

Research reports

A survey of the weed status and management of *Leucaena leucocephala* (Lam.) de Wit in Queensland, Australia

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Summary

Surveys of Queensland local government shire councils and leucaena (*Leucaena leucocephala*) growers were conducted in August 2000, to ascertain the general distribution and level of weed leucaena populations in Queensland and to determine the incidence and degree of spread of leucaena from commercial leucaena/grass pastures.

Eighty-three of 125 shires (66%) responded reporting that leucaena was present in 60 (72%) shires. Thirty (50%) shires reported the presence of both cultivated and weed leucaena, 20 (33%) had cultivated only and six (10%) had weed leucaena only. Leucaena weed infestations were considered to be of 'minor' or 'no significance' in 80% of shires that reported leucaena was present. One shire, Calliope, viewed leucaena as a 'major' weed. The total area of weed leucaena in shires that responded ranged from 650–5650 ha. The total area of weed leucaena in the state was estimated to be in the range of 1000–9100 ha, compared to our estimate of 50 000–100 000 ha of cultivated leucaena. Leucaena infestations were reported to be localized and commonly occupied disturbed, ungrazed and riparian habitats, however nine (15%) shires reported leucaena had invaded undisturbed native habitats.

Seventy-three leucaena growers responded to the survey. Most had properties >2000 ha with >20–100 ha of cultivated leucaena, predominantly cvv. Cunningham and Tarramba. Forty-five per cent of leucaena plantings were <10 years of age, 48% 10–20 years of age and 6% >20 years of age. Growers viewed the current level of spread of cultivated leucaena as minor. Forty-two (58%) growers reported no spread, 23 (32%) had inter-row spread, seven (10%) had spread outside of

paddocks but within properties while one observed spread outside his property boundary. Most growers did not control volunteer seedling recruitment. Mechanisms of seed dispersal were reported to be water, wind, animals and via cattle dung. There was no statistical relationship between incidence of spread and environmental parameters (soil type and annual rainfall) or specific grower management practices. There was anecdotal evidence that incidence of spread may increase with the age of leucaena plantings. At present, graziers considered cultivated leucaena a minor threat to the environment, as grazing appeared to control the level of seed production and volunteer seedling recruitment.

The results of these surveys indicate that at present, most local government weed control officers and commercial leucaena growers considered cultivated and weed leucaena were a minor environmental threat in Queensland. However, incomplete and sometimes inaccurate shire responses emphasized the need to educate local governments and communities regarding the identification and importance of potential environmental weeds. Immediate selective control of weed leucaena infestations in sensitive areas and support for the voluntary 'Code of Practice' initiated by The Leucaena Network was recommended.

Introduction

Leucaena leucocephala (Lam.) de Wit (leucaena) is a relatively common weed of disturbed urban and riparian habitats in coastal northern Australia (Lazarides *et al.* 1997, Batianoff and Butler 2002). It is also a highly productive forage legume for cattle production in the tropics and subtropics of Australia (Larsen *et al.* 1998). We estimate that graziers have planted between 50 000

and 100 000 ha of commercial cultivars of leucaena on grazing properties located in the 500–750 mm rainfall zone, and this area is rapidly expanding. There have been minor plantings for the rehabilitation of mined land e.g. by Comalco at Weipa.

The success of leucaena in agriculture arises from its multi-purpose traits. Leucaena/grass pastures form a robust silvopastoral system that simultaneously meets the requirements of graziers to: intensively graze cattle and achieve high levels of production; protect soil from erosion and salinization; and improve soil nitrogen fertility (Middleton *et al.* 2002). Unfortunately, the same attributes of leucaena that confer agronomic success (vigour, robustness, longevity and hard seededness) are the characteristics of woody weeds (Hughes and Jones 1998).

There is considerable debate over the current weed status of leucaena in Australia with increasing concern (Anon. 1991, Lambert 1996) regarding the potentially adverse environmental effects of large-scale plantings by graziers. Leucaena growers are aware of the weed potential of cultivated leucaena and established The Leucaena Network in 1999 to promote responsible leucaena management. The Leucaena Network has developed a voluntary 'Code of Practice for the Sustainable use of Leucaena-based Pasture in Queensland' ('Code of Practice') that promotes effective leucaena management strategies to minimize the weed risk of commercial leucaena/grass pastures. Nevertheless, it is not known whether commercial leucaena plantings have contributed to the current weed problem. These issues require investigation.

