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

Case study III: Bioeconomic analysis of potential Southern Qld. Blueberry production

(1 August 2014 to 30 June 2016)

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Case study III: Bioeconomic analysis of potential Southern Qld. Blueberry production

Blueberries are plants of the genus *Vaccinium* that are grown for their much sought-after dark berries which can be consumed raw, added to breakfasts, baked goods, yogurts or made into jams. A number of species of blueberries occur naturally in the northern hemisphere in particular in North America were cultivation of these species first occurred. The berry colour ranges from maroon to purple-black and the flesh remains semi-transparent and encases tiny seeds. Cultivated berries are usually mildly sweet, whereas those which grow in the wild have a more tangy flavour. Blueberries are a good source of antioxidants as well as being a rich source of vitamins and minerals.

Blueberries were first introduced into Australia in the early 1970s. The cold climate varieties such as ‘northern highbush’ are suited to southern Australian regions such as Victoria, Western Australia, South Australia, and the southern highlands of New South Wales and Tasmania. By 1978 it was recognised that the warmer climate ‘southern highbush’ and ‘rabbiteye’ varieties from the southern states of the USA would grow on the New South Wales north coast and produce high value, early season fruit. For this reason a large percentage of Australia’s blueberry production now comes from the New South Wales north coast. Currently, production continues to increase in all states of Australia (Keogh 2010).

There is currently a high demand and price offer for fresh blueberry in Australia and internationally (P.Wilk, pers comm.). Blueberry production within Australia is a relatively new industry and as such there are numerous agronomic and economic questions around the optimal production techniques that could maximise grower returns.

Blueberries are grown on a long lived bush and plantation establishment costs are significant but offer ongoing returns over a number of years (4 – 6). Blueberry plantations can be either grown in-ground under netting or in bags within tunnels. Like most ground grown crops replanting the same crop in the same area will result in a build-up of soil born pests and diseases, affecting yields and crop returns. Growers commonly use two production methods to manage this issue, 1) moving netting and replanting in another part of the farm or 2) planting more intensively in bags within tunnels.

Potential growers with in the QMDB study area sought more information about these two production systems including, annual gross margins, capital investment costs, expected net profits, payback periods, and cash flows over time. Information was also sought about the optimal plant replacement time from both an agronomic and economic perspective, and the projected return on investment under both the soil grown and bagged production systems. Being a relatively new niche industry there is little published information about packaging costs (on farm or contracted out) or what size

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plantation is required to maximise profit potential. The blueberry economic analysis developed for the Queensland Murray Darling Basin study area growers assumes an existing landholder is considering alternative high value horticulture crops, hence land values are not been included within the analysis. Growers considering purchasing land and developing it for blueberry production will need to include additional land costs, including water.

1. Blueberry margins and cash flows over time

Variable costs and yields differ from year to year; therefore, the gross margins and net profits also change over time. The two main contrasting periods (years) are the first and steady-state (full production) years (Table 9; Wilk & Simpson 2015). This table provides a detailed overview of the typical inputs required for blueberry establishment and production. All prices are based on today's prices and are not financially discounted, as some growers already have existing blueberry production, so can use AgMargins™ to assess their current steady-state production and marketable yield

Crop gross margins for tunnel production are higher due to decreased fruit damage from weather effects and therefore give increased yields and enhance fruit quality. However, setting up tunnel based production systems is initially more expensive and has higher capital costs than ground grown plantations under net. Throughout this analysis a farm gate price of $20/kg for blueberries has been used in developing these gross margins. Should this change then the gross margins and profits will also change. A sensitivity analysis of blueberry prices is also provided and this demonstrates the effect of changes in both crop yield and price.

Within the bioeconomic model the figures used will consider financial discounting and the time to breakeven.

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Table 9 – Gross income, variable costs and resulting gross margins over time under netting and in tunnels at Goondiwindi (Inglewood) 2016 (AgMargins™).

Blueberry gross margins (2016)

based on 3600 bushes/ha under netting in Goondiwindi (AgMargins)

	Establishment (Year 1)	Year 2	Year 3	Year 4-7	Year 8-10
Yield	0 kg/ha @ $20/kg	3600 kg/ha @ $20/kg	7200 kg/ha @ $20/kg	14,400 kg/ha @ $20/kg	10,800 kg/ha @ $20/kg
Income ($/ha)	**$0**	**$72,000**	**$144,000**	**$288,000**	**$216,000**
Variable Costs ($/ha)					
Preperation & plant management					
Spraying, green manure, bed forming, weed matting & labour	10,981				
Plants	30,240				
Weeding		2,551	2,551	2,551	2,551
Pruning & thinning		5,103	5,103	5,103	5,103
Pollination services (bee hive)		900	900	900	900
Nutrition					
Sprayer		812	812	812	812
Nutrients	96	959	959	959	959
Leaf & soil testing		185	185	185	185
Crop Protection					
Spraying FORM	271	1,015	1,015	1,015	1,015
Chemicals	1,168	2,541	2,541	2,541	2,541
Irrigation					
2ML+FORM	140				
6ML+FORM		420	420	420	420
Harvesting					
Picking labour		13,608	27,216	54,432	40,824
Packaging		8,976	17,952	35,904	26,928
Cooling fruit		36	72	144	108
Packing Labour		1,134	2,268	4,536	3,402
Packing electricity		450	900	1,800	1,350
On-farm cartage (FORM)		152	303	606	455
Cartage					
Transport		836	1,672	3,344	2,508
Levies					
Commission 10%		7,200	14,400	28,800	21,600
Industry levies 1.1%		792	1,584	3,168	2,376
Royalties 3.0%		2,160	4,320	8,640	6,480
Total variable costs ($/ha)	**$42,895**	**$49,829**	**$85,172**	**$155,860**	**$120,516**
Gross margins ($/ha)	-$42,895	$22,171	$58,828	$132,140	$95,484

Blueberry gross margins (2016)

based on 3600 bushes/ha in tunnels in Goondiwindi (AgMargins)

	Establishment (Year 1)	Year 2	Year 3	Year 4-7	Year 8-10
Yield	0 kg/ha @ $20/kg	4200 kg/ha @ $20/kg	8500 kg/ha @ $20/kg	17,000 kg/ha @ $20/kg	12,700 kg/ha @ $20/kg
Income ($/ha)	**$0**	**$84,000**	**$170,000**	**$340,000**	**$255,000**
Variable Costs ($/ha)					
Preperation & plant management					
Spraying, bags, soil & labour	35,520				
Plants	30,240				
Weeding		2,551	2,551	2,551	2,551
Pruning & thinning		5,103	5,103	5,103	5,103
Pollination services (bee hive)		900	900	900	900
Nutrition					
Sprayer		812	812	812	812
Nutrients	96	958	958	958	958
Leaf & soil testing		185	185	185	185
Crop Protection					
Spraying FORM	271	1,015	1,015	1,015	1,015
Chemicals	840	2,311	2,311	2,311	2,311
Irrigation					
2ML+FORM	140				
6ML+FORM		420	420	420	420
Repair drippers		98	98	98	98
Harvesting					
Picking labour		15,876	32,130	64,260	48,195
Packaging		10,472	21,193	42,387	31,790
Cooling fruit		42	85	170	128
Packing Labour		1,323	2,677	5,355	4,016
Packing electricity		525	1,063	2,125	1,594
On-farm cartage (FORM)		177	358	716	537
Cartage					
Transport		975	1,974	3,948	2,961
Levies					
Commission 10%		8,400	17,000	34,000	25,500
Industry levies 1.1%		924	1,870	3,740	2,805
Royalties 3.0%		2,520	5,100	10,200	7,650
Total variable costs ($/ha)	**$67,107**	**$55,587**	**$97,803**	**$181,253**	**$139,528**
Gross margins ($/ha)	-$67,107	$28,413	$72,197	$158,747	$115,472

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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. When entering an industry, gross margins information is insufficient as additional overheads and investment in capital is also required.

1.1 Blueberry labour cost

Current blueberry production systems required high levels of labour. From the information provided in AgMarginsTM for blueberry production in Goondiwindi under netting and in tunnels, it is estimated that over 40% of total variable costs can be attributed to labour costs alone. Initial plant establishment (planting), crop harvesting and crop packing are all high labour activities.

