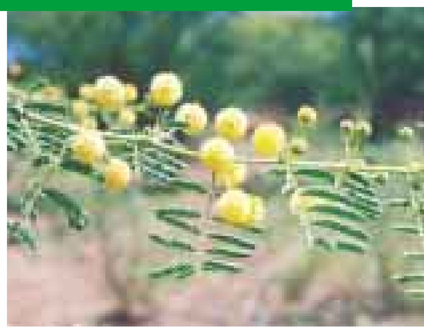
Prickly acacia (*Acacia nilotica*) in Queensland

PRICKLY ACACIA

PEST STATUS REVIEW SERIES - LAND PROTECTION BRANCH

Edited by A.P. Mackey

Assessment team:
M. Barker
W. Dorney
P. James
P. Jeffrey
N. March
J. Marohasy
D. Panetta



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Contents

1.0 Summary 1

2.0 Taxonomic Status. 2

3.0 History of Introduction and Spread. 3

4.0 Current and Predicted Potential Distribution. 4

5.0 Estimates of Current and Potential Impact. 7

5.1 Impact on Primary Industry. 7
5.2 Control Costs. 7
5.3 Environmental Cost. 10
5.4 Land Value 10

6.0 Biology and Ecology of Weed Spread and Control. 11

7.0 Efficacy of Current Control Methods 12

7.1 Prevention 12
7.2 Chemical Control 12
7.3 Mechanical Control 13
7.4 Fire 13
7.5 Biological Control 13
7.6 Commercial Exploitation 14
7.7 Grazing Management Systems 16

8.0 Management and Control Practices. 17

8.1 Legislative Status in Queensland 17
8.2 Containment and Eradication Strategies in Queensland 17
8.3 Property Management Strategies 18

9.0 References. 19

1.0 Summary

Prickly acacia in Queensland is generally accepted to be *Acacia nilotica* subspecies *indica*. Scattered populations are found throughout Queensland but its major distribution is across at least 6.6 M ha of the northern Mitchell grass downs. Bioclimatic modelling suggests much of Queensland, the Northern Territory and Western Australia is climatically suitable for this species. Prickly acacia reduces pasture growth, ultimately affecting carrying capacity of the land. The economic impact of prickly acacia on the grazing industry has not been fully established but could be as much as $5 m annually due to reduced production. The cost of control to landholders is estimated to be $3-4 m annually with the control of medium to heavy infestations being uneconomic because of the large areas and high number of plants that are involved. The environmental impact of prickly acacia is high but difficult to quantify. Failure to adequately control the weed could lead to much of the Mitchell grass downs losing their grass cover and developing into thorn veldt.

Stock, particularly cattle, are the main agents for dispersing prickly acacia. There is great potential for long distance transport of the weed because the seed remains viable in the gut for up to six days. Mass establishments appear to be episodic and dependent upon a succession of higher than median, wet season, rainfall events.

Relatively cheap and effective chemical controls are available. Mechanical grubbing also is cost-effective. Other mechanical control methods are expensive although double chain pulling is potentially the only economically effective control for heavy infestations. The potential for biocontrol is high but no really effective agent has yet been released. Property management practices, particularly the use of quarantine at times when pods are present, are effective in limiting spread.

2.0 Taxonomic Status

Prickly acacia, *Acacia nilotica*, is generally accepted as a single, natural, though exceedingly variable species. The species is divided into nine subspecies which are considered to be morphologically and ecologically distinct (Brenan 1983). In Kenya the zone of overlap between the subspecies is well defined and the subspecies easily distinguished. It is believed that the prickly acacia in north Queensland is *A. nilotica* subspecies *indica* and comes originally from India. However, variations in pod form, hearsay-reports of introductions from Africa and at least one reported case of possible hybrid sterility, suggest that introductions may have been made from other parts of prickly acacia's range. The assumption that all prickly acacia in north Queensland is subspecies *indica* is probably correct, but in view of the importance of correct identification, this assumption needs to be verified.

3.0 History of Introduction and Spread

Prickly acacia was first introduced into Queensland in the 1890's (Bolton 1989). It was grown extensively as a shade and ornamental tree in the Bowen and Rockhampton districts (Pollock 1926). In 1926 it was recommended by the Department of Agriculture and Stock as a suitable shade tree for sheep in western Queensland and was extensively planted around homesteads, bore drains and dams during the second quarter of this century, not only for shade but also for fodder, because of the protein rich pods. Seeds were often carried around in saddle bags and distributed from horseback.