On the other hand, it is local governments who have responsibility for maintaining community infrastructure on Crown land such as roads, parks, waterways and drains (Land Protection (Pest and Stock Route Management) Act 2002) that are the habitats where weed leucaena is commonly found (Lambert 1996). There are 125 local governments (excluding Aboriginal and Islander communities) in Queensland, including City, Town and Shire Councils. Some shires in Queensland (Barcoo, Burdekin, Ipswich City, Mackay City, Rockhampton City, and Townsville City) have declared leucaena a weed and have developed management strategies for its control, while many others are reviewing the weed status of leucaena in their pest management plans. However, the statewide extent of weed leucaena is not known and requires investigation.

A complicating factor is that *Leucaena leucocephala* has three subspecies (Hughes 1998), of which two commonly occur in Australia. Subspecies *glabrata* is commercially cultivated, while subsp. *leucocephala* is the invasive pantropical 'common'/weedy type (Hughes 1998,

Cronk and Fuller 2001). *Leucaena* was first recorded in Australia at the end of the 19th century (Anon. 1984). Hutton and Gray (1959) reported that naturalized *leucaena* occurred throughout northern Australia at Brisbane, Gympie, Gayndah, Rockhampton, Mackay, Innisfail and Darwin, and morphologically identified these populations as the 'common'/weedy type, i.e. subsp. *leucocephala*. They postulated this naturalized *leucaena* originated from seed brought in from New Guinea, Fiji or other parts of the Pacific. Thus *L. leucocephala* subsp. *leucocephala* has been in Australia for over 100 years in ungrazed and unmanaged habitats, particularly in tropical coastal areas (White 1937). In contrast, cultivars of subsp. *glabrata* have only been commercially available in Australia since the release of cv. Peru in 1962 by the Commonwealth Scientific and Industrial Research Organisation (Oram 1990). However, due to uncertainties regarding establishment and management, and to severe predation by a psyllid pest (*Heteropsylla cubana*) in humid environments since the mid 1980s, widespread commercial adoption of *leucaena* in subhumid areas did not occur until the 1990s.

This project aimed to conduct a preliminary investigation into the weed status of *leucaena* in Queensland, by ascertaining the general distribution of 'weed' *leucaena* in shires and determining the incidence and level of 'spread' of *leucaena* from commercial plantations established for grazing. To achieve these aims, local shire councils of Queensland and graziers with commercial *leucaena* pastures were surveyed.

Methods

Shire survey

All 125 Queensland local governments were asked to complete a survey in August 2000, which asked specific questions on the location, ecology and extent of *leucaena* populations in their shire. Other questions queried the density and extent of spread, whether *leucaena* was cultivated or occurred as a weed, and council attitudes towards the commercial use of *leucaena* in their shire.

The surveys were addressed to the environmental/weeds section of local government offices. With each survey, a letter was provided, detailing the importance of *leucaena* both as a potential/current weed in Queensland and as a valuable forage plant for agricultural use. A photograph of the plant and a detailed botanical illustration (Hughes 1998) was provided to assist with correct identification. Shires who had not responded after one month were reminded a second time to complete the survey.

Graziers' survey

A second survey was undertaken to investigate the level of spread of *leucaena* from commercial cattle properties in Queensland. The associated management practices of the property owners were also surveyed. All current members of The *Leucaena* Network, as well as other graziers known by the members of The Network to have expressed an interest in growing *leucaena* or who had attended *leucaena* field days, were sent surveys. Many of these graziers were not *leucaena* growers, as there was no way of

distinguishing growers from non-growers.

The survey included questions on the property/enterprise attributes, the characteristics and management of *leucaena* plantings and the evidence of spread of *leucaena* within and outside properties. To ensure that the survey was answered honestly and correctly, members were approached at a meeting of The *Leucaena* Network in mid-2000 and the purpose of the questionnaire explained. Graziers were also informed that their confidentiality would be protected and that results would be analysed collectively rather than individually. The graziers gave their enthusiastic support to the survey.

