Economic Evaluation of Leucaena and Stylo Pastures at Goshen Station

Establishing Leucaena on a 500-ha rundown pasture

- **Six-fold increase in carrying capacity**
- **19% improvement in emissions intensity**
- **25% improvement in annual liveweight gain**

Fertilising and spelling a 500-ha rundown stylo-buffel pasture

- **Four-fold increase in carrying capacity**
- **6% improvement in emissions intensity**
- **20% improvement in annual liveweight gain**

Goshen Station is a beef cattle grazing property located near Mount Garnet in North Queensland. In 2018, the Queensland Department of Agriculture and Fisheries established a producer demonstration site at Goshen Station. The demonstration site was developed with leucaena and inter-row sown pasture species, including stylo, on a cleared red earth soil with low fertility. The operations and practices listed in this factsheet, wherever possible, reflect the real activities and costings. This project utilised collected data to examine the profitability of three scenarios for a 500-ha native grass pasture:

1. Maintaining a native grass pasture (business as usual)
2. Leucaena planted in strips with inter-rows sown to mixed grass species and Seca stylo (based on known inputs from actual practice)
3. Mixed grass species and Seca stylo across the whole paddock (i.e., no leucaena), based on assumed inputs and methods.

Were the changes profitable?

A 30-year discounted cash flow (DCF) investment analysis was conducted to assess the financial impact of transitioning to either of the two different strategies. Using a 5% discount rate, the results illustrate the trade-offs between the two strategies. The leucaena and stylo-grass scenario offers higher returns and quicker payback despite higher initial costs and deficits.

Table 1: Investment analysis results

	Leucaena and stylo-grass	Stylo-grass
Set up costs (nominal value)	$342,737	$296,647
Net present value (NPV)	$716,305	$314,032
Annualised NPV (per year)	$46,597	$20,428
Internal rate of return (%)	15.2%	11.1%
Payback period (years)	12	15
Breakeven initial cost outlay	$1,059,042	$610,679
Peak deficit with interest	-$434,635	-$338,671

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Advantages of leucaena and stylo pastures

Sown leucaena and stylo pastures offer several advantages to beef enterprises, including higher stocking rates, increased liveweight gains, enhanced nutrition and soil health, and reduced emissions intensity compared to undeveloped pastures.[1] Leucaena, the most productive forage in central Queensland, shows potential for northern expansion, especially the new psyllid-tolerant 'Redlands' variety suitable for higher rainfall areas.[2]

Stylosanthes legumes (commonly known as stylo), though less productive than leucaena, are well-suited to a broader range of bioregions and soil types. They are particularly well suited to northern Australia, currently established over 600,000 ha, with an additional 60,000 ha sown annually[3]. Advantages include lower initial establishment costs and less ongoing management demands than leucaena[3].

Establishment process and initial costs

The analysis examines steers entering a 500-ha paddock as weaners, which are then sold after 12 months as yearling feed-on steers. There were two development strategies, both beginning with the preparation of the paddock following the removal of the last cohort of steers grazed on native grass: this marked the start of Year 1. Table 2 shows the grazing timeline for each scenario during implementation along with stocking rates and grazing periods in the initial 6 years.

Table 2*:* Grazing timeline in calendar years with stocking rates and periods of grazing

Year	Leucaena and stylo-grass strips	Stylo-grass across whole paddock
1	No grazing – prepare paddock then plant pasture	No grazing – prepare paddock then plant pasture
2	No grazing	Half stocking for 4 months
3	Full stocking for 10 months	Full stocking for full 12 months
4	Full stocking for full 12 months	Full stocking for 8 months (wet season spell)
5	Full stocking for 9 months (leucaena pruning and wet season spell)	Full stocking for full 12 months
6	Full stocking* for full 12 months (then repeat year 5-6 to year 30)	Full stocking* for full 12 months (then repeat year 3-6 to year 30)

** Full stocking incorporates wet season spelling 25% each year and 50% every third year*

[1] Shelton, M., Dalzell, S., Tomkins, N., & Buck, S. R. (2021). Leucaena-The productive and sustainable forage legume.

[2] M.K Bowen, F. Chudleigh, J.W Rolfe and B.H English (2019) Northern Gulf Beef Production Systems. DCAP. 58-84.

[3] Beutel TS, Corbet DH, Hoffmann MB, Buck SR, Kienzle M (2018) Quantifying leucaena cultivation extent on grazing land. *The Rangeland Journal 40,* 31-38.

Table 3 details the costs involved in preparing the soil, planting, fertilising and weed control for each scenario. Input prices were sourced from local suppliers and operations were costed based off the producer's machinery costs, work rates and fuel use. Labour was costed at $35/hour and diesel at $1/L (ex GST and rebate). Machinery costs included labour, repairs, and maintenance if machinery was already owned. Depreciation, interest, travel, insurance, and storage costs plus profit were also included if the machinery was purchased to establish or manage the sown pastures, reflecting contractor rates.