The wool crash of the 1970's saw a change from stocking sheep to cattle. This, and the series of wet years during the 1950's and again in the 1970's promoted massive spread of prickly acacia throughout the northern downs and the establishment of dense impenetrable thickets. The slump in cattle prices during the 1970's led to high stocking rates which may also have been significant in providing large numbers of cattle as dispersal agents. Prickly acacia was declared noxious in 1957.

4.0 Current and Predicted Potential Distribution

In Queensland, prickly acacia is currently distributed from Karumba in the north to the New South Wales border in the south, and from Bowen in the east, to the Barkly Tableland in the west (Fig.1a) (Carter 1989a) and is still spreading. There are scattered populations across most of Queensland and isolated occurrences in the Northern Territory, New South Wales and South Australia. The major part of the distribution includes 6.6 M ha of the northern Mitchell grass downs of Queensland. The heaviest infestations are along water courses and drainage lines but other infestations also occur on stock routes.

The total area covered by the infestation is not known but the results of a mail survey (Bolton and James 1985, Carter *et al*. 1991) (Table 1) indicate that in the nine shires surveyed, 6.65 M ha or 28% of the area, was infested. It is likely that in the 10 years since the survey was conducted, prickly acacia has expanded to cover well over 7 M ha.

Figure 1. (a) *Current distribution of prickly acacia (Carter 1989a).*
(b) *Potential distribution of prickly acacia*