Approximately 230 surveys were individually posted in August 2000 with background information as well as a return self-addressed envelope. Since most of the significant *leucaena* growers in Queensland were surveyed, the results do not represent a small sample of a larger population of growers and therefore could be directly analysed for trends.

Results

Shire survey

Eighty-three (66%) of the 125 shires surveyed responded. The questionnaire responses indicated that *leucaena* was present in 60 (72%) of the 83 shires (Table 1).

In shires with *leucaena*, 30 (50%) had both cultivated and weed *leucaena*, 20 (33%) had only cultivated *leucaena*, six (10%) shires reported only weed *leucaena* and four (7%) shires were unsure of the status of *leucaena* (Table 1). In terms of

Table 1. Shire survey responses to the questions: Is *leucaena* present in this Shire? If present, which category best describes why *leucaena* occurs in this Shire?

Response	Shires
No	Aramac, Chinchilla, Dalby Town, Diamantina, Eidsvold, Ilfracombe, Inglewood, Johnstone, Maryborough City, Paroo, Tambo, Toowoomba, Waggamba.
Unsure	Booringa, Bulloo, Clifton, Gatton, Herberton, Pittsworth, Redcliffe City, Roma Town, Stanthorpe, Woocoo.
Yes	
Deliberately planted (forage or garden)	Barcaldine, Barcoo, Beaudesert, Belyando, Bendemere, Boulia, Broadsound, Cambooya, Carpentaria, Crows Nest, Croydon, Flinders, Jericho, Kilkivan, Kingaroy, Kolan, Millmerran, Monto, Mundubbera, Noosa.
Naturally occurring as a weed	Bundaberg City, Burnett, Cairns City, Charters Towers City, Rosalie, Sarina.
Deliberately planted and naturally occurring as a weed	Bauhinia, Biggenden, Blackall, Bowen, Brisbane City, Burdekin, Caboolture, Caloundra City, Cook, Cooloola, Dalrymple, Douglas, Duaringa, Esk, Gayndah, Gladstone City, Gold Coast City, Ipswich City, Isis, Kilcoy, Laidley, Livingstone, Mackay City, Mareeba, Mount Isa City, Mount Morgan, Pine Rivers, Rockhampton City, Taroom, Whitsunday.
Unsure of origin or current use	Calliope, Cardwell, Etheridge, Mirani.
Shires that did not respond to survey	Atherton, Aurukun, Balonne, Banana, Boonah, Bungil, Burke, Cloncurry, Eacham, Emerald, Fitzroy, Goondiwindi Town, Hervey Bay City, Hinchinbrook, Isisford, Jondaryn, Logan City, Longreach, Maroochy, McKinlay, Miriam Vale, Mornington, Murgon, Murilla, Murweh, Nanango, Nebo, Peak Downs, Perry, Quilpie, Redland, Richmond, Tara, Thuringowa, Tiaro, Torres, Townsville City, Wambo, Warroo, Warwick, Winton, Wondai.

scale of infestation, 33 (55%) shires subjectively declared that the infestation was 'no problem', five (25%) said it was a 'minor' weed, 11 (18%) said it was a 'moderate' weed, while one (2%) (Calliope Shire) viewed it as a 'major' weed. Interestingly, all of the latter 12 shires reported leucaena both planted on properties for grazing and occurring as a weed.

Of the 60 shires with leucaena present, 23 (38%) estimated weed infestations covered less than 50 ha, five (8%) had between 50 and 100 ha, and four (7%) had between 100 and 1000 ha (Figure 1a). Thirteen (22%) respondents were unsure of the area occupied by weed leucaena. Only three shires reported cultivated areas of between 1000 and 10 000 ha. The maximum area of cultivated leucaena in the 60 shires was estimated to be 37 000 ha.

Eighteen shires (30%) reported that the oldest weed plants were <10 years old and 19 (32%) estimated weed leucaena had existed for 10–50 years (Figure 1b). Only one (2%) shire (Bowen) indicated that weed leucaena had been present for >100 years, while eight (13%) respondents were unsure of the age of weed leucaena. Many shires (53%) reported that leucaena cultivation had begun in the last 5–20 years (Figure 1c).

