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Prepared by: Sean Kenny & Geoff Drysdale
Rural Consulting Group Pty Ltd

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Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Leucaena-grass pastures and target markets for adoption

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Abstract

The Leucaena Grass pastures and target markets for adoption project was commissioned by MLA to examine the scope for further adoption of Leucaena grass pastures in Northern Australia. Drawing upon stakeholder and producer interviews, focus groups, mapping of biophysical factors critical to growing Leucaena and a review of existing literature, regional adoption profiles were developed using the ADOPT model (Kuehne et.al 2017). Together this work outlines the current and future potential for Leucaena adoption in Northern Australia and recommends five interrelated strategic actions designed to support the ongoing adoption of Leucaena. These actions have been designed to address the complex technical, social and biophysical requirements for successful adoption and will require collaboration between MLA, The Leucaena Network, producers, government and the private sector to be effective.

Executive summary

The purpose of the Leucaena grass pastures adoption project is to inform the development of an industry strategy to increase the adoption of Leucaena-grass pastures across suitable regions of northern Australia. This study was commissioned with 4 objectives;

1. Describe the potential for future Leucaena production in northern Australia
2. Examine the current production level of Leucaena-grass pastures in Australia
3. Explore the barriers and incentives to adoption (scope) and the ROI MLA can expect from its RD&E investments into Leucaena, and;
4. Make recommendations on a strategy to increase the adoption of Leucaena-grass pastures.

The first step in this review was to assess the geo-climatic potential for Leucaena. A review of the literature enables us to summarise the core requirements for Leucaena as follows:

- The 600 mm-800 mm rainfall zone is likely to provide greatest potential so long as soil and temperature conditions are adequate.
- The 800 mm plus rainfall zone offers potential with the new Redlands psyllid-tolerant variety, however a greater prevalence of acid soils, opportunities for higher value crop production, perceptions in coastal areas of Leucaena being a weed, and establishment and management challenges means that these areas are also seen as marginal for adoption.
- Average minimum temperatures and frosts are unlikely to be a barrier in northern Australia, except for a small area around Charleville.
- Soil depth >1 m and pH>5.5 appear to provide a best-bet option for land suitability.

Throughout this report we refer to five regions in northern Australia, each with a unique combination of adoption characteristics. These regions differ in one or more key elements critical to the potential adoption of Leucaena, namely farming system types, Psyllid risk, access to markets and producer density/critical mass. These are Central Queensland, the Queensland coastal high rainfall zone, Queensland Gulf, Northern territory and Western Australia.

Across the five regions the geo-climatic potential of Leucaena was mapped, based on soil depth >1 m and pH>5.5 as per the methodology of Beutel et al (2018), and rainfall greater than 400 mm, to determine the upper limit of beef properties and cattle numbers in suitable areas. From this data it was concluded that:

- 40% of properties comprising 42% of cattle in northern Australia are in the broadest geo-climatic range for growing Leucaena. This represents 6266 properties and 6,329,606 cattle.
- 26% of properties (4064) and 21% of cattle (3,204,357) are in the 'ideal' zone for Leucaena (suitable soils and rainfall above 600 mm)
- Almost three quarters of properties in this 'ideal' zone are in Central Qld (CQ) (2640 properties, 73%), nearly a quarter are in the Queensland coastal high rainfall (HRF) zone (817, 23%), 124 properties in the Queensland Gulf (the Gulf) (3%), and approximately 42 properties in the Northern Territory (NT).

In terms of actual adoption, this report draws on the work of Beutel et al (2018) in CQ and input from local operatives in the other zones to assess the extent of current planting. This found:

- In CQ, Beutel (ibid) estimates that 3.9% of properties (103) were growing Leucaena in the study area, of which approximately three quarters (79) were in the ideal zone of 600mm-800mm rainfall, and one quarter (24) in the <600mm zone.
- It is estimated that approximately 1000ha were sown in the HRF zone in 2017/18 with this constituting around half to one third of total plantings.

- The Gulf has few known Leucaena properties with approximately 700ha of planting either completed or underway.
- The NT has one known commercial-scale area grown with several in the planning phase and a number of plantings which have failed or been removed.
- WA has environmental restrictions which preclude the use of current (seeded) varieties on leasehold land which is the dominant land tenure in Leucaena-suitable areas.

The next component of this review was to explore barriers and incentives to adoption. This was informed by multiple 'data' sources including; producer interviews and focus groups in CQ; discussions with R&D personnel involved with Leucaena; review of literature on the attributes of Leucaena and; an analysis of MLA producer segmentation work. This data was then incorporated into the ADOPT model (Adoption and Diffusion Outcome Prediction Tool - Kuehne et al, 2017) to better understand the potential scope and rate of adoption.

Using the ADOPT model the upper limits of adoption were deduced at a regional level as follows;
- In CQ high profitability, combined with excellent enterprise fit and social learning support has the highest predicted upper adoption level of 18% and shortest time to peak adoption of 14 years.
- Compared to CQ the two key adoption drivers of profit and enterprise fit are considerably lower, and moderated in areas where Leucaena offers greater risk reduction (Gulf, NT and WA).
- Areas other than CQ, particularly more remote areas, have considerably reduced learning opportunities combined with lower general awareness and base knowledge of Leucaena management, which lead to an extension of the time to peak adoption. Upper adoption rates and time to peak adoption are estimated at 6%/ 19 years for HRF, 8%/ 2 years in the Gulf, 8%/ 25 years in the NT, and 5%/26 years in WA.

Upon developing these adoption 'profiles' for each region, a rationale for investment in extension and adoption activities can be developed. From this, the following was concluded for each region:
- CQ offers a large pool of likely adopters, robust estimates of significant per-farm benefits (Chudleigh et.al., 2018), coupled with significant existing extension support, suggesting reliable returns from investment using appropriate adoption strategies.
- The HRF has a significant number of properties likely to adopt with the right support, evidence of profitability, and regionally specific management practices.
- Benefit in the Qld Gulf and the NT are difficult to assess due to a lack of data. This combined with relatively low numbers of properties in the ideal zone for Leucaena means that any investment must focus on proof of concept under commercial conditions via a cost sharing model.

Five interrelated strategic actions are recommended which have been designed to support the consolidation of knowledge associated with Leucaena management and support ongoing adoption:

1. **Codify systems fit planning process** - To support the process of analysis at the property level to assess the appropriateness or otherwise of changes to the forage base.
2. **Develop proof of concept outside CQ** - Key elements of systems fit are yet to be adequately codified for the HRF, Gulf and NT. Addressing this is critical to enabling delivery of action 1 in areas outside of CQ.
3. **Support continuous improvement of knowledge resources** – This is a critical component of any 'knowledge' system and has been occurring to a certain extent already, albeit not in a strategic and coordinated fashion.
4. **Ensure sustainability of the support industry** – Critical to the longevity of the Leucaena industry given the ongoing decline in publicly funded extension.

5. **Drive awareness and understanding of potential benefits and support services** – To ensure the pros and cons of Leucaena, the benefits of a strategic approach to forage planning (action 1) and core elements of responsible management (the code of conduct) are communicated to current and prospective growers.

The potential costs of these actions are outlined in this report. This combined with the other insights in this report will allow MLA and its key stakeholders to assess the merit of further investment in the adoption of Leucaena grass pastures from this point forward.

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1 Background

1.1 Project purpose and structure

The purpose of the Leucaena grass pastures adoption project is to inform the development of an industry strategy to increase the adoption of Leucaena-grass pastures across suitable regions of northern Australia. The aim is to develop a rich picture of the history and potential of Leucaena based pastures in northern Australia, along with the current and future prospects for adoption. Combined, these insights will enable an assessment of the ROI for MLA investment in Leucaena RD&E and form the basis of an ongoing adoption strategy supporting increased uptake of Leucaena where appropriate. The project was structured in four phases:

Phase 1 – Describing the attributes and potential of Leucaena in Australia.
Phase 1 explored the attributes and scope for Leucaena in Australia and consolidate data central to understanding the 'relative advantage of the Leucaena as a 'technology, as per the ADOPT model (Kuehne et.al., 2017). The approach taken in phase 1 included desktop literature and resource review and preliminary interviews with researchers and extension staff across Australia.

Phase 2: Understanding the history of Leucaena adoption in Australia
Phase 2 described the current production level of Leucaena-grass pastures in northern Australia. Estimates of current (and potential) production were developed for northern NSW, Qld, NT and Western Australia and regions as appropriate, along with associated farming systems. Through this phase we built an assessment of the 'learnability characteristics of the practice', which includes an understanding of key elements associated with growing and managing Leucaena such as trialling ease, practice complexity, and observability relevant to adoption (Kuehne, et.al., 2017).

Phase 3: Developing adoption profiles for growers in regions where Leucaena has a high likelihood of success
Phase 3 explored the barriers and incentives to adoption on farm. Interviews, focus groups and case studies were used to understand and describe the key barriers and incentives for implementing Leucaena. This phase of the investigation also explored other characteristics of the producer population that influences adoption such as what Kuehne (2017) calls 'relative advantage for the population' and 'population-specific influences on the ability to learn about the practice'.

Phase 4: Developing recommendations for future investments in Leucaena RD&E
Phase 4 developed the recommendations for an adoption strategy and an analysis of the rationale for investment in further extension RD&E investments into Leucaena for improving cattle productivity across the value chain. Findings from phases 1-3 were consolidated into a series of maps and reports and an interpretive workshop held with The Leucaena Network and MLA program managers to explore and interpret the findings.

1.2 The northern Australian beef industry

More than two-thirds of Australia's beef herd is located in northern Australia, covering subtropical northern - NSW (6%) Queensland (47%), Northern Territory (10%), and the rangelands area of Western Australia (5%) (ABS, 2017). These northern production systems are based in the summer dominant rainfall zones (Figure 1), with higher stocking densities in south-east Queensland decreasing further north, and into the Northern Territory, the Kimberly and Pilbara (Figure 2).