Leucaena was planted in twin rows (~ 1 m apart) at 10 m centres. Following leucaena planting and early establishment, the stylo-grass mix was then spread and rolled in the inter-rows, covering 70% of the paddock in the same season. Assuming no establishment failure, the total cost to establish leucaena and stylo-grass strips across the 500-ha paddock amounted to $342,737 over five years, or approximately $685/ha. In contrast, establishing stylo-grass pasture cost $296,647 over four years, or about $593/ha. Both strategies staggered the planting with 125 ha established each year to better ensure manageable areas for reliable establishment. The costs listed throughout this factsheet apply to the development of the entire 500 ha.

Table 3*:* Operations and cost outlays to prepare the soil, plant and fertilise pasture and control weeds (500 ha costs)

Leucaena and stylo-grass strips	Stylo-grass across whole paddock
1. Dozer blade and stick rake ($20,938) Offset disc whole area twice ($50,773). Rip leucaena strips ($10,324) and tyne cultivate whole area ($16,516). *Subtotal = $98,551*	1. Dozer blade and stick rake ($20,938) Offset disc whole area twice ($50,773) and one tyne cultivation ($16,516). *Subtotal = $88,227*
2. Plant leucaena ($76,650), spray with imazethapyr (e.g. Spinnaker) ($2,237) and fertilise with DAP+S at 200kg/ha ($82,850). Follow up with two sprays of glyphosate (e.g. Roundup ($6,465). *Subtotal = $168,202*	2. Fertilise stylo area before planting with DAP+S at 200 kg/ha ($117,993). Spread a mix of Seca stylo with Callide Rhodes and Bisset grasses then roll ($85,553). *Subtotal = $203,546*
3. Fertilise inter-row area before planting with DAP+S at 200 kg/ha ($32,850). Spread a mix of Seca stylo with Callide and Bisset grasses then roll ($51,837). *Subtotal = $84,687*	
Total cost = $342,737	**Total cost = $291,713**

For the leucaena-grass-stylo system, leucaena seed was planted at 1.5 kg/ha using a leucaena planter with seed priced at $80/kg. The inter-row pasture mix included bare Seca stylo applied at 1 kg/ha ($23/kg), Callide Rhodes grass at 2.5 kg/ha ($10/kg) and Bisset creeping bluegrass at 3 kg/ha ($25/kg). For the stylo-grass system, the stylo planting rate was increased to 2 kg/ha.

Regular wet season spelling was incorporated into the renewed pasture scenarios since it is essential to maintain good pasture condition and productivity. To allow this, additional fencing (4.5 km at $22,500) costs were included plus the installation of three additional water points including troughs and accompanying poly-pipe ($15,900).

Ongoing annual costs

Table 4 shows the additional activities required to effectively maintain the sown pastures systems over 30 years along with the associated costs. The leucaena scenario had a phosphorus and sulphur fertiliser applied every second year to maintain soil fertility, which is particularly important for leucaena.

An allowance was included for mechanically cutting the leucaena every three years, starting in Year 5, using an offset slasher/mulcher. This keeps the leucaena at a suitable grazing height for cattle. At Goshen, the cattle are not administered leucaena rumen inoculant, as the herd has long been exposed to leucaena. However, cattle naïve to leucaena should be inoculated (one in ten animals is sufficient) to enable detoxification of mimosine: the inoculation cost averaged over the whole herd was $4.50 per head. The owners at Goshen also periodically slash the inter-row pasture between leucaena rows on an as-needed basis to promote fresh pasture growth and reduce woody weeds. Once established, an allowance was included for slashing: 20% of the inter-row area every year.

The stylo-grass scenario also included regular fertiliser applications to maintain pasture productivity. The frequency of application was one-in-three years, which was less than for the leucaena-pasture scenario. This stylo scenario also included dry season supplementation (lick).

Table 4: Ongoing annual costs (nominal values – not discounted to present value) (500 ha costs)

Leucaena and stylo-grass scenario	Stylo-grass scenario
Spread DAP-S fertiliser at 200 kg/ha across the whole paddock. ($117,932) every two years from Year 5	Spread DAP-S fertiliser at 150 kg/ha across the whole paddock. ($90,558) every three years from Year 4
Mechanically cut leucaena. ($24,557) every three years from Year 5	Dry season supplementation ($10/head). $4,305/year once fully stocked from Year 3
Dry season supplement ($1,318/yr)	Maintain new fencing ($200/yr) & Mustering ($1,680)
Slash 25% of interrow area ($6,358) every year from Year 3	**Additional costs over 30 years = $999,020**
Muster and rotate stock around ($1,680/yr)	
Maintain new fencing ($450/yr)	
Monitor/control leucaena escaping paddock ($280/yr)	
Additional costs over 30 years = $2,029,789	

Did forage and cattle production increase?