Shires indicated that common habitats for weed leucaena were ungrazed (26%), grazed (21%), drainage (17%) and riparian habitats (20%). In terms of disturbance of habitats, 31% of shires found weed leucaena in partially disturbed natural habitats, 25% in highly disturbed natural habitats and 23% in artificial habitats, while 15% reported weed leucaena in undisturbed natural habitats. Weed leucaena was mostly found as isolated plants (34%) and clumps/thickets (48%), but could also appear in lines (16%) along creek banks/drainage lines.

In the 60 shires with leucaena present, most shires (70%) reported leucaena planted as fodder while only three (5%) had used leucaena in land/mine rehabilitation. However, 32% reported garden plantings and 10% of shires indicated that leucaena was cultivated in parks. Attitudes to the use of leucaena for agriculture were 37% supportive, 25% against and 38% unsure.

Most councils were against the cultivation of leucaena in residential gardens (63%) and council areas (75%). Management strategies for the control of weed leucaena existed in 12 (20%) shires and were predominantly legislative, chemical and mechanical in nature.

Growers' survey

Seventy-three responses were received from actual leucaena growers from the 230 graziers sent questionnaires. A large proportion of the graziers sent surveys had not planted leucaena and many of these did not return the questionnaires. For this reason we cannot report the response level from actual leucaena growers, although it was believed to be quite high.

Property characteristics. Leucaena was being utilized in cattle (76%) and cattle/cropping (24%) enterprises. Half of properties were >2000 ha in size (Figure 2a) and 73% had >20 ha of cultivated leucaena (Figure 2b). The principal cultivars planted were Cunningham (56%), Tarramba (53%) and Peru (40%). Most of the oldest plantings were <20 years of age (Figure 2c). The following characteristics of the leucaena/grass pastures were surveyed, as they were considered likely to influence the incidence of spread of leucaena within and outside paddocks. Growers used a row spacing of <3 m (13%), 3–5 m (42%) and >5 m (45%) and most (63%) planted grass in their leucaena areas (Figure 2d). Of those that did not plant grass, 77% reported grass had naturally invaded the inter-row and 69% of growers described the vigour of the grass as strong. Most (90%) leucaena paddocks were surrounded by healthy grass pastures, of which 73% were continuously grazed by cattle. The majority (95%) of leucaena growers were located in the 500–750 mm annual rainfall zone (Figure 2e) and had planted leucaena on flat/undulating clay soils (40%) (Figure 2f).

Management practices. The questions on spread of leucaena indicated that 42 (58%) growers found no evidence of leucaena spread within their properties. Of the remaining growers, 23 (32%)

reported inter-row spread only, while seven (10%) reported that leucaena had spread outside their paddocks but remained within property boundaries. Only one grower reported spread of leucaena outside his property. Of the 31 growers that reported spread, six (19%) had plantings 2–5 years old, eight (26%) had plantings 5–10 years old, 15 (48%) had plantings 10–20 years old, and two (6%) had plantings >20 years old. Only four growers conducted control of leucaena outside planted paddocks, while one grower had treated inter-row spread.

The majority of growers (58%) reported none of their trees out of the reach of cattle, however, 14% of growers reported >5% of trees out of reach (Figure 2g). Approximately 50% of growers indicated that they had planted leucaena rows <5 m from fence-lines (both internal and boundary fences). Seventy per cent of growers maintained moderate (1–2 ha head⁻¹) to high (0.4–1 ha head⁻¹) annual stocking rates on their leucaena pastures.

Growers reported that the major habitats where they had noted weed leucaena occurring (not necessarily on their properties) were riparian areas (23%), roadsides (32%), gardens (21%) and undisturbed natural habitats (7%) (Figure 2h). Growers reported that the most likely mechanisms of spread of weed and cultivated leucaena were water (33%), wind (21%) and animals (including birds, native and feral animals) (18%), vehicles (12%) and via cattle dung (12%).

