bodies to education and research into property weed preparedness to help combat inevitable future weed invasions, before they become an extremely expensive problem.

WEEDS OF SIGNIFICANCE TO THE AUSTRALIAN AGRICULTURAL COMPANY - AN ECONOMIC AND MANAGEMENT CASE STUDY

Jenny White, Rangelands Officer, Australian Agricultural Company

The Australian Agricultural Company owns 19 cattle properties covering 6.5 million hectares of land in Queensland and the Northern Territory. Therefore, the potential to encounter weeds is enormous.

Weeds have the potential to invade the landscape and affect both agricultural production and the environment. The plants that are present on AACo properties or have the potential to invade them are shown in Table 18.

Table 18. Weeds present on or threatening AACo properties

Woody Weeds

Common name	Scientific name
Bellyache bush	*Jatropha gossypiifolia*
*Calotrope/rubber-bush	*Calotropis procera*
Chinee apple	*Ziziphus mauritiana*
Mesquite	*Prosopis pallida*
Prickly acacia	*Acacia nilotica*
Parkinsonia	*Parkinsonia aculeata*
Rubber vine	*Cryptostegia grandiflora*
Parthenium	*Parthenium hysterophorus*

Grass weeds

Common Name	Scientific Name
[1]Asbestos grass	*Pennisetum basedowii*
Grader grass	*Themeda quadrivalvis*

[1] Greatest threat to AACo due to a lack of knowledge of species ecology and dynamics.

Intimidating weeds for AACo

All of the weeds listed in Table 18 are controlled/managed through property weed management plans. However there are a couple of weed species that are of concern to AACo mainly because there has been little investigation undertaken on these weeds to assist land managers in managing them appropriately.

Possibly the greatest threatening woody species for AACo is calotrope/rubberbush in that little is known of the impacts, spread potential or control of it. There is not even a chemical that is registered for calotrope (in Qld) – AACo had to apply for an emergency use permit through the TWRC to ensure chemicals used were adequate in the control of this species. The spread potential of calotrope is absolutely enormous under ideal seasonal conditions on specific landtypes, of which many north Australian properties have witnessed.

Asbestos grass is a native and is probably one of the greatest 'unknown' threatening grass species in northern Queensland's Mitchell Grass Downs and floodplain country. It has been recognised on AACo stations from Chillagoe to Gregory to the northern parts of the Channel country and is in all probability further afield. It is thought to predominate on pasture deteriorating in condition, but can be the dominant species in locations greater than 8 kilometres from water – areas rarely utilised by livestock. It is a silent achiever, often unnoticed, but has been recognised as engulfing valuable Downs and floodplain country - slowly.

Further research is essential to gain a better understanding of the ecology of these weeds to allow land managers to adopt appropriate management regimes before these weeds further inundate and reduce both the production potential and biodiversity of Northern Australian rangelands.

Overview of exotic woody weed economics study

An economics study was conducted on the seven AACo northern Queensland stations in 2001. This study was at the request of the Board of Directors to justify a significant increase in the woody weed budget. A woody weed study at this scale has never been conducted before and was a significantly complex task. However, it was a very valuable task in that AACo were able to justify the budget increase was an economically viable proposition.

Summary of Methodology

All significant exotic woody weed infestations were mapped with a Global Positioning System detailing the following:

- Weed species
- Areas infested
- Density
- Growth stages

Although there is currently little impact on productivity, the woody weeds are spreading and increasing in density and have enormous potential to affect production and management. The Current Control Program (prior to 2001) was proving ineffective at controlling the spread of weeds, especially after a run of exceptionally good wet seasons. Following the mapping of weed infestations and evaluation of control options, control programs have been developed for each station. The Proposed Control Programs are designed to contain current infestations and reduce the potential for spread by quickly removing as many seed producing plants as possible. Some instances the proposed programs are designed to eradicate particular species.

Economic Evaluation

The *Breedcow and Dynama Herd Budgeting Package V 5.031* was used to evaluate the performance of the AACo Gulf stations under the Current and Proposed Weed control programs over a 20 year period (2002-2021). Key issues included when evaluating the economics under the two programs of shrub control were:

- Carrying capacity
- Shrub control costs
- Mustering costs
- Land values

Carrying Capacity

The change in carrying capacity was determined by identifying the area that would become shrub infested over the 20-year period and the impact of that infestation on pasture production.

Shrub Control Costs

Shrub control costs were based on the control programs proposed to be undertaken to contain spread and remove as many seed producing plants as possible for each station.

Mustering Costs

The change in mustering costs was determined by identifying the area that would become shrub infested and the increased cost of mustering country with shrub cover.

Land Values

Increasing concern about the impact of woody weed infestation on productivity and management is likely to see discounted land values reflecting the degree of weed infestation (under the Current Control Program). The potential decline in land values of the infested areas was taken into account when calculating the Internal Rate of Return (IRR) for the Proposed expenditure (% return on additional capital) over the 20-year period (Table 19). Because it was difficult to put actual figures on the potential decline in land values of infested land, a range of values were used being 0, 10,15 and 20 percent decline in land values.