As the blueberry plantation increases in size so does the annual expenditure on labour , for example a 10 hectare enterprise will spend on average >$0.5m p.a. while for 20 hectares this cost will increase to >$1m p.a. Labour management and efficiency is a crucial skill in maximising viability in these high labour input businesses. Agricultural automation and possibly even to the use of robotics for picking fruit or on farm transport activities may offer cost savings in future years to larger scale plantations.

Table 10 – Labour requirements for blueberry production systems under netting and in tunnels at years 1-10 of production.

		Labour / ha				
		Year 1 Establish-ment	Year 2	Year 3	Year 4-7	Year 8-10
Under netting	**$/ha**	**$ 7,796**	**$22,396**	**$37,138**	**$66,622**	**$49,967**
	(% of total variable costs)	(2.6%)	(44.9%)	(43.6%)	(42.7%)	(43.2%)
In tunnels	**$/ha**	**$11,907**	**$24,853**	**$42,462**	**$77,269**	**$57,952**
	(% of total variable costs)	(3.0%)	(44.7%)	(43.4%)	(42.6%)	(43.0%)

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2. Blueberry overhead (fixed) costs and cash flows over time

Production systems often have overhead costs that relate directly to production enterprises as well as general business overheads. For example, blueberry production under netting will have periodic capital expenses in relation to the replacement of netting, moving poles, irrigation systems and planting preparation. This also applies for blueberry crops produced in tunnels. There are general overhead costs associated with manager/owner wages, insurance, machinery, irrigation/fertigation and for example purchasing a spray unit, these will differ based on enterprise size and plantation layout.

2.1 Replanting frequency effects on production and capital payments

Most tangible assets have a life expectancy, and the replacement frequency of the asset will also depend on when it can physically be incorporated into the production system. The replacement of netting or tunnel plastic, for example, needs to occur when there are no plants within that area (Table 11). The same holds true for many other production capital costs such as replacing irrigation systems. Asset replacement costs will therefore affect plant replacement frequency. For example, netting has a life expectancy of 10-15 years, and with a planned seven year blueberry plant replacement program this will result in the netting being used for two crops and the nettings full life expectancy curtailed at 14 years. However with an eight year planned plant replacement strategy, the netting will have to be replaced with each crop, as it is unlikely to last 16 years. This is just one example to explain the need to consider the life expectancy of all tangible crop growth assets as well as the cost of replacement plants, planting labour costs and most importantly plant yield potentials as they age. These are examples of capital overhead costs that can be apportioned on a per hectare basis, and therefore can be considered independent of economies of scale. In addition, there are general business overheads, which are fixed for a given enterprise scale, and tend to decreased on a per hectare basis as the enterprise increases in size (until the optimum enterprise/input level is reached).

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Table 11 - Production capital expenditure ($/ha) over time for blueberry enterprise under netting and in tunnels with different replanting frequencies.

Blueberry production under netting

Plant replacement frequency	Life expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25
3 year	5-10 years 10-15 years 25 years	B D E+F+G		A		A		A		A+B		A		A C+D		A		A		A+B		A		A		
4 year	5-10 years 10-15 years 26 years	B D E+F+G			A			A			A+B			A C+D			A			A+B			A			
5 year	5-10 years 10-15 years 27 years	B D E+F+G				A				A+B				A C+D				A+B				A				
6 year	5-10 years 10-15 years 28 years	B D E+F+G					A					A+B C+D					A					A+B C+D				
7 year	5-10 years 10-15 years 29 years	B D E+F+G						A+B						A+B C+D						A+B						
8 year	5-10 years 10-15 years 30 years	B D E+F+G							A+B							A+B C+D							A+B			
9 year	5-10 years 10-15 years 31 years	B D E+F+G								A+B C+D								A+B C+D								
10 year	5-10 years 10-15 years 32 years	B D E+F+G									A+B C+D									A+B C+D						

ID	Under netting (Life expectency)	Cost
A	Resetting poles, planting & labour (5-10Y)	$15,000
B	Irrigation & labour (5-10Y)	$5,330
C	Replace netting (10-15Y)	$15,000
D	Air-conditioner (10-15Y)	$4,500
E	New netting with poles & labour (25Y)	$50,000
F	Water licence @ $800/ML (25Y)	$4,800
G	Scales and tables (25Y)	$3,000

Assuming removal and relacement of plants same year

Blueberry production in tunnels

Plant replacement frequency	Life expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25
3 year	5-8 years 10-15 years 25 years	A+B D E+F+G								A+B+C				D						A+B+C						
4 year	5-8 years 10-15 years 25 years	A+B D E+F+G									A+B+C			D						A+B+C						
5 year	5-8 years 10-15 years 25 years	A+B D E+F+G								A+B+C				D				A+B+C								
6 year	5-8 years 10-15 years 25 years	A+B D E+F+G										A+B+C D										A+B+C D				
7 year	5-8 years 10-15 years 25 years	A+B D E+F+G						A+B+C						A+B+C D						A+B+C						
8 year	5-8 years 10-15 years 25 years	A+B D E+F+G							A+B+C							A+B+C D							A+B+C			
9 year	5-8 years 10-15 years 25 years	A+B D E+F+G								A+B+C D								A+B+C D								
10 year	5-8 years 10-15 years 25 years	A+B D E+F+G									A+B+C D									A+B+C D						

ID	In tunnels (Life expectency)	Cost ($/ha)
A	Piping, risers, drippers & labour (5-10Y)	$20,350
B	Weedmat, pavers & tunnel wire (5-10Y)	$13,770
C	Replace tunnel plastic + labour (5-10Y)	$20,000
D	Air-conditioner (10-15Y)	$4,500
E	Spanish High Tunnels (25Y)	$85,000
F	Water licence @ $800/ML (25Y)	$4,800
G	Scales and tables (25Y)	$3,000

Best management practices (BPM) of blueberry production under netting requires replacement plants to be placed at another location on the farm due to pest and disease build up in the soil, requiring capital expenditure on ground preparation, netting, poles and irrigation relocation. Planned blueberry plant replacement in tunnel production requires tunnel plastic replacement to occur when tunnels are vacant of plants.

2.2 Overhead costs with respect to enterprise size

Blueberry enterprises have general overhead costs which cannot easily be directly contributed to individual production activities. These include permanent wages, insurance, and general equipment depreciation (Table 12). As the size of the enterprise increases, overheads tend to also increase in a step wise manner. For example, a manager of a 1-5 hectare blueberry enterprise may need to spend a third of their time on the business, organising labour, ordering product and working on general business activities. Once the business enterprise increases beyond this size the manager will need to spend considerably more time in an organisational role in the business. Each blueberry enterprise will have different overheads and therefore Table 12 should be considered an example of a blueberry enterprise, but it will for our purposes indicate economies of scale effects. Although overheads do tend decrease per hectare as enterprise sizes increase, there are thresholds where they initially increase per hectare. For the blueberry example, when the enterprise increases from five to six hectares, overheads per hectare initial increases from $10,833/ha to $16,111/ha but then tends to decrease again as the enterprise size increases.

Table 12 – Total overheads of different sized blueberry enterprises ($/year) for both blueberry production under netting and in tunnels.

Overheads for different sized blueberry enterprises ($/year)

Hectares	1-5	6-10	11-20
Manager/own wages (1/3, 2/3 & full time)	$20,000	$40,000	$60,000
Insurance, phone, advertising & misc.	$20,000	$25,000	$30,000
General machinery depreciation	$5,000	$10,000	$15,000
Fertigation/filter depreciation	$2,500	$5,000	$7,500
Tractor depreciation	$3,333	$8,333	$13,333
Spray unit depreciation	$3,333	$8,333	$13,333
Total	**$54,167**	**$96,667**	**$139,167**
Max overheads/ha per enterprise size	$54167/ha for 1ha	$16111/ha for 6ha	$12652/ha for 11ha
Min overheads/ha per enterprise size	$10833/ha for 5ha	$9667/ha for 10ha	$6958/ha for 20ha

3. Cash flows and net present values (NPV) based on economies of scale

By combining gross margins and production capital payments over time, as well as general business overheads it is possible to estimate the cash flow over time, as well as the payback period. Using an industry standard based on an 8-year plant replacement cycle it is possible to estimate cash flows for 5, 10, and 20 hectare blueberry enterprises over time (Figure 83) both under netting and in a tunnel based system working on farm gate blueberry prices of $20/kg. The discounted annual cash flows indicated by the green blocks include the gross margins, production capital costs and overhead costs in that year. The effects of discounting benefits far in the future can be observed by the decreasing annual cash flows as time increases (compare cash flow in years 4, 11, 18, and 25). The line is the cumulative cash flow discounted 7% Per annum for the time value of money, this can also be considered the net present value of the enterprise through time ignoring all future benefits.

