Activity # 1- Assessing Horticultural Crop Suitability for the Queensland Murray Darling Basin Study Area

Case study II: Bioeconomic analysis of Southern Qld. Pecan production

(1 August 2014 to 30 June 2016)

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Case study II: Bioeconomic analysis of Southern Qld. Pecan production

The pecan (*Carya iffinoensis*) is a native American tree nut and is a member of the hickory family. The US and Mexico are responsible for around 90% of the world's trade in pecan nuts, with the prime production area being from New Mexico through to Georgia. Other pecan producing countries include Australia, Mexico, China, Argentina, Israel and South Africa. China is the world's leading importer of pecan nuts and the market has grown exponentially in recent years.

In Australia pecans are primarily grown in Northern New South Wales and South eastern Queensland. Small plantings also exist in South Australia and south-western Western Australia. In Australia around 1,300 ha is currently planted to pecan trees producing 3,260 tonnes of nut in shell (1,746 tonnes of kernel according to the latest published data 2009).

Pecans are a slow growing tree, cropping lightly after five years and not cropping commercially until around eight to ten years old. Well maintained pecan trees can live and produce well for generations. Normally pecans are planted on a square grid, with spacing of 12-15 metres between trees, though this may vary as a number of varieties with differing cropping characteristics are available.

The Australian pecan season, being counter seasonal to the northern hemisphere, creates a lucrative opportunity to export into China. Australian pecan grower's use of innovative production techniques (mechanisation), and the relatively pest free environment, mean that the bulk of the crop is grown without the use of chemical pesticides. The Australian industry is recognised for having high quality control standards and this is valued by modern quality conscious consumers

The following economic analysis investigates the feasibility of growing pecans within the Queensland Murray Darling Basin (QMDB) study area. The DAF project economist and staff spent considerable time in conversation and discussion with several pecan producers and processors to developed this annual gross margins based on a 100-hectare pecan enterprise, with 200 trees/ha. This industry sourced information was then used to identify the time to breakeven based on capital expenditure and discounted cash-flow rates. One of the key initial biophysical risk drivers (other than sufficient water supply) is the probability of getting sufficient chill hours to guarantee full production potential.

The Australian pecan industry is still small compared to other horticulture crops, and therefore there is very little production or financial information publically available. The worked contained in this report will therefore provide baseline data and information to the Australian pecan industry and the wider public. As outlined above the DAF project economist obtained and developed the reported information through an iterative process. Developing the economic model by interviewing three experts within the Australian pecan industry experienced in growing, processing and marketing the crop and seeking feedback from them to refine and validate the economic model.

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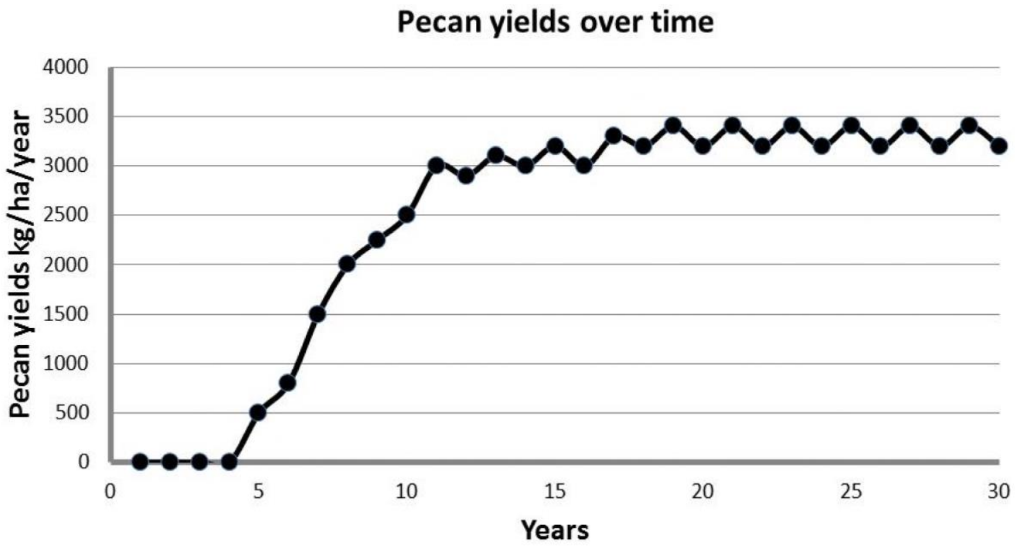
The pecan is a perennial tree crop, which takes a number of years to reach full production; this time lag is a primary driver of finical returns over time (Figure 75).