Table 5 outlines the key production figures for each scenario once the pasture was fully established. The underlying forage and grazing parameters used for each scenario were informed by project data and local specialists. Compared to native pasture, the stylo-grass scenario produced 2.6 times the amount of dry matter, increased pasture utilisation by 75% and improved digestibility. The leucaena and stylo-grass scenario was even more productive, and produced 2.9 times the amount of dry matter, increased pasture utilisation by 150% and had the highest digestibility.

Table 5: Key production figures (established pasture)

Scenario	Native pasture	Leucaena and stylo-grass	Stylo-grass
Dry matter produced (kg/ha)	1,800	5,500	4,800
Pasture utilisation rate (%)	23	57	40
Dry matter digestibility (%)	49.5	55	52
Steer liveweight gains (kg/yr)	98 (0.27/day)	166 (0.46kg/day)	148 (0.41/day)
Dry matter intake (kg/hd/day)	5.8	6.6	6.1
Dry matter required (kg/hd/yr)	2,132	2,391	2,230
Dry matter available (kg/ha)	414	3,192	1,680
Carrying capacity (ha/hd)	5.1	0.76	1.16
Steer mortality rates (% losses/yr)	**2**	**1**	**1**

Total steer liveweight gains over the 12 months averaged 98 kg on native pasture, 166 kg on leucaena with stylo-grass and 148 kg on stylo grass. While the sown pasture strategies had slightly higher dry matter intake requirements (due to higher liveweight gains), the substantial increase in available dry matter improved carrying capacity almost four-fold for the stylo-grass scenario and seven-fold for leucaena and stylo-grass. Steer mortalities were also lower for the sown pasture strategies.

Table 6 outlines the production and sales figures along with variable costs and gross margins for each scenario. All strategies assumed enough weaner steers were purchased to sustainably graze the 500-ha paddock over 12 months. Cattle prices were 7-year averages recorded at North Queensland saleyards (2016-23). Weaner steers were $3.39/kg (liveweight), while re-stocker steers were $3.10/kg (200-330 kg). Steers lost 7% of their weight from paddock to sale. Figures in Table 5 reflect averages at full production.

Table 6: Average production, sales, costs and gross margins (500 ha)

Scenario	Native pasture	Leucaena and stylo-grass	Stylo-grass
Total steers carried (head/yr)	97	659	430
Mortalities (hd/yr)	2	7	4
Total steers sold (hd/yr)	95	652	426
Steer sale weights (kg)	230 kg	294 kg	277 kg
Weaner purchases, freight and husbandry costs ($/yr)	$49,960	$338,924	$212,459
Increase in pasture costs ($/yr)	$0	$65,083	$33,301
Net cattle sales ($/yr)	$59,887	$530,515	$325,709
Gross margin ($/yr)	$8,471	$123,932	$70,949

** Net cattle sales = sales revenue - commission, levies, yard fees & freight.*

Compared to native pasture, the stylo-grass scenario carried and sold almost four times the number of steers and had 21% higher sale weights. The leucaena and stylo-grass scenario was more productive selling seven times the number of steers and had 28% better sale weights. While annual variable costs for the stylo-grass scenario increased by an average $202,811 per year (weaner purchase and pasture costs), net cattle sales increased by $265,822 per year to make the gross margin $62,478 per year higher than native pasture.

In comparison, costs for the leucaena with stylo-grass scenario increased by $350,696 per year and net cattle sales were $530,515 per year higher, which made the gross margin $118,037 per year higher than for the native pasture.

What about Risk?