Table 19. Results of the economic study were as follows:

Decline in land values (%)	**IRR for weed control expenditure (%)**
0	12.73
10	12.99
15	13.12
20	13.24

Tax Benefits

The analysis did not take into account the 100% deductibility for weed control in the year of expenditure. Tax benefits are received early in the program and tax costs on higher income occur later. The effect of this timing if tax effects were included would be to improve the IRR.

The Unpriced Issues

Unpriced costs were identified as those variables that do have an impact on station management and productivity but can only be qualitatively assessed and cannot be valued in dollar terms. They include the following:

Impact on management:	Reduced management options
Environmental damage:	Impact on biodiversity
Increased erosion:	Potential future production losses
Harbour for feral & native animals:	Contributes to production losses
Increased damage to infrastructure:	Increases variable costs
Staff safety:	Increased medical attention
Reduced herd performance:	Contributes to production losses
Cattle shot or abandoned:	Contributes to production losses

Upon compiling a report to support the economic figures above, the seven AACo stations were granted their increase in woody weed budgets. Today all stations are undertaking control and management regimes as per individual station Weed Management Plans, to kill as many seed producing trees as possible and contain weed spread.

Overview

A great deal of input to this project was from the land managers themselves. Most of AACo land managers have a lifetime of experience in rangelands and have a wealth of knowledge and an understanding of science in their own lingo. On a day-to-day basis, they can monitor the occurrence of changes in their environment and are familiar with changes in weed dynamics over time.

Significant input from the relevant departmental agencies was much appreciated, but was frustrating in that a lot of departmental personnel kept passing the buck on to others in the department, which was probably due a lack of knowledge or possibly research in the weed impact and economics fields.

Further technical assistance was sought from a Beef Production Adviser from the QDPI, Mt Isa to assist in the changes in stock numbers, herd structure and future production trends as a result of woody weeds. Together we input data to *Breedcow* and *Dynama*.

Breedcow and *Dynama* was a very valuable tool in this exercise as we were able to input changes in herd and financial situations. The technical support from the modeller of the software was overwhelming, as major changes to the software had to be undertaken to allow us to undertake this study.

- Gaps identified in weed Research & Development
- Impacts of many weeds on pasture yield
- Pasture yield declines as woody trees shade more and more ground. Significant work is required to determine the impact of most weed species on pasture yield including variations in:
- Weed density
- Growth stages; and
- On different landtypes.
- Understanding spread potential and the management of spread

Whilst the killing or control of woody weeds is imperative, the management of spread is also crucial but often not fully understood. Furthermore, the management strategies for prevention of weed spread are not emphasised enough at the property management level; and should be identified as a *priority* in developing any weed control strategy from the property level through to national level. Management options are often based on anecdotal regimes eg: fire is useful in killing some weed species, but how is land to be managed post-fire to gain maximum benefit from the control option. Weed control activities will not occur adequately without extension staff who can provide motivation and support for weed control groups

Economics of Woody Weeds R&D

To undertake an economic assessment of the economic impacts of weed species, would clarify the extent and damage of weed species, but would have little benefit to actually getting things happening on-ground. Devoting R&D to developing a tool that may facilitate activities on-ground would be far more beneficial from a technical and extension point of view and would certainly benefit the meat and livestock industries in the longer term.

A better understanding of the economics of weed control would be an extremely valuable decision making tool for land managers. However, for this tool to be utilised effectively, a great deal of knowledge is required from the paddock (waterway flood heights, watering points), station (susceptible landtypes, waterway dynamics, herd structure) and catchment level (potential for weed spread from upstream).

OUTCOMES OF WORKSHOP

Weeds list

The workshop produced a list of 119 species and species groups that are relevant to grazing industries (Table 20). Two additional groups were added during the review period. Table 21 indicates the weed species that are of greatest significance in each of the regions for which a review was prepared.

To deal with this long list of weeds the species and species groups were allocated to seven catgories:

- Annual grasses
- Perennial grasses
- Annual forbs
- Perennial forbs
- Aquatics
- Climbers
- Trees and shrubs

The importance of each of these categories of weeds was assessed for each of six bioclimatic zones. These zones:

- Monsooon tropics
- Tropical rangelands
- Tropical and subtropical east coast
- Temperate rangelands
- Cropping/pasture zone
- Perennial pasture zone

Table 20. Exotic weed species and species groups referenced in regional reviews or during the workshop. NOTE: Some of these species DO NOT have a significant negative impact on grazing industries. The impacts of these weeds on pastoralism are indicated by the following categories: U unpalatable, C competes with pasture species, T toxic, P contaminates produce, A aquatic weeds that affects waterways, E environmental weed.

