Changing Farming Systems – Financial Implications for Farming Businesses

Anne Bennett,
Alex Edward,
Allan Herbert,
Ross Kingwell,
Caroline Peak,
David Rodgers

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Changing Farming Systems – Financial Implications for Farming Businesses

Anne Bennett[1], Alex Edward[2], Allan Herbert[1], Ross Kingwell[1, 2], Caroline Peek[1], David Rogers[1]
([1]Department of Agriculture, Western Australia, [2]The University of Western Australia).

1. ABSTRACT.

Future prosperity of farming businesses depends not only on immediate prospects, but also on the capability to adapt to changing circumstances. In looking to the future, farm managers need to assess where the current farming system is taking them, and whether changing to an alternative farming system might be more profitable.

There are various techniques for assessing the profitability of alternative farming systems, but frequently the cost of transition is overlooked. The financial consequences of transition to a new farming system are assessed for two case study farms using a spreadsheet tool (STEP), developed by the authors. The tool assists farm managers in assessing the risk of transition strategies as well as comparing rotations.

2. INTRODUCTION

A user-friendly tool integrating paddock scale decisions with the whole farm has been developed for undertaking whole farm analysis of changing from one enterprise mix to another. The tool has been created in response to farmer demand. With increasing economic and environmental pressures farmers are considering changing their farming systems more than ever and need a tool to financially evaluate proposed changes.

In response to this need, STEP (Simulated Transitional Economic Planning) has been developed for farmers to analyse future systems they are interested in incorporating on their property. However, this tool is only one step in the process of assessing a new farming system. There are many other steps involved before undertaking a whole farm analysis like STEP, of a proposed change in farming system. These can include:

- Undertaking a cost benefit analysis of the enterprise (if one is being considered).
- Determining specific skills required (if any) for the new enterprise.
- Understanding the possible failures of the system as well as the benefits.
- Deciding what area of the farm will be put into the new system.
- What changes they can afford to make.
- How the transition into the new system is undertaken.

Once the proposed change is defined a whole farm financial analysis can be done. The STEP spreadsheet provides an easy way of financially testing new options.

The following paper is split into two section. The first describes STEP, the second gives two cases studies of how STEP can be used.

3. STEP (SIMULATED TRANSITIONAL ECONOMIC PLANNING)

3.1. What does STEP do?

STEP allows the user to simulate over time the financial consequences of changing from one enterprise mix to another. It allows different production possibilities to be financially assessed over time and different options to be compared. It gives the user a strong indication of the viability of a new system comparative to the old system.

Microsoft Visual Basic automation reduces data input time. After entering a few parameter values STEP automatically generates information over a number of years.

Determining the crucial ingredients of the relative profitability of a system is easy by undertaking a sensitivity analysis of variables. Sensitivity analysis assessment increases the user's overall understanding of a system, placing them in a more knowledgeable and therefore less risky situation when changing their farming system.

STEP is a tool that assesses the financial consequences of a shift in production. It does not replace conventional assessment tools such as gross margins, partial budgets, whole farm budgets, cost benefit analysis or the use of optimisation models such as MIDAS.

STEP fills the gap in using the information these tools deliver and practical implementation of a new system. Assessing the long term consequences gives the user a guide as to the possible outcomes of incorporating the new system on their farm.

Although STEP is most suited to broadacre cropping enterprises, its flexibility and generic characteristics mean it is applicable to a number of other industries.

Climatic risk and inter-year price variation assessment is not easily accommodated by the model due to the complexity of relationships. However if this is desired, all figures can be altered on a yearly basis.

STEP has been tested with a number of farmers, the majority of whom gave favourable reviews.

3.2. What are the limitations of the tool?

As with all tools there are a number of limitations. These are listed below.

1. The user is required to be knowledgeable about the farming system being tested. No prices or biological interactions are preset in the model. Lack of familiarity with the system interactions can result in incorrect and misleading results. Or said another way – rubbish in, rubbish out.
2. Requires Microsoft Excel 97 or later to run.
3. Making changes to STEP will require some knowledge of Excel and depending on the extent of the changes, possibly Microsoft Visual Basic.
4. Planning of what is going to be tested is essential before starting the analysis. If a farm is represented incorrectly in the model it can inhibit extensive analysis. Consequently time spent planning how the analysis is undertaken is time worth spending.
5. STEP does not link into other farm management tools that are currently on the market such as PAM™ and Pinpoint™. This means that information existing in other computer programs needs to be re-entered into STEP.
6. STEP is a simulation not an optimisation model.