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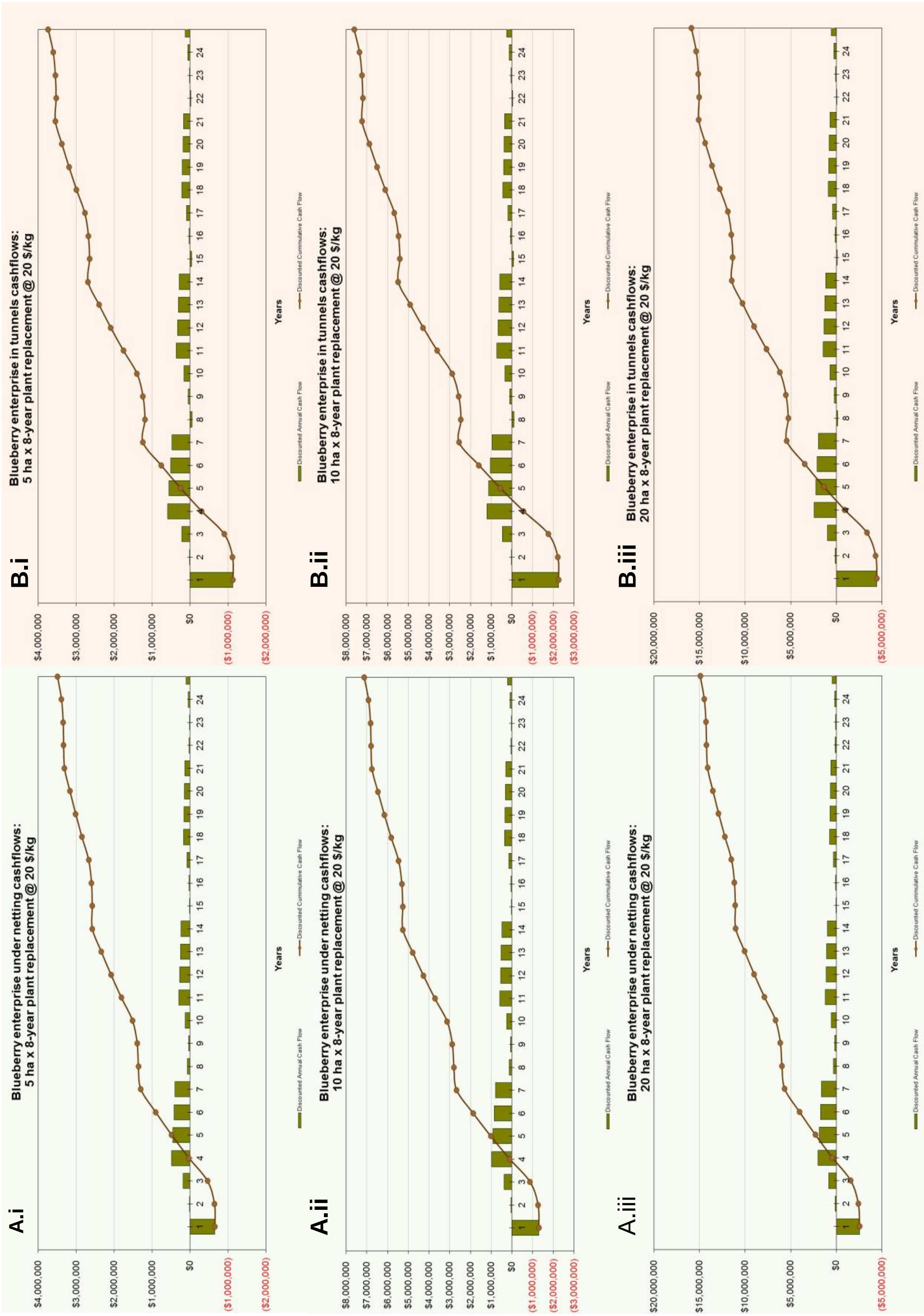
Figure 83 – Projected annual cash flows using gross margins based on $20/kg return, production capital investment and overhead costs over time; and the discounted cumulative cash flow based on 7.0% pa., for 8-year plant replacement under (A) netting and in (B) tunnels using (I) 5, (ii) 10 and (iii) 20 ha enterprises.



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Although gross margins in tunnels tends to be higher, so too are the initial capital investment costs, as indicated in year one (Figure 83). This extra capital outlay also extends the payback period for blueberry production systems in tunnels, where the cumulative discounted cash flow becomes positive. Due to the higher gross margins achieved in tunnel production systems, they also tend to have high net present values over the longer term.

4. Investigating the net present values of different replanting frequencies and economics of scale

To investigate the implications of both plant replacement frequency and enterprise size these variables are combined to provide the net present values (NPVs) at years 5, 10 and 25, under netting and in tunnels. These time periods can be considered as a measure of estimated wealth after the initial investment.

4.1 Net present values (NPVs) at year 5

At year five in an 8-year plant replacement blueberry production system on 10 hectare under netting, with blueberry prices of $20/kg, the estimated discounted NPV is $1,024,090 (yellow arrow in Figure 84.A.i). This value also correlates with Figure 83.A.ii at year five. In other words, ignoring all future benefits, an investor would be indifferent of receiving a cheque $1,024,090 now or all the cash flows (both outgoing and incoming) over that 5-year period. As the enterprise tends to increase in size (hectares) and time between plant replacement increases NPV tend to increase. As this is a snapshot at year five the benefits of plant replacements beyond this period has not been realised and therefore the graph is flat for plant replacement of 6-10 years.

Figure 84.A.i provides an indication of the relationship between plant replacement frequency and enterprise size; however, it is difficult to see actual values for a given plant replacement frequency and enterprise size, therefore we have provided the same information as a topographical graph – Figure 84.A.ii. (see yellow arrow). This indicates that with a blueberry prices at $20/kg, a plant replacement cycle of four years or less will result in net losses (negative NPVs), regardless of the enterprise size.

Figure 84.B.i and B.ii provides the NPVs for blueberry production in tunnels. As indicated in Figure 83.A.ii and B.ii, due to the high initial capital investment cost tunnels offer lower NPVs at the five year mark. Figure 84 also indicates that NPVs are highest for enterprises of 5, 10 and 20 hectares; this is due to stepped increases in overhead costs (Table 12).

4.2 Net present values (NPVs) at year 10

Many farmers consider ten years to be a long term investment and do not tend to consider the benefits beyond this time period (Figure 85). It is worth noting that at the ten year mark, there appears to be little difference in NPVs between blueberry production systems under netting or in tunnels, regardless of plant replacement cycles or enterprise size. Both offer the highest NPVs for plant replacements at ten years (if this is agronomically possible). Under netting there appears to be little difference in NPVs between plant replacements of 6-9 years. Within tunnels, 8-years appears to be sub-optimal due to the high cost of replacing tunnels plastic, irrigation systems and labour, which has occurred twice within the ten year period.

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Figure 84 – Discounted net present value (NPVs) at 5-years for blueberry production under (A) netting and in (B) tunnels for different enterprise sizes and frequency of replanting, ignoring any future cash flows. Results are given (i) 3-dimensionally to demonstrate the effects of enterprise size and replanting frequency and as a (ii) topographical map for a given production system, enterprise size and replanting frequency, i.e. the yellow arrow indicates that tunnel production of 10ha and 8-year replanting to have a NPV of ~$1m; which correlates with the value given in Figure 83.A.ii.