	Common name	Scientific name	Growth form	Impacts
1	Afghan melon	*Citrullus lanatus*	annual forb	UC
2	Afghan thistle	*Salamum holopetalum*	perennial forb	C
3	African boxthorn	*Lycium ferrocissimum*	shrub	CE
4	African lovegrass	*Eragrostis curvula*	perennial grass	UC
5	aleman grass	*Echinochloa polystachya*	perennial grass	UC
6	alligator weed	*Alternanthera philoxeroides*	aquatic	CPAE
7	American rat's tail grass	*Sporobolus jacquemontii*	perennial grass	UCP
8	arum lily	*Zantedeschia aethiopica*	perennial forb	T
9	athel pine	*Tamarix aphylla*	tree	E
10	bahia grass	*Paspalum notatum*	perennial grass	UC
11	barley grass	*Hordeum* spp.	annual grass	P
12	Bathurst burr	*Xanthium orientale*	annual forb	UCP
13	bedstraw	*Galium tricornutum*	annual forb	
14	bellyache bush	*Jatropha gossypifolia*	shrub	CE
15	blackberry	*Rubus fruticosus*	shrub	UCE
16	blue heliotrope	*Heliotropium amplexicaule*	perennial forb	T
17	bracken fern	*Pteridium aquilinum*	perennial forb	T
18	branched broomrape	*Orobanche* spp.	perennial forb	P
19	brassicas	*Rapistrum rugosum* *Sisymbrium spp.* *Brassica tournefortii*	annual forbs	UC
20	broad-leaved pepper tree	*Schinus terebinthifolius*	tree	E
21	broom	*Cytisus scoparius*	shrub	CE
22	browntop bent grass	*Agrostis capillaris*	perennial grass	C
23	cabomba	*Cabomba caroliniana*	aquatic	AE
24	calotrope	*Calotropis procera*	shrub	C
25	caltrop	*Tribulus terrestris*	annual forb	
26	camphor laurel	*Cinnamomum camphora*	tree	E
27	Cape tulip	*Homeria miniata*	perennial forb	T
28	capeweed	*Arctotheca calendula*	annual forb	UC
29	cat's claw creeper	*Macfadyena unguis-cati*	climber	E
30	cat's ear = flatweed	*Hypochaeris radicata*	annual forb	
31	Chilean needle grass	*Nassella trichotoma*	perennial grass	UC
32	chincherinchee	*Ornithogalum thyrsoides*		
33	chinee apple	*Ziziphus mauritiana*	shrub/tree	C

Table 20 (Continued)

	Common name	Scientific name	Growth form	Impacts
34	Chinese celtis	*Celtis sinensis*	tree	E
35	coffee bush	*Senna occidentalis*	shrub	UC
36	common heliotrope	*Heliotropium europaeum*	annual forb	T
37	coolatai grass	*Hyparrhenia hirta*	perennial grass	UC
38	cotula	*Cotula* sp.	annual forb	UC
39	creeping lantana	*Lantana montevidensis*	shrub	U
40	crofton weed	*Ageratina adenophora*	perennial forb	UCT
41	devil's claw	*Ibicella lutea,*	annual forb	T
42	devil's claw	*Proboscidea louisianica*	annual forb	T
43	devil's claw	*Martynia annua*	annual forb	T
44	espartillo or puna grass	*Achnatherum caudatum*	perennial grass	UC
45	erodium	*Erodium* spp.	anual forb	P
46	fireweed	*Senecio madagascariensis*	annual or perennial forb	UC
47	fountain grass	*Pennisetum setaceum*	perennial grass	UC
48	fumatory	*Fumaria* spp.	anual forbs	
49	gamba grass	*Andropogon gayanus*	perennial grass	UCE
50	giant Parramatta grass	*Sporobolus fertilis*	perennial grass	UCP
51	giant rat's tail grass	*Sporobolus pyramidalis*	perennial grass	UCP
52	giant sensitive plant	*Mimosa pigra*	shrub	CE
53	gorse	*Ulex europaeus*	shrub	CE
54	grader grass	*Themeda quadrivalvis*	annual grass	UC
55	green cestrum	*Cestrum parqui*	shrub	E
56	groundsel bush	*Baccharis halmifolia*	shrub	UC
57	Guildford grass = onion grass	*Romulea rosea*		UC
58	harrisia cactus	*Eriocereus martini*	shrub	UC
59	hawkweeds	*Hieracium* spp.		UC
60	horehound	*Marrubium vulgare*	perennial forb	UCT
61	hyptis	*Hyptis suaveolens*	annual forb	UC
62	ice plant	*Mesembryanthemum crystallinum*	perennial forb	
63	lantana	*Lantana camara*	shrub	UCTE
64	Lincoln weed = sand rocket	*Diplotaxis tenuifolia*	perennial forb	
65	lesser swinecress	*Coronopus didymus*	annual forb	C
66	lippia	*Phyla canescens*[1]	aquatic/perennial broadleaf	ACE
67	lobed needle grass		perennial grass	UC
68	mesquite	*Prosopis glandulosa* *P. juliflora* *P. pallida*	shrub/tree	C
69	Mexican feather grass	*Nassella tenuissima*	perennial grass	UC