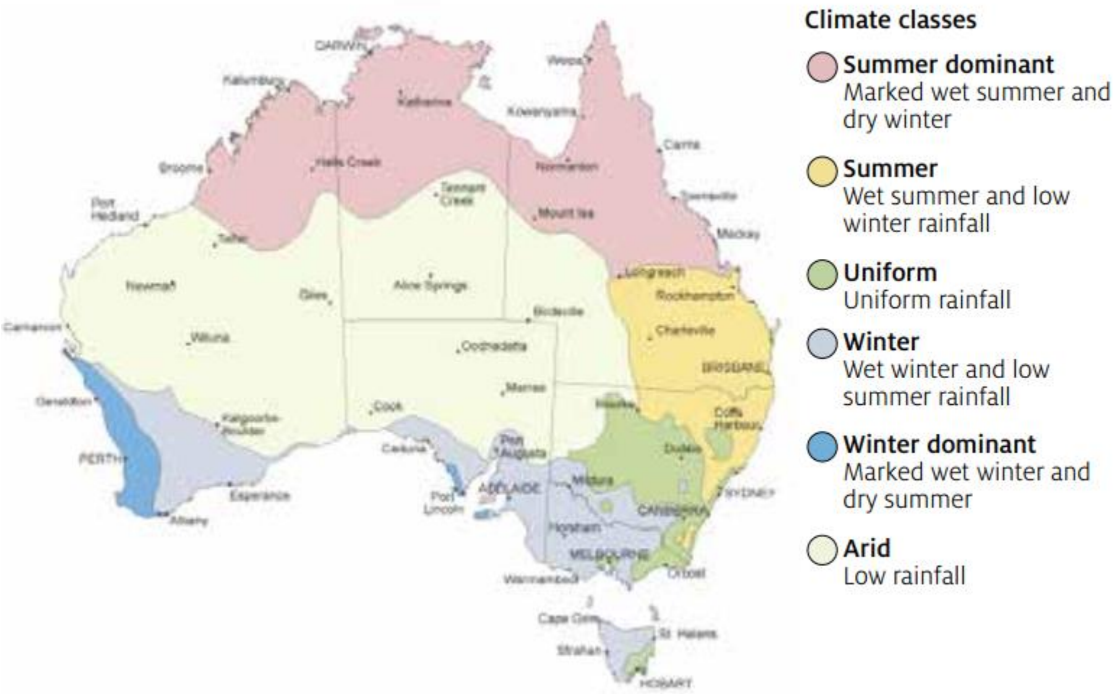


Figure 1: Australian rainfall zones (Gleeson *et al,* 2012) – BOM data

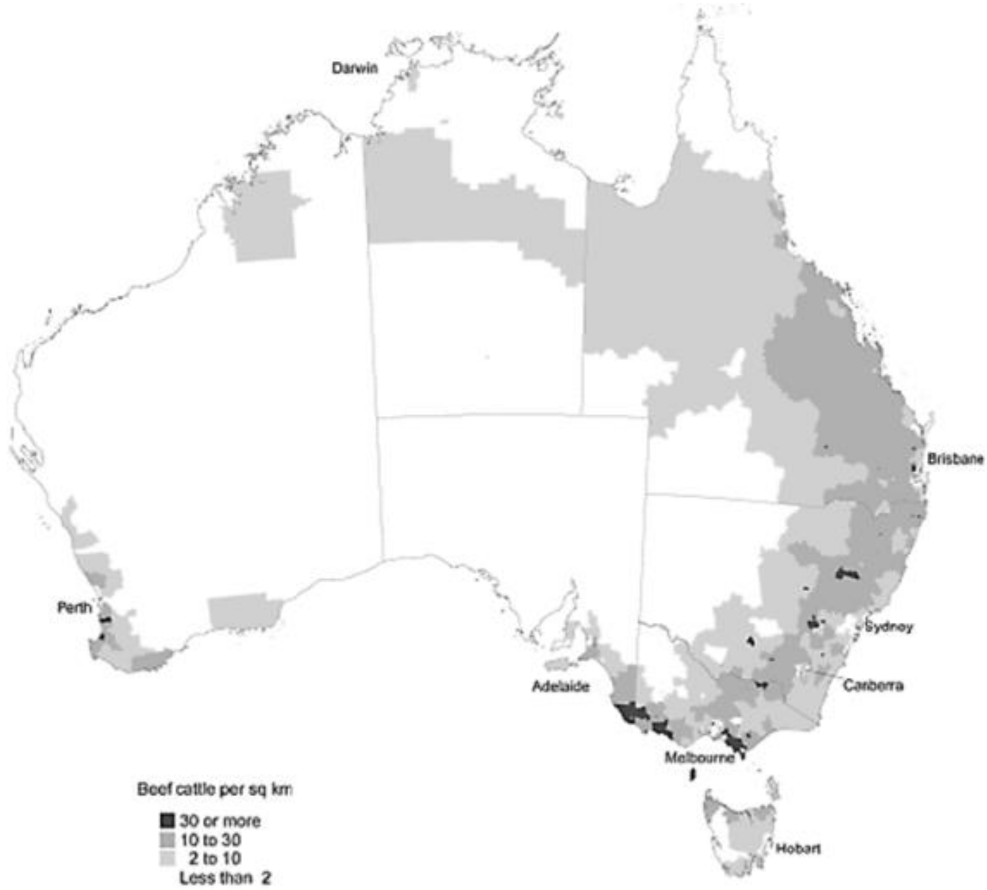


Figure 2: Beef cattle stock density (PWC, 2011) – ABS data

Cattle production and sale across the north is tailored to a variety of 'production sectors' from breeding and sale of weaners or store yearlings, through to backgrounding and finishing for specific domestic and export markets (Ausvet, 2006). A key challenge faced by northern producers is to obtain the rapid weight gains required to meet market specifications because of the relatively poor nutritional value of tropical grass pastures.

1.3 Leucaena as a forage option

Amidst the search for more nutritious species the forage legume Leucaena, used in combination with grass pastures, was reported by Dalzell et.al (2006) to be the most productive, sustainable and profitable system of producing grass-fed beef in northern Australia, when compared to other finishing options. Dalzell's (*ibid*) pronouncements of the virtues of Leucaena were reinforced by Bowen et. al. (2015) in a study of forage systems on 24 producer sites in the Fitzroy region. The study found that Leucaena-grass pastures resulted in the highest average total beef production, and highest gross margin. Production from Leucaena-grass pastures was 2.6 times greater than the average annual beef production from perennial grass pastures, and 1.6 times higher than the nearest legume pasture, with less variability between sites and years in total beef.

Leucaena, whilst being highly productive and profitable, presents significant challenges to establish and manage, and is only suited to a particular range of soil and rainfall zones in northern Australia. Producer Demonstration Sites (PDS) and research projects have demonstrated the challenges involved in managing and establishing Leucaena, highlighting a 3 to 7 year payback time to recover establishment costs for Leucaena–grass systems (Bowen et al 2015). In summary, the strengths and weaknesses of Leucaena as defined by Dalzell et.al (2006) are:

Strengths

- Very high nutritive quality for ruminant livestock.
- Highly productive on suitable soils.
- Drought tolerant, retaining leaf during dry periods.
- Long life means lower lifetime cost overall
- Enables targeting of higher value markets
- Reduces soil erosion and prevents rising water tables due to deep roots
- Reduces greenhouse gasses via carbon sequestration and reduced methane production

Limitations

- Poorly adapted to acid-infertile soils.
- Poor growth at low temperatures and is susceptible to frosting.
- Relatively weak in seedling stage and slow to establish.
- Psyllid susceptibility in humid/coastal conditions
- Costly to establish
- Mimosine toxicity requiring additional management

2 Project objectives

Despite significant investment by MLA into Leucaena RD&E for northern states and the territory, little is known about the extent of its adoption across northern Australia. Evidence on how much Leucaena is grown in the north is difficult to collect, but anecdotal evidence suggests adoption is lower than initially predicted. The MLA Stakeholder Segmentation and Value Proposition Project (2016) raised the prospect of targeting the Driving Growth sector in the adoption of Leucaena-grass pastures, however this needs to be verified, as the market for any innovation is segmented according to the adoption behaviour of participants in the market for that specific innovation.

Anecdotal evidence reveals producers with cropping experience are more likely to trial Leucaena/grass pastures and have more success in establishing and managing it for the long term – another claim which needs verification. Given the adoption environment for Leucaena is poorly understood, this study was commissioned to examine;

1. the potential for future production (in relation to topography, land type and Leucaena species available)
2. the current production level of Leucaena-grass pastures in Australia
3. the barriers and incentives to adoption and the ROI MLA can expect from its RD&E investments into Leucaena, and
4. make recommendations on an adoption strategy to increase the adoption of Leucaena-grass pastures will also be included.

3 The potential for growing Leucaena in northern Australia

3.1 Scope for Leucaena

Geographic potential for Leucaena production is dependent upon four key biophysical elements; 1) growing temperature, 2) frost incidence, 3) annual rainfall, and 4) soil type as described by Dalzell (2006):

1. *Temperature* - growth slows when daily maximum temperatures fall below 25°C in autumn, and stops when minimum temperatures fall below 10°C. Soil temperatures need to be above 18°C for Leucaena seed to germinate rapidly.
2. *Frost* - can kill seedlings of all cultivars, however mature plants recover after leaf drop caused by mild frosts (0 to –3°C) and after death of above-ground stems from severe frosts (below 3°C).
3. *Rainfall* - can tolerate and produce leaf during dry spells and droughts however performs best in areas that receive more than 600 mm annual rainfall. Above 800 mm psyllid insect damage becomes problematic with current varieties. The new psyllid-tolerant 'Redlands' variety has potential to address this issue.
4. *Soils* – grows best on deep, fertile, well-drained, neutral to alkaline soils.

From this data, the following can be concluded with regards to the geographic potential of Leucaena across northern Australia:

- The 600mm-800mm rainfall zone is likely to provide greatest potential so long as soil and temperature conditions are adequate. The 400mm-600mm may also be sufficient on some properties, depending upon annual rainfall distribution, is deemed 'marginal' in terms of its appropriateness.

- The 800mm plus rainfall zone offers huge production potential with the new Redlands psyllid-tolerant variety, however a greater prevalence of acid soils, opportunities for higher value crop production, perceptions in coastal areas of Leucaena being a weed, and establishment and management challenges means that these areas are also seen as marginal for adoption.
- Average minimum temperatures and frosts are unlikely to be a barrier in northern Australia, except for a small area around Charleville.
- Soil depth >1m and pH>5.5 appear to provide a best-bet option for land suitability.
- Suitable areas in NSW fall into LGA's which prohibited the use of Leucaena.

In order to quantify the upper limit with regards to potential area in northern Australia suitable for growing Leucaena, data from the CSIRO National Soils Grid for pH($CaCl_2$) and soil depth, along with Bureau of Meteorology (BoM) annual rainfall data were collated to form maps and data tables. This data is represented in figure 3 and table 1 below.

From this data it can be seen that:

- 16% of northern Australia or 88,106,354 ha fits the broadest temperature/rainfall/soils requirement for growing Leucaena
- Of this, 5% or 25,351,588ha fits the ideal rainfall and soil characteristics.
- Of the total ideal area suitable for Leucaena, 5% is in NSW, 14% is in the NT, 79% is in Queensland and 2% is in WA.

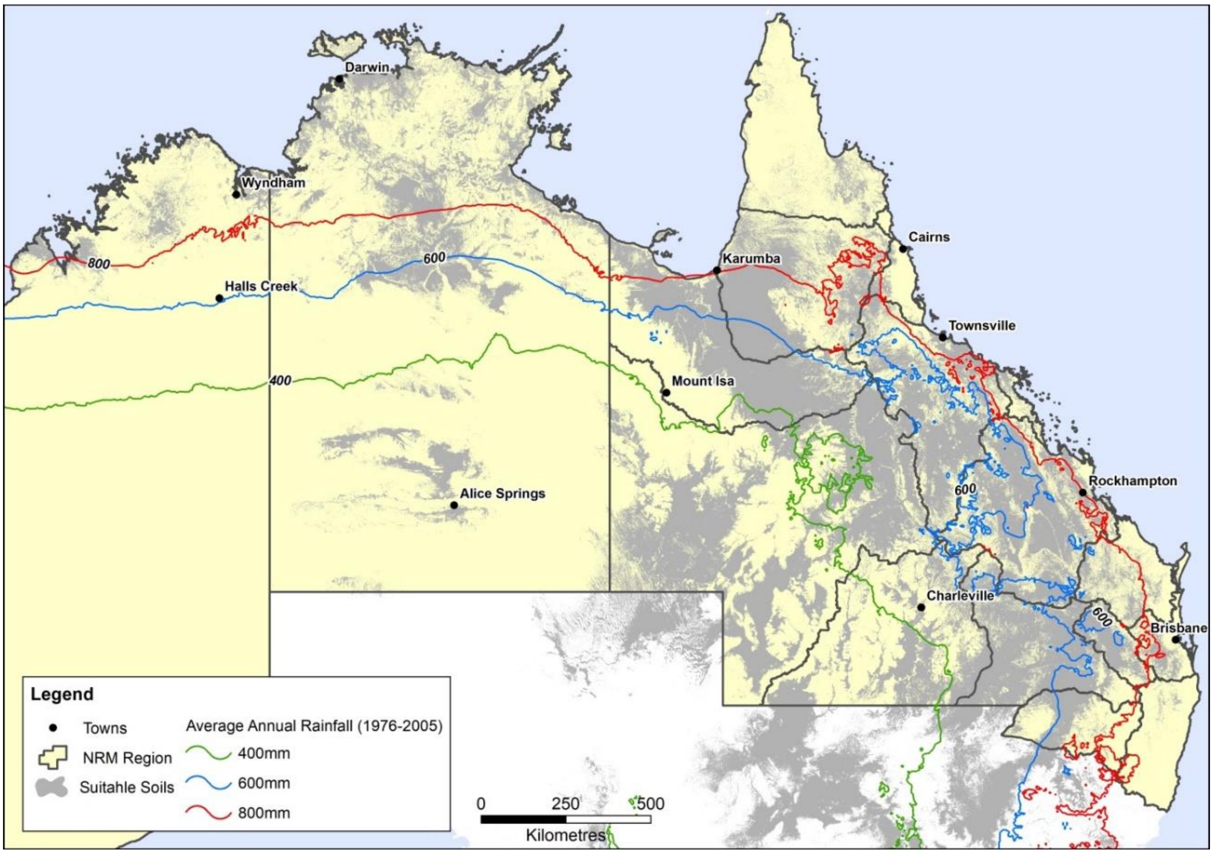


Figure 4 – Soils suited to Leucaena (depth >1m with pH>5.5) in rainfall zones across northern Australia.

Table 1: Total area suitable for growing Leucaena in northern Australia

			Rainfall Zone Area [1] with Suitable Soils [2] (ha)		
STATE	**Total Area (Ha)**	**% of ideal area**	**400 to 600mm**	**600 to 800mm**	**>800mm**
New South Wales	10,103,329	**5%**	543,964	1,218,044	145,696
NT	134,735,520	**14%**	2,697,013	3,523,638	11,344,726
Queensland	172,935,408	**79%**	36,125,260	20,106,218	8,765,528
WA	220,803,174	**2%**	16,235	503,689	3,116,343
Total (ha)	**548,680,762**				
Total potential (ha)	**88,106,354**		**39,382,471**	**25,351,588**	**23,372,294**
Total potential (%)	**16%**		**7%**	**5%**	**4%**

Notes
All areas are calculated using GDA 94 Albers Projection
1. Rainfall based on BoM 30 year annual mean from 1976-2005
2. Suitable soils based on a combination of soil depth > 1m and pH CaCl2 >5.5 (in soils >1m) - Data sourced from CSIRO - National Soils Grid of Australia (90m)

3.2 Beef enterprises and cattle numbers in areas suited to Leucaena

The beef industry across northern Australia, encompasses almost 16,000 producers and over 15 million cattle. In order to estimate beef cattle numbers and the number of producers in areas suited to Leucaena we have mapped the distribution of cattle and producers across the 17 NRM zones in northern Australia. We then overlayed the area with the rainfall and soil suitability characteristics in order to evaluate the upper level of producers who may adopt Leucaena, along with the number of cattle this represents. Figures 4 and 5 show the cattle producers and numbers for each NRM region whilst tables 2 and 3 show overall producer and cattle numbers for each state and in areas potentially suited to Leucaena.