Figure 75 - Typical observed median pecan yields in the Northern NSW and Southern Qld regions over time. Trees continue to produce for many decades beyond the 30-years shown in the graph.



Pecan trees are long lived and can yield over 3000Kg/ha (nut in shell) but in order to achieve these yields, trees require sufficient water, deep draining soil, sunlight and sufficient chilling. It is essential that there is sufficient water supply for the plant to at least survive every year and to maximise nut yield and quality supplementary irrigation is essential. Most regions within Queensland are assumed to have sufficient sunlight for pecan production in all years. Assuming the grower has sufficient secure water, deep draining soil and best management practices are adopted for pest and disease control, the primary annual variable (limiting factor) for pecan production is sufficient chilling. Chill hour accumulation will be investigated for various regions within the QMDB as well as Moree in NSW which is currently the primary pecan production region in Australia.

1 Pecan gross margins and cash flows over time

Like most perennial crops variable costs and yields will differ from year to year; therefore, gross margins and net profits also change over time. The two main contrasting production periods (years) are the early growth and steady-state years. These production phases are presented in Figure 76 and Figure 77 respectively. This gross margin output provides an overview of the typical inputs required for both the pecan orchard establishment and production phase of growth (steady state). All price information is based on today's prices and are not financially discounted. Growers with existing pecan production capacity can use AgMargins™ to assess their current steady-state production outputs. When evaluating a new enterprise the bioeconomic model will utilise financial discounting in considering the time to breakeven.

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Figure 76 - Inputs, variable costs and gross margins for the first-year of pecan production.

AgMargins Queensland Government

Pecan - year 1 - Plant 2016 (Darling Downs)

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Commodities

	YIELD	PRICE	TOTAL
Pecan			$0/ha
Pecan	0 kg/ha	4.50 $/kg	$0 /ha

Total Income: $0 /ha

Variable Costs

	QTY	RATE	COST	TOTAL
Machinery Operations				$480/ha
Operation: Slashing + FWA Light FORM	4 operations	4 ha/hr	31.78 $/hr	$32 /ha
Operation: Spreader + FWA Light FORM	1 operation	1.75 ha/hr	32.76 $/hr	$19 /ha
Self-propelled: sprayer FORM	7 operations	4 ha/hr	62.32 $/hr	$109 /ha
Operation: Post hole digger + FWA Light FORM	200 Trees/ha	25 tree/hr	40.03 $/hr	$320 /ha
Tree Management				$4,550/ha
Tree: Planting, staking, tree guards & tying (labour)	200 Trees/ha		4.05 $/tree	$810 /ha
Tree: Stakes	200 Trees/ha		2.00 $/tree	$400 /ha
Tree: Guards	200 Trees/ha		0.35 $/tree	$70 /ha
Tree: Painting	200 Trees/ha		1.35 $/tree	$270 /ha
Tree: Pecan	200 Trees/ha		15.00 $/tree	$3,000 /ha
Fertiliser				$350/ha
Fertiliser: Urea (fertigate)		10 kg/ha	0.82 $/kg	$8 /ha
Fertiliser: Zinc Chelate (fertigate)		1 kg/ha	12.00 $/kg	$12 /ha
Nutrient: Compost - Farm Gate		3000 kg/ha	0.11 $/kg	$330 /ha
Crop Protection				$95/ha
Pest: Bird control	2 operation		24.57	$49 /ha
Herbicide: Gramoxone 250	7 operation	1 L/ha	6.50 $/L	$46 /ha
Irrigation				$319/ha
Irrigation: Drip (FORM)		1 ML/ha	50.00 $/ML	$50 /ha
Consumable: Water		1 ML/ha	20.00 $/ML	$20 /ha
Irrigation: Water License		0 ML/ha	100.00 $/ML	$0 /ha
Contract: Labour Laying and removing drip tape	5 hrs	1 hr/ha	27.00 $/hr	$135 /ha
Irrigation: Layflat 100mm	0.2 application	75 m/ha	4.00 $/m	$60 /ha
Contract: Labour irrigation	2 hrs	1 hr/ha	27.00 $/hr	$54 /ha
Harvesting & Freight Costs				$0/ha

Total Variable Costs: $5,794 /ha

Gross Margin: -$5,794 /ha

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Figure 77 - Inputs, variable costs and gross margins for the lower biannual steady-state pecan production (>year-15). The median higher biannual steady-state yield is estimated to be 3200 kg/ha and having a gross margin of $11,209/ha.