Table 20 (Continued)

	Common name	Scientific name	Growth form	Impacts
70	mission grass	*Pennisetum polystachion* *P. pedicelatum*	perennial grass	UC
71	mistflower	*Ageratina sericifera*	perennial forb	UC
72	mother-of-millions	*Bryophyllum delagoense*	perennial forb	UC
73	mouse-eared chickweed	*Cerastium glomeratum*		
74	neem	*Azadirachta indica*	tree	E
75	noogoora burr	*Xanthium occidentale*	annual forb	UC
76	olive	*Olea europaea*	tree	E
77	onion weed = wild onion	*Asphodelus fistulosus*	perennial forb	UC
78	paddy melon	*Cucumis myriocarpus*	Annual forb	UCT
79	parkinsonia	*Parkinsonia aculeata*	shrub	UC
80	Parramatta grass	*Sporobolus africanus*	perennial grass	UC
81	parthenium	*Parthenium hysterophorus*	annual forb	UCT
82	Paterson's curse	*Echium plantagineum*	annual forb	UC
83	pennyroyal	*Mentha pulegium*	perennial forb	U
84	prairie ground cherry	*Physalis viscose*	perennial forb	UCT
85	praxelis	*Praxelis clematidea*	perennial forb	
86	prickly acacia	*Acacia nilotica* ssp. *indica*	tree/shrub	CE
87	prickly pear	*Opuntia* spp.	shrub	UC
88	privets	*Ligustrum lucidum* *L. sinese*	tree	E
89	ragwort	*Senecio jacobaea*	perennial forb	UCT
90	rubbervine	*Cryptostegia grandiflora*	climber/shrub	UCTE
91	rushes	*Juncus* spp.	perennial forb	A
92	salvinia	*Salvinia molesta*	aquatic	AE
93	serrated tussock	*Nassella trichotoma*	perennial grass	UC
94	sicklepod	*Senna obtusifolia*	shrub	UC
95	sida	*Sida acutifolia*	perennial forb	UC
96	silverleaf nightshade	*Solanum elaeagnifolium*	perennial forb	UCT
97	sisal hemp	*Agave sisalana*	perennial forb	UC
98	small crumbweed = goosefoot	*Chenopodium pumilio*	Annual forb	C
99	small flowered mallow	*Malva parriflora*	Annual forb	CT
100	small-seeded dodder	*Cuscuta planiflora*	annual forb	C
101	snakeweed	*Stachytarpheta* spp.	shrub/perennial forb	UC
102	sorrel	*Acetosella vulgaris*	annual forb	
103	spiny emex	*Emex australis*	annual forb	UCP
104	squirting cucumber	*Ecballium elaterium*	perennial forb	
105	St John's wort	*Hypericum perforatum*	perennial forb	UC

Table 20 (Continued)

	Common name	Scientific name	Growth form	Impacts
106	stinking passion flower	*Passiflora foetida*	climber	
107	stinkwort	*Dittrichia graveolens*	annual forb	UC
108	storksbill	*Erodium* spp.	annual forb	P
109	sweet briar	*Rosa rubiginosa*	shrub	UC
110	thistles	*Carduus nutans*	annual forbs	UC
		Carduus pycnocephalus *Carthamus lanatus* *Centaurea calcitrapa*		
		Centaurea maculosa		
		Centaurea nigra		
		Centaurea solstitialis *Cirsium arvense*		
		Cirsium vulgare		
		Cynara cardunculus		
		Onopordium acanthium		
		Onopordium. acaulon		
		Onopordium illyricum		
		Scolymus maculatus		
		Silybum marianum		
111	three-horned bedstraw	*Galium tricornutum*	annual forb	C
112	tobacco weed	*Elephantopus mollis*	perennial forb	UC
113	tumbleweed	*Amaranthus albus*		
114	typha	*Typha* spp.	aquatic	A
115	vulpia	*Vulpia* spp.	annual grass	CP
116	Ward's weed	*Carrichtera annua*	annual forb	UC
117	water hyacinth	*Eichhornia crassipes*	aquatic	AE
118	wild radish	*Raphanus raphanistrum*	annual forb	UC
119	Yorkshire fog	*Holcus lanatus*	annual grass	C

[1] Lippia (*Phyla canescens*) is often incorrectly referred to as *Phyla nodiflora.*

Table 21. Weeds of greatest significance to Australian grazing industries in each region. NQ northern Queensland, NT Northern Territory, nWA northern Western Australia, sWA southern Western Australia, Tas Tasmania, iNSW inland New South Wales, cNSW coastal New South Wales, Vic Victoria, SQ southern Queensland.