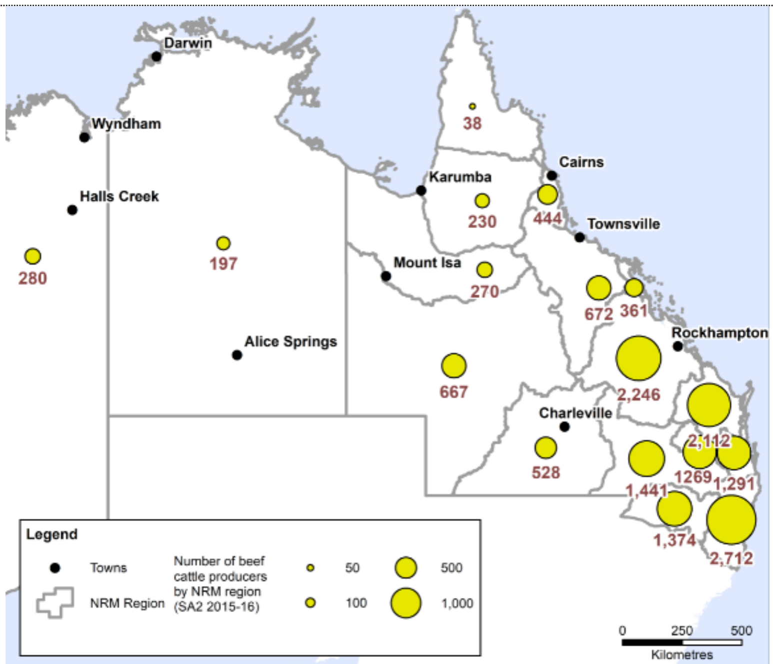


Figure 4 – Number of beef cattle producers in NRM regions across northern Australia

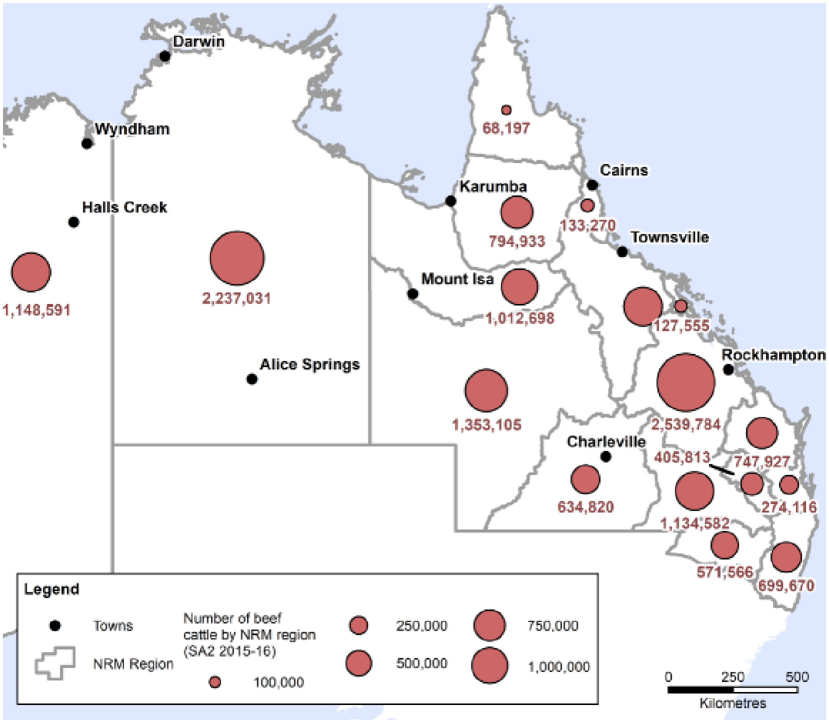


Figure 5 – Number of beef cattle in NRM regions across northern Australia

Table 2: Beef cattle properties suitable for growing Leucaena in northern Australia

			Beef Cattle Properties [1] in Rainfall Zone Area [2] with Suitable Soils [3]		
STATE	**Beef Cattle Properties [1]**	**% ideal properties**	**400 to 600mm**	**600 to 800mm**	**>800mm**
New South Wales	4,086	8%	68	238	85
NT	197	0.2%	3	7	35
Queensland	11,125	92%	2,131	2,835	860
WA	280	0%	0	0	4
Total properties	15,688				
Total potential properties	6,266		2,202	3,080	984
Total potential (%)	40%		14%	20%	6%

Table 3: Beef cattle numbers in areas suitable for growing Leucaena in northern Australia

STATE	Beef Cattle numbers [1]	% cattle in ideal zone	Beef Cattle Numbers [1] in Rainfall Zone Area [2] with Suitable Soils [3] 400 to 600mm	600 to 800mm	>800mm
New South Wales	1,271,236	4%	25,214	92,770	21,457
NT	2,237,031	5%	75,727	107,773	220,657
Queensland	10,387,505	91%	3,024,138	2,168,123	541,025
WA	1,148,951	0.4%	170	8,420	44,132
Total cattle	15,044,723				
Total cattle in potential zone	6,329,606		3,125,249	2,377,086	827,271
Total potential (%)	42%		21%	16%	5%

Notes
1. Counts are based on ABS SA2 polygons that fall within NRM regions, rainfall areas and combined rainfall/suitable soils areas. Note that SA2 areas do not coincide with NRM Regions. ABS counts have therefore been apportioned based on the percentage of area within an NRM Region
2. Rainfall based on BoM 30 year annual mean from 1976-2005
3. Suitable soils based on a combination of soil depth > 1m and pH CaCl2 >5.5 (in soils >1m) - Data sourced from CSIRO - National Soils Grid of Australia (90m)

From this data it can be concluded that:

- 40% of properties comprising 42% of cattle in northern Australia have the potential to grow Leucaena. This represents 6266 properties and 6,329,606 head of cattle.
- 20% of properties and 16% of cattle are in the 'ideal' zone for Leucaena with regards to rainfall and soils. This equates to 3080 properties and 2,377,086 cattle.
- Queensland is the dominant area with regards to ideal conditions for Leucaena with 92% of properties comprising 91% of all cattle in areas highly suitable for growing Leucaena.

In summary:

- 16% (88,106,354 ha) of northern Australia fits the broadest temperature/rainfall/soils requirement for growing Leucaena, comprising 6048 properties and 6,302,595 cattle.
- 5% (25,351,588ha) of Northern Australia fits the ideal requirements for growing Leucaena comprising 3080 properties and 2,377,086 cattle.
- 79% of the ideal area is in Queensland which equates 20,106,216 ha, 92% of properties (2835) and 91% of all cattle (2,168,123) in areas highly suitable for growing Leucaena.

4 Exploring adoption of Leucaena using regional segmentation.

4.1 Regional segments

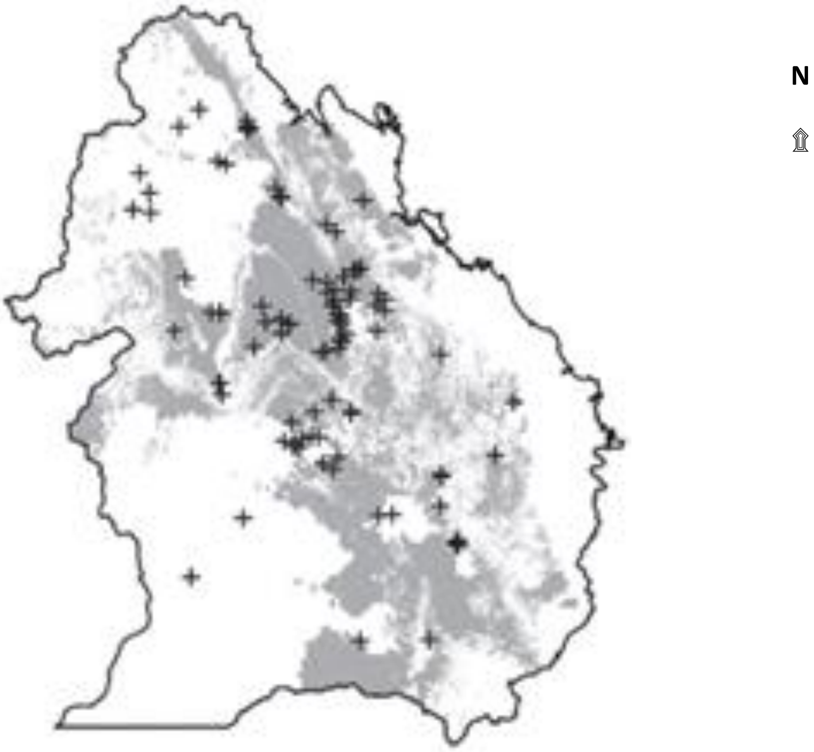
The vast majority of Leucaena plantings in northern Australia are in what is variously known as the Brigalow belt, Central Queensland, or the Fitzroy/Mary/Burnett region of Queensland. In addition to this we have identified 4 other primary geographic zones in northern Australia; High Rainfall Coastal, Gulf Country, Northern Territory and Western Australia. These five zones differ in one or more key elements critical to the potential adoption of Leucaena, namely; farming system types; psyllid risk; access to markets and; producer density/critical mass. The following section will outline the current understanding of the history and extent of Leucaena adoption in each of these geographic zones.

The Central Queensland section is naturally larger than the others given the history of Leucaena production in this region.

4.2 Central Queensland

For the purposes of this study, we have used the geographical boundary defined by Beutel et.al (2018) to describe the Central Queensland beef region. This area comprised the Fitzroy, Burnett Mary, Border Rivers Maranoa Balonne, Condamine, and the western subregion of the South Eastern Queensland natural resource management regions. Bray et al (2014) describe the climate of this region as subtropical to tropical, varying from humid near the coast to semi-arid inland. The wet season is in the summer months with frequent flood events after cyclones and monsoonal downpours. Brigalow and buffel grass are synonymous with central Queensland but many other land types and native grasses exist in the region. Approximately 95% of the area is utilised by agriculture, with 87% grazing and 8% cropping (Cobon and Toombs 2007).

To examine the extent of Leucaena in the region, Beutel et al (2018) mapped the geographic potential in the region using a combination of rainfall and soil attributes. In addition, they mapped the actual distribution of Leucaena (Fig 6 – see crosses on the map) which provides an ideal test of actual locations against recommended parameters.



<u>Fig 6. Beutel et al (2018) composite map of Leucaena potential and actual distribution for the Fitzroy, Burnett Mary, Border Rivers Maranoa Balonne, Condamine, and the western subregion of the South Eastern Queensland natural resource management regions</u>

From this work the following can be noted:

- *<u>Temperature</u>*: The majority of Leucaena is planted in the area of the catchment which has minimum average temperatures of 6^0C or above. The average minimum temperature in the coldest month within the study area falls to 6^0C which is below the 10^0C threshold for winter growth. The limited prevalence of Leucaena in these cooler areas suggests that whilst producers may push the limits of Leucaena' s temperature tolerance it is not a common occurrence.

- *Frost*: The majority of Leucaena is planted in the area of the catchment which is least frost prone. Whilst some plantings occur in the moderate frost-prone area south-east of Charleville (10-20 frosts less than 0^{0}C), more severe frosts less than -2^{0}C are less likely to occur in this band.
- *Rainfall:* Three quarters of Leucaena plantings were found in the 'ideal' 600mm to 800mm zone, with almost a quarter of plantings occurring in the 'suboptimal' rainfall zone of less than 600mm. This suggests that a significant proportion of producers value Leucaena in more marginal areas. As could be expected, no Leucaena plantings were located in the >800mm zone, which Beutel et al (2018) suggest reflects challenges to Leucaena production in wetter parts of the study area which include; a) susceptibility to psyllid predation, b) acidic soils with high exchangeable aluminium levels, c) opportunities for higher value crop production, and d) higher weed burdens during crop establishment.
- *Soils:* Cultivated Leucaena was not found in more acid soils of pH <5.5 comprising 11.3% of the study area, and Leucaena cultivation was under represented on shallow soils, with only 1.2% of the Leucaena cultivation occurring on 31.6% of the study area. 98% of all Leucaena was found on the 'ideal' soils with depth greater than 1m and pH>5.5.