3.3. Potential Users of STEP

The following groups are seen as potential users of STEP:

- Financial consultants.
- Farmers.
- Researchers.
- Development officers.
- Universities.

Financial consultants are considered to be the biggest group expected to use this tool for individual property assessment. Using STEP, financial consultants will be able to test the comparative profitability of different options their clients are considering.

Farmers may use STEP to assess system options for themselves. Though it is assumed the pool of farmers with Excel, Excel skills and the time to undertake such a task will be small.

Researchers could use the tool to evaluate the difference their research may make to an average farmer's profitability in the long term.

Development officers may use the tool as a way of testing different systems for their area, as a workshop tool with farmers as well as an educational tool for themselves.

Finally universities could use the tool as a teaching aid for students. As it does not hide system interactions, it will force students to think about the farm as a system and consider the interactions of enterprises.

3.4. Spreadsheet design

STEP (Simulated Transitional Economic Planning) is a spreadsheet model that integrates paddock management and whole farm management decisions. The package is separated broadly into modules that 'dock' onto the budget. A conceptual overview is shown in Figure 1.

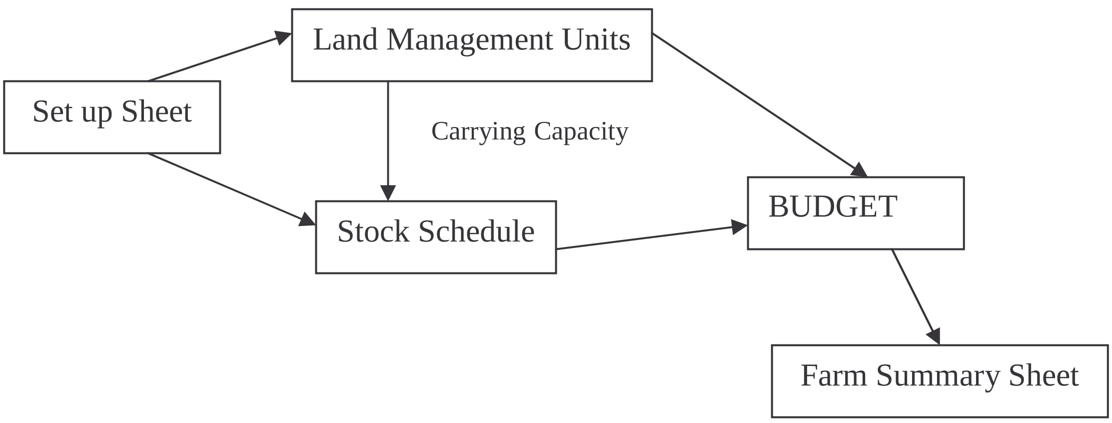


Figure 1: Conceptual representation of the STEP model

3.4.1. Set Up Sheet

Information put into this page determines the number of land management unit and stock schedule sheets created, and sets up the budget. Examples of information required for this page include; the number of land management units (LMU's), the number of paddocks in each LMU, a list of the different crops and pastures grown, and the names of the different livestock enterprises on the property. Associated with the crop and stock enterprises, the user needs to enter estimated returns and costs. These are automatically fed into the LMU and stock sheets.

3.4.2. Land Management Units

The farm is represented by a series of land management units (LMU's). An LMU is a grouping of land with the same properties and rotation sequence. It could be a group of paddocks or a single paddock.

In this sheet the user is required to fill in the current enterprise sequence for the paddocks in the LMU, as well as the size of each paddock and the year of the designated sequence in the first year of the simulation for each paddock. If wanting to investigate the option of changing to a new enterprise sequence the user can enter the future sequence and the year each paddock is going to move into the future sequence. The costs and returns given in the Set Up Sheet are then automatically fed into the LMU for each paddock according to the designated enterprises. The user can adjust any of these values to capture specific nuances for all paddocks in the land management unit, or for individual paddocks, or for individual years.