	Species	NQ	NT	nWA	sWA	Tas[1]	Vic	iNSW	cNSW	SQ
1	African boxthorn							×		
2	African lovegrass				×		×	×		×
3	Bathurst burr		×					×		
4	Bellyache bush	×	×	×						
5	Blackberry				×		×	×		
6	Blue heliotrope							×		
7	Bracken fern				×					
8	Browntop bent grass						×	×		
9	Caltropis	×	×	×						
10	Cape tulip				×		×			
11	Cape weed				×		×	×		
12	Chilean needle grass							×		
13	Coffee bush		×							
14	Coolatai grass						×	×		
15	Creeping lantana									×
16	Erodium					×				
17	Fire weed								×	
18	Fumatory					×				
19	Giant sensitive plant	×	×							
20	Gorse							×		
21	Grader grass	×								
22	Common heliotrope				×			×		
23	Hyptis	×								
24	Lantana	×							×	×
25	Lippia							×		×
26	Annual grasses					×	×	×	×	
27	Mesquites	×	×	×				×		×
28	Mother-of-millions	×						×		×
29	Noogoora burr			×				×		
30	Onion weed							×		
31	Parkinsonia	×	×	×						
32	Parthenium	×						×		×
33	Paterson's curse				×			×		
34	Perennial mission grass		×	×						
35	Prairie ground cherry						×	×		
36	Prickly acacia	×	×							
37	Rat's tail grasses	×					×		×	×
38	Rubber bush	×	×							
39	Rubber vine	×								
40	Serrated tussock						×	×		×
41	Sicklepod	×	×							
42	Sida	×	×							
43	Silverleaf nightshade				×		×	×		×
44	Spiny emex				×		×	×	×	×
45	St John's wort							×		
46	Thistles				×	×	×	×		
47	Tobacco weed	×								
48	Wild radish				×					

[1] Information for Tasmania was obtained during the post-workshop review process.

Regional priorities

Key conclusions in relation to the important weed groups and species in each of the bioclimatic zones are as follows:

Monsoon tropics

High priority weed groups in the monsoon tropics are perennial grasses and perennial forbs. The most important species from these two groups are **gamba grass, mission grass** and **giant rat's tail grass** and the perennial forbs **calotrope, sida** and **hyptis**. There are critical knowledge gaps for the perennial grasses and the three perennial forbs and research toward developing **systems approaches** to these weed groups should be a high priority. **Suitable extension material is not available** for the perennial forbs or most of the perennial grass weeds and the material that is available for giant rat's tail grass should be further developed.

Tropical rangelands

The weeds that are of most serious concern in the tropical rangelands are the trees and shrubs. The species involved include **parkinsonia, mesquites, lantana, prickly acacia** and **chinee apple**. For parkinsonia, in particular, there is a need to develop a basic understanding of critical aspects of its ecology and for the exotic "woody weeds" in general, species responses to grazing land management in the longer term should be examined. There are few control options available for lantana that is a problem in the higher rainfall parts of the tropical rangelands. **Bellyache bush**, which could be classified as either a shrub or a perennial forb is of as much concern as the more typical invasive shrubs of the tropical rangelands. The perennial grass weeds, notably giant rat's tail grass, and the annual forb **parthenium**, are also of concern and should be given medium priority in terms of research and development. The annual forb **noogoora burr** requires attention where current biological control measures are ineffective. The woody exotics and unpalatable grasses reduce production potential and the woody species also increase management costs and restrict livestock movements, particularly near water. Further biological control work is justified for mesquite and prickly acacia. Aquatic weeds are generally not significant in the tropical rangelands except locally and the effort in relation to them should be directed at education and prevention. Some climbers are common in parts of the tropical rangelands but overall of low priority. For example viable management strategies are available for rubber vine, which is a Weed Of National Significance, and the need is for education and extension and encouragement to apply those strategies.

In many parts of the tropical rangelands, the proliferation of **native woody species** is of greater concern to producers than the spread of exotic trees and shrubs. A large number of species is involved. Practical and environmentally sustainable management strategies are required in relation to this issue, as is improved understanding of how the proliferation of trees and shrubs relates to grazing and fire regimes.

Tropical and subtropical east coast

In the tropical and subtropical east coast, high priority should be given to perennial grass weeds. Most important among these are the **rat's tail grasses** for their impacts on pasture productivity. The research needs relate to the basic ecology of the species, suitable herbicides for use in pastures, management options for extensive grazing systems and taxonomic studies to distinguish and identify the various species.

The perennial semi-aquatic forb **lippia** is a medium priority species. Little is known of its ecology and no management options or strategies are available. **Lantana** and **creeping lantana** are shrubs that are of medium importance in the tropical and subtropical coastal zone, with the need for suitable management strategies for these weeds in common with the tropical rangelands. In some parts of the east coast tropics, shrubs such as **parkinsonia**, are also of medium importance.

The annual forbs **tobacco weed** and **sicklepod** are also significant to grazing industries in the tropical

and subtropical coastal zone. These species are of medium priority with a need for basic ecological knowledge.