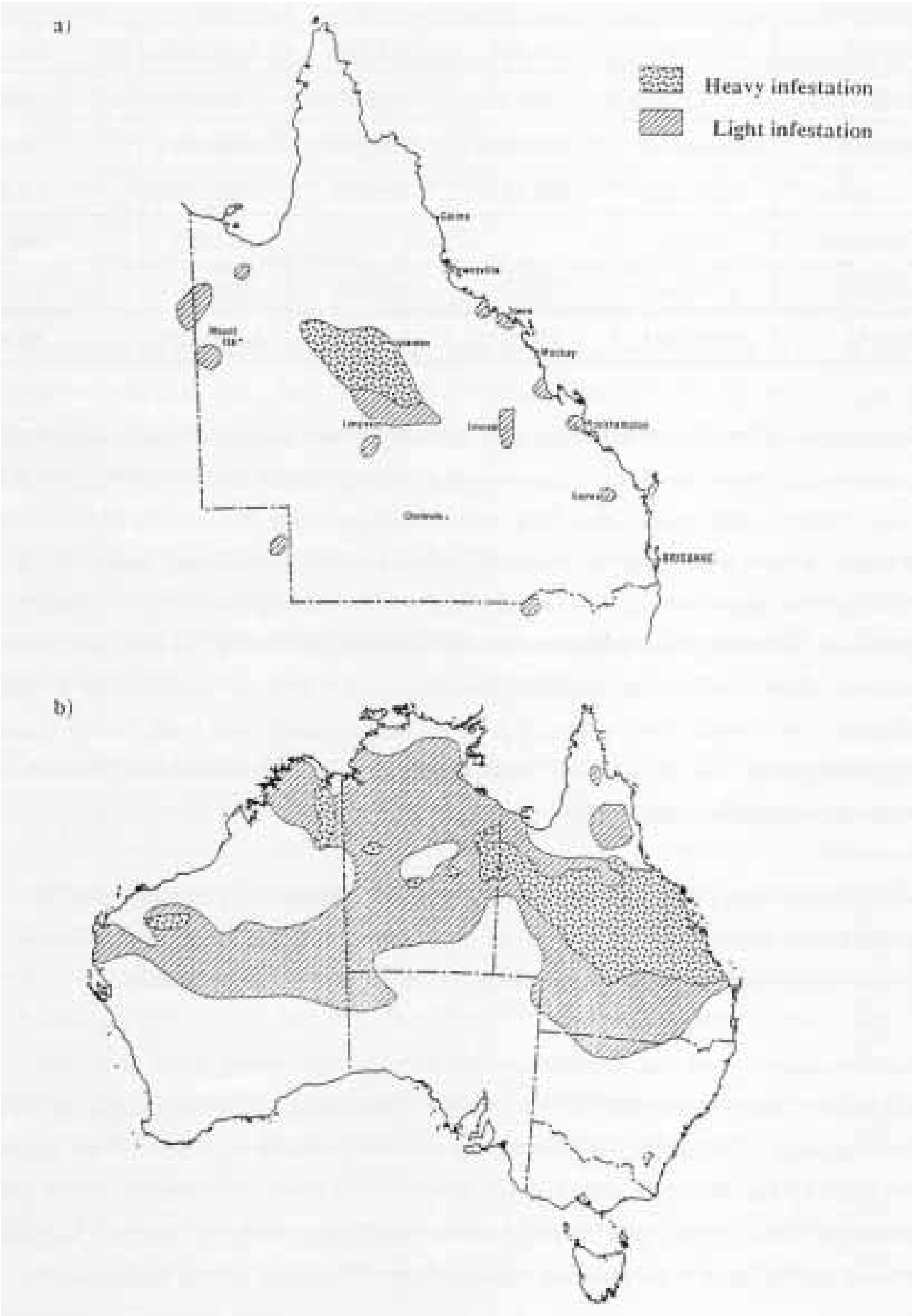

Table 1. *Areas infested with prickly acacia in nine Western Queensland Shires based on density estimates from individual properties (Densities: low - present on <5%; medium - present on 5-50%; high - present on >50% of the surveyed property) (Carter 1989a).*

SHIRE	LOW DENSITY	MEDIUM DENSITY	HIGH DENSITY	TOTAL AREA (ha)	% SHIRE INFESTED
Longreach	17,739	-	6,652	24,391	1.0
Aramac	707,348	114,195	42,130	863,674	37.2
Ilfracombe	23,282	-	-	23,282	3.5
Winton	1,510,044	293,804	87,717	1,882,566	35.0
Barcaldine	7,760	19,956	2,217	29,934	3.6
Flinders	1,124,218	165,195	109,761	1,399,175	33.6
Richmond	833,739	339,261	180,717	1,353,718	50.3
Cloncurry	57,652	-	-	57,652	1.2
McKinlay	650,804	298,239	67,630	1,016,674	25.0
TOTAL	**4,932,591**	**1,230,653**	**487,826**	**6,651,071**	**28.4**

The potential distribution of prickly acacia in Australia has been predicted using BIOCLIM, by establishing a climate profile for prickly acacia in India and back matching this to all of Australia (Carter 1989a, Carter *et al.* 1991). This analysis indicated that the majority of Queensland, the Northern Territory and much of Western Australia may be climatically suited to this species (Fig. 1b). The data used for the climatic matching do not represent the full extent of prickly acacia's climatic range and therefore the distribution shown in Fig. 1b may be a conservative prediction. Conversely, other ecological factors probably limit its habitat range to part of that predicted from climate. Prickly acacia prefers heavy cracking clay soils, heavy coastal clays and basalt soils and its establishment on lighter soils is sparse and related to cattle transportation routes (Bolton 1989).

It would seem that prickly acacia is sufficiently well adapted to semi-arid, arid and northern Australia that it has the potential for a major increase in its area of infestation, and for increasing its population density in the region where it is already established.

The consequences of the greenhouse effect on woody weeds such as prickly acacia is speculative (Carter *et al.* 1991) but the spread of prickly acacia would appear to be a rainfall driven episodic event. Were the greenhouse effect to produce a greater rainfall it is likely that the rate of spread of prickly acacia would increase and current infestations would intensify. If the rainfall were to be more evenly spread, seedling growth, as well as survival, would increase. An increase in temperature would extend the range of prickly acacia south.

5.0 Estimates of Current and Potential Impact

5.1 Impact on Primary Industry

At low densities prickly acacia can increase stock productivity by providing shade and, perhaps, pods and leaves as fodder. This may be particularly important during dry periods of the year. Increases have been documented of up to 16% in lambing percentage, due to the presence of shade in paddocks (Carter 1989b). However, despite this, because of its invasiveness and the difficulty and cost of effectively maintaining prickly acacia at acceptable levels, most landholders view the presence of prickly acacia in their paddocks as undesirable. Dense infestations of prickly acacia significantly reduce pasture production, increase mustering time and cost, exacerbate soil erosion, impede stock movements and the access of stock to water, and increase water loss from, and maintenance costs of, bore drains.

Mustering costs in dense prickly acacia have been estimated at $17 per head, more than 10 times the usual cost of $1.50 per head. Clean mustering a heavily infested paddock is very difficult. Stock remaining in these paddocks are increasingly difficult to handle, and harbour diseases and parasites that can rapidly reinfect treated stock returning to the paddock. Mustering from heavily infested paddocks may not be possible without the added cost of pushing tracks through the prickly acacia.

Under normal grazing pressure a 20% canopy cover of prickly acacia reduces pasture production by 50% compared with acacia-free pasture, and pasture growth is virtually prevented by a 50% canopy cover (Carter *pers. comm*.). This reduction in pasture growth translates directly into a reduction in carrying capacity of the affected pasture.