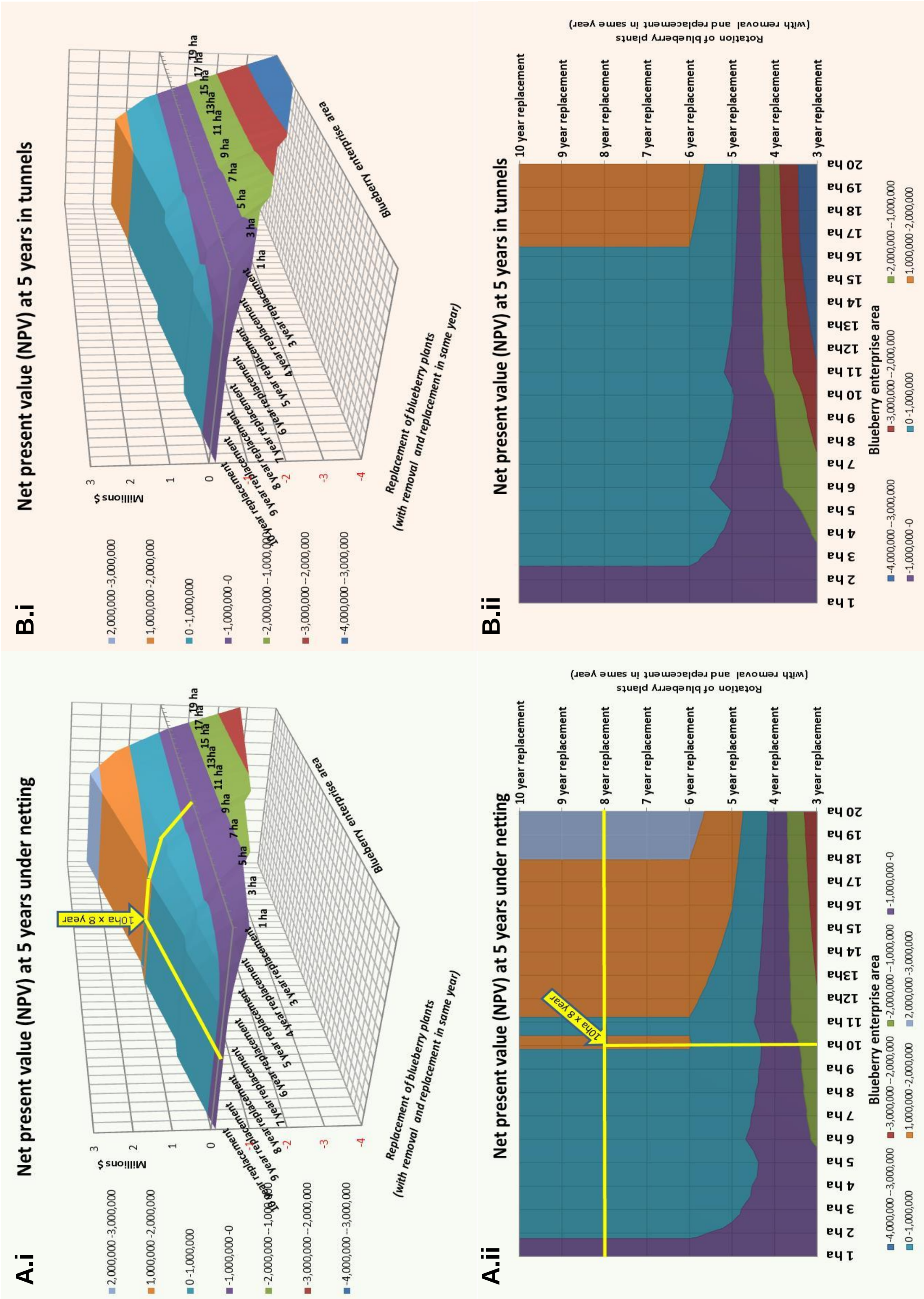

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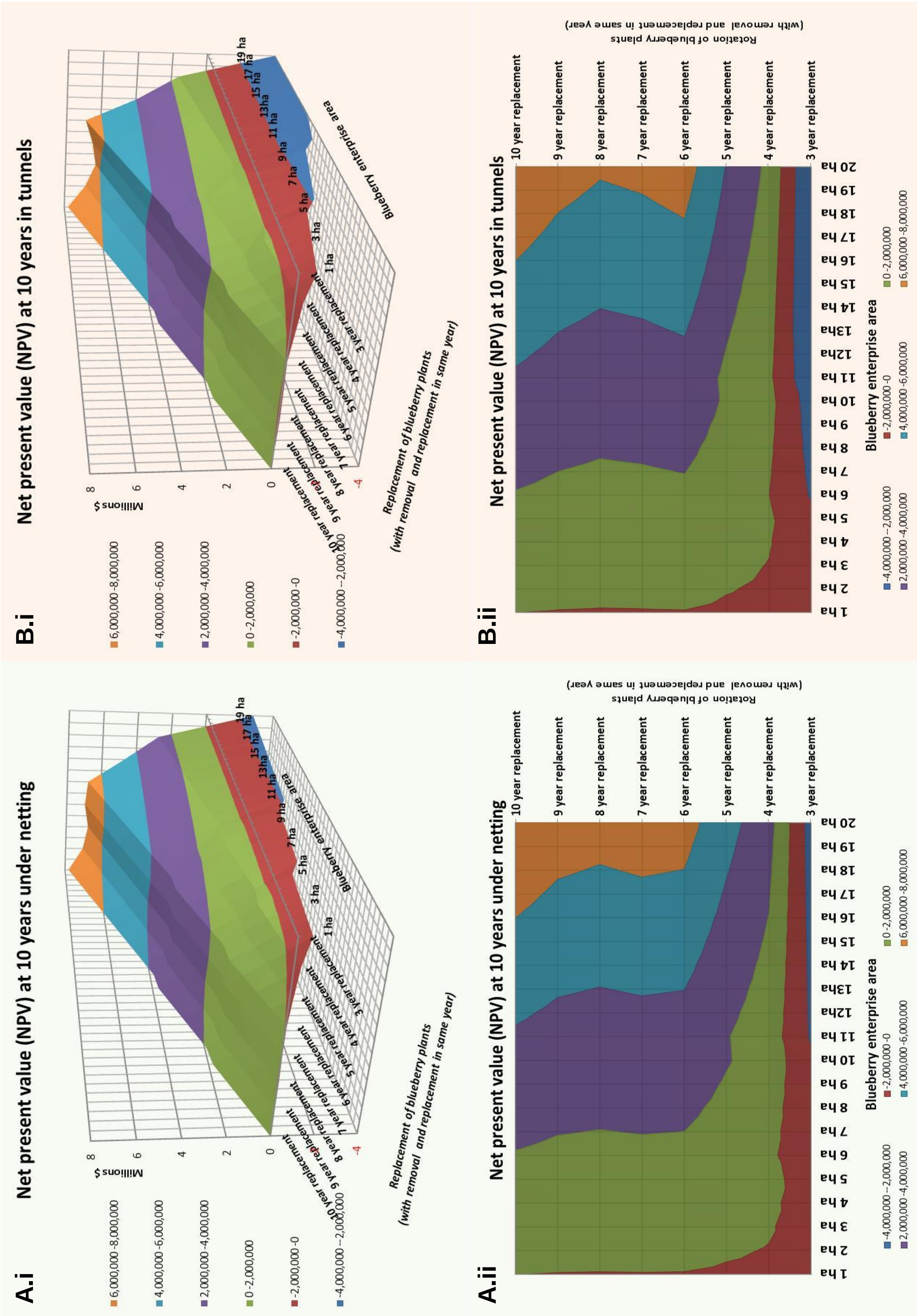
Figure 85 – Discounted net present value (NPVs) at 10-years for blueberry production under (A) netting and in (B) tunnels for different enterprise sizes and frequency of replanting, ignoring any future cash flows. Results are given (i) 3-dimensionally to demonstrate the effects of enterprise size and replanting frequency and as a (ii) topographical map for a given production system, enterprise size and replanting frequency.



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4.3 Net present values (NPVs) at year 25

It is possible for perennial production systems to operate for decades; however, benefits in the far future have little current benefit, as can be seen in Figure 83, year 25 contributes little to the current NPVs. There are however benefits at looking at the longer time horizon as production systems often expand over time with different parts of the farm in different plant growth states (Figure 86). This longer term scale can provide insight about plant replacement frequencies as well as economies of scale and can be considered the “steady state” production system.