Temperate rangelands

Several weed groups are relevant to the temperate rangelands. Several exotic woody species occur in the temperate rangelands but, currently, many of these are relatively restricted in their distributions. For example, parkinsonia and the mesquites are species that are prevalent and widespread in the tropical rangelands but in the temperate rangelands are sparsely distributed at relatively few locations and are of low priority. On the other hand, African boxthorn is a most important exotic shrub weed in the temperate rangelands. There is a need to understand its ecology, developmanagement strategies and explore the prospects for its biological control.

The proliferation of native trees and shrubs has long been of concern to livestock producers in many areas of the temperate rangelands. The research and development that has been undertaken since the mid-1960s have provided the best prospects for managing these species and further consideration of the issue should be limited to education and extension in relation to the approaches that are already available.

Annual grass weeds are an issue in some parts of the temperate rangelands but are of only low priority.

Lippia is a perennial forb that warrants high priority as a weed of the temperate rangelands. It is significant for its impacts on pastoral productivity as well as an environmental weed. Management strategies and, consideration of the potential for biological control are required. **Mother-of-millions** is another perennial forb that is relevant to the temperate rangelands because of its predicted potential distribution into that region. However, its current Australian range is restricted to Queensland and parts of New South Wales.

Annual forb weeds important in the temperate rangelands are onion weed and saffron thistle. Onion weed requires priority attention to develop an understanding of its ecology as a basis for management and saffron thistle requires action toward its biological control.

Cropping/pasture zone

The greatest need in relation to weed issues for the cropping/pasture zone is for a systems approach to the complex of weed species and groups that are relevant there. Three weed groups are prominent: annual grasses (e.g. *Vulpia* spp.) annual (e.g. spiny emex, heliotropes, *Erodium* spp.) and perennial forbs (e.g. silverleaf nightshade, prairie ground cherry). The **annual and perennial forbs** warrant high priority with attention being direct at management strategies and education. **Silverleaf nightshade** and **prairie ground cherry** should be given high priority at the species level to identify and understand critical aspects of the ecology and develop strategies to contain and control.

Perennial pasture zone

Annual grasses, perennial grasses, annual forbs and perennial forbs are the most important groups of weeds in this zone. Perennial grasses in particular are having serious impacts on property values and enterprise viability. The most threatening species are **African lovegrass, Chilean needle grass, browntop bent, Parramatta grass** and **serrated tussock**. Important emerging weeds are the annual forb **silverleaf nightshade** and the perennial forb **prairie ground cherry**. Shrubs weeds are of medium importance, the outstanding example being gorse. Climbers are present, particularly in riparian zones, but are regarded as being of low priority as weeds of grazing industries. Although the critical aspects of the ecology of other weed groups of the perennial pasture zone are reasonably well-understood, this is not the case for the important perennial grass weeds. High priority should be given to developing **systems approaches** to the weed complexes of the perennial pasture zone, rather then simply attempting to deal with individual species. Current knowledge, and that developed under a more comprehensive systems approach, should be incorporated into **improved management packages and extension material**.

In Table 22, low, medium and high priority areas of R&D are summarized by species and species group (annual grasses; perennial grasses; annual forbs; perennial forbs; aquatics; climbers; trees and shrubs) for each bioclimatic zone (monsooon tropics; tropical rangelands; tropical and subtropical east coast; temperate rangelands; cropping/pasture zone; perennial pasture zone).

Table 22. Research and development needs for important weeds and weed groups in each of six bioclimatic zones. R&D priorities under each of three general topics (ecology, biocontrol and management systems) are listed as low (L), medium (M), high (H) or not relevant (0). A lack of recent or current research in a particular area is indicated where these priority rankings are in bold (**L, M, H**). Note that species that do not or are not likely to have major impacts on grazing industries are indicated as being of low priority even if they are important from other perspectives, for example some environmental weeds.

Weed group	Species	Ecology	Biocontrol	Management
Monsoon tropics				
Annual grasses				
	grader grass	M	L	H
	annual mission grass	H	L	H
Perennial grasses				
	perennial mission grass	H	L	H
	rat's tail grasses	M	M	H
Perennial forbs				
	rubber bush	M	L	M
	sida	H	M	M
	coffee bush			
	hyptis	M	M	M
Climbers				
	rubber vine	L	L	M
Trees and shrubs				
	giant sensitive plant	L	L	M
	chinee apple	L	L	M
Tropical rangelands				
Annual grasses				
	grader grass	M	0	H
Annual forbs				
	parthenium	M	L	M
	noogoora burr	M	M	M
Perennial forbs				
	bellyache bush	H	H	H
	rubber bush	M	L	M
Aquatics				
	salvinia	L	M	M
	water hyacinth	L	M	M
	typha	L	0	L
Climbers				
	rubber vine	L	L	M
Trees and shrubs				
	mesquites	M	M	H
	parkinsonia	H	H	H
	prickly acacia	L	M	L
	chinee apple	L	L	L
	lantana	H	M	H