The overall impact of prickly acacia on animal production in the infested region can be judged from Table 1, although it must be remembered that the data were collected on a property unit basis. Another series of wet years would result in much of the 6 M ha with low or medium density developing to high density infestations, with virtually complete loss of animal production from a third of the Mitchell grass downs. The likely cost to the grazing industry in terms of reduced production would exceed $5 M annually (income from grazing in the five shires most affected by prickly acacia was $187 M in 1990-91) (ABARE Production Report, 1990/91).

Whilst many graziers report that prickly acacia infestation does not reduce carrying capacities and accordingly do not adjust stocking rates on infested land, stocking rates will have to be reduced to prevent the complete degradation of Mitchell grass pastures (Carter and Cowan 1988). Prickly acacia acts mainly as a nitrogen supplement to poor Mitchell grass pasture. Since the browse has high tannin levels, it may suppress animal production if fed in large amounts (Thompson 1992).

5.2 Control Costs

Currently, the Lands Department expends about $40,000 annually on the control of prickly acacia on vacant crown land. Of the $350,000 for 1992/3 levied on the 5 most affected shires for the Trust fund, the shires probably spent less than $40,000 on prickly acacia. Undoubtedly the majority of costs

are borne by landholders, many of whom use fencing, stock management, herbicides and mechanical measures for control of prickly acacia. Jeffrey (pers. comm.) estimates that $3-4 million annually is currently spent by landholders on control.

There are a variety of control options for prickly acacia with the most important being chemical control for light and medium density infestations. For heavy infestations chemical treatment is very expensive but for sparse infestations is relatively cheap (Table 2). Current chemical control methods use basal barking, cut stump application, stem injection and overall foliar spray. Residual chemicals are used in the treatment of bore drains. Basal bark spraying is the most effective way of treating light and medium infestations across a paddock although Starane is an effective foliar spray, and if registered for aerial application might prove an effective control for heavy infestations. The herbicides currently registered for the control of prickly acacia and estimated costs for their use are summarised in Table 2.

Table 2. *Herbicide costs for the control of prickly acacia*.

Chemical	Application	Rate	Cost per specified rate[1]	Cost/tree[2]
fluroxypyr (Starane®)	basal bark	1L/100L diesel	$26 + diesel	12-16¢
triclopyr (Garlon®)	basal bark	0.83L/100L diesel	$53.50 + diesel	13-19¢
2,4-D ester	basal bark	1.25L/100L diesel	$18 + diesel	11-15¢
diesel	basal bark	straight		8-10¢
triclopyr/ picloram (Access®)	basal bark	0.83L/100L diesel	$41.50 + diesel	11-13¢
hexazinone (Velpar®)	spot gun individual plants	4 mL/m tree ht.		4.2¢/spot/m ht.
Diuron	bore drains	64L/ha	$470	$40/km drain

1. Prices are from Brisbane, January 1994.
2. Jeffrey (1992).

For scattered plants on open downs the use of Velpar with a spot gun or ground injection lance (to avoid heat destabilisation of the herbicide) gives good, reliable results (Jeffrey and Dodd 1992). The cost of mechanically grubbing light and sporadic infestations is about 20¢/tree (Thompson 1992) and is competitive with the cost of chemical treatments (Table 2). Control costs (as cost/tree) appear not to be dependent upon level of infestation (Thompson 1992) but of course overall costs depend upon the number of trees to be treated.

For heavy infestations where the cost of chemical control becomes prohibitive, the use of double chain pulling (Jeffrey and Bode 1992) at a cost of $20-50/ha depending on the machinery used, plus the cost of transport of heavy machinery to the site may be an economic alternative, although follow

up chemical treatment of survivors and regrowth and erosion control add considerably to the cost.

Diuron successfully controls heavy prickly acacia infestations along side bore drains and turkey nest dams but dense infestations along creek lines remain difficult to control with herbicide. The aerial application of fluroxypyr is a promising control option for creek frontages and in trials a 62-90% mortality of plants has been achieved (Jeffrey 1994).

It is probable that at least 6.7 million hectares of grazing lands are infested with prickly acacia (Table 1) but due to the variable levels of infestation, any estimate of the total cost for controlling prickly acacia over this area must be uncertain and indicative only. The three infestation levels used in Table 1 are not formally defined, but information in Jeffrey (1992) suggests the three infestation categories could be defined as follows: light, 1-20 plants/ha; medium, 20-150 plants/ha; heavy more than 150 plants. Taking the median infestation rates for light and medium infestations, the average cost for chemical control as 15¢ per plant
(Table 2) and mechanical control for heavy infestations at $45/ha gives the costs listed in Table 3.