3.4.3. Stock Schedule

The stock schedules include births, deaths, sales, purchases and transfers. It is the users responsibility to ensure the total farm dry sheep equivalents (DSE) does not exceed the carrying capacity of the farm.

3.4.4. Budget

The budget is an annual time step of farm finances as determined in the Stock and LMU sheets. Fixed costs and some variable costs that are not captured in the LMU or stock sheets can be entered directly into the budget.

3.4.5. Farm Summary Sheet

The Farm Summary Sheet provides an overall summary of the simulation analysis. It gives financial and production summary information

4. CASE STUDY EXAMPLES USING STEP

Two case studies undertaken using STEP are described in the following section. Both studies compare the introduction of lucerne into the farming system and illustrate how the management style of lucerne affects its profitability.

4.1. Case Study 1: Incorporating lucerne using a cover crop

4.1.1. The farming system

The case study farm is located near the town of Wickepin in the shire of Wickepin with an annual rainfall of 383 mm.

Prior to the introduction of lucerne this farm engaged in production of annual pastures, lupin, wheat and oaten hay. Following the introduction of the lucerne as a rotational phase by the farmer, barley and canola were also introduced. Whilst this farmer had not grown barley or canola in the past they are crops now commonly grown in the area.

4.1.2. The profitability of lucerne

The farmer introduced lucerne to one third of his property through a phase farming approach. The paddocks changed from a wheat: sub. clover rotation to a phase rotation of three years of lucerne followed by annual phases of wheat, canola, wheat and barley. In the year of transition, lucerne followed a wheat crop from the wheat: sub. clover rotation. A cover crop of barley was sown over the lucerne in the establishment year and then the lucerne was managed as a pasture until it was sprayed out at the end of the third year. It is expected that the wheat crop following lucerne will have an increased protein per cent (this is reflected in the analysis by a $5/t premium) and slightly reduced fertilizer costs of $2/hectare due to the increased nitrogen availability after lucerne. Table 1 shows the sequence of crops for both rotations.

Table 1: Sequence of crops for both rotations

	Sequence Year						
Rotation	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Wheat: sub clover	wheat	sub.clover	wheat	sub.clover	wheat	sub.clover	wheat
Lucerne	Lucerne/ barley	lucerne	lucerne	wheat	canola	wheat	barley

Ewes grazing lucerne at the same winter stocking rate as sub clover have been found to have an increased reproductive rate, and their lambs have an increased liveweight. A study undertaken by the Western Australian Department of Agriculture at Borden reported an increase in reproductive rate from 85% to 130%, and an increased live weight of 8kg per head on average for lambs grazing lucerne compared to those grazing sub. clover. Hence, in this analysis, ewes grazing lucerne were given a reproductive rate of 100% whilst the rest of the flock had a rate of 80%. An increase in lamb price due to live weight gain was not considered as the farmer said he would turn his lambs off earlier.

The flock size was decreased in the new system to match the decreased stocking rate of the lucerne pasture and the reduced proportion of the farm in pasture. The lucerne rotation has only two years of pasture in seven (as the first year of lucerne is the establishment year) in comparison to the wheat clover rotation that has three and a half years of pasture in seven.