Table 22 (Continued)

Weed group	Species	Ecology	Biocontrol	Management
Tropical and sub-tropical east coast				
Perennial grasses				
	rat's tail grasses	H	M	H
	african love grass	H	0	H
	chilean needle grass	H	L	H
Annual forbs				
	fire weed	L	L	M
	parthenium	M	L	M
	mother-of-millions	H	H	H
	tobacco weed	H	H	H
	sicklepod	H	M	H
Perennial forbs				
	lippia	H	H	H
	blue heliotrope	M	M	M
aquatics				
	alligator weed	H	H	H
climbers				
	rubber vine	L	L	M
Trees and shrubs				
	prickly acacia	L	M	H
	mesquites	M	H	H
	parkinsonia	H	H	H
	green cestrum	M	M	M
	camphor laurel	L	L	M
	broad-leaved pepper tree	L	L	M
	chinese celtis	L	L	L
	privets	L	L	L
	lantana	H	H	H
	creeping lantana	H	H	H
Temperate rangelands				
Annual grasses				
	barley grass	L	L	L
Annual forbs				
	onion weed	H	M	H
	noogoora burr	L	L	L
	saffron thistle	M	M	M
Perennial forbs				
	lippia	H	H	H
	mother-of-millions	H	H	H
Trees and shrubs				
	mesquites	M	H	H
	african boxthorn	M	M	H
Cropping/pasture zone				
Annual grasses				
	vulpia spp.	L	L	L
	lolium spp.	L	L	L
	bromus spp.	L	L	L
	barley grass	L	L	L
Perennial grasses				
	african lovegrass	H	L	H

Table 22 (Continued)

Weed group	Species	Ecology	Biocontrol	Management
Annual forbs				
	cape weed	L	M	H
	spiny emex	L	M	H
	paterson's curse	L	M	H
	wild radish	L	M	H
	erodium spp.	L	L	H
	blue heliotrope	L	M	H
	ice plant	L	M	H
	caltrop	L	L	H
	heliotrope	L	L	H
	bathurst burr	L	L	H
Perennial forbs				
	silverleaf nightshade	H	H	H
	prairie ground cherry	H	H	H
Perennial pasture zone				
Annual grasses				
	Vulpia spp.	L	L	M
Perennial grasses				
	serrated tussock	M	M	H
	chilean needle grass	H	L	H
	african lovegrass	H	L	H
	rat's tail grasses	L	L	H
	browntop bent grass	H	L	H
	st john's wort	L	M	M
Annual forbs				
	cape weed	L	M	H
	paterson's curse	L	H	H
	thistles	L	M	M
	silverleaf nightshade	H	H	L
Perennial forbs				
	cat's ear	M	L	M
	prairie ground cherry	H	H	H
	onion grass	M	M	H
	cape tulip	M	M	M
	bracken fern	L	0	M
Trees and shrubs				
	blackberry	M	M	M
	gorse	L	M	M

Emerging weeds

A number of species were identified as emerging or recently emerged weeds. At least some of these are on the way to becoming or have the potential to become highly significant for grazing industries. Some are already a problem over portions of their potential ranges. These species are listed in Table 23.

Table 23. List of emerging weeds that may present problems for grazing industries.

	Common name	Scientific name	Notes
1	spotted knapweed	*Centaurea maculosa*	Currently expanding its range
2	black knapweed	*Centaurea nigra*	
3	Hawkweeds	*Hieracium* spp.	
4	bahia grass	*Paspalum notatum*	Expanding in productive riparian zones in southern Queensland
5	cape tulip	*Homeria* spp.	
6	chilean needle grass	*Nassella trichotoma*	
7	chinese celtis	*Celtis sinensis*	
8	fountain grass	*Pennisetum setaceum*	
9	green cestrum	*Cestrum parqui*	
10	lippia	*Phyla canescens*	Occurs in many sub-catchments but much scope for expansion
11	mother-of-millions	*Bryophyllum delagoense*	>10,000ha infested
12	Neem	*Azadirachta indica*	
13	perennial mission grass	*Pennisetum polystachion*	Currently rapidly expanding range
14	prairie ground cherry	*Physalis viscose*	Restricted but with much scope for expansion
15	praxelis	*Praxelis clematidea*	Still relatively restricted
16	silverleaf nightshade	*Solanum elaeagnifolium*	Already widespread but much scope for increased abundance
17	sisal hemp	*Agave sisalana*	
18	tobacco weed	*Elephantopus mollis*	
19	yellow oleander = captain cook bush	*Thevetia peruviana* = *Cascabela peruviana*	Still restricted as naturalized plant
20	branched broomrape	Orobanche sp.	
21	small-seeded dodder	*Cuscuta planifolia*	
22	three-horned bedstraw	*Galium tricornutum*	
23	Chincherinchee	*Ornithogalum thyrsoides*	
24	Lincoln weed	*Diplotaxis tenuifolia*	

RECOMMENDATIONS

The following are indicated as priorities for research and development in relation to weeds relevant to Australian grazing industries.