Table 3. *The estimated cost for a one-off control of prickly acacia in nine Western Queensland shires.*

Area (ha)		Cost/ha	Total Cost ($'000,000)
Low	5.0 million	$ 1.50	7.5
Medium	1.2 million	$12.75	15.3
High	0.5 million	$45.00	22.5
Initial Treatment			**45.3**
Follow-up			**10.0**
Total			**55.3**

All control options require follow up treatments. If it is assumed that the cost of such treatment approximates the cost for treating a light infestation, then for the total area of infestation the cost would be approximately an additional $10 million giving an estimate of about $55 million to treat the current infestation. This is a conservative estimate as it does not include on-costs for the control programme. Of course further treatment would be needed in years subsequent to the main and follow-up treatment to ensure continuation of control. Whilst $55 M for the total treatment of prickly acacia across the state may seem a large amount it should be considered in the context of increased yearly return from rehabilitated land and the saving in current per annum control costs.

In five western Queensland shires infested with prickly acacia, the mean property size is approximately 18000 ha with 20 km of bore drains (Bolton and James 1985). Assuming the average infestation levels of Table 1 on such a property and the previous definitions of the infestation levels, the cost of controlling prickly acacia on an average property, including a follow up treatment is $46450. Clearly this may be beyond the resources of many graziers. There have been requests from landholders for consideration of tax concessions, fuel rebates, the removal of duty on herbicides and cheap loans to assist control efforts, particularly for the medium to heavy infestations.

Control of dense infestations in the headwaters of the Barcoo-Thomson River system (Aramac Creek, Politic Creek), Flinders River (Alick Creek, Walkers Creek, O'Connell Creek) and Diamantina River (Oondaroo Creek) is also beyond the financial capability of landholders. The cost for a control program in these areas of dense infestation is about $1-2 million. It is in these areas that a suite of suitable biocontrol agents could be most effective.

5.3 Environmental Cost

The environmental cost of prickly acacia is significant but difficult to quantify. The Mitchell grass downs cover 21.9 million hectares in Queensland and lesser areas occur in the Northern Territory and Western Australia (Orr and Holmes 1984). They are one of the major grassland ecosystems of the world. Whilst the prickly acacia infestation is restricted to Queensland and a small area of the Barkly Tableland in the Northern Territory, there is no doubt that the Mitchell grass downs are being converted into a thorny scrubland similar to the African thornveld. Because it is changing such a large and important ecosystem, prickly acacia is considered one of Australia's worst environmental weeds. The impacts of this invasion on biodiversity and the ecology of native species have not been systematically studied. Since even a moderate canopy cover of prickly acacia reduces grass cover markedly and changes the relative abundance of native plant species in favour of forbs and annual grasses a dramatic affect on native fauna habitat and the overall ecology of the system can be expected.

5.4 Land Value

A major cost of prickly acacia could be from a reduced value of the state's leased land asset. Heavily infested land is almost worthless since reclamation costs are often close to, or exceed, the value of uninfested land. Care must be taken to ensure that flow on effects of land revaluation, such as reduced rents for infested leasehold properties, are managed in such a way that they do not become disincentives for the control of prickly acacia.

6.0 Biology and Ecology of Weed Spread and Control

Stock are the main agent of dispersal for prickly acacia and cattle are generally regarded as favouring the spread of prickly acacia more than sheep. Cattle pass about 80% of ingested seeds in their faeces and about 40% of these are viable. The faeces also provide an environment which enhances germination (Harvey 1981). Sheep pass few viable seeds in their faeces, but spit out about 35% of seed during ingestion and regurgitate about a further 15% as viable seed (Carter and Cowan 1988). Since seed takes about 6 days to pass through the gut, stock moved by road transport can disperse viable seed over large distances. The key factor in seed production, the establishment of dispersed seed and seedling growth and survival is the availability of water (Carter and Cowan 1988, Thompson 1992). Further, floods from heavy rain disperse seeds down catchments. Trees on the open downs, where there is no permanent source of water, produce very few viable seeds unless there is significant winter rain, and even so, seedling mortality can be very high. Conversely, trees growing along bore drains and creeks produce many seeds every year (Carter and Cowan 1988). Seed may also be dispersed in mud adhering to the legs of animals. Since prickly acacia favours clay soils, its future spread may be limited by the distribution of this soil type.