Discussion

Shire survey

In assessing the results of the survey it is important to consider the assumptions. Forty-two (34%) shires did not respond. Unfortunately many (at least 21) of these shires (e.g. Banana, Fitzroy, Townsville City) are in coastal and subhumid areas where leucaena is known to be both a weed and/or a significant contributor to local pastoral industries (Table 1). The incomplete participation of shires will adversely affect interpretation of the survey results. Furthermore, the questions relied on the knowledge of personnel in shire offices regarding the specific areas and

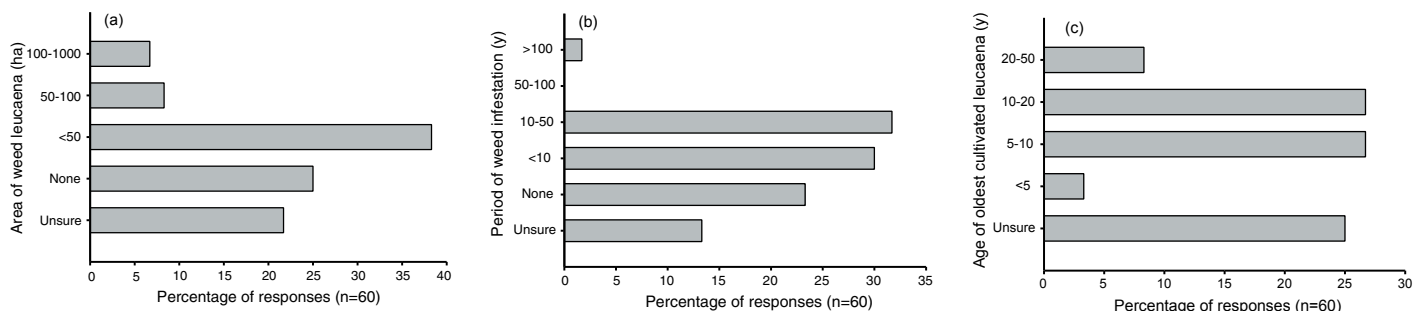


Figure 1. Percentage of responses from shire surveys regarding a) estimated area (ha) of weed leucaena, b) age (y) of oldest weed leucaena infestations, and c) age (y) of oldest cultivated leucaena in shire.

characteristics of leucaena in the shire. Some shires do not have environmental or weed control officers and may not have known the extent of the problem. For example, Gatton Shire Council reported it was unsure if leucaena was present, whereas weed leucaena does infest roadsides and riparian areas and leucaena has been commercially planted in this shire. This survey highlights the need to raise awareness of local government to the presence and potential threat of environmental weeds in their districts. Nevertheless, the shire survey did provide a preliminary indication of the extent of the weed leucaena problem in Queensland.

No shire reported greater than 1000 ha of weed leucaena (Figure 1a). The total area of weed leucaena in the 83 shires that responded was estimated to be 650–5650 ha. To approximate the total area of weed leucaena in Queensland, estimations of the area of weed leucaena in those shires that did not respond or were unsure of areas infested were made. These shires were allocated an area of weed leucaena based on the survey responses from neighbouring shires combined with the authors' knowledge of the presence of leucaena in those shires. The resultant statewide area

of leucaena infestation was thus estimated to be 1000–9100 ha. This is low compared to areas of northern Australia infested by major environmental weeds, such as 30 million ha infested by *Cryptostegia grandiflora* (rubber vine) (Tomley 1998), 17 million ha by *Parthenium hysterophorus* (parthenium) (Navie *et al.* 1998), 7 million ha by *Acacia nilotica* (prickly acacia) (Mackey 1998), 4 million ha of pasture by *Lantana camara* (lantana) (Swarbrick *et al.* 1998), and 800 000 ha by *Prosopis pallida* (mesquite) (Thorp and Lynch 2000).

It is likely that the area occupied by weed leucaena is increasing and there can be no complacency. Larger infestations (100–1000 ha) were reported in Cook, Brisbane City, Esk and Ipswich City Shires. In sensitive environments (urban, coastal and riparian), complete eradication and revegetation will be costly and time consuming, but possible as the areas infested are still relatively small. In many shires, severe infestations of other noxious weeds have diverted attention from dealing with the less significant threat posed by leucaena. Immediate pre-emptive action will prevent more severe levels of leucaena infestation in the future.

Thirty-five per cent of shires reported

that leucaena had been present for 10–50 years, and these were the shires with a moderate or major weed problem. The estimates of the age of weed leucaena stands in many shires may be inaccurate, as White (1937) reported that leucaena has been present in coastal Queensland for over 100 years and Hutton and Gray (1959) reported well-established weed populations in northern Australia over 40 years ago. Therefore, many of the reported weed populations have been established for long periods of time on public land, and are not recent weed outbreaks from commercial leucaena pasture development over the last 20 years.