Beutel et al (2018) detected Leucaena on 94 quadrats which included 103 cadastral sites in south-east Qld in the region using a random sampling of aerial images, where presence was confirmed before image inspection. Based on ABS data, there are 8359 beef properties located across these five NRM regions with 2640 in the ideal rainfall/soil zone and 1289 in the marginal zone (rainfall of 400-600mm). Given the 103 properties successfully identified by Beutel, this equates to:

- 3.9% of properties adopting Leucaena in the study area (103).
- 2.9% of these properties were in the ideal zone of 600mm-800mm rainfall (80).
- 1.0% of properties were in the <600mm zone (24).
- Views from adopters in CQ.

To gain greater context for the adoption of Leucaena in the CQ region field work was conducted which involved meetings with DAFQQ staff at Toowoomba, Biloela, and Rockhampton, and with Leucaena network members who provided insights and helped arranged focus groups and property visits from Millmerran to Wandoan and Taroom, then south of Banana, west to Moura and east to Thangool.

Interviews were conducted with individuals or in focus groups from twenty cattle properties in central Queensland. Fifteen of these currently grow Leucaena and are advocates for the technology (adopters). Three do not currently have any Leucaena and have reservations about it (non-adopters) and two have purchased properties where it has been sown many years ago and is out of control and unsuccessful efforts have been made to eradicate or get back into rows. In addition, the views of six individuals involved in either Leucaena R&D or extension were also garnered and recorded.

Benefits and advantages

Those interviewed had Leucaena planted on between 3% and 44% of their property with a mean planting of 18%. The majority thought the best economic advantage gained from Leucaena / grass pastures was by finishing weaner cattle with weight gains of 1 – 1.3 kg/ day regularly quoted with production gains of between 30% and 100%. Gains of 0.7 kg day were recorded in older cattle. The ability to meet target markets was enhanced and young cattle could be regularly turned off twelve months earlier than grass pastures.

Leucaena was most often used on lighter country with low nitrogen levels with the legume being used to raise protein production. With the introduction of vegetation clearance laws Leucaena was also seen as a way of getting increased production from existing land without further purchase. Leucaena's ability to provide nutritional feed after the grasses taper off and its use to fill the autumn/winter feed gap was widely recognised.

Case Study: Craig Antonio, Millmerran *- Craig has a 3,000ha property near Millmerran and currently has 400 ha of Leucaena planted with plans to increase that to 1500ha. He turns off Angus weaner cattle at about 9 months to feedlots. Craig uses it to develop his light country and believes it give him an edge for markets as he gets cattle to weight earlier than on just grass. He feels Leucaena has enabled him to double his production. It's a lot less stressful than cropping to fill a feed gap; "if you sow a crop and it doesn't rain, you have spent your money and lost it, with Leucaena if it doesn't rain you just sell cattle." Craig says his environment is a bit cold and it is better suited to central Queensland but it still gives him good feed over summer and fills a feed gap in autumn winter. He rotates stock on 50 ha cells and uses water points to muster stock. He aims for 350 cattle mobs with 12 week turn around. He has three other places with grass which he uses to iron out dry periods and wants to run more breeders and may use winter oats to fill the feed gap. As far as the environmental risk goes, he feels that in his environment it is of little concern because it is difficult to establish and cattle and a variety of pests readily consume it. He has found the odd plant out of place but if the code of practice is applied there should be no problems. Craig lists establishment as a major challenge and failure as the major cost. If successful in a good year Leucaena can be grazed within a few months but it can take 2 years if things don't go right. Apart from the cost of establishment, Craig believes that grazing management, the fact that some people don't like trees, and perceived environmental issues are reasons that prevent some people from using Leucaena.*

Case Study: John Howard, Banana-Biloela: John is a fourth generation cattleman with 12,000ha between Banana and Biloela with 1800 ha of Cunningham and Taramba. He prefers Cunningham but says he can put weight on cattle all year round with the mixture. He says 16m wide gaps are preferred and he can hammer it all year and not kill it. He can fatten cattle to 400 kg LW at 18 months of age and dress out cattle to 269 kg at 24 months still with 2 teeth. He planted on rising country as he believes it will dies out earlier perhaps after 15-20 years if regularly frosted. John has never had an establishment failure but says ripping beneath the rows is essential to ensure a profile full of moisture. He thinks the cattle prefer grass over summer but when this starts to dry off they then start on the Leucaena for protein and you start to see branches being broken. John runs Santas because he is above the tick line which runs through about Taroom. When asked why he thought many didn't grow Leucaena he thought many were "too tired" or couldn't be bothered with the risk and the extra work. Some are going OK and there is no need. He saw the results of a feedlot vs Leucaena trial in 1991 and was convinced.

Drawbacks and limitations (potential barriers to adoption)

The high cost of establishment, including the cost of land being out of production, and the associated risks of establishment failure were an important consideration, although many felt the risks of failure were greatly reduced by the use of contractors and not as likely with experienced croppers.

Leucaena is a weak seedling that won't tolerate weed competition which means long lead-time in preparation and attention to detail on establishment. The frost impact on production lessens the benefits but planting on higher ground and utilising the leaf prior to frosts were common strategies. The regions history of land clearance and maintaining land free of scrub (suckers) has produced a mindset in some against Leucaena. "*Grandfather and father spent their lives clearing this country and I'm not going to be putting trees back".*

Grazing management is important and requires proper set up with fences and watering points and this is seen as too much additional work and expense by some. *"It is a big decision and almost a lifetime commitment which cannot be reversed which reduces land flexibility. If not managed Leucaena can get away and get out of control and this is almost impossible to rectify".*

Much of the Brigalow belt suffers from scrub regrowth, which requires blade ploughing from time to time, and people think this will be difficult in Leucaena stands and scrub will reinfest their land.

Leucaena is not as profitable and does not produce the cash flow on good country which can be cropped therefore it is often confined to poorer soils and production decline is being witnessed.

In CQ with proper management and adherence to the code of conduct, it should not present a weed problem however many consider in the higher rainfall warmer districts it could be a significant weed risk.

***Case Study: Aston Price** – Aston has 2000ha between Moura and Banana and his mother Leonie has an additional 800ha closer to Banana. He turns off young cattle for the feedlots and fattens some older cattle. Both he and his mother conduct some farming (cropping). Aston is considering Leucaena for the future but has some reservations. He is unsure of the economic benefits in his situation. Because he is a cropper and has the gear, the cost of establishment and risk of failure at establishment are not a big factor and he is reasonably confident he could establish it successfully. The ongoing cost of management and the payback time to break even is a concern and he would like to see a detailed economic analysis as it pertains to his situation to give some confidence. Layout and watering point cost on his place would be significant. It is a big decision and you only get one go at it (reversibility). Keeping it managed to an appropriate height would probably require slashing and keeping scrub regrowth out of it would be a major challenge. The scrub regrowth problem would be even greater on Leonie's place and wattle regrowth is prevalent. There have been failures on the red soils of her neighbouring properties*

***Case Study: Warren Luhrs, 'Ridgedale'** – Warren has 1200 ha close to Moura, he turns off weaner steers and heifers and sells some cull cows and doesn't think Leucaena would be worthwhile for him. He leases some land so can't establish it there and doesn't think it suits his system. He thinks it is difficult to manage and is wary of the environmental issues. The high cost of establishment is a barrier to him because of his scale and reliance on leased land. He also didn't think it would deliver economic returns for his weaner steer operation. Warren has cropped in the past and worked with the department in establishing legumes and would be reasonably confident of establishment so risk of failure is not a deterrent. Locking up country during establishment is an issue, again related to scale, and managing grazing in order to keep the bug with his system would need to be considered. Although aware of potential environmental impacts the fact that you can't get rid of it easily (reversibility) means you lose flexibility and this is of greater concern.*

Learnings from experience

Extension recommendations have been to plant dual rows 6m apart. A common theme emerging from experience is that many prefer much wider rows commonly 12 – 15 m apart. There are several reasons behind this thinking. Flexibility is mentioned, that is to say inter-row activity such as slashing or cultivation for weed control and even inter-row cropping (however some think Leucaena is too thirsty for this). The Leucaena/grass balance is of significant interest and seen as a key to production. This can be achieved by limiting the area sown to Leucaena or by having the rows further apart. Sown at 6m means for some grazing hard enough to control the Leucaena means the grass component is grazed out. The Leucaena is also very competitive for nutrients and moisture.

The third reason relates to paddock preparation, is more complex and views are divided. Some strongly advocate that paddock should be ploughed fence to fence, Leucaena strips planted with attention to weed control, then and only then when plants are established introduce grasses between the rows. This delays the time the paddock before the paddock reaches full production and is more costly. The alternate view held equally strongly is to go into an established grass pasture and take out strips (herbicide and cultivation) in which Leucaena is then planted. If successful, the economics suggest this is effective and the benefit is reached sooner. Wider row spacing's would make success of the later more likely. Weed control efforts are concentrated on the Leucaena strips and grasses eventually spread to their edges. One grower questioned the amount of nitrogen that Leucaena actually provides back to the soil saying it doesn't share its N like other legumes and it also uses a lot of moisture at the expense of the grasses.

Cunningham, Taramba and Wondergraze were the 3 varieties commonly grown in the study area. As a general comment several producers preferred Cunningham over the other two with the perception it was more palatable, and more easily controlled through grazing. One producer thought Taramba was more productive and cold tolerance of Wondergraze was seen as an advantage by some.

Case Study: Swin and Kathy Hudson, Banana *- have 10000ha on which they share crop 1000ha and breed cattle and take steers through to the Jap Ox and EU markets. They have 520 ha of Leucaena and Swin acknowledges its benefits but is markedly qualified in his praise. He says grass pastures can produce .5kg weight gain per day while Leucaena mix can produce .7 kg per day. Leucaena plantings in the early 90s failed but they had success in 1996 and 1999. Swin has reservation about Leucaena and says there are serious management issues around maintaining the right Leucaena grass balance. Traditional 6m rows are far to close in his country to maintain the grass. To graze hard enough to control Leucaena means the grasses are flogged out. To manage grazing to maintain the grass sees the Leucaena get away. He thinks 12m rows would be optimal and intends to take out every second row in his existing stands by over grazing to weaken the plants, and then mulching. Blade ploughing alone doesn't work he says. Swin thinks that not enough is said about the downside of Leucaena. It uses too much nitrogen and outcompetes the grasses. It produces a lot of protein for the cattle but doesn't share much N with the grasses like other legumes, you need to mulch and spread to get N put back in. It also robs the grasses of moisture. If we have several small rainfall events the grasses do well with access to shallow moisture but if we get fewer big events the Leucaena empties the profile. He thought that 25m rows might be required in higher rainfall tropical areas or Leucaena would be trees at the end of the wet season. He is not negative toward Leucaena and may plant more in the future, but it is not as good as many say and it presents real challenges and people need to be aware of its drawbacks. You need to be a good cropper to establish it and a switched on grazier to manage it.*

Case Study: Alister and Melanie Shannon of Banana: *purchased a property with an existing stand of Cunningham Leucaena. It was planted many years ago when mistakes were made and the view was because it was costly to plant it was considered the best approach to get as much of it growing as possible, consequently it is now a dense stand with no distinguishable rows with little grass present. Alister has tried to clear it into rows by mulching and blade ploughing and blade ploughing alone but both attempts were very expensive and largely ineffective although the mulching blade plough combination gave a better result. When asked about chemical control he thought Tordon pellets may be effective but getting them into such a dense thicket was problematic and he doesn't like the idea of a residual total herbicide on his place. He will try again with mulching and blade ploughing but says using the blade plough on this stuff is different to Brigalow and Wattle. It has strong tap and lateral roots, which have to be popped up at the correct depth rather than cut off. He will then cultivate with a heavy "all farm plough" between 8 m rows. Despite this experience Alister intends to plant more Leucaena to help him turn off young cattle for the feeder market. Although he has not grown it before he says the knowledge is now around to do the job properly. He thinks people in the past have made the mistake of looking after the Leucaena first and neglected the grass component. He says forget about trying to get as much Leucaena as possible and use less of it to compliment the grass. He will plant Cunningham in at least 12 m rows and try* *and get as much grass as possible. Grazing management and following the code will ensure future stands do not get out of control.*

Several landowners mentioned that while in early days Leucaena was thought to be useful as a drought reserve, in practice it is not. Certainly, it hangs on after the grasses dry off and fills a feed gap but when a long dry hits it drops it leaves and shuts up shop. Likewise, when frost hits so it should be grazed hard and utilised when it got green leaf. Two of the non-land owner professionals we spoke to had done some work on phosphorus depletion under Leucaena, they were of the view that because it was often planted on poorer soils and because of heavy P removal without replacement that this was a potential and emerging issue.