Blueberry plant replacement cycles must be greater than every four years for both netting and in tunnels to return positive NPVs. The benefits of extending the time between planting increases significantly for up to seven years, and then it continues to increase but only marginally up to a 10-year cycle for plant replacements. Therefore, if there are agnomical reasons to replace plants more regularly, but at a minimum of every seven year, there will be little impact on economic returns. Therefore the industry standard of replacing blueberry plants every 8 years appears to be both agronomically and economically sound. The impact of economies of scale persist due to increased overhead costs for enterprises greater than 5 and 10 hectares, but with reduced overall impact. In Figure 84, Figure 85, and Figure 86, there is a clear correlation between increasing the enterprise size and the total net profit; however, this does not entirely indicate the economies of scale on a per hectare basis, i.e. is there a minimum or indeed a maximum size which maximises returns?

5. Investigating the NVPs

*per hectare at different replanting frequencies and economics of scale averaged over 25 years.

By dividing the results in Figure 86 by the number of hectares in a blueberry enterprise we can get the average NPV per hectare with respect to plant replacement frequency and enterprise size (Figure 87). Over a 25-year period there are significant benefits of enterprises being a minimum size of five hectares both under netting and in tunnel production systems, however if the enterprise expands to six hectares the average NPV per hectare decreases. Ideally, the enterprise should increase to nine and eight hectares for netting and tunnel production systems, respectively (Figure 87.A.ii and B.ii). Beyond the 10 hectare, enterprises should look at expanding to > 13 hectares to maximise NPVs per hectare.

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Figure 86 – Discounted net present value (NPVs) at 25-years for blueberry production under (A) netting and in (B) tunnels for different enterprise sizes and frequency of replanting, ignoring any future cash flows. Results are given (i) 3-dimensionally to demonstrate the effects of enterprise size and replanting frequency and as a (ii) topographical map for a given production system, enterprise size and replanting frequency.

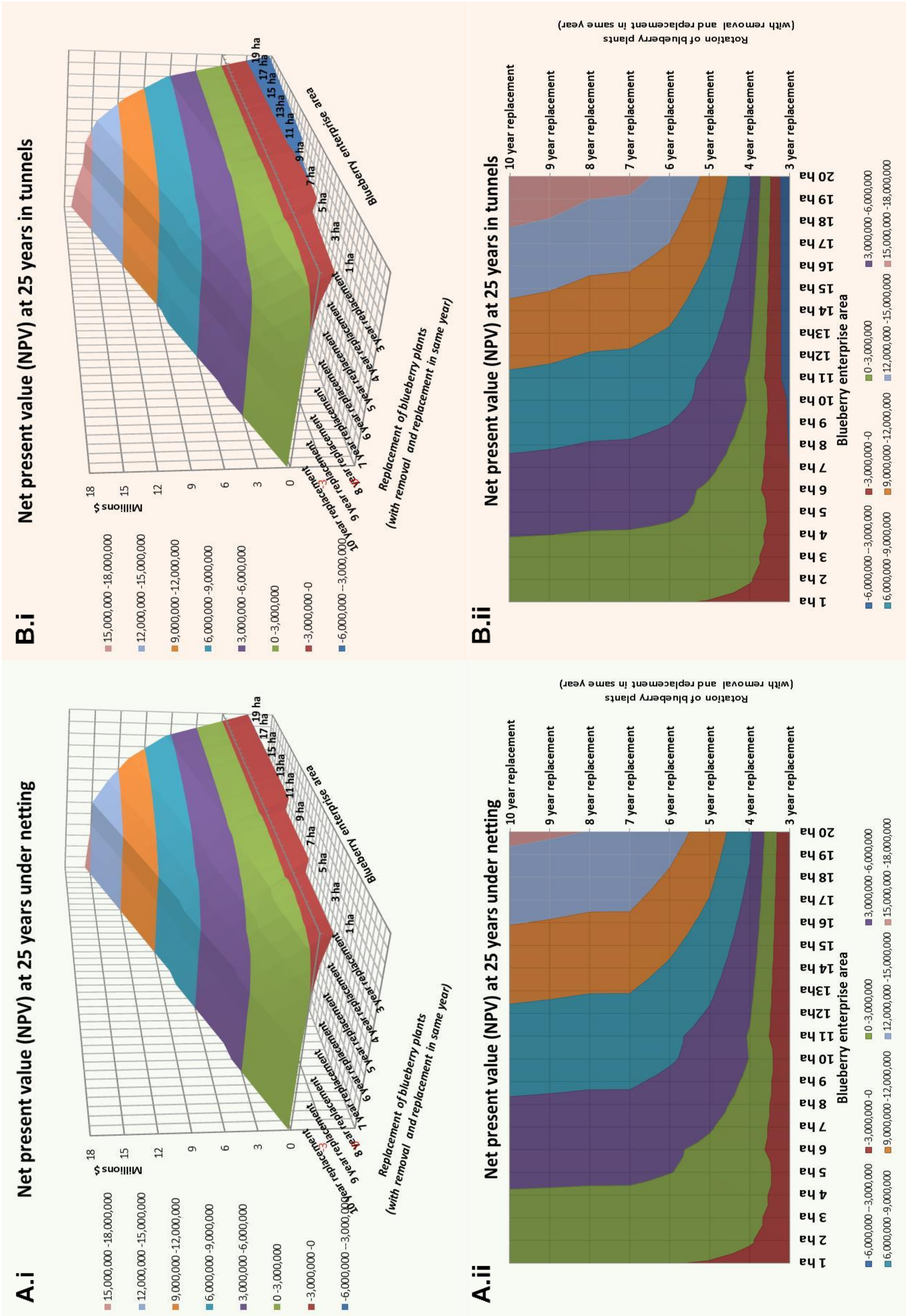

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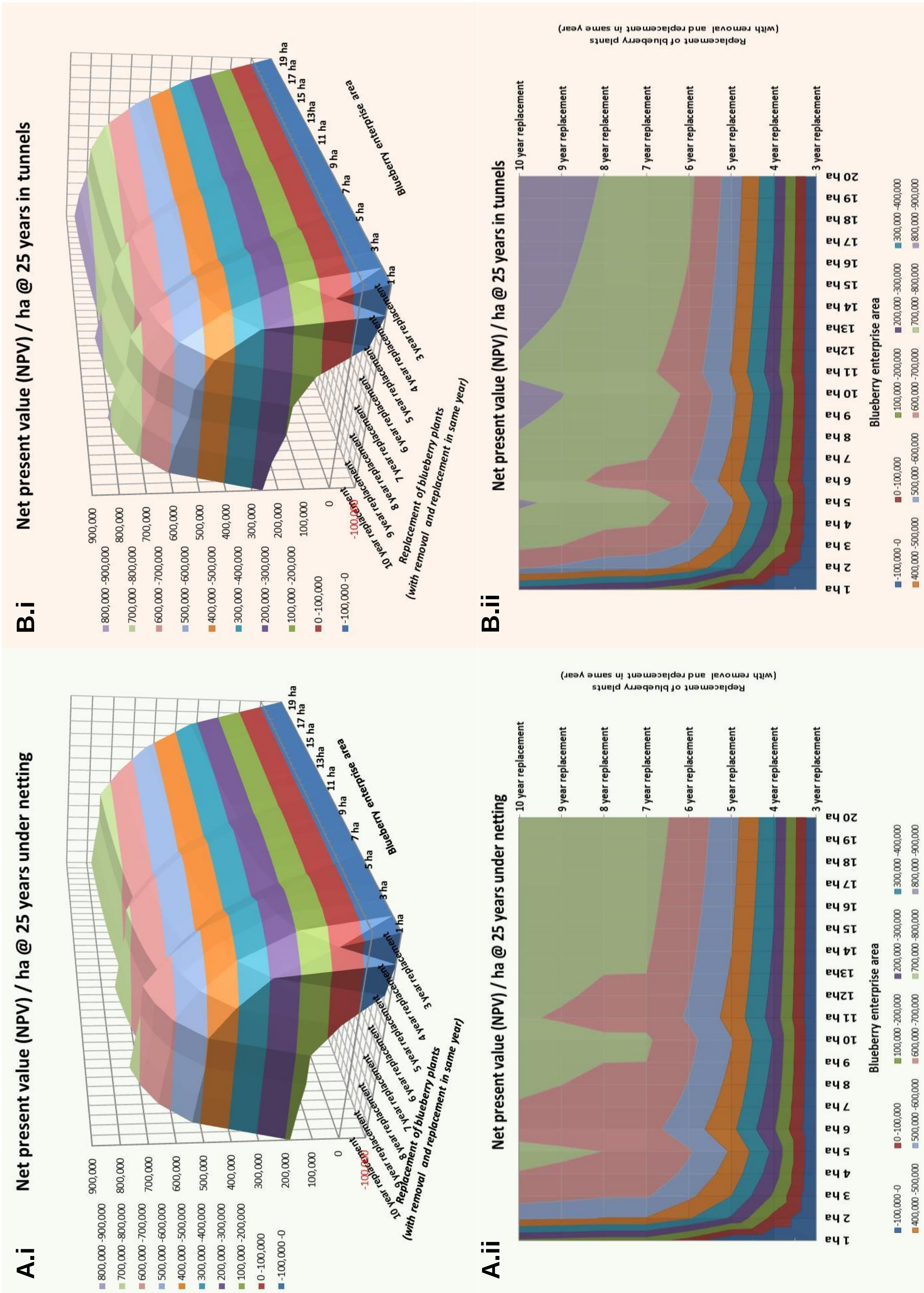
Figure 87 – Economies of scale can be presented as discounted net present value (NPVs) per hectare ($/ha) at 25-years for blueberry production under (A) netting and in (B) tunnels for different enterprise sizes and frequency of replanting, ignoring any future cash flows. Results are given (i) 3-dimensionally to demonstrate the effects of enterprise size and replanting frequency and as a (ii) topographical map for a given production system, enterprise size and replanting frequency.