AgMargins Queensland Government

Pecan - Steady state Low - Plant 2016 (Darling Downs)

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Commodities

	YIELD	PRICE	TOTAL
Pecan			**$14,400**/ha
Pecan	3200 kg/ha	4.50 $/kg	$14,400 /ha

Total Income: $14,400 /ha

Variable Costs

	QTY	RATE	COST	TOTAL
Machinery Operations				**$140**/ha
Operation: FWA Light + Slashing FORM	4 operation	0.25 hr/ha	31.78 $/hr	$32 /ha
Operation: FWA Light + Spreader FORM	1 operation	1.75 ha/hr	32.76 $/hr	$19 /ha
Operation: Self-propelled sprayer FORM	4 operation	4 ha/hr	89.32 $/hr	$89 /ha
Tree Management				**$266**/ha
Tree: Pruning mature pecans		1.2 hr/ha	221.87 $/hr	$266 /ha
Fertiliser				**$516**/ha
Fertiliser: Urea (fertigate)		600 kg/ha	0.82 $/kg	$492 /ha
Fertiliser: Zinc Chelate (fertigate)		2 kg/ha	12.00 $/kg	$24 /ha
Crop Protection				**$73**/ha
Pest: Bird control	2 operation		24.57 $/op	$49 /ha
Herbicide: Glyphosate 450 CT	2 operation	2 L/ha	6.05 $/L	$24 /ha
Irrigation				**$420**/ha
Irrigation: Drip (FORM)		6 ML/ha	50.00 $/ML	$300 /ha
Consumable: Water		6 ML/ha	20.00 $/ML	$120 /ha
Irrigation: Water License		0 ML/ha	100.00 $/ML	$0 /ha
Total Harvesting & Freight Costs				**$1,776**/ha
Operation: Tree shaking	2 operations	1 hr/ha	73.03 $/hr	$146 /ha
Operation: Sweeping pecans	4 operation	1 hr/ha	35.00 $/hr	$140 /ha
Operation: Tree harvesting pecans	2 operation	1 hr/ha	153.35 $/ha	$307 /ha
Operation: Cleaning pecans $/kg	3200 kg/ha		0.30 $/kg	$944 /ha
Operation: Transportation of nuts $/kg	3200 kg/ha		0.07 $/kg	$239 /ha