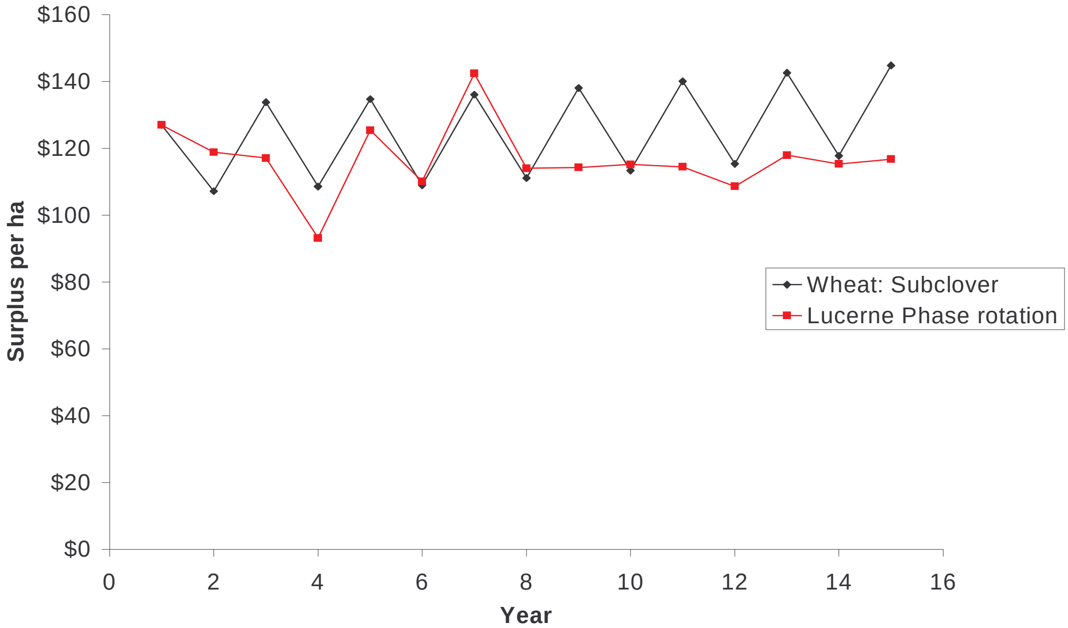
The extensive root system of lucerne may dry out the soil profile reducing crop yields. This impact may be important in lower rainfall areas such as in east Wickepin. However, yields in this analysis were not reduced to account for this possibility. Conversely, there is also no account made for the possibility of yield increases as a result of reduced waterlogging due to greater water use by lucerne.

Biological interactions and seasonal adjustment factors are also not considered in this analysis.

Figure 2 shows the expected returns from the conventional sub.clover: wheat rotation versus the rotation sequence that includes a long phase of lucerne. The lucerne phase system is not as profitable. There are several reasons for the difference. Not only does the farmer change the pasture component on this particular soil type to the lucerne phase but he also changes the mix of crops in the cropping phase. The yields the farmer expects to achieve for his barley and canola give lower returns than those generated from his wheat enterprise. Therefore not only was there a reduction in pasture and therefore a forced reduction in flock numbers during the establishment of lucerne, but the new cropping phases are not as profitable as the original wheat phases.

The higher levels of surplus in years 5 and 7 of the lucerne rotation are the result of selling excess stock to meet the new carrying capacity as a result of the reduced proportion of pasture and lower stocking rates on the lucerne pasture.

Figure 3 shows the surplus generated by the wheat: sub. clover rotation and the lucerne phase rotation compared to the lucerne phase rotation if all crop types , apart from the cover barley crop in the establishment phase for lucerne, produce the same gross margin. In the year of



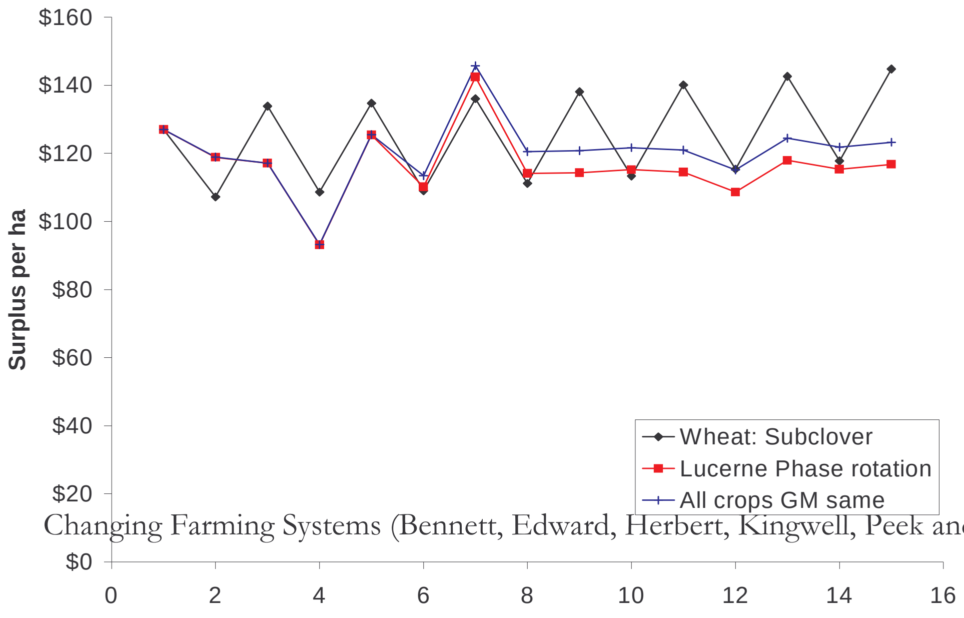
establishing lucerne the cover crop of barley yields only 65% of a monoculture of barley.