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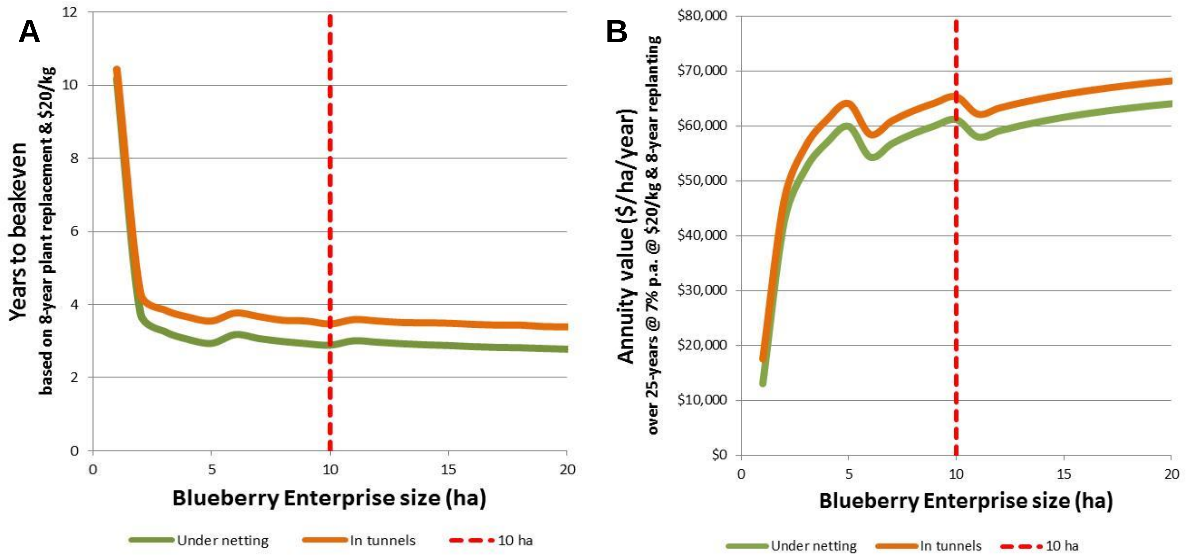
6. Years to breakeven and annual returns with respect to economics of scale.

Another important economic measure when considering blueberry enterprise size is the time period to breakeven and the average discounted annual return per hectare over time. When considering longer term decisions it is important to know when an investor gets their money back. Figure 88.A indicates that based on blueberry prices of $20/kg and an 8 year plant replacement cycle the estimated time to breakeven is significantly increased when an enterprise is less than two hectares using either netting or tunnel production systems. The minimum time to breakeven occurs for 5, 10 and 20 hectare enterprises, which is driven by stepped overhead costs. The breakeven period under netting is consistently sooner that within tunnels, due to the higher initial infrastructure investment costs incurred in setting up tunnels.

An alternative measure to Net Present Values (NPVs) is to consider the average annual returns over the life of the investment. This is achieved by dividing the NPV/ha by the serviceable life of the system (years), which is called an annuity. This this can be thought of as the equivalent value of a cheque that an investor would receive annually over the life of the investment. Figure 88 B indicates that annuities are greatly reduced for blueberry enterprise of less than four hectares. This is due to the general overhead costs associated with the enterprise size, annuities are maximised for 5, 10 and 20 hectare enterprises (Figure 88.B). Blueberry production in tunnels consistently returns higher annuities which is simply the result of higher yields and gross margins.

Figure 88 – When considering economies of scale for blueberry production both (A) years to breakeven (payback period) and the (B) average annual discounted (annuity) per hectare using both netting and tunnel production are important. Many of the analysis so far have been based on ten hectares as indicated by the red dotted line. This indicates that there is a 3ha threshold for both blueberry production systems when blueberry prices are $20/kg.



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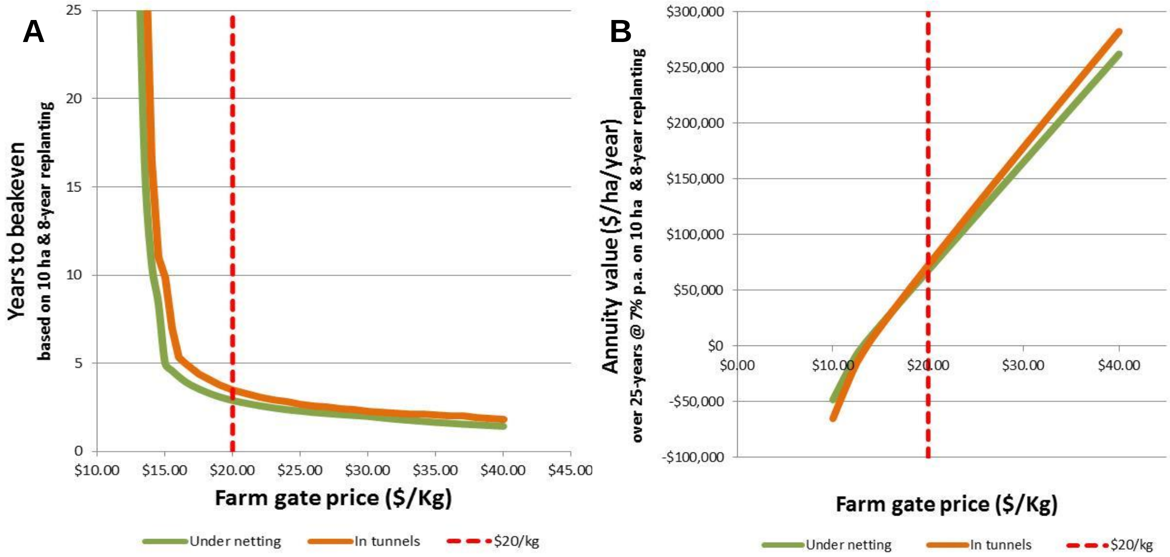
7. Effects of price on blueberry enterprises

All the analysis so far has assumed a farm gate blueberry price of $20/kg, however these outcomes are sensitive to price change – both the years-to-breakeven and average annuities ($/ha/year). Based on a 10 hectare blueberry enterprise with plants replaced every eight years, the years-to-breakeven significantly increase when blueberry prices are below $15/kg and $16/kg under netting and in tunnels, respectively (Figure 89.A). Therefore it is unlikely that blueberry production with the assumed costs and agronomic practices will be viable when prices are below $15/kg. When blueberry prices >$20/kg there is an almost linear relationship between years-to-breakeven and every additional dollar received per kilogram of blueberries sold.