4.3 High Rainfall Coastal

The high rainfall coastal zone can be categorised as areas with greater than 800mm of rainfall, on the coastal fringes of northern Australia, roughly stretching from Cooktown in the north to Maryborough in the south. The region currently supports approximately 2.5 million cattle on 817 properties. Current levels of Leucaena production in the high rainfall zone are hard to accurately define, however anecdotal evidence would suggest that its very small in comparison to plantings in Central Queensland. A key reason for this is the susceptibility of current varieties to psyllid damage. The psyllid, which arrived in Australia in 1986, is a leaf sucking insect specific to the Leucaena genus, feeding on the growing tips of susceptible cultivars (Bray 1994). Psyllid damage can reduce production by 50-70% in humid regions and 20-50% in sub-humid environments (Bray 1994, Mullen and Shelton 2003), and as such is a significant impediment to Leucaena in the high rainfall zone. Shelton (2017) suggest that the availability of a psyllid-resistant variety could increase the range of adaptation of Leucaena by 30%. The current 'Redlands for Regions' project (P.PSH.0920) is exploring the establishment of the new Redlands variety on 5 properties in the High Rainfall Zone and is in the process of clarifying key establishment and management requirements.

4.4 Gulf Country

The northern Gulf region comprises the catchments of the Norman, Gilbert, Staaten and Mitchell River systems, all of which flow into the Gulf of Carpentaria. Around 60% of the region is contained in the Northern Gulf Plains bioregion while the remaining 40% is contained in the Northern Einasleigh Uplands bioregion (Sattler and Williams 1999). There are approximately 196 grazing businesses covering an area of about 12.4 million hectares. These businesses rely on (principally) native pastures to turn off about 260,000 head of cattle per year with a value of approximately $180 million. A range of markets is targeted from live export, the store market, the US grinding beef trade and the transfer of weaners to growing and fattening areas in southern and central Queensland. Total herd size in the Northern Gulf Region is approximately 834,000 head of which about 520,000 are breeders and heifers 12 months and older. Rolfe et al. (2016) found that high female mortalities, poor reproductive performance and low annual liveweight gains are commonly recorded with low annual liveweight gain (70–90 kg per head) being a major constraint for those production systems located solely in the northern Gulf savannahs. Low profitability and debt servicing pressures in these areas were also found to make pasture improvement and the installation of additional infrastructure unaffordable for most businesses. It is therefore not surprising that currently there are limited Leucaena plantings in the Gulf country despite large areas being in the ideal zone. Current estimates suggest there is in the vicinity of 700 ha either recently planted or being planted as of December 2018 (Rolfe et.al 2018, Rolfe pers comm.)

4.5 Northern Territory

The Northern Territory has 197 beef cattle properties with approximately 2,237,031 beef cattle. In areas of soils suitable for Leucaena (>1m and pH>5.5), most of these properties (35) are in the >800mm zone, with seven properties in the 600-800mm zone. Three properties are in the 400-600mm zone.

Lemcke and Shotton (2010), in their Agnote on Leucaena, report that the deep sandy red Kandosols (Blain soils) and deep clay red Kandosols (Tippera soils) of the Douglas Daly and Katherine regions appear most suitable for growth and production of Leucaena. In contrast they note that on the gravelly laterite soils, further north closer to the coast, severe leaf fall occurs within four to six weeks of the last of the wet season rains, and suggest that supplementary irrigation would be needed during the dry season on those soils. They note that the deeper red earth soils in the north may be more successful. They re-state the widely accepted minimum rainfall preference for Leucaena of 600 mm, with mean temperatures above 10°C in the cooler months, and with frost-free conditions a factor which is not always adhered to in southern Queensland.

Douglas Daly Research Farm (DDRF – annual rainfall = 1,200 mm) has been researching the production of introduced pastures for many years. Grazing trials indicated that best liveweight gains came from the grass/Leucaena mix pastures with an average of 200 kg/hd/yr @ 1.25 – 1.5 h/ha. Over 12 months Buffel only produced LWG 171 kg (179 LWG/ha) vs Buffel & Leucaena LWG 222 kg (278 LWG/ha) (Shotton, 2012). The irrigated grass - Leucaena results (non-replicated) were around the 0.5 kg/head/day and 2.7 kg/ha/day (Shotton, pers comm, 2018).

According to Peter Shotten (2018, pers com), despite interest being shown in establishing Leucaena, very few have taken up the opportunity, with only relatively small areas of Leucaena planted in the Katherine-Daly Basin and Victoria River District. Best estimates are that less than 1,000 ha has been planted in the territory to date, many as small plantings which have been neglected or removed for horticulture or forestry. The situation is summarised as follows;

- DDRF established 97 ha between 1990 and 2014 of which 58 ha remains and still growing well.
- Limbunya station in the VRD district planted 354 ha planted in 2012 (Bray et al 2014) however was not optimally managed and has not survived. There is currently over 400ha being planted (Ernie Young, pers comm.)
- Bunda station in the VRD district established approximately 50 ha.
- Mustang Hill in the Douglas-Daly established some 60+ha in 2009, but it has been since removed for tree plantations.
- Bonalbo station in the Douglas-Daly established approximately 10 ha around 2009, but is no longer there due to termites and heavy grazing.
- Douglas station in the Douglas-Daly established 58 ha in January 2017 but the establishment failed. The reason for the failed establishment was not known.
- Fox Road Farm near Katherine established approximately 30ha and irrigated under centre pivots, but was subsequently was removed for horticulture.
- Katherine Research established approximately 10 ha pre-1990 but has since died or been removed.

4.6 Western Australia

In Western Australia, Leucaena can be found near wetlands and riverine sites in Halls Creek, Kununurra, Cockatoo Island, Christmas and Coolan Islands, Broome and Derby (Hussey et al. 1997, Cowan 1998). Leucaena has been planted for pasture production in the Ord River Irrigation Area of the Kimberley (Larsen et al. 1998) since CSIRO plantings in the 1970s. After the discovery of the DHP destroying bacteria an industry began to develop, and over 2 000 ha of Cunningham was under grazing, however this area has been reduced in recent years, with several properties removing the planted trees and changing from grazing to horticultural crop production. This subspecies has spread over 60 km along the Ord River, between the Ord River Dam and the Diversion dam and downstream from the Diversion dam, to create dense riparian thickets. Currently there are no commercial plantings of Leucaena in WA and current regulations prevent any new plantings on leasehold land (basically all of WA).

4.7 Summary of current Leucaena production

- The vast majority of Leucaena plantings are in the CQ region. There are limited plantings in the Gulf, Northern Territory and HRF coastal areas and small remnant plantings in WA. Given this, Beutel's work (2018) would seem quite close with regards to current estimates of area under Leucaena in Australia.
- The history of dis-adoption is primarily in relation to economic competition, which in turn is due to a mix of poor beef prices and small-scale plantings. Beef prices recently altered the equation in the northern territory in particular where the live export market takes the vast majority of beef marketed. Increasing returns leads to investment in feed and forage being more cost effective/competitive, hence the current renewed interest from some in the NT.
- There is significant scope for expansion of Leucaena plantings in the High Rainfall and Gulf zones, however regionally relevant information is lacking as is access to skills and support.
- Evidence from producers would suggest there exists a gap between what research says is possible with Leucaena and what is occurring in reality. This however would require further in field measurements and weight gain trials to fully assess.
- There are some questions around the best way to enable the grass/Leucaena synergy with row spacing being the key.

5 Legislative weed status of Leucaena across Local Government Areas in Australia

5.1 Introduction

Earlier sections of this report have noted concerns by growers and others about the weed potential of Leucaena. This section of the report explores the weed status of Leucaena across Local Government Areas (LGA's) in Australia, and implications for its use as a fodder species. It draws on a survey sent to all LGA's in Queensland and NSW October 2018, and analysis of the legislative status of Leucaena in each state.

5.2 Weed status in states other than Queensland

Weed legislation in the Northern Territory is via the 'Weeds Management Act' 2013 which has the power to specify eradication, control, and to prevent entry. Leucaena leucocephala ssp known as coffee bush is not a declared weed in the NT. Weeds are regulated in WA under the Biosecurity and Agriculture Management Act 2007, and although Leucaena is not a declared plant under the act, it is specifically prohibited from being cultivated on WA crown land.

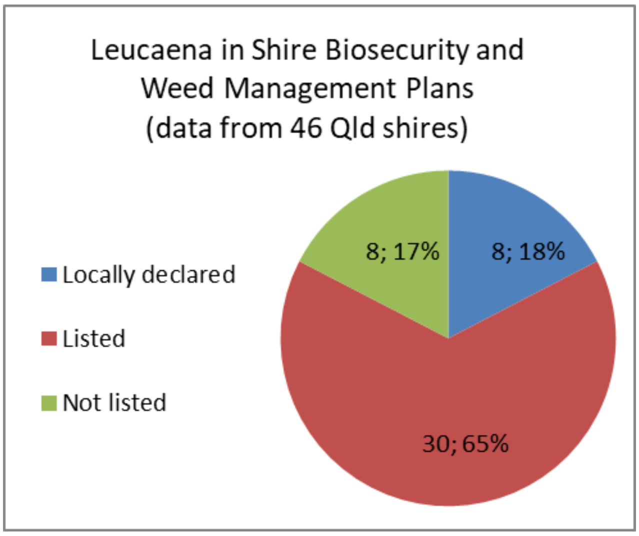
In NSW, invasive weeds are covered in the Biosecurity Act 2015. According to the NSW WeedWise website, Leucaena leucocephala is subject to an exclusion zone in the North Coast region comprising all lands in the region except the core infestation area of Richmond Valley Council, Ballina Shire Council, Lismore Council, Kyogle Council, Byron Shire Council, Tweed Shire Council. LGA's in the region but outside the core area include Coff's Harbour, Clarence Valley, Belingen, Nambucca, Kempsey, and Port Macquarie-Hastings. Throughout the region the plant or parts of the plant should not be traded, carried, grown or released into the environment. Within the exclusion zone the plant should be eradicated from the land and the land kept free of the plant and land managers should mitigate the risk of the plant being introduced to their land. In the core infestation area land managers should reduce impacts from the plant on priority assets.

5.3 Weed status in Qld

The (Qld) Biosecurity Act 2014 has repealed the Land Protection (Pest and Stock Route Management) Act 2002, which provided regulatory controls and powers to manage declared plants and animals in Queensland and used the nomenclature of 'declared' plant classes. Under the Biosecurity Act, invasive plants may be listed as 'prohibited' matter whereby it is an offence to deal that species or fail to report its presence or listed as 'restricted matter' with categories of restriction ranging from reporting its presence, restricted distribution or outright movement, or prohibition on possessing the plant. Plants not listed as prohibited or restricted under the Biosecurity Act may be listed as an 'invasive plant' under the Act or declared by a local government level under local laws.

Leucaena is not a prohibited or restricted invasive plant under the Biosecurity Act 2014 but is listed as an invasive plant, and by law, everyone has a general biosecurity obligation (GBO) to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. Local governments must have a biosecurity plan that covers invasive plants and animals in their area and these plans typically list Leucaena as an invasive species. Shires where Leucaena is locally declared generally specify management responsibilities for landholders.

An internet search of biosecurity and/or weed management plans or guidelines produced by Queensland LGA's located 46 such plans from the 78 LGA's. Of the 32 LGA's where information was lacking, about half of these were the small areas of DOGIT (deed of grant in trust) land. Eight (18% of the LGA plans) have Leucaena 'locally declared' or will do in future (including Banana, Burdekin, Carpentaria, Cassowary Coast, Fraser Coast, Mount Isa, Somerset, and Whitsunday), while 30 (68%) simply listed Leucaena as an invasive species without local declaration, and the remaining 8 LGA's (17%) mentioned weeds other than Leucaena.



Few LGA's differentiated between ssp leucocephala and ssp glabrata (e.g. Banana, Gladstone, Central highlands referred to 'feral Leucaena'), which is not surprising as this is not specified in the state list of invasive plants. In general, biosecurity plans provided little in the way of specific guidelines or requirements for growers, with some encouraging graziers to comply with the Leucaena Growers Code of Practice (e.g. Burdekin, Cook, Mt Isa), introducing prevention and eradication zones which affect stock movement (Cook), exemptions for fodder production (Mt. Isa), or requirement for monitoring and control (Gympie).

5.4 LGA Survey

An online survey was sent to all LGA's in Queensland and New South Wales during October 2018 seeking to ascertain the locations and extent of Leucaena in the shires, and local laws, and attitudes. A total of 30 shires responded to the survey, with 19 stating that Leucaena was present in the shire (3 of these in NSW), and 11 indicating that Leucaena was not present or were unsure (7 in NSW). Interestingly, only 53% of shires with Leucaena said it was used on farms for fodder, whereas Leucaena was reported on roadsides in 89% of these shires, and native bush/forest in 68% of these shires, raising the question of where the Leucaena has come from. Presence in riparian areas was reported by 53% of shires, gardens and council parks (42% and 32%), with fewer shires reporting coast areas (21%) and other (21%), and land rehabilitation (16% of shires).