Respondents indicated a variety of habitats where weed leucaena could be found, but highlighted partially disturbed, ungrazed and riparian habitats. Weed leucaena was also reported in undisturbed natural habitats in 15% of shires. Batianoff and Butler (2002) also listed *L. leucocephala* as a 'generally invasive plant – escaping from cultivation and spreading into natural areas', where 'natural vegetation' was described as plant communities that comprised >70% indigenous species in a structure that approached that of remnant communities. If the results of this survey and the assessment of Batianoff and Butler (2002) were accurate, this would be cause for concern as other researchers have reported that leucaena does not readily invade undisturbed natural habitats (Lazarides *et al.* 1997, Hughes 1998, Hughes and Jones 1998, Middleton *et al.* 2002). Whilst alarming, it is our belief that many respondents may have been unaware of the level of current disturbance and/or

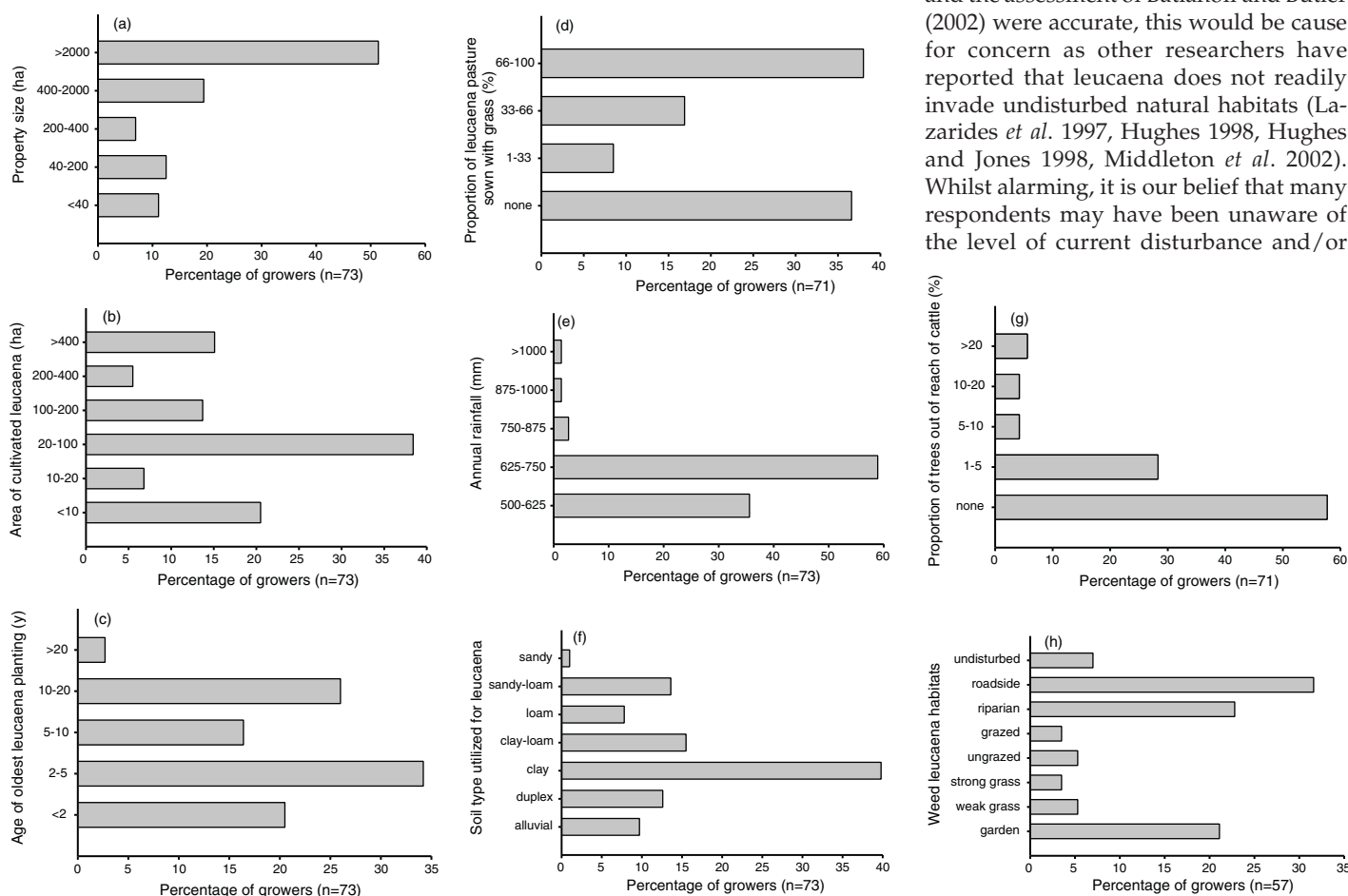


Figure 2. Percentage of responses from growers' survey reporting a) property size (ha), b) area of cultivated leucaena, c) age (y) of oldest leucaena planting, d) percentage of leucaena pasture sown with grass, e) annual rainfall (mm), f) soil type utilized, g) proportion of cultivated trees out of reach of cattle, and h) weed leucaena habitats observed by growers.

incidence of previous disturbance of weed leucaena habitats around the state, and that in fact leucaena is predominantly a ruderal weed. However, further investigation of these 'natural' habitats is recommended to validate these reports, and to quantify the extent of leucaena infestation and formulate eradication/control strategies.

Grazing and forage production was reported to be the major (70%) use of leucaena in Queensland shires. Unfortunately many shires also reported leucaena was present in parks and gardens, and had been used in land rehabilitation programs. These unmanaged (ungrazed) plantings are not desirable, will contribute to the weed problem and emphasize the need for education of shires concerning the weed characteristics of leucaena. Exotic plants cultured for ornamental/landscaping purposes have been a primary source of invasive environmental weed species in Queensland (Batianoff and Butler 2002). Shires and landholders should be urged to remove these plants immediately.

The Queensland Department of Natural Resources and Mines (NR&M) is currently notifying local governments of the weed status of leucaena. As the responsible authority (Land Protection (Pest and Stock Route Management) Act 20), the onus is on shire councils to understand the methods of control of weed leucaena, and to provide landholders, the community and Land Care groups with relevant information to encourage control and minimize future weed risk.

Growers' survey