Systems approaches are required for the management of weeds of the cropping/pasture zone. This is because even in individual pasture/cropping systems, a number of weed species, and weed groups including annual grasses and annual and perennial forbs, are involved.

Research on the ecology and management of unpalatable grasses is required. A variety of species are invasive in the monsoon tropics, tropical and sub-tropical east coast and the perennial pasture zone. Currently, the most important species are the **serrated tussock**, **Chilean needle grass**, the various **rat's tail grasses** and **African lovegrass**. Serrated tussock has been the focus of considerable research already but effective and economic management strategies have not yet been developed. This species and its relative **Chilean needle grass** are targets of research by the CRCAWM under its unpalatable grasses project. **Serrated tussock** is also a Weed Of National Significance and so the focus of a national strategy. Likewise, some effort is being put into at least some of the **rat's tail grass** complex. However, the rat's tail grasses are not Weeds Of National Significance and resources available for research and development on them are currently limited. On the other hand, the **rat's tail grasses** are spreading rapidly and any management strategies that would slow or halt this process would help avoid even larger problems in the future. At least 17 species of unpalatable perennial grass are listed in Table 21. Research on any of these individual unpalatable grass species should also be designed to contribute to the development of principles for managing unpalatable grasses as a whole.

Management strategies are required to deal with invasive shrubs in tropical and temperate rangelands. For a number of important species (**rubber vine, *Prosopis pallida*, prickly acacia**) work is already underway as components of the national strategies for Weeds Of National Significance and additional resources may not be required at this stage. The need is to further promote amongst pastoralists the application of currently available techniques and strategies for managing these species. For **prickly acacia**, management of infestations associated with bore drains is critical and weed management should be promoted as a major consideration with respect to the sustainable use of artesian water. For other species, fewer resources are available for R&D. Notable among these is **bellyache bush** (see recent report to CRCAWM by Tim Heard, CSIRO) that is a target weed of CRCAWM. Additional support for biological control of this species is warranted and development and application of other control techniques are required.

In the tropical and sub-tropical coastal regions, **lantana** continues to present major problems in terms of both pastoral productivity and management and its environmental effects. Opinions differ as to the potential for the successful biocontrol of this species. It is a current target of research by CRCAWM, focusing on biocontrol and the processes whereby it spreads. The potential for using competition from pasture species as part of control strategies requires consideration. Along with **blackberry**, **lantana** is currently among the most intractable of the widespread invasive shrubs that affect grazing industries. Effort is required to collate all currently available information on control techniques. Research is urgently required to develop practical, economic strategies for countering lantana. This should include further biocontrol work that takes into account genetic variation of the species.

Measures to counter establishment and spread of emerging weeds should be developed. Very little research has been done on these species. Complementary ecological studies, biocontrol research and the development of control techniques are required. Three important emerging weed problems involve:

- **silverleaf nightshade**
- **lippia**
- **prairie ground cherry**

While it is highly unlikely that these particular emerging weeds can be eradicated, each is still restricted compared with its potential Australian range. Strategies to minimize the risks of further spread would be valuable. Lippia is significant not only to grazing industries but also to the cotton industry, in regard to the management of waterways and as an environmental weed, so a collaborative approach involving these various interest groups should prove productive.

Effort should be made to design and evaluate weed management strategies in economic terms. Such work would be more valuable than simply evaluating the economic impacts of weeds and would help provide tools for decision-making in relation to weeds.

LIST OF ATTENDEES

Allan, Cameron	Meat and Livestock Australia, Orange NSW
Arbuthnot, Alex	Producer, Victoria
Bray, Steven	Qld Dept Primary Industry, Rockhampton QLD
Dellow, Jim	NSW Agriculture, Orange NSW
Emmery, Margaret	Producer, Rockhampton QLD
Grice, Tony	CSIRO Sustainable Ecosystems, Townsville QLD
Heard, Tim	CSIRO Entomology, Brisbane QLD
Julien, Mic	CSIRO Entomology, Brisbane QLD
King, Warren	NSW Agriculture, Orange NSW
McLaren, David Vic.	Dept Natural Resources and Environment, Melbourne VIC
Officer, David	NSW Agriculture, Grafton NSW
Palmer, Bill	Qld Dept Natural Resources and Mines, Brisbane QLD
Revell, Clinton	Agriculture Western Australia, Perth WA
Sheppard, Andy	CSIRO Entomology, Canberra ACT
Sinclair, Howard	Producer, Bathurst, NSW
Sutherland, Steve	NSW Agriculture, Wagga Wagga NSW
Vitelli, Joe	Qld Dept Natural Resources and Mines, Charters Towers QLD
White, Jenny	Australian Agricultural Company, Canobie Station, QLD
Wingrave, Steve	NT Dept Business, Industry & Resource Development, Darwin T