Total Variable Costs: $3,191 /ha

Gross Margin: $11,209 /ha

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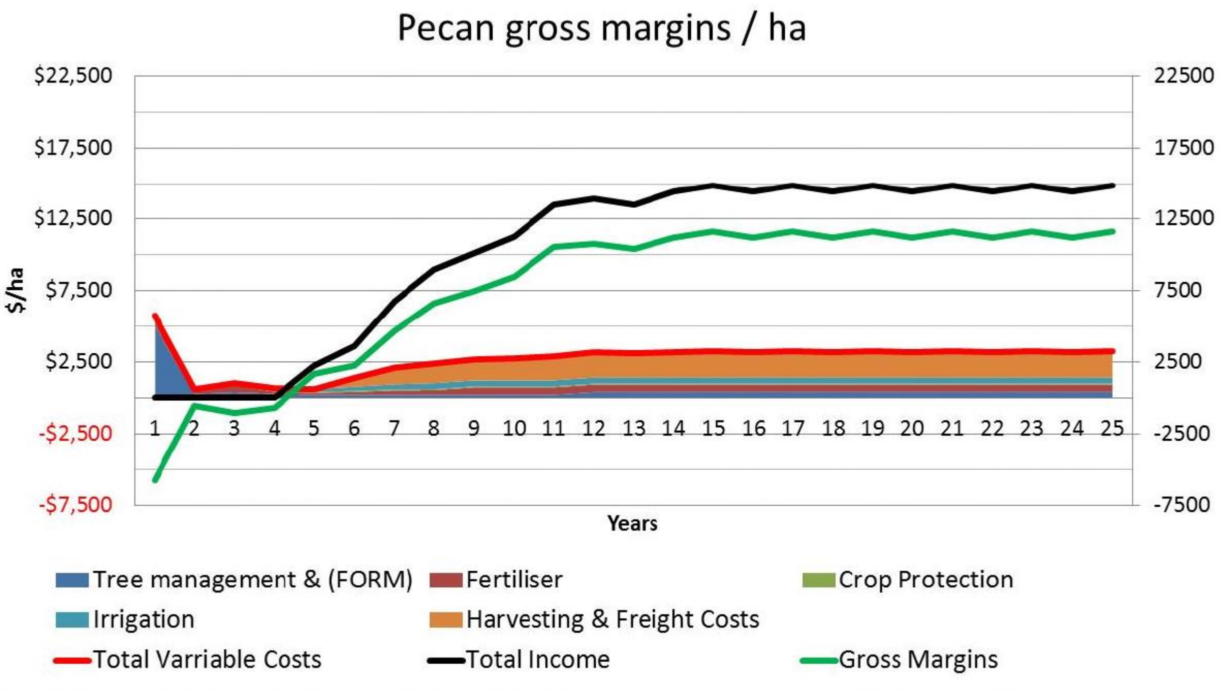
To illustrate potential input costs, incomes and gross margins over time, the project economist has grouped the variable costs of pecan production and income from AgMarginsTM into Figure 78. Due to both machinery costs and crop production costs being relatively small compared to other costs and income they have been grouped together. Initially tree management cost is high due primarily to tree planting costs, as indicated in Figure 78. Costs increase again after year-12 due to mainly to increased pruning costs necessary to manage the canopy of large mature trees. As the trees mature yields increase, fertiliser application rates also increase, water demand rises and plant health maintenance costs reach their peak. The largest increases in input costs are for harvesting and transportation. The figure below highlights the impact of the one off expensive tree establishment phase costs. This combined with the fact that there is no pecan income in that year results in the lowest gross margin (Figure 76 and Figure 78). However as illustrated below in year 5 income exceeds variable costs and the gross margins are expected to be $1653/ha. In year 11 production is nearing steady-state yields, and the crop gross margins peak and plateau.

Figure 78 - Income, gross margins and variable costs over time.



Gross margins are often used for short-term decisions where capital and overhead cost are considered sunk costs. That is, they cannot be easily changed in the short-term. <u>When establishing a new enterprise, gross margins information is insufficient as additional overheads and investment in capital is also required.</u>

Annual overheads for this 100 hectare enterprise is set at $94,000 to cover permanent family labour $30k, permanent labour hire $55k, and other costs at $9k. The cost of land has not been included as this research is investigating cropping options for current farmers within the QMDB study area so only the production systems upon the current land might change. The capital cost of investment for the 100 hectare pecan enterprise is given in (Table 8).

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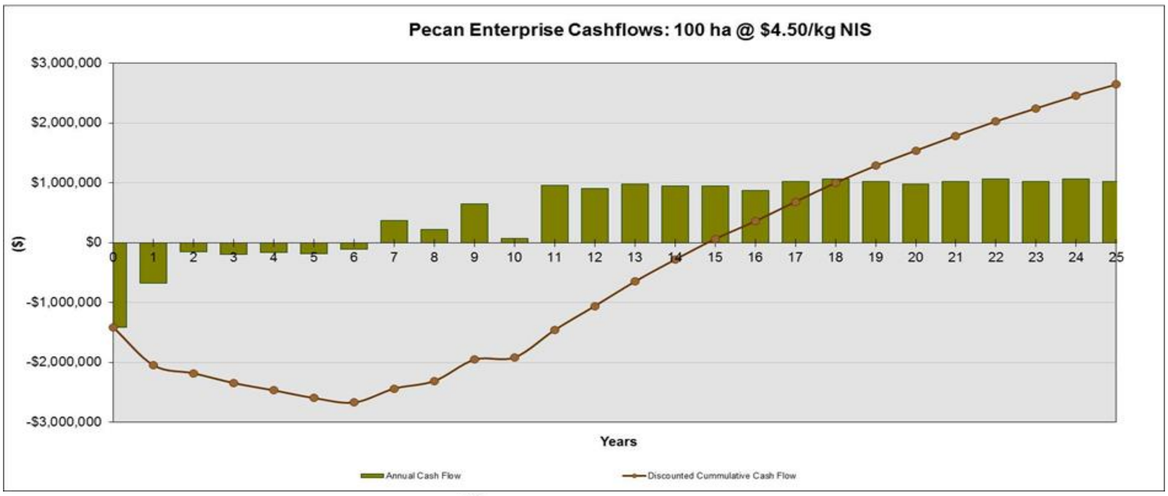
Table 8 - Capital investment cost over time for a 100 ha pecan enterprise.