In terms of prevalence in these locations, the survey asked shires to rate the extent as none, low, moderate, and high. Nearly half (47%) of shires rated Leucaena prevalence as low, and 22% as moderate to high on farms for fodder. The extent of Leucaena on roadsides was highest with 42% of shires rating prevalence as high, and 11% of the shires with Leucaena rating the prevalence in native bush/ forested areas and riparian as high.

Almost half of the 30 responding shires offered comments at the end of the survey, and whilst some acknowledge the agricultural benefits of Leucaena, all raised concerns or signalled future restrictions such as future plans to locally declare, and concerns about introducing new varieties better suited to local environments:

- *"I would be reluctant to welcome a new plant that has the potential to be invasive into the area as we have spent plenty of time and money trying to reduce infestations of a similar plant (Honey Locust) in our area", "The problems caused by Honey locust (Gleditsia triacanthos) are ongoing"*

- *"Release of a strain that is more pest and disease resistant is of concern considering the local history of legume releases that have left a legacy of problematic environmental weeds. Most have been released by DPI or agriculture departments in the misguided hope that they can provide fodder or browse or fix nitrogen in soil",*

- *"The introduction of frost (or cold) tolerant cultivars would heighten the risk of Leucaena becoming more prominent and prompt Council to consider its potential for weediness through biosecurity planning processes".*

- *"... some of the watercourses that run through that area also run down in to this shire so once this drought breaks we could see it along the watercourses in the shire."*

- *"Voluntary Code of Practice has resulted in massive off farm infestations of riparian zones and wider landscape. The distinction between production crops of Leucaena and feral Leucaena needs to be clearly defined in legislation such as Biosecurity Act and the Code of Practice made into law not voluntary"*

- *"Leucaena would be a good alternate grazing fodder in drier warmer areas/Climates but it would readily become a weed here due to high rainfall and hot humid summer climate…if not continuously managed and once a land manager plants it then sells the property, the next owner may not manage the land in the same way then leading to potential takeover of pastured paddock"*

Whilst the number of shires with heightened sensitivity to Leucaena is low, these comments highlight the way in which perceptions of weediness in relation to Leucaena can be influential. The overall commentary around this survey therefore suggests that expectations of shires need to be carefully managed.

6 Understanding adoption of Leucaena in Northern Australia using the ADOPT model

6.1 Predicting adoption using the ADOPT model

Predicting and understanding the adoption of technologies requires an appreciation of; a) the specific technical attributes of a technology, b) the attributes of the population being targeted, c) the relative ease with which a practitioner can learn the technology and d) the adequacy of the learning environment within which practitioners are operating.

An initial first step in understanding the technical appropriateness of Leucaena is through using a decision tree approach to explore 4 key variables. These are described below:

- **Climatic suitability** – Is the minimum daily temperature above 10^0C for most of the year, is the area free of severe frost (or risks manageable), and is rainfall above 600 mm? (HRF 600-800 suitable for current varieties, over 800mm suitable for Redlands).
- **Soils** – Does the property have soils great than 1m deep and with pH > 5.5?
- **Regulatory barriers** – Is the location free of regulatory barriers that would prevent Leucaena being grown?
- **Farm system fit** – Would the farm benefit from a drought tolerant, nutritious, palatable plant species to rear or fatten cattle?

For enterprises that answer yes to these questions, the next step is to draw on the ADOPT model (Kuehne et al, 2017) as a framework to understand barriers and incentives to adoption, and better understand the potential scope and rate of adoption. ADOPT is an acronym for 'Adoption and Diffusion Outcome Prediction Tool' which was constructed to quantitatively predict adoption for planning agricultural research, development, extension and policy. Based on past research and conceptual thinking the ADOPT model identifies and utilises variables that are considered to contribute to either Peak Adoption Level (scope) and/ or Time to Peak Adoption (rate) using both characteristics of the population and the practice of interest described below (Figure 7).

Peak Adoption Level driven by 'Relative Advantage '

- Relative advantage for the population – including business and environmental orientation, planning horizon and financial constraints (Q's 1 to 6).
- Relative advantage of the practice – including profitability, riskiness, upfront costs, reversibility, and ease of management (Q's 14-22).

Time to Peak Adoption driven by 'Learning of Relative Advantage'

- Population-specific influences on the ability to learn about the practice – such as advisory support, group involvement, additional skills required, and general awareness of the practice (Q's 10 - 13).
- Learnability characteristics of the practice – such as trialling ease, observability of benefits, prior to use, and complexity of evaluating benefits after use (Q's 7 to 9).

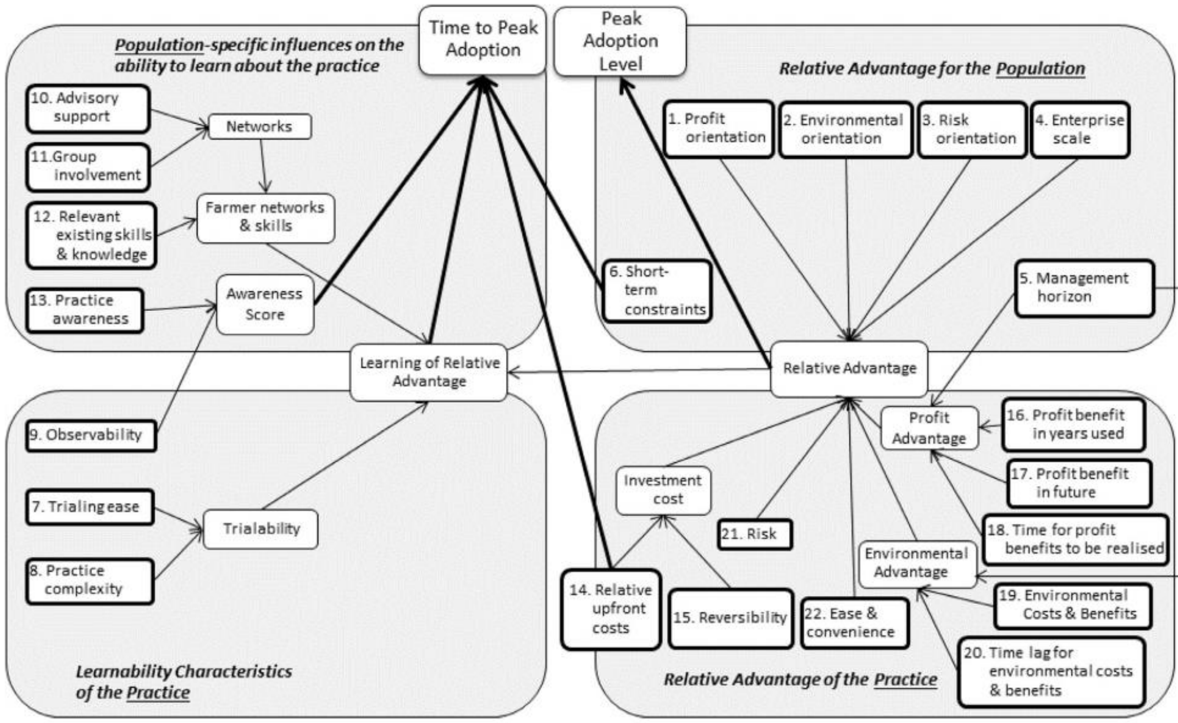


Figure 7 - The conceptual framework of influences on Peak adoption level and Time to peak adoption (from Kuehne et al, 2017).

Input to the ADOPT model was informed by population data interpreted from MLA's producer segmentation survey and 'innovation/ practice' response data derived from literature on Leucaena. An example of reasoning used for each element is outlined in Table 2 and Table 3.

Table 5 – Example input for factors affecting level of peak adoption

Question	Response	Reasoning
Relative Advantage for the Population		
1: Profit orientation	3: About half have maximising profit as a strong motivation	Based on weighted scaling of MLA producer segmentation category 'Commercial orientation'
2: Environmental orientation	2: A minority have protection of the environment as a strong motivation	Based on weighted scaling of MLA producer segmentation category 'Environmental benefits'
3: Risk orientation	2: A minority have risk minimisation as a strong motivation	Based on weighted scaling of MLA producer segmentation category 'Risk attitude'
4: Enterprise scale	4: A majority of the target farms have a major enterprise that could benefit	Assumes producers in the climatic zones could benefit
5: Management horizon	3: About half have a long-term management horizon	Based on weighted scaling of MLA producer segmentation category 'Five year outlook'
6: Short term constraints	4: A minority currently have a severe short-term financial constraint	Based on weighted scaling of MLA producer segmentation category 'Relevant financial outlay'
Relative Advantage of the Innovation		
14: Relative upfront cost of innovation	3: Moderate initial investment	Requirement for specialised sowing equipment/ contracting
15: Reversibility of innovation	3: Moderately difficult to reverse	Removal of plants would require spraying and possibly cutting taking time and money

16: Profit benefit in years that it is used	7: Large profit advantage in years that it is used	Significantly more profitable than other species on areas planted
17: Future profit benefit	5: Small profit advantage in the future	Assume small specific additional profits such as carbon sequestration
18: Time until any future profit benefits are likely to be realised	3: 3 - 5 years	Takes 3 – 7 years to reach full potential
19: Environmental costs & benefits	2: Moderate environmental disadvantage	Specific need to manage to the code of practice considered to be an 'environmental disadvantage'
20: Time to environmental benefit	3: 3 - 5 years	Environmental disadvantage relate to spread of seeds from this age onwards
21: Risk exposure	6: Moderate reduction in risk	Leucaena more likely used to increase growth rates/ fatten, but drought tolerance offers degree of risk reduction
22: Ease and convenience	2: Moderate decrease in ease and convenience	More difficult to manage than pastures alone, tending to Leucaena and managing stock access/ timing to access

Table 6- Factors affecting rate of peak adoption

Learnability Characteristics of the Innovation		
7: Trialable	2: Difficult to trial	Trialling requires specialised sowing equipment, seeds need inoculating, specialised animal management, weed and pest management
8: Innovation complexity	4: Slightly difficult to evaluate effects of use due to complexity	Benefits should be reasonably self-evident so only slightly difficult to evaluate performance
9: Observability	4: Easily observable	Fairly easy to observe on other producer properties
Learnability of Population		
10: Advisory support	3: About half use a relevant advisor	Based on weighted scaling of MLA producer segmentation category 'Paid consultants'
11: Group involvement	3: About half are involved with a group that discusses farming	Based on weighted scaling of MLA producer segmentation category 'Networks'
12: Relevant existing skills & knowledge	1: Almost all need new skills and knowledge	Requires a whole new suite of cropping and pasture management skills, and animal management
13: Innovation awareness	4: A majority are aware that it has been used or trialled in their district	Based on weighted percentages MLA producer segmentation category attending 'Field days'

6.2 Sensitivities within the ADOPT model

Factors impacting Peak Adoption Level

The model predicts that four key aspects of Leucaena's 'relative advantage' have the largest impact on adoption with Profitability (Q16's, Q.17 & Q18) being the standout, whilst 'Reduction in risk exposure' (Q21), Ease and convenience (Q22), and Environmental costs/ benefits (Q19, Q20) also significantly impact the model's output.

Regarding those producers most likely to adopt Leucaena, profit orientation (Q1) is an important precursor for adoption and based on MLA producer segmentation, about half have maximising profit as a strong motivation. However, within this profit-motivated farmer cohort the enterprise fit (Q4) has huge potential to influence adoption because of;

- Technology 'fit' in the system re: scale, intensity, farm layout, labour and machinery, and access to markets.
- Property-specific attributes of Leucaena on profitability, risk exposure, ease of use and integration within the system, plus environmental considerations.

Note systems fit is not adequately addressed through the model with this function being rather coarse in its application.

Factors impacting time to Peak Adoption

Major factors affecting Time to peak adoption include characteristics of Leucaena which limit the capacity of producers to learn about the technology. These include:

- Learnability' characteristics of using Leucaena, particularly trialling ease and complexity of evaluating benefits after use (Q's 7 & 8).
- Social learning including advisory support, group involvement, additional skills required, and general awareness of the practice (Q's 10 - 13), and
- Short-term financial constraints (Q6) combined with start-up costs (Q14).

6.3 Exploring upper limits of adoption at a regional level

In this section, we explore the upper limits of adoption at a regional level, using sensitivities in the ADOPT model described above. Table 4 summarises the way in which we adjusted the model for sensitivities on a regional basis along with the model output for upper levels of both rate and scope. Note that all other factors apart from these sensitivities remained constant within the model and did not change from region to region.