A similar relationship is also fund with the average annual return per hectare over a 25-year period, based on a 10ha plantation with an 8-year plant replacement program. Assuming input costs and agronomic practices are unchanged blueberry production will be unviable when prices are below $13.50/kg (Figure 89.B). Above this price, there is a linear relationship between the average annual return per hectare and blueberry prices. When blueberry prices are significantly higher tunnel production offers higher returns. That is when prices are very high it is worth trying to minimise yield losses, which can be achieved in tunnels. However, even at these very high prices tunnel production is only marginally better than under netting which also offers very high returns per hectare

Figure 89 – The other consideration when considering (A) years to breakeven and the (B) average annual discounted (annuity) per hectare using both netting and tunnel production average over 25 years. Many of the analysis so far have been based on $20/kg as indicated by the red dotted line. Both indicate that there is $15/kg breakeven-threshold for both blueberry production systems for given input and overhead costs.



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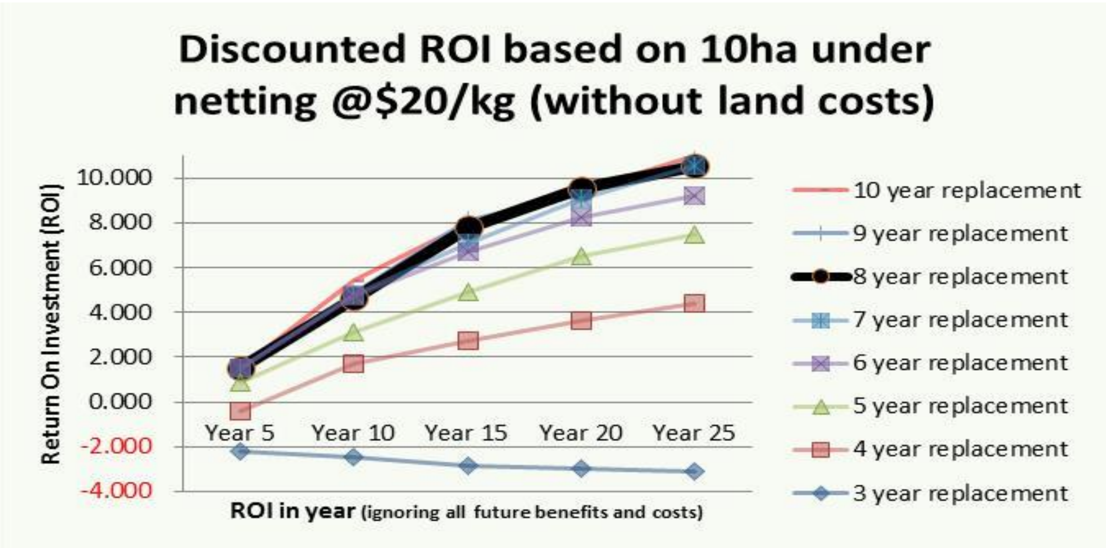
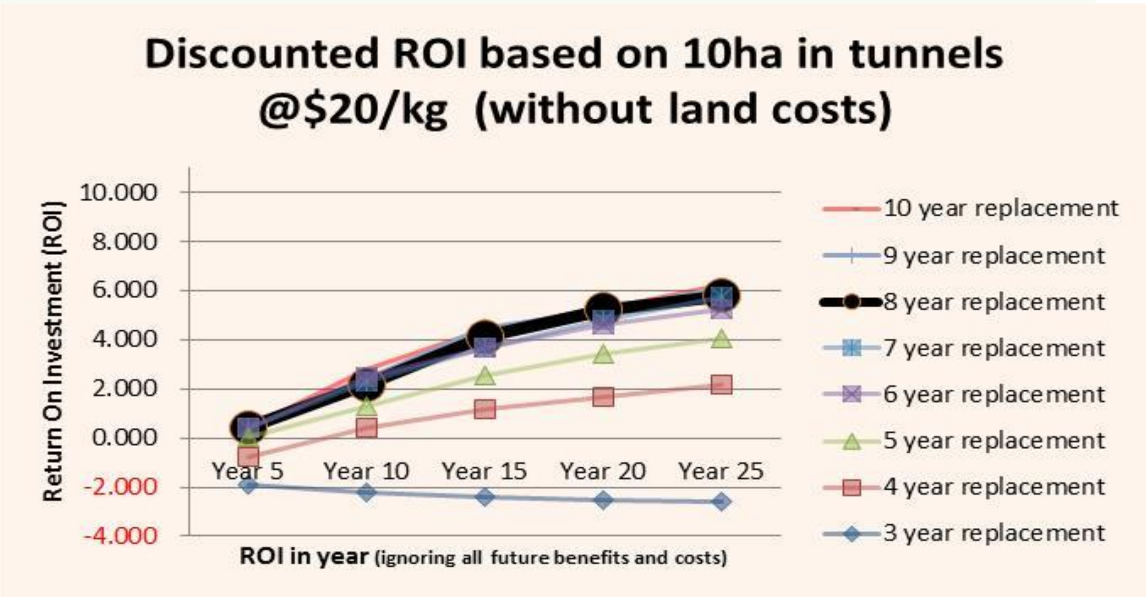
8. Returns on investment for blueberry production

Another consideration for long-term investments is the return on your initial investment. Throughout this analysis tunnel production has dominated under-netting production with respect to net present values and annuities; however, due to the increased initial capital investment payments of tunnels, the payback period is shorter under netting. The discounted returns on investment (ROI) are given for a 10 hectare blueberry enterprise over time (5, 10, 15, 20 and 25 years) of all plant replacement cycles under netting and also in tunnels (Figure 90.A and B). In both production systems the ROI is similar for seven to ten year plant replacement programs. There is however, a significant difference between the ROI of under netting production compared to tunnels. The ROI, under an 8-year plant replacement program is doubled under netting compared to that in tunnels at year 10 and 15. That is, for every dollar invested under netting it is estimated that an investor will received $4.62 (year 10) and $8.11 (year 15), compared to $2.20 (year 10) and $4.12 (year 15) in tunnels. This is due to the higher initial investment incurred establishing the tunnel system.

Figure 90 – Return on investment over time in blueberry production (A) under netting and (B) in tunnels, using 7% p.a. discount rate. For example a dollar invested under a 10ha netting production system will return $4.63 (in today's value) in 10-years' time (using 8-year plant replacements) as opposed to $2.20 in tunnels.





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9. Economies of scale for different packaging facilities.

Economic analysis so far has assumed off-farm packaging of blueberries, but there may be benefits from doing it on farm - both financially and from a quality control and marketing perspective. The efficiency of the packing facility will be driven by the volume of production and therefore farm size. Table 13 lists the estimated capital and variable costs of four different packing options: off-farm, syndicate of 3 farm pack house, small sole pack house and large sole pack house. The syndicate pack house may be on on-farm, a neighbouring farm, or another convenient location. The information in Table 13 was used to generate the total cost per kilogram of blueberries for each enterprise (Figure 91). The relationship between blueberry production and enterprise size is based on an under netting system. The same figure can be used for tunnel production with respect to total blueberry production; however, as yields are higher per hectare, the total area required will decrease. Netting production needs 40 hectares to produce 456 tonnes of blueberries, whereas, this can be achieved with 34 hectares of tunnels.

Table 13 – Capital and variable costs for different sized blueberry packing options.