Capital Costs of Project				
Item	**Cost ($)**	**Year of Initial Purchase**	**Item Life (Years)**	**Salvage Value (%)**
Tractors & Vehicles				
Tractor 80hp	$80,000	1	10	20.00%
Tractor 80hp	$80,000	5	10	20.00%
Four wheel bike	$12,000	1	5	20.00%
Implements				
Slasher (8ft)	$8,000	1	20	20.00%
Trailer (4)	$2,000	2	10	20.00%
Trailer (2)	$1,000	5	10	20.00%
Boomspray for herbicides	$3,000	1	10	25.00%
Harvesting (PTO type)	$60,000	6	10	20.00%
Sweepers x 2	$70,000	6	10	20.00%
Shaker	$110,000	6	10	20.00%
Irrigation inferstructure				
Main system costs (pump, filter, mainline & automation)	$300,000	1	40	0.00%
Infastructure cost based on $/ha	$800,000	1	40	0.00%
Captial water allocation purchase costs: 1st x 2 ML/ha	$160,000	1	40	100.00%
Captial water allocation purchase costs: 2nd x 2 ML/ha	$160,000	5	40	100.00%
Captial water allocation purchase costs: 3rd x 2 ML/ha	$600,000	10	40	100.00%
Workshop equipment	$5,000	1	10	0.00%
Shed Machinery				
Cleaning shed	$200,000	8	40	10.00%
Drying units	$150,000	8	20	10.00%
Buildings & Sheds				
Machinery shed	$25,000	1	40	30.00%
Maintenance shed	$25,000	1	40	30.00%

By incorporating the gross margins, overheads and capital investment costs over time, along with a financial discount rate of 7.0% p.a. for the time value of money, it is possible to estimate the annual cash flows and the cumulative discounted cash flows to ascertain the time to breakeven (Figure 79). This is based on the yields indicated in Figure 75. It is estimated that the enterprise will break even in the 15th year. The cumulative net benefit before tax and interest (EBIT) are estimated to be greater than $2.6m in today's money from the 100 ha enterprise by the 25th year. The cash flow is expected to be positive in the 7th year. This is two-years after making a positive gross margin (Figure 78) due to the additional overhead and capital costs. The greatest out flow of cash occurs in the first years (purchasing of capital and planting cost).

Figure 79 - Annual cash flows based on gross margins with nut in shell (NIS) at $4.50/kg, overheads and capital investment costs over time; and the discounted cumulative cash flow based on 7.0% pa.