The survey contained some questions that were subjective in nature and answers may reflect the observational ability of growers. For instance, the authors observed that one grower failed to notice volunteer seedling recruitment, however, it is believed that farmers know their properties well and that the information provided was reasonably accurate. The growers understood the importance of the survey and the response of the growers was most co-operative.

Very little spread of leucaena was reported and therefore there is currently little cause for concern that property owners are initiating a major weed problem. The questionnaire indicated that only 11% of growers had noted spread outside paddocks, and of these only one (1%) reported spread outside his property boundary. This latter grower had over 400 ha of leucaena 10–20 years of age, did not graze the area surrounding the leucaena, and reported 1–5% of trees were out of reach of the cattle. This provided some evidence to suggest that poor tree management and lack of grazing around leucaena paddocks e.g. along roadsides, may have contributed to spread. Of the remaining growers with 'spread', 32% reported inter-row spread only.

An important factor, which may reflect rate of spread, is the age of the plantations. The responses indicated that 71% of leucaena stands were planted in the last 10 years. Only two growers indicated that their stands were over 20 years old and both noted the spread of leucaena within their properties. Leucaena is known for its ability to produce a large seed bank protected by exogenous dormancy, which would enable seedlings to continue to emerge for many years after a seeding event (Hughes and Jones 1998). Since there may be a long lag phase before significant spread occurs (Jones and Jones 1996), older plantations may be at greater risk of becoming weedy. For this reason, it may be too early to determine whether current management practices effectively control spread although current indications are that leucaena spreads slowly.

Of the eight growers who found spread (other than inter-row), only four took action to control these plants. Growers generally did not attempt to control volunteer seedling recruitment on their properties as they considered all leucaena a valuable forage resource. However, the 'Code of Practice' now encourages them to use grazing management to prevent seeding events and to eradicate all plants that have spread outside of planted paddocks.

Interestingly, the survey results showed no statistical relationships between management practices and spread. For instance, in rows less than 5 m apart, inter-row shading may be expected to reduce grass growth thus promoting the establishment of leucaena seedlings. However, the results indicated no relationship between row spacing and spread. Similarly, growers with grass swards that were of poor to medium vigour under sown leucaena (31%) did not report greater spread, and the presence or absence of grass surrounding the leucaena paddocks to provide a natural barrier was not related to spread. It was widely acknowledged that grass naturally invaded leucaena areas thus reducing opportunity for leucaena seedlings to establish.