The mass establishment of prickly acacia is episodic, relying on a succession of above median wet season rainfalls (Thompson 1992). A rainfall event of this nature is a clear indication that a greater than normal effort may be required for the control of a mass germination of seedlings. Subsequent dry years provide a window of opportunity for the control of the pest at a time when seedling germination and survival is relatively poor. The longevity of the seed bank is an important aspect of the reinfestation of prickly acacia in apparently well controlled areas. Seed can remain viable for six years (Bolton, Carter and Dorney 1987) and the seed bank can contain from 5-724 intact seeds m^{-2}, so under favourable environmental conditions heavy reinfestation could occur in areas that have been well controlled for some years. Although some progress has been made on understanding the conditions required for mass establishment events, more research to elucidate the appropriate conditions is required. More information on floral biology, seed production, seed bank and germination dynamics, seedling establishment and survival, the dynamics of invasion and spread will provide a greater understanding to develop contingency control plans.

7.0 Efficacy of Current Control Methods

Effective chemical and mechanical controls for prickly acacia are available especially for low density infestations but they offer are a short-term solution to a long-term problem. Currently, their use is barely limiting the population of prickly acacia - it is still spreading slowly and levels of infestation are only slowly being reduced. Non-compliance with leasehold conditions by some landholders has contributed to the current level of infestations. Many landholders seem unaware of the problem on their property and are reluctant to face it until the infestation is heavy and very costly to control. Current control costs are increasing at a time when returns from the land are declining and it is unlikely that chemical and mechanical control are sustainable in the long term.

With establishment of prickly acacia being episodic, even if current control methods are effective, control efforts and costs will follow approximately 25 year cycles. Each mass establishment will be followed by a delayed control effort which will only restrict the problem; most of the reduction of the population will be by old age, until the population is boosted by another mass establishment.

The range of available control methods has been described by Jeffrey (1992) and the current strategies and methods are summarised below.

7.1 Prevention

The following prevention activities are effective but may not be practical in years when trees on the open plains produce seeds:

(a) fencing off seed sources
(b) removing stock from infested paddocks before pods ripen
(c) killing plants along drainage lines to remove profusely seeding trees
(d) quarantining stock kept in dense infestations during pod drop.

7.2 Chemical Control

Chemical control should achieve a kill of greater than 90%, but follow up treatments are needed to kill missed plants and control new seedlings. The cost of 10-20¢ per tree becomes unacceptable in high density infestations and other control measures are necessary. For such high density infestations aerial application appears promising but are also expensive.

Water availability affects the efficacy of herbicides, particularly the soil-applied systemics, which rely on being carried to the root zone by rain for their efficacy. There are also major seasonal effects on herbicide efficacy - the optimum time for use of root absorbed herbicides occurs late in the year (November) but best results from basal barking occur form April to August (Jeffrey 1989).

Chemical treatments include:
(a) Velpar spot gun treatment - the favoured, cheapest treatment for scattered trees
(b) Basal bark spraying
(c) Cut stump treatment

(d) Overall spraying of seedlings
(e) Clearing infested bore drains and turkey nest dams with Diuron

7.3 Mechanical Control

There are three main mechanical methods used for control of prickly acacia:
(a) Tractor grubbing: this achieves kills of 90% and is cost competitive with herbicides
(b) Cutter bar, and
(c) Double chain pulling are expensive but appear to be the best available methods for medium to heavy infestations. Chain pulling achieves a 70% kill of larger plants, but is relatively ineffective against seedlings. Trials so far indicate little or no regrowth problems but little rain has fallen during these trials.

7.4 Fire

Prickly acacia does not seem to be susceptible to fire and germination may be stimulated due to the seeds being scarified by the fire (Parsons and Cuthbertson 1992).

7.5 Biological Control

Biocontrol offers a sustainable long term control option. Although initially estimated as costing $150,000-200,000 p.a. over 10 years (J. Marohasy, pers. comm.) it is the cheapest control option in the long term (c.f. Table 3).

Prickly acacia is known to be attacked by a great diversity of insect species in the few regions where its insect fauna has been studied. Pakistan (Mohyuddin,1986) and Kenya have been investigated for biocontrol agents but other African regions and India are also potential sources. Table 4 lists some species which are likely to be host specific and damaging to prickly acacia and others which need to be re-evaluated. Marohasy (1995) suggests investigating galling insects, whilst technically difficult to work with, have the potential to be particularly damaging because they act as energy sinks consuming resources which would otherwise be available for growth, maturation and reproduction.