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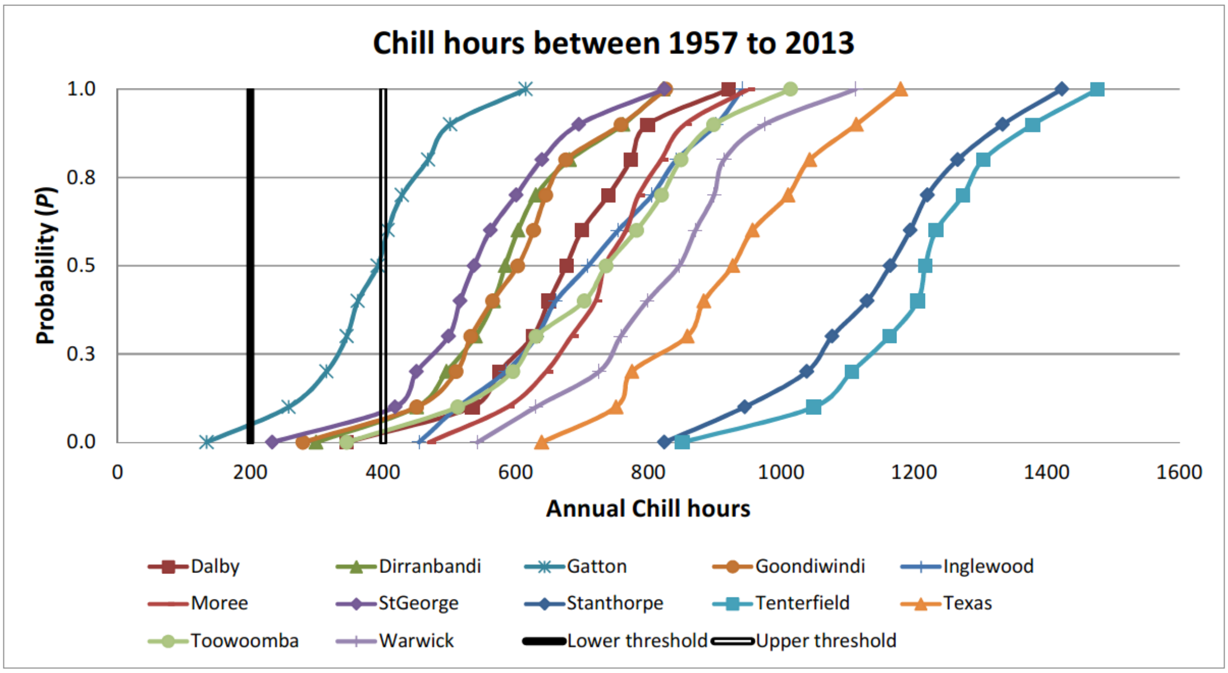
2 Bioeconomic modelling of pecan production in Southern Queensland

The four key biophysical production drivers are sufficient water, deep draining soil, sunlight and chilling hours. By securing water and choosing an area with deep draining soil, a grower can mitigate these two constraints. It will be assumed that there is sufficient sunlight within Queensland to obtain unconstrained yields. Sufficient chilling is however highly variable and may impact on pecan yields. Chill hours being all hours between 0 and 7.2°C (Weinberger, 1950). The chill hours for the different regions are reported as cumulative distribution function (CDF) to indicate the probabilities of chilling hours in different regions (Figure 80). The lower (200) and upper (400) threshold for the minimum chill hours required for pecan production is also reported.

Figure 80 - A cumulative distribution function of chill hours across Southern Queensland and Northern NSW (1957-2013). The measured chill hours are on the x-axis and the probability (P) is given on the y-axis; where 0.5 is the median (expected), 0.0 is the worst-case and 1.0 the best-case scenario.



This data indicates that many regions within the QMDB study area have suitable chill hour accumulation to allow effective pecan yield.

3 Economies of scale for pecan enterprises

Economies of scale come from an efficient enterprise size (plant, equipment and labour are all used to maximum efficiency), minimising waste and down time. To determine the most efficient enterprise size it is essential to consider both the payback periods and the annuity equivalent of the 25-year net present value of the deterministic model, with the same level of capital equipment and overheads (Figure 80). For this analysis the irrigation capital costs are treated as both fixed and variable with respect to the size of the property (Figure 76, Figure 77, and Table 8). The fixed components include the pump, filter, mainline and automation at $300k, the irrigation infrastructure within the paddock cost $8k/ha and capital water allocation purchase cost for 2 ML/ha in years 1,5 and 10, being $1.6k, $1.6k and $6k with the latter being for more secure water (guaranteed supply), respectively.