We suggest that grazing controlled the spread of leucaena, as evidenced by the overall low incidence of spread and the lack of statistical relationships between specific management practices and spread. Furthermore, the majority of properties were in the subhumid 500–750 mm annual rainfall zone and inter-plant competition for limited soil moisture is likely to limit the incidence of successful volunteer seedling recruitment (Jones and Jones 1996). There was also a recent trend towards greater plantings of cv. Tarramba, a less precocious seed producer than cv. Cunningham, which will further minimize the risk of leucaena escaping from commercial plantings.

Many growers (33%) indicated that water was the main agent for distributing seed. Two growers had leucaena invade their properties via floodwaters. Wind (21%) was also suggested as a significant cause of spread. Pods containing seeds were found up to 20 m from the parent trees indicating the importance of buffer zones between the leucaena paddocks and surrounding waterways and other vulnerable areas. In another study, leucaena seed, retained in fallen pods, has been dispersed up to 35 m from cultivated trees in highly disturbed farming systems in India (Patil and Kumar 1990). Interestingly, 18% of growers indicated that animals, other than domestic livestock, were a cause of spread. Recent research in north Queensland has found that feral pigs ingested mesquite (*Prosopis pallida*) pods and that ingested seed remained viable posing a significant threat to the control and eradication of this woody weed (Lynes and Campbell 2000). It is not known if feral pigs consume and disperse leucaena seed. No growers thought that leucaena spread was due to seeds attached to cattle hooves, but 12% of growers attributed spread to seed carried in cattle dung, supporting the anecdotal observations of Jones and Jones (1996). The spread of other leguminous woody weeds, such as *Acacia nilotica*, has been linked to the ingestion, scarification and distribution of viable seed by livestock, particularly cattle (Mackey 1998). The significance of animal-mediated (both feral and domesticated) leucaena seed dispersal needs further study.

Conclusions and recommendations

While the statewide area of cultivated leucaena (subsp. *glabrata*) was estimated at 50 000–100 000 ha, the area of weed infestation (probably subsp. *leucocephala*) appears to be small and localized, occupying a projected 1000–9100 ha of predominantly ungrazed, disturbed habitats such as roadsides, riparian and urban areas.

Since local governments have responsibility for weed control, the rapid increase in the area of cultivated leucaena should be viewed as a catalyst for shires to begin monitoring, controlling and removing weed leucaena populations on public land. Restriction of its use to commercial grazing properties and rehabilitation of damaged riparian areas would seem prudent, if the latter is economically feasible. However, many shires did not currently consider leucaena a major environmental threat, which may preclude the implementation of these recommendations.

Eleven per cent of growers surveyed reported spread of cultivated leucaena outside of planted paddocks and only 1% reported spread outside of properties. No statistical link between specific management practices and spread was found. This suggested grazing was the

critical factor minimizing seed production and dispersal, and seedling recruitment. However, as most pastures were less than 10 years old, the long-term effects of current grazing management practices need to be monitored. The role of feral/native animals and cattle in leucaena seed dispersal requires evaluation, as it may affect the spread of leucaena.

Both shire officers and growers reported that leucaena had invaded undisturbed native habitats. This is of great concern as it contradicts previous reports and experience that indicate that leucaena only invaded disturbed habitats. These cases need to be investigated immediately and remedial measures undertaken if shown to be accurate.

Cultivated leucaena subsp. *glabrata* does have weediness attributes, however the results of these surveys indicate that it is presently a minor threat to the environment where it is currently planted and that grazing has prevented significant spread to date. Negotiation between representatives of environmental, government and grazing groups is recommended to officially endorse, publicize, and regularly review and update the voluntary 'Code of Practice'. This will minimize the risk of commercial plantings contributing to weed populations in ungrazed environments. Education of and adherence to the 'Code of Practice' by growers, combined with regular pasture and property monitoring, and associated efforts by government agencies to control or eradicate weed leucaena infestations on public land, will ensure the benefits of leucaena are realized while environmental damage is minimized.

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