Two species from Pakistan, *Bruchidius sahlbergi* and *Cuphodes profluens*, were released by Alan Fletcher Research Centre, Queensland (Marohasy 1995) however, less than 4,000 individuals of *C. profluens* were field released before the mass rearing programme was terminated. It is unlikely that this provided a large enough population for permanent establishment of the species as it established at only one site (St. Lawrence, near Rockhampton) and the trees here were subsequently destroyed in an unsuccessful attempt to eradicate prickly acacia.

In contrast, over 110,000 adults of *B. sahlbergi* were released and the insect is now well established and destroys up to 80% of new seed but it appears to be having a minimal impact on the spread of prickly acacia (Carter and Cowan 1988). A large percentage of seed is eaten by stock and remains viable in cow dung where it is inaccessible to these insects as they will only search for seed in pods under or on trees.

Three Kenyan species (*Bruchidius grandemaculatus, Acizzia sp.* and *Weiseana barkeri*) were host specificity tested at the Alan Fletcher Research Station. At the completion of the project, no insect species had been completely tested and a colony of one species remained in quarantine. Host specificity testing of this species, *Weiseana barkeri*, was completed in March 1994. In September 1994 permission was given for its field release however, rearing problems remain.
In the future, biocontrol will depend on finding, testing and liberating a suite of biocontrol agents. The species listed in Table 4, particularly *Cuphodes profluens*, provide a starting point for re-evaluating and continual testing of known biocontrol agents. Surveys for agents in unexplored parts of prickly acacias range, especially western and southern Africa, may provide more suitable species.

7.6 Commercial Exploitation

Woodchipping has been suggested as one way of coping with heavy infestations. Unfortunately, a study by Advanced Biotechnologies Pty Ltd found that whilst prickly acacia is suitable for modern woodchipping, harvesting was not economically feasible (Thompson 1992).

Table 4. *Insects from Kenya and Pakistan with potential as biocontrol agents for prickly acacia.*

Species	Mode of Action	Comment
From Pakistan:		
Bruchidius sahlbergi	mature seed feeding beetle	>110,000 released, established.
Cuphodes profluens	green shoot boring beetle	<4,000 released, not established.
Anarsia trianota	green shoot boring moth	preliminary tests suggest not sufficiently host specific.
Ascalenia callynella	stem galling moth	preliminary tests suggest host specific but difficult to rear.
Cydia sp.	leaf feeding moth	field surveys suggest is host specific but not tested.
Tephrina disputaria	mature seed feeding beetle	small cage host tests ambiguous; needs retesting.
Bruchidius sp.	leaf feeding moth	not tested.
Comibaena cassidera	leaf feeding moth	not tested.
Chlorissa punctifimbria	leaf feeding moth	not tested.
From Kenya:		
Weiseana barkeri	leaf feeding beetle	release approved; problems with rearing - egg dormancy.
Semiothisa inconspicua	leaf feeding moth	preliminary tests in Kenya indicate host specific.
Acizzia sp.	sap sucking psyllid	host specific quarantine colony at AFRS died out.
Acacidiplosis imbricata	galls flower buds	field survey indicates host specific.
Acacidiplosis spinosa	galls flowers	field survey indicates host specific.
Aposchizomyia acuta	galls stem ends	field survey indicates host specific.
Bruchidius grandemaculatus	mature seed feeding beetle	preliminary test suggest specific to s.g. *Acacia*; colony destroyed.
Risbecoma capensis	green seed feeding insect	field surveys suggest specific to s.g. *Acacia.*
Tephrina sp.	leaf feeding moth	field surveys suggest specific to s.g. *Acacia.*
Aspidoproctus sp.	sap sucking scale insect	field surveys suggest specific to s.g. *Acacia.*

7.7 Grazing Management Systems

For many years it has been argued that low grazing pressure reduces establishment of woody weed seedlings through competition for soil moisture and nutrients. Low grazing pressure conserves perennial grasses and encourages a vigorous herbaceous layer (Westoby *et al.* 1989). Recent experimental evidence (Brown and McIvor 1993) suggests that competition by grasses has little effect on the establishment of prickly acacia seedlings.

Seed dispersal and seedling establishment are influenced by the species of grazing animal. Sheep feed on small seedlings when no other feed is available, and cattle damage seedlings by trampling. Temporary high stocking rates of both sheep and cattle may be used to control a mass establishment of seedlings.