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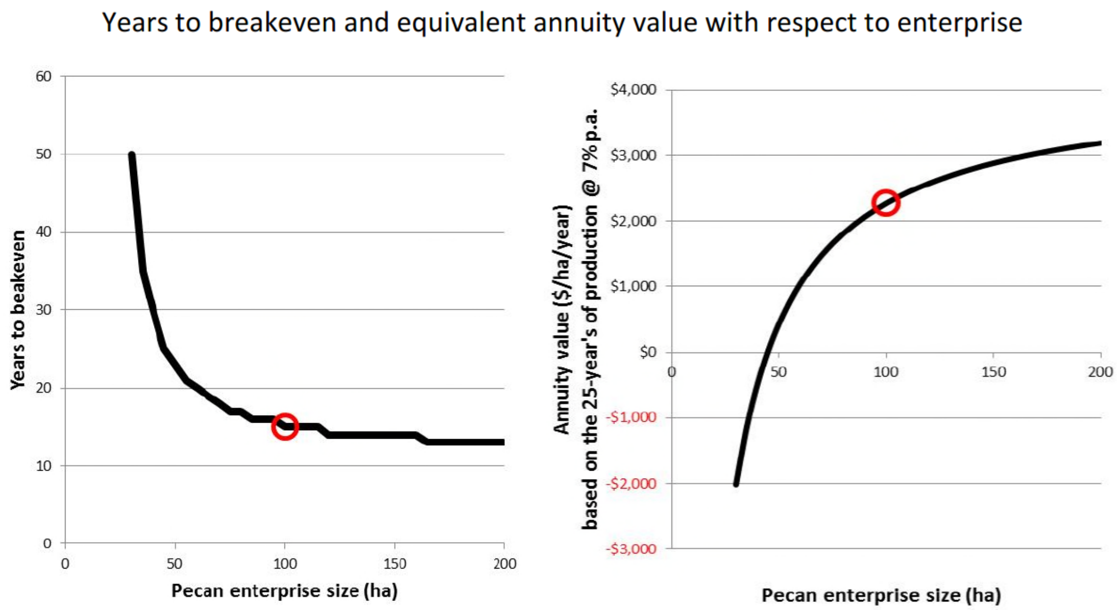
Figure 81 - The estimated years to breakeven and annuity value ($/ha/year) based on the discounted cumulative cash flows for 25-years of production (deterministic) with respect to different pecan enterprise sizes (ha). Apart from in field irrigation capital costs and water allocation capital costs, all other capital costs and overhead costs are assumed to be constant. The red circles indicates a 100 ha enterprise which has been used as the basis for this analyses.



Project economists also investigated the change in 25-year discounted cumulative cash flow (DCF) which resulted in a linear relationship of DCF = -$2M+ $47,851x *ha* therefore it was not graphed. This indicates 42 hectares being the minimum area to have a positive DCF which is also illustrated in Figure 81.

4 Effects of price on pecan enterprises

Pecan nut price is one of the two the major drivers affecting the viability of pecan production. This economic analysis used the 2015 farm gate price of $4.50/kg nut in shell (NIS). Based on a 100 ha pecan enterprise with 200 trees/ha the project economist investigated the likely effect of a range of pecan prices between $2.50 to $10/kg NIS (Figure 82).

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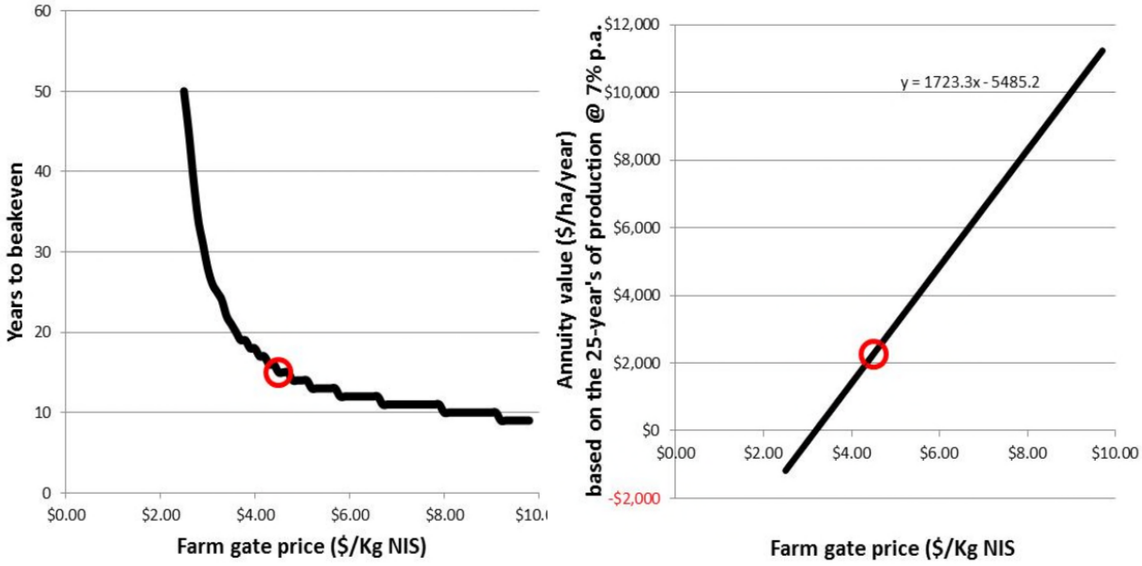
Figure 82 - The estimated years to breakeven and annuity value ($/ha/year) based on the discounted cumulative cash flows for 25-years of production (deterministic) with respect to different pecan farm gate prices ($/kg nut in shell). The red circle indicates the 2014 price of $5.33/kg NIS).