Hectares	Off-farm packing	Syndicate pack house (3 farms)	Sole small pack house (<300t), additional units packed with 15% loading due to increased labour cost	Sole large pack house (>300t)
Hydro cooler		$25,000	$50,000	$75,000
Cool room		$45,000	$90,000	$135,000
Shed		$20,000	$40,000	$70,000
Concrete		$20,000	$40,000	$70,000
Electrical		$10,000	$20,000	$35,000
Toilets		$5,000	$10,000	$15,000
Total capital cost	**$0**	**$125,000**	**$250,000**	**$400,000**
Annual interest & depreciation	$0	$12,500	$25,000	$40,000
Other overheads: electricity, phone, insurance, admin …	$0	$7,500	$25,000	$40,000
Total annual overhead costs	**$0**	**$20,000**	**$50,000**	**$80,000**
Variable costs $/kg	**$3.00**	**$2.70**	**<300t $2.50 >300t $2.875**	**$2.40**

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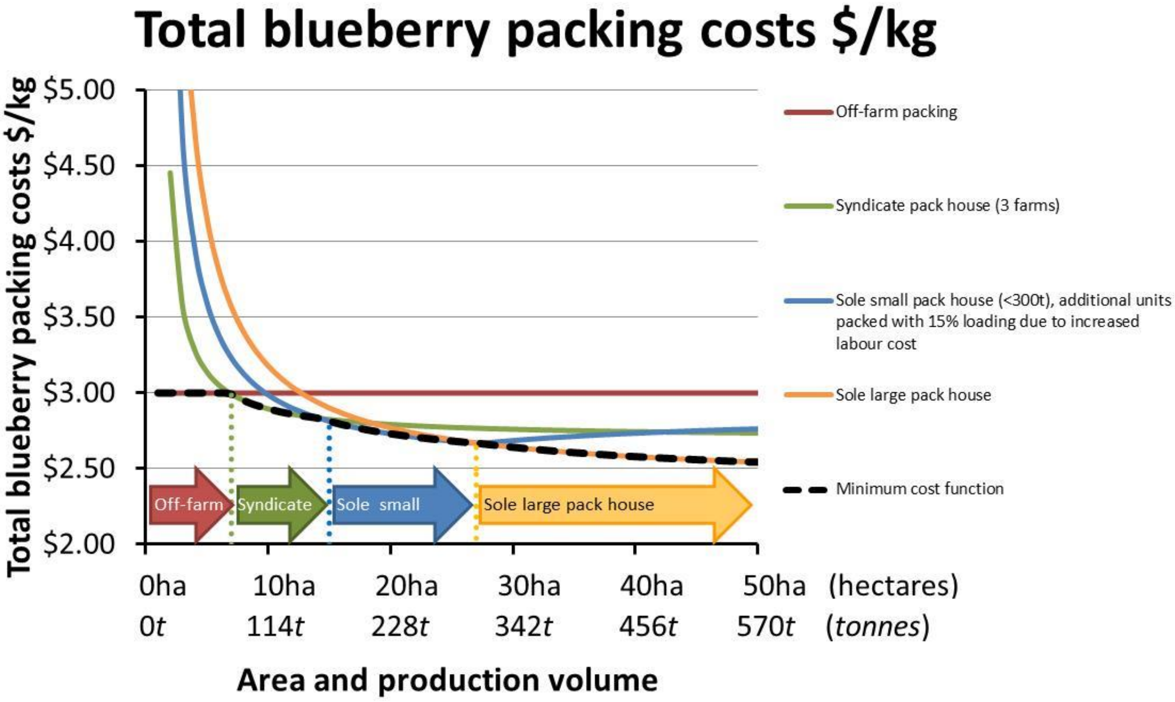
Figure 91 demonstrates how economies of scale can reduce blueberries packing costs under the different packing options (see Minimum cost function). It is possible to reduce the total packing cost by $0.50/kg with a very large blueberry plantation and associated large pack house facility. At this scale there may be additional savings through better purchasing power on production inputs, this would further improve gross margins and profits.

Figure 91 – Economies of scale on the average blueberry packing costs ($/kg) for different packing options.



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10. Discussion and Conclusion

Blueberry enterprises look favourable at a price of $20/kg (Table 9), but as production expands across Australian and consumers settle into the existing Blueberry market, prices may increase due to increased demand or decrease due to increased supply in coming seasons. The gross margins for blueberry production in tunnels is higher, than under net but so too is the investment in capital and infrastructure necessary for tunnel production (Table 11). Blueberry price only need to decrease by 25% to $15/kg for blueberry production to be unviable using current production practices under netting or in tunnels (Figure 89).

Blueberry production under netting and tunnels has high labour costs at ~40% of total variable costs. Tunnel production also tends to have higher labour costs per hectare due to increased yields, but as a percentage of total variable costs both systems' labour costs are similar. If current labour costs per hectare can be reduced through some form of mechanisation or varietal improvement then profits may be maintained or further increased. Blueberry production may remain viable even when blueberry prices drop below $15/kg, provided there is sufficient production area to justify the investment cost associated with mechanisation. Packing shed mechanisation may be a first step in production cost reductions.

Both plant replacement frequency and economies of production scale were investigated with respect to cash flows, years to breakeven, net present values (NPV) over time at both enterprise scale and on a per hectare basis for blueberry production under netting and in tunnels. We investigated 3-10 year plant replacement frequencies, with respect to blueberry production yields, annual gross margins, production capital and overhead costs. As expected the longer the time period between plant replacements the higher the NPV; however, the most significant increase is from 3-years to 7-year plant replacement frequency (Figure 86-Figure 87). In fact replacing plants less than every 4 years is uneconomical at any production scale. From planting intervals of 7-years to 10-years NPVs do tend to increase but only marginally, and there may be agronomical reasons to opt for higher plant replacement frequency. 8-year plant replacement which is not uncommon appears to be both agronomically and economically sound for both net and tunnel blueberry production. Assuming an 8-year plant replacement, the years to breakeven tends to be one year sooner for net production, due to lower production capital costs (Figure 88). Both systems need to be greater than two hectares otherwise years to breakeven increases exponentially from ~3 and 4 years for net and tunnel production respectively. The average annual return (annuity $/ha) also tends to increase significantly up to five hectares, and then tends to increase slightly with local optima (Figure 88). These optima are a result of stepped increases in overhead costs with respect to enterprise size (Table 12). Therefore, there may be benefits in consolidation before a marginal expansion in production (Figure 87 and Figure 88). For example increasing production from five hectares to six hectares may reduce the enterprises returns due to increased overhead costs, whereas increasing to ten hectares may increase both NPVs and annuities (Figure 87 and Figure 88).

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Returns on investment (ROI) can provide long-term investment information about the merits of blueberry production under netting and in tunnels. Figure 90.A and B provided the discounted returns on investment (ROI) based on a 10 hectare blueberry enterprise over time (5, 10, 15, 20 and 25 years) of all plant replacement programs under netting and in tunnels based on blueberry prices of $20/kg. Blueberry production under netting offered significantly higher ROIs than tunnel production due to the higher initial investment of tunnel systems. For example, for every dollar invested under netting it is estimated that an investor will received $4.62 (year 10) and $8.11 (year 15), compared to $2.20 (year 10) and $4.12 (year 15) in tunnels. This is also reflected in Figure 83, which is based on blueberry prices of $20/kg and an eight year plant replacement program. If an investor had ~$1.3m for a blueberry enterprise, they could either invest in 5 ha in tunnels ($1.13m) or 10 ha under netting ($1.30m). In 10 years the netting system is estimated to have a net present value (NPV) of $3.13m compared to $1.4m for the tunnel system. And at 25 years, it is $7.14m under netting compared to $3.74m for tunnel production. Moreover, the netting system will have a payback period of 4 years, compared to 5 years in tunnels. The ROIs are similar for seven to ten year plant replacement programs under both production systems. This further supports the agronomic and economic rationale for industry practices of 8-year plant replacement programs.

Savings can be achieved in packing costs with economies of scale (Figure 90). There is a logical progression in the reduction in packing costs from off-farm, syndicate, sole small pack house through to sole large pack houses, the latter offering total savings of ~$0.50 per kilogram of blueberries. This may not seem significant, but for a 20 hectare blueberry enterprise this can represent savings of ~$0.27/kg and at 228 tonnes of blueberries this equates to ~$61k per year, and for a 50 ha enterprise with savings of ~$0.48/kg producing 570 tonnes of blueberries, this can represent savings of ~$260k per year. However, these savings will need to be weighed against the benefits of marketing already established blueberry brands, and the effort of expanding the business into blueberry production and packing facilities.

In conclusion, 8-year blueberry plant replacement, which is not uncommon, appears to be both agronomically and economically sound for both net and tunnel blueberry production. With blueberry prices at $20/kg both netting and tunnel production offer good economic returns, but returns on investment (ROI) are about doubled using under net plantings. Blueberry prices of $20/kg offer good economic returns; and this combined with vertical supply integration and marketing has seen increased blueberry plantings throughout Australia in recent years. Should fruit supply be increased it is fair to assume blueberry returns could be pushed downwards to a point where it is no longer an economically viable crop ($15/kg). Through economies of scale and expanded export markets, there are opportunities for mechanising picking and shed processing operations to decrease labour costs. This increase in productivity should be co-ordinated with other Australian blueberry production regions to ensure that Australia can provide continuity of supply to export markets.

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