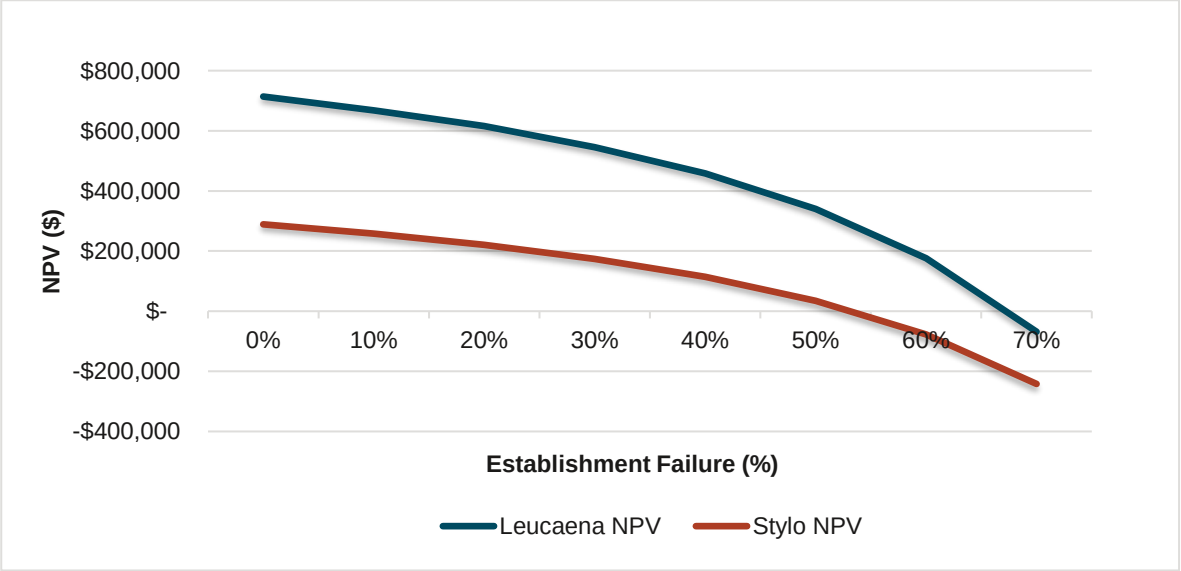
The processes described above should result in a low risk of establishment failure. However, to mitigate the risk of establishment failure during the sowing of leucaena and stylo, it is essential to consider several key factors, such as:

- Climatic suitability and the prognosis for suitable rainfall before and after sowing (SOI)
- Suitability of the site (soil fertility, depth and pH and whether cleared)
- Pests and diseases
- Weed competition.

Figure 1 illustrates the financial consequences of establishment failures in the two scenarios, under the assumption that unsuccessful pastures are replanted in subsequent years until successful establishment is achieved. The graph demonstrates that the absence of establishment failure results in the highest profitability. However, profitability decreases progressively with increasing rates of establishment failure, attributed to the escalating costs of soil preparation, replanting, and fertilisation required after repeated failures.

Specifically, the profitability of the stylo scenario becomes negative if more than 53% of the area fails to establish during each replanting attempt. Similarly, the leucaena scenario becomes unprofitable when the failure rate exceeds 68%. Adhering to established best practices can significantly reduce the risk of establishment failure. For detailed guidance on successfully establishing leucaena, please visit How to Reliably Establish Leucaena.

Figure 1: Risk analysis: Effect of establishment failure on net present value (NPV)



Environmental considerations including net carbon emissions

Legumes such as leucaena and stylo offer significant production advantages when grown in suitable environments. They enable more intensive production contributing to an overall reduction in land usage, facilitating rehabilitation and conservation efforts in other areas of properties. Through a symbiotic relationship with nitrogen-fixing bacteria, legumes enhance soil vitality, fostering resilient and productive pastures. The extensive root structures of leucaena and stylos can also stabilise soil, reducing erosion, and enhancing water infiltration. In doing so, they contribute to the preservation of water quality, an issue of particular importance in reef catchments.

The Australian Red Meat Industry has pledged to achieve carbon neutrality by 2030, making the impact of management practices on net carbon production increasingly important for producers. The successful introduction of climate-active carbon-neutral beef labelling highlights a growing consumer preference for sustainability in some markets, offering opportunities for premium pricing and green financing.

We assessed the carbon consequences of sowing stylo and leucaena on our 500-ha paddock using the Meat and Livestock Australia (MLA) carbon calculator. The results for the full 30 years of analysis are presented in Table 8[5].

Table 8. The estimated carbon emissions intensity of the three assessed scenarios based on the MLA carbon calculator (2024)

Scenario	Emissions Intensity	Cattle Carried 500 Hectares (steady state)
Native grass	13.5 kg co_2e / kg LW	97 – hd/yr
Stylo-grass	12.3 kg co_2e / kg LW	430 - hd/yr
Leucaena-Stylo-Grass	11.4 kg co_2e / kg LW	659 - hd/yr

The results indicate that these paddocks have become more efficient on an emissions intensity basis, as younger cattle reach target weight sooner. In the case of the leucaena-grass pasture, there were additional emissions intensity reductions due to leucaena's anti-methanogenic properties which reduce emissions for each kilogram of feed consumed[6]. – However, the increase in the number of cattle carried (and beef produced) has increased aggregate emissions.

[4] Shelton, M., & Dalzell, S. (2007). Production, economic and environmental benefits of leucaena pastures. Tropical grasslands, 41(3), 174.

[5] Carbon calculator (2023) MLA. Available at: https://carbon-calculator.mla.com.au/ (Accessed: 2023).

[6] Taylor A., et al (2016) Modelled greenhouse gas emissions from beef cattle grazing irrigated Leucaena in northern Australia. Animal Production Science 56, 594-604