Both the change in yield (kg/ha) and pecan prices ($/kg) affect the viability of the pecan enterprise. To investigate which has a greater impact on a 100 ha enterprise, both will be independently decreased by 10%. Both these changes resulted in the payback period increasing from 15 years to 17 years. The average annual equivalent of 25-years of discounted cumulative cash flow per hectare (annuity) at a discount rate of 7%, decreased from $2270/ha/year to $1557/ha/year and $1494/ha/year, for a 10% change in yield and price, respectively. This equates to a 31.4% and 34.2% decrease, indicating that the enterprise is slightly more sensitive to changes in pecan farm gate prices than changes in yield.

5 Discussion and Conclusion

This analysis investigated the feasibility of growing pecans across the Queensland Murray Darling Basin (QMDB) study area with respect to capital investment costs, annual returns, and the payback periods in conjunction with environmental factors.

There are four primary requirements to attain unconstraint yields: sufficient water, deep draining soil, sunlight and chilling conditions. Local knowledge and a review of the biophysical constraints impacting pecan growth show chilling requirements to be a primary risk driver in maximising pecan production potential in the QMDB study area. To investigate and quantify this potential constraint a bioeconomic model was developed based on the historic chill hours for 16 locations across southern Queensland and northern NSW (1957-2013). The analysis was based on a 100-hectare enterprise with 200 trees/ha over a 25-year time horizon.

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The first step was to develop a deterministic model based on historic yields to identify the annual and discounted cumulative cash flows and payback periods. The greatest cash outflow of about $1.4M occurred in the first year due to costs incurred from the purchasing of capital equipment, infrastructure, a water licence and planting trees. The analysis was based on a current grower converting part of their farm to pecan production and therefore the cost of land was not included in the analysis. The cash outflow continued to accumulate to a total of -$2.67M, after which production was sufficient to produce positive annual cash flows. Breakeven is estimated to occur after the 15th year, and the pecan enterprise had a net present value of $1M at 18 years, $2M at 22 years and $2.6M at 25 years.

The size of the enterprise will also have an impact on the viability of the enterprise due to capital infrastructure costs. Figure 80 indicates that doubling the size of the enterprise to 200 ha will reduce the payback period from 17 years to 13 years. This will also increase the average annual equivalent of 25-years of discounted cumulative cash flow per hectare (annuity) at a discount rate of 7% from $2270/ha/year to $3188/ha/year, being a -40% increase; however, the discounted cumulative cash flow in year 6 also increases from -$2.67M to -$4.27M which is a -60% increase in investment funds that are required. If on the other hand the enterprise is halved to 50 ha, the payback period increases from 17 years to 23 years, and the annuity decreases from $2270/ha/year to $433/ha/year, a -81% reduction. This indicates that decreasing economies-of-scale have a greater impact on the viability of the pecan enterprise. This is also indicated in the shape of the curves in Figure 80. For enterprises <45 hectares in size a positive annuity is unlikely within 25 years.

The market price of pecans will also affect the viability of the enterprise. Figure 81 investigates the effects of pecan farm gate prices on the payback period and the annuity value ($/ha/year) over 25-years. For a 100 ha pecan enterprise, if the market prices were to double the payback period will decrease from 17 years to 10 years; whereas, a halving in the prices will increase the payback period from 17 years to -60 years. That is, payback period is more sensitive to a downward movement in pecan prices. The relationship of the annuity to pecan farm gate prices is linear (Figure 81) being: Annuity ($/ha/year) = -5485 + $1723 x $ 1 kg (NIS). This means that for every dollar increase in pecan prices the annuity increases by $1723/ha/year. If the pecan farm gate price is <$3.20/kg (NIS) the 25-year annuity will also be negative. The analysis also found that pecan enterprises are slightly more sensitive to a 10% decrease in pecan farm gate prices (31.4%) than a 10% decrease in yields (34.2%) with respect to annuities.

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