Table 7: Regional ADOPT output accounting for the key sensitives within the model

	CQ	HRF	Gulf	NT	WA
Profit	+++	+++	+?	+?	+?
Environment	X	XX	X	?	XXX
Enterprise fit	+++	++	+?	+?	+?
Risk	+	+	+++	+++	+++
Social Learning	+++	XX	XXX	XXX	XXX
Scope (peak adoption)	18%	6%	8%	8%	5%
Rate (time to peak)	14yrs	15yrs	17yrs	20yrs	21yrs
Seedless (remove envt disadvantage)	23%	10%	9%	9%	9%

In CQ we can see that high profitability, combined with excellent enterprise fit and social learning support has the highest predicted upper adoption level of 18% and shortest time to peak adoption of 14 years. Note that the percentage for scope should be applied to those properties within the ideal zone identified previously. Compared to CQ the two key adoption drivers of profit and enterprise fit are considerably lower, moderated in areas where Leucaena offers greater risk reduction (Gulf, NT and WA). A key qualifier here is the lack of information on farm systems profitability in areas outside of CQ (Table 4).

Areas other than CQ, particularly more remote areas, have considerably reduced social learning opportunities in terms of advisory support, group involvement, general awareness of Leucaena, and typically have a lower base knowledge and skills for Leucaena management, all extending the time to peak adoption.

Whilst weed-related considerations confer a small environmental disadvantage in CQ, the Gulf and possibly the NT, risks are higher in HRF and totally exclude Leucaena in most of WA. Across all regions, altering the model to have no-net environmental disadvantage has potential to increase adoption by about a third, and double adoption in more environmentally sensitive areas.

7 Building a rationale for investment in extension

Rationale for investment into extension essentially revolves around the benefit/ cost of the intervention, where benefits are characteristically economic but also take into account social and environmental impacts arising from the intervention. Extension benefits are derived from the combination of per-farm benefits and the defined scope of adoption.

7.1 Adoption scope

Upper-levels of adoption discussed in the previous section provide a starting point for analysis of potential benefit. These levels then need to be explored to ensure they adequately account for key systems factors which are difficult to account for within the model. These include:

- The capacity of Leucaena to ‘fit’ within the system in terms of scale, intensity, farm layout, labour and machinery, and impact on access to certain markets/price premiums, and
- Property-specific attributes (vs generic) of Leucaena with regards to profitability, risk exposure, ease of use and integration within the system, plus localised environmental considerations.

These considerations will be discussed further at the end of this section.

Table 5 reports the estimated ‘scope’ for Leucaena adoption based on the ADOPT model output and uses property data based on ABS SA2 polygons that fall within NRM regions and combined rainfall/suitable soils areas. Note that SA2 areas do not coincide with NRM Regions. ABS counts have therefore been apportioned based on the percentage of area within an NRM Region:

Table 8: Estimated scope for Leucaena adoption based on ADOPT model output for regional segments

	CQ	HRF	Gulf	NT	WA
Peak adoption % as predicted by ADOPT	18%	6%	8%	8%	5%
Est. no properties ideal rainfall/soils	2640	817	124	42	4
Est. no properties to Adopt Leucaena	475 (371*)	49	10	3	0
Time to peak adoption (years)	14	19	22	25	36

**371 is the number of properties yet to adopt Leucaena allowing for the estimate of current adoption from Beutel et.al (2018).*

7.2 Regional and industry scale economic benefits of Leucaena adoption

Industry scale economic benefits are a product of adoption rates and per farm benefit, both of which will differ between regions. In this section we explore regional benefits based on the data above and summarise by collating these into an industry scale benefit.

7.2.1 Central Queensland

If we take the modelled farm assessment of net annualised per farm benefit for investing in Leucaena from Chudleigh et.al (2018) of $40,336, and we multiply this by the 371 properties in CQ based on our ADOPT model output which represents the upper scope for additional Leucaena adoption in CQ, a total maximum, annualised benefit of $15 million is calculated.

If we then consider the upper level for the time to peak adoption generated by the ADOPT model of 14 years, an annual increase in properties adopting Leucaena of 27 would be required to reach peak adoption in this time frame which would deliver an annualised benefit of $1.1 million. This equates to a cumulative value over the expected time to peak adoption (14 years) of $115 million.

Taken together, the large pool of likely adopters, robust estimates of significant per-farm benefits, coupled with significant existing extension support, suggests reliable returns from investment into appropriate adoption strategies for Central Queensland.

7.2.2 High Rainfall Zone

Approximately 817 properties with suitable soils are located in the HR zone. Up until now Leucaena usage has been restricted because of likelihood of yield reductions due to psyllid damage. However, the recent release of the psyllid resistant variety Redlands has paved the way for Leucaena usage in this zone. Based on our modelling and the associated assumptions, it is estimated that 6% of these properties, i.e. 49 properties, are potential adopters.

Regarding per-farm economic benefit, current trials show early indications of psyllid resistance and impressive forage growth, however there is still a lack of cattle production data on which to base reliable estimates of economic benefit.

The industry scale benefit in the HR zone is therefore based on a significant pool of producers likely to adopt if farm trials prove profitable, and/if appropriate extension support and strategies are delivered. Further investment into extension in this zone calls for a stepped approach, with the first step aimed at establishing farm-level profitability and systems fit.

7.2.3 Gulf and NT

The Queensland Gulf Country offers significant areas of land suitable for Leucaena, encompassing an estimated 124 properties. There are also some 42 properties on suitable soils in the NT. Based on our modelling and the associated assumptions, it is estimated that 8% of properties in both regions are potential adopters, which equates to approximately 10 properties in the Gulf, and 3 in the NT.

Although Leucaena has been used on some properties in the NT, and is being trialled on a handful of properties in the Gulf, there is a lack of reliable data on the farm systems fit and management of Leucaena and its profitability in these environments.

Notwithstanding lack of real-world data on the performance of Leucaena in these regions, there has been interest shown particularly from corporate enterprises. These entities may 'go it alone' on minimal information, however opportunity exists for some form of funded support to enhance success as discussed in the next section.

7.2.4 Western Australia

In contrast to the NT and the Gulf, Leucaena was used on a number of farms in the Ord River but has since been replaced by alternative land use in this area. Suitable soils and climate for Leucaena do exist outside the Ord, however all bar a few properties are on leasehold land where Leucaena cannot be grown. Given this scenario, it is difficult to mount a case to support these extremely limited opportunities for Leucaena under current state legislation.

7.3 Industry scale scenario

An industry scale assessment of benefits is difficult given the lack of conclusive data on systems fit, performance and profitability in regions outside of CQ. A scenario can be done however using a number of conservative assumptions:

- Only part of the benefit realised in CQ is used for other regions due to the factors outlined previously. For the purposes of this analysis we have used 50% of the total benefit.
- Only a proportion of properties are used when assessing overall 'scope' due to the unique barriers in these regions. We have used 75%.
- Average the time to peak adoption to 20 years for the Gulf, NT and HRF. Exclude WA.

This approach leaves the existing annual benefits as calculated for CQ as $1.1 million, and adds to this an annualised benefit of $20,168 to be applied to 47 properties outside CQ. This delivers a total benefit of $948K and an annual benefit of $47k. Clearly, the vast majority of benefit for investment in Leucaena adoption will be derived from CQ.

As stated previously, this is a conservative estimate, however, even if the benefit was to equal that of CQ and 100% of the predicted number of properties adopted Leucaena, the total benefit would be relatively small in comparison to CQ. The total benefit using these assumptions would be $1.9 million and the annual benefit $95K.

7.4 Systems fit adoption considerations

Throughout this review, the complexity of integrating Leucaena into farming systems has become increasingly apparent, with potential adopters needing to firstly be convinced of its appropriateness for their property (soils, climate, profitability), assess its fit within the farm system (marketing approach, labour, resources), and have the skills and equipment to establish and manage it. Other key considerations, informed via field work and discussions with regional experts, which may impact on ADOPT outputs and therefore need to be addressed via strategy are:

- Competition for land - high land prices and suitability for alternative high value crops and timber species have reduced potential areas sown to Leucaena in the Ord, parts of the NT, and is likely to be the case in the high rainfall zone.
- The need for the 3 C's = cash flow to ride out the production gap that new sown Leucaena could present, capital to invest in the gear to develop land, and, capability to 'farm' – the fear of farming seems to be a big barrier to adoption the further you get from cropping country.
- Perceptions associated with key management and grazing issues – agronomy, rotational grazing, height management, broad leaf weed control, and cattle mustering – may negatively impact adoption to a greater extent in areas with less exposure to farming (i.e. Gulf, parts of the HRF and NT).
- The availability of cleared country outside of CQ is a clear limitation to Leucaena's use given the Queensland vegetation management laws. (https://www.dnrme.qld.gov.au/land-water/initiatives/vegetation-management-laws).
- The harshness of the climate in both the Gulf and NT means that whilst soils may be suitable and average rainfall data suggests moisture will not be limiting, the extremes of heat and periodic inundation increases the risks of sowing failures and the overall risk perceptions of Leucaena (Rolfe et.al, 2018).
- Extension and expertise – CQ is in the fortunate position of having a pool of Leucaena knowledge gained over many years and embedded in advisory personnel, growers, and The Leucaena Network. Knowledge, support and grower experience is far more limited and fragmented in other areas.
- The precarious position of many beef businesses across northern Australia means that they are not well placed to cope with establishment risk, market risk, and climatic risk in the absence of significant advisory support and 'proof-of-concept'.
- The fact that 25% of adoption in CQ has occurred in the 400-600mm rainfall zone. This is significant as all assessment to date has focused on the 600mm+ rainfall zones. This factor may balance out the negative aspects of the considerations above.
- The lack of marketing options in WA, NT and parts of the Gulf; the traditional market for cattle in the Territory is live cattle trade. The Livingstone meatworks established 50km south of Darwin around 2015 reportedly processed about 500 head of cattle a day (ABC, 2018) presenting some opportunities, but has recently suspended operations due lack of profitability. Yeeda abattoir in the Kimberly has re-started and has a similar capacity to the Livingstone meatworks, offering some access to the slaughter market for north west WA. Without such access to slaughter markets the benefits of Leucaena may not be fully realised.

Clearly the fundamental challenge is to enable property owners and their advisors to balance the pros and cons of Leucaena, compare it with other alternatives and make decisions based on how they envisage the future of their business. In CQ where there is a growing pool of expertise and experience based on 30 years of RD&E, this challenge is largely process based (i.e. developing strategic forage plans). For regions outside of CQ, there is also a requirement for process around forage planning, however these property owners lack the basic inputs to support such a process. As such further investment is required to 'prove' and codifying the fundamental aspects of a profitable Leucaena system for these regions. Given this, we see two primary tasks for the strategy:

(i) Codification of the process to explore systems fit for the new generation of adopters
(ii) Enhancing the understanding of what constitutes systems fit in regions with little or no experience.

8 Conclusion and Recommendations

This study was commissioned to address four objectives;

1. the potential for future Leucaena production in northern Australia
2. the current production level of Leucaena-grass pastures in Australia
3. the barriers and incentives to adoption and the ROI MLA can expect from its RD&E investments into Leucaena, and
4. make recommendations on a strategy to increase the adoption of Leucaena-grass pastures.

Conclusions in relation to these 4 objectives are outlined below.

8.1 Objective 1 – Potential for Leucaena production

Throughout this report we refer to five regions in northern Australia, each with a unique combination of adoption characteristics. Across these five regions the geo-climatic potential of Leucaena was mapped, based on soil depth >1 m and pH>5.5 as per the methodology of Beutel et al (2018), and rainfall greater than 400 mm, to determine the upper limit of beef properties and cattle numbers in suitable areas. From this data it was concluded that:

- 40% of properties comprising 42% of cattle in northern Australia are in the broadest geo-climatic range for growing Leucaena. This represents 6266 properties and 6,329,606 cattle.
- 26% of properties (4064) and 21% of cattle (3,204,357) are in the 'ideal' zone for Leucaena (suitable soils and rainfall above 600 mm).
- Almost three quarters of properties in this 'ideal' zone are in CQ (2640 properties, 73%), nearly a quarter are in the Queensland coastal HRF (817, 23%), 124 properties in the Gulf (3%), and approximately 42 properties in the NT.

8.2 Objective 2 – Current production of Leucaena

In terms of actual adoption, this report draws on the work of Beutel et al (2018) in Central Queensland and input from local operatives in the other zones to assess the extent of current planting. This found:

- In CQ, Beutel (ibid) estimates that 3.9% of properties (103) were growing Leucaena in the study area, of which approximately three quarters (79) were in the ideal zone of 600mm-800mm rainfall, and one quarter (24) in the <600mm zone.
- Approximately 1000ha were sown in the high rainfall zone in 2017/18 with this constituting around half to one third of total plantings.
- The Gulf has few known Leucaena properties with approximately 700ha of planting either completed or underway.
- The NT has one known commercial-scale area grown with several in the planning phase and a number of plantings which have failed or been removed.