Large browsing animals such as camels, goats, antelopes and deer are possible biocontrol agents for prickly acacia. An on-going study is being carried out by Carter *et al.* (1990) on the potential of the complementary use of goats and sheep as control agents. It appears that browsing does not affect the mortality rate of trees, although it does open up the canopy which is important for the regrowth of pasture grasses (a canopy higher than 1.5 m is not available for browse). Goats did not reduce the seedling population. Additional factors that need to be considered in such studies include the increased costs of fencing and mustering and the economic and pest potential of the animals used.

Infestations of Prickly acacia are an increasing problem along stock routes and require additional attention. Similarly roadside and borrow pits need control. A high level of farm hygiene needs to be maintained during use of stock routes. Restrictions on the movement of stock from infested sections during the period of pod drop can minimise spread. Stock movements change with economic opportunities and the expanding live cattle export industry based out of Darwin will facilitate the spread of prickly acacia across the Northern Territory unless controls are placed on movements at pod times.

8.0 Management and Control Practices

Control programs, whether national, regional or local, are sensitive to economic disruption. Failure to spend money on control in financially lean years may put an entire control objective at risk. The economic and environmental implications of any reduction in control activities must be clearly understood by the landholder as the responsibility for stopping the spread of prickly acacia lies with his management.

Fundamental to management is the need to formally define (a) the core areas of infestation, (b) the strategically important infestations and (c) develop property management plans for individual landholders.

8.1 Legislative Status in Queensland

Prickly acacia is a declared plant under the provisions of the Rural Lands Protection Act. In the Shires of major infestation, Aramac, Bowen, Flinders, McKinley and Richmond, it is declared as Category P3, and plants are to be reduced in numbers and distribution. Elsewhere in Queensland the declaration is Category P2, and plants must be destroyed.

8.2 Containment and Eradication Strategies in Queensland

Responsibility for, and the costs of restricting spread, depend on the scale of operation (property, region, catchment) and the degree of "restriction" sought. At an operational level, the term "restriction" requires legal definition and interpretation especially when the responsibility for stopping the spread of the weed onto uninfested land lies with the landholder.

The Queensland Department of Natural Resources and Mines initiative, Strategic Weed Eradication and Education Program (SWEEP), has been used to develop the proposed action plan of the National Weeds Strategy. The National Weed Strategy has two goals for action on prickly acacia:

- To contain prickly acacia within the northern Mitchell grasslands of Queensland, ensuing that the remainder of Australia remains free of this weed.
- To minimise the economic, environmental and social impacts of prickly acacia in the northern Mitchell grasslands of Queensland.

Landholder support for strategic control of prickly acacia is strong, with a significant shift in attitudes occurring over the past decade. Few landholders now regard prickly acacia as a predominantly beneficial plant. It is now practically, as well as technically feasible, to restrict the spread of prickly acacia by:

- Preventing stock from moving out of infested areas when pods and seeds are present. (This includes interstate transport and restricting movement along stock routes.)
- Herbicide treatment of prickly acacia along watercourses.

SWEEP and Landcare initiatives are carrying out many of the activities proposed under the National Weeds Strategy National Action Plan:

- For the northern Mitchell grasslands of Queensland:
  Control strategically important infestations to prevent further spread.
  Educate land managers on the adverse impact of prickly acacia to facilitate adoption of management strategies.
- For areas outside the northern Mitchell grasslands of Queensland:
  Eradicate the current scattered infestations and establish a monitoring program to prevent re-infestation.
  Educate the community, with special attention to land managers, on the impact of prickly acacia, its spread and the responsibilities landholders have in restricting its spread.
- Develop improved integrated management through research and “best practice” development.
- The development and promotion of non-weedy alternatives for shade and browse.

There are currently no strategies for the enforcement of holding periods or quarantine of animals from infested properties as part of regional or interstate stock movement regulations.

8.3 Property Management Strategies

There are two major problems constraining property management strategies:

- For low density infestations there is lack of recognition of the problem and lack of action until the problem becomes severe.
- For heavy infestations the cost of control is very high.

Control practices are being integrated into whole property management plans to include marketing, grazing and chemical control factors e.g.

- Chemically control infestations along open bore drains or pipe the water away.
- Use as drought fodder in high density infestations by pushing the browse over or cutting and chemically treat the stump.
- Browsing only leaf and immature pod.
- Clearing fence lines especially between clean and infested paddocks.
- Restricting stock movement and browse availability during times of pod maturity.
- Chemically treating creek lines and bore drains to reduce continued reinfestation. Currently about 85% of infested bore drains have been treated.

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For further information contact:

C.S. Walton,
Land Protection,
Natural Resources and Mines.
Phone: (07) 3406 2879.