- WA has environmental restrictions which preclude the use of current (seeded) varieties on leasehold land which is the dominant land tenure in Leucaena-suitable areas.

8.3 Objective 3 - The scope for adoption and the ROI MLA can expect from its RD&E investments into Leucaena

Drawing on a mix of producer interviews and focus groups in CQ; discussions with R&D personnel involved with Leucaena; review of literature on the attributes of Leucaena and; an analysis of MLA producer segmentation work, potential adoption profiles for each region were developed using the ADOPT model. From this, the upper limits of adoption were deduced as follows;

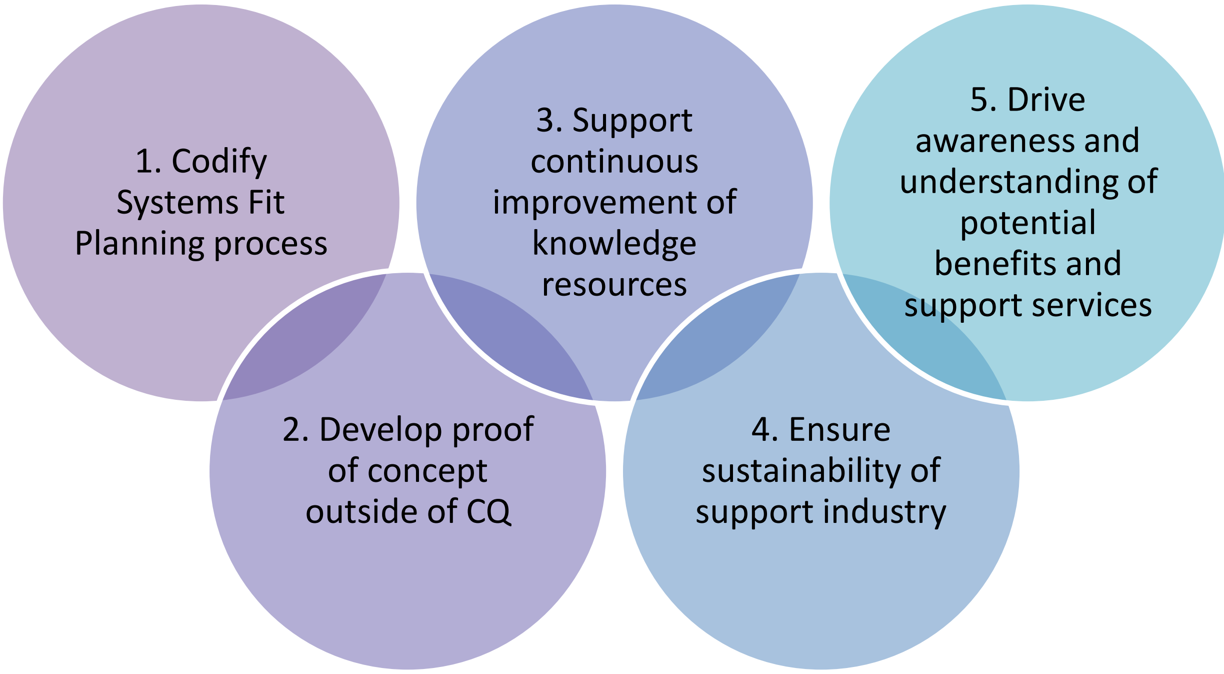
- In CQ high profitability, combined with excellent enterprise fit and social learning support has the highest predicted upper adoption level of 18% and shortest time to peak adoption of 14 years.
- Compared to CQ the two key adoption drivers of profit and enterprise fit are considerably lower, and moderated in areas where Leucaena offers greater risk reduction (Gulf, NT and WA).
- Areas other than CQ, particularly more remote areas, have considerably reduced learning opportunities combined with lower general awareness and base knowledge of Leucaena management, which lead to an extension of the time to peak adoption. Upper adoption rates and time to peak adoption are estimated at 6%/ 19 years for High RF, 8%/ 2 years in the Gulf, 8%/ 25 years in the NT, and 5%/26 years in WA.

Upon developing these adoption 'profiles' for each region, a rationale for investment in extension and adoption activities could then be developed around the benefit/ cost of the intervention. From this, the following can be concluded for each region:

- CQ offers a large pool of likely adopters, robust estimates of significant per-farm benefits (Chudleigh et.al., 2018), coupled with significant existing extension support, suggesting reliable returns from investment using appropriate adoption strategies.
- The HR zone has a significant number of properties likely to adopt with the right support, evidence of profitability, and regionally specific management practices.
- Benefit in the Gulf and the NT are difficult to assess due to a lack of data. This combined with relatively low numbers of properties in the ideal zone for Leucaena means that any investment must focus on proof of concept under commercial conditions via a cost sharing model.

8.4 Objective 4 - Recommendations on a strategy to increase the adoption of Leucaena-grass pastures

The combination of the conclusions above lead to 5 interrelated strategic actions designed to support ongoing adoption of Leucaena. As can be seen from the diagram below, these actions have been developed to address the 2 primary tasks outlined in the previous section.



The logic of the 5 actions can be understood as follows:

- **Action 1** is designed to support the process of analysis at the property level to assess the appropriateness or otherwise of changes to the forage base. This action aims to address the key issue of systems fit identified at multiple stages in this report. It is intended that investment in this action would be a discrete period and that the process itself would become embedded in practice over time.
- **Action 2** will deliver the fundamental elements necessary to enable action 1 in areas outside of CQ. Key elements of systems fit such as establishment best practice, weight gain potential across various stock classes, realising benefits of Leucaena through systems change and risk associated with establishment and management are yet to be adequately codified for the HRF, Gulf and NT. Investment in this action would also be for a discrete time period as by definition, once the concept is 'proved' producers can then move confidently on to investment and implementation.
- **Action 3** is a critical component of any 'knowledge' system and has been occurring to a certain extent already, albeit not in a strategic and coordinated fashion. An ongoing investment linked to broader strategic objectives at an industry scale is required to ensure rigour around knowledge resource management.
- **Action 4** is critical to the longevity of the Leucaena industry given the ongoing decline in publicly funded extension. Given the potential for Leucaena to deliver significant value to producers it is highly likely that once actions 1-3 are achieved the viability of private support services will be enhanced. Required however is an ongoing investment in the skills and capability of the support sector given the well-known limitations of many service providers to invest in skill development. Also required is ongoing investment in the integrity of key elements of the Leucaena supply chain, particularly seed production and distribution.
- **Action 5** will ensure that the past, present and future investments in Leucaena RD&E are realised and leveraged for industry benefit for the long term.

The following section outlines each action in further detail.

8.4.1 Codify systems fit planning process

Objective: To develop a process that can be used by advisors to enable producers/managers to develop a 'forage plan' that fits their unique set of resources (economic, physical, human).

Rationale: How would/could Leucaena fit into my farm business? Is the fundamental question behind the effective implementation of Leucaena. Codifying a process which enables those exploring its utility prior to committing to investment is critical. Such a process would enable producers to explore the problem which they aim to address through forages other than pasture and enable a considered plan to be developed which may or may not include Leucaena.

Suggested approach: Develop and pilot a 'forage planning' process which explores the whole farm systems elements of changing the forage base of an enterprise, not just the agronomic elements of growing Leucaena. This should be the first task of the expert panel recommended in action 3. The process should follow a 'now, where, how' planning framework at the whole of business level before examining the particular forage requirements that this raises. Such an assessment needs to explore the climate, physical, social and economic elements of Leucaena and its management for the business.

Cost: $100K to develop and pilot with 20 producers. Ongoing cost of application dependent upon demand. Resourcing via action area 4.

Who should lead: DAFQ to lead with support from The Leucaena Network.

8.4.2 Develop proof of concept outside CQ

Objective: To establish key management practices, understanding of system fit factors and profitability measures for Leucaena in areas outside CQ

Rationale: There is a lot of noise around how far critical success factors can be stretched in practice i.e. row spacing, timing of grazing, fertilizer use, soil types, soil preparation. Along with this is a lack of confidence to invest due to:

  - Perceptions of first mover disadvantage in Gulf and NT (failure risk).
  - The absence of support services and confidence to farm.
  - The variable nature of Gulf country and the challenge of establishment.

Suggested approaches:

- Enhancement of the Redlands for regions approach to enable greater sharing of insight from practicing Leucaena growers and codification of management practices for the HRF region:
  - Increase the number of 'partner farms.
  - Enhance data collection around critical success factors.
  - Ensure broader sharing of approaches and insights.
  - Link project participants in to action 3.
- Co-investment in proof of concept sites
  - Using MDC funds, pilot a 50/50 co-investment approach to establish commercial scale planting of Leucaena in targeted areas of the Gulf in the first instance and NT in the second.
  - Aim would be to develop proof of concept, drawing on local knowledge and external expertise. The process would apply the 'forage planning' concept from action 1 and be a key focus area of the technical advisory group in action 3.

    - Provide resources for technical support, data collection and codification of practice and benefits of Leucaena at a whole farm scale. This would in effect be an advisory board established to support the project.
    - Public tender process used to identify investment partners. Scale would need to be significant to warrant investment (i.e.500+ hectares).

Who should lead: MLA to drive through a properly resourced Leucaena Network (see action 5) with DAFQ support.

Cost

- Redlands for Regions: $200K per year for 3 years.
- Proof of concept project - $350K per tender includes $100k for support and data collection.

8.4.3 Support continuous improvement of knowledge resources

Rationale

- The International Leucaena Conference (Brisbane 2018) highlighted the diverse and fragmented nature of the skills and knowledge around Leucaena management in Australia. There are pockets of insight that aren't being drawn upon and a range of practical experience that needs to be better understood.
- Current skills and knowledge are understandably CQ centric.
- Resources such as the code of practice and info/tech notes require updating and refinement. There is currently no formalised process in place to enable this.

Suggested approach

- Resource the Leucaena Network to oversee resource improvement, code enhancement and further development of new technical resources. This needs to be guided by a resource development strategy, overseen by the National Technical Advisory group (see next point).
- Establish a national technical advisory group to oversee RD&E delivery and advise the network on strategy. This group should have a mix of perspectives and balance science and research, producer input and the service sector.
- A key first task would be to enhance the code of practice to enable engagement with all levels of government.

Who should lead?

- The Leucaena Network.

Cost

- $50,000 per year for up to 5 years.

8.4.4 Ensure sustainability of support industry

Rationale

- A number of concerns raised about the nature and sustainability of the seed supply chain.
- Scale and transparency critical. Feedback loops important for this.
- Service sector in regions outside of CQ is a challenge.

Suggested approach

- Audit current service provider capacity and capability across all critical success factors
- Establish an industry supported (partial cost recovery) flying squad of technical experts to implement the forage planning process from action 1 and respond to enquiry around Leucaena establishment and management. This approach provides an entry point for ongoing support.
- Explore opportunities to separate seed production from distribution and marketing (i.e. review PBR agreements).

Who should lead?

- The Leucaena Network.

Cost

- $50-100K per year, for 3 years, depending upon industry demand.

8.4.5 Drive awareness and understanding of potential benefits and support services

Rationale

- The pros and cons of Leucaena and the benefits of a strategic approach to forage planning (action 1) need to be communicated.
- Support services need to have the opportunity to network and access information and support with regards to developments in practices and understanding of the best use of Leucaena.
- Currently The Leucaena Network lacks the resources and remit to adequately provide this function to industry.

Suggested approach

- Resource the Leucaena Network to enable delivery of actions 2, 3 and 4.
- Link resourcing to the development of a 5-year strategy for the network, which is built upon this strategy and overseen by the national technical advisory group.
- Ensure evaluation and industry feedback loops to assess value being added.

Who should lead?

- MLA & The Leucaena Network.

Cost

- Linked to previous elements as an addition to existing funding of the Network ($50K pa).

The total cost of this program of work over a 5-year period is summarised below.

Table 9: Summary of estimated costs associated with strategic actions

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Totals**
Action 1	$100K	$100K				$200K
Action 2	$350K	$350K	$350K			$1050K
Action 3	$50K	$50K	$50K	$50K	$50K	$250K
Action 4	$100K	$100K	$100K	$100K	$100K	$500K
Action 5	$50K	$50K	$50K	$50K	$50K	$250K
Total	**$650K**	**$650K**	**$550K**	**$200K**	**$200K**	**$2250K**

The critical next step is for MLA to now review the recommendations and information in this report and work closely with The Leucaena Network to plan further action designed to support the enhancement of Leucaena adoption and management in Australia. The key questions to consider are;

1. Do the potential benefits of investment warrant the program of work outlined in this report?, and;
2. What systems will be put in place to monitor progress to ensure the adoption targets linked to these benefits are tracked and change to the strategy made if they are not being met?

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