Figure 2: Surplus from a wheat:sub.clover rotation versus introducing lucerne.

Figure 3: The wheat: sub clover and the lucerne phase rotation compared to the lucerne phase rotation if all crop types produce the same gross margin.

As

Figure 3 shows, even if the gross margins for barley and canola could be raised to equate to that of wheat, the introduction of lucerne would still not be profitable due to the reduced



carrying capacity in the year of lucerne establishment.

After transition, when the system reaches equilibrium on the 7 paddocks, there are 2 years of pasture and 5 years of crop, with the barley over-cropping yielding less than a monoculture of barley. In year 11 of the analysis the wheat: subclover rotation has 3 paddocks of pasture and 4 of wheat, whereas the lucerne rotation has 2 paddocks of pasture and 5 of crop. There is a difference in the carrying capacity of the property of 1360 DSE. This results in a difference in the value of wool clip of $44,073 per year and a reduction in the income from sheep sales of $47,142, due mainly to lower lamb numbers. The 1360 difference in carrying capacity stems from a decrease of 340 DSE in carrying capacity due to lucerne having a carrying capacity of 1 DSE per ha less than sub clover and 1020 DSE reduced stock numbers from the reduction in pasture area. If only the effect of the reduced pasture area of 170ha is considered then stock income is reduced by $68,411. The same 170ha converted to wheat with a gross margin of $309/ha would generate profit of $52,530. This leaves a discrepancy of $15,881 per year with the new rotation from changing the paddock from a pasture to a crop.

4.1.3. Cautionary Remarks: Wickepin farm

Introducing lucerne into the system is not as profitable as the wheat sub. clover rotation. However there are other production advantages of introducing lucerne that this analysis has not covered. These factors include:

1. A further increase in reproductive percentage from 100% up to 130%
2. Increasing lucerne stocking rates above those of sub. clover stocking rates.
3. Reducing the amount of water reaching the water table and consequently reducing the salinity risk.

For salinity management, the latter is particularly important. For example, greater water use of lucerne may assist to avoid cereal yield losses attributable to salinisation and/or waterlogging. If these benefits generate long term benefits that equate to around $2 to $4/ha/year, then the lucerne-based system would be comparable in profitability to the current land use system. It is worth noting that the farmer expects lucerne to deliver these long term benefits to justify the inclusion of lucerne in the system.

Figure 4 compares the returns from the lucerne phase system to that of the sub. clover: wheat system when 0%, 0.2% and 1% annual production losses occur due to water-logging and/or salinity. The lucerne phase system demonstrates greater returns when the sub. clover: wheat system is affected by either annual rate (0.2% or 1%) of production decline.

A greater understanding of the sustainability of the wheat: sub. clover and lucerne phase systems in this particular location would assist the judgement about which system is preferable. Knowledge about water-logging risk, salinity impacts and drought risk at the site would assist decision-making over system choice.

If environmental and feed quality issues were able to be included in the analysis then it is highly likely that the lucerne phase system would be superior in profitability to the sub. clover: wheat system. Certainly the farmer included the environmental factors in his decision to implement the new system. His main motivation for change was hydrological and soil health incentives. The land that the lucerne was planted on had been subject to waterlogging and the farmer expected that the deeper rooted lucerne would reduce the incidence of waterlogging. The farmer also expected benefits for soil health such as increased soil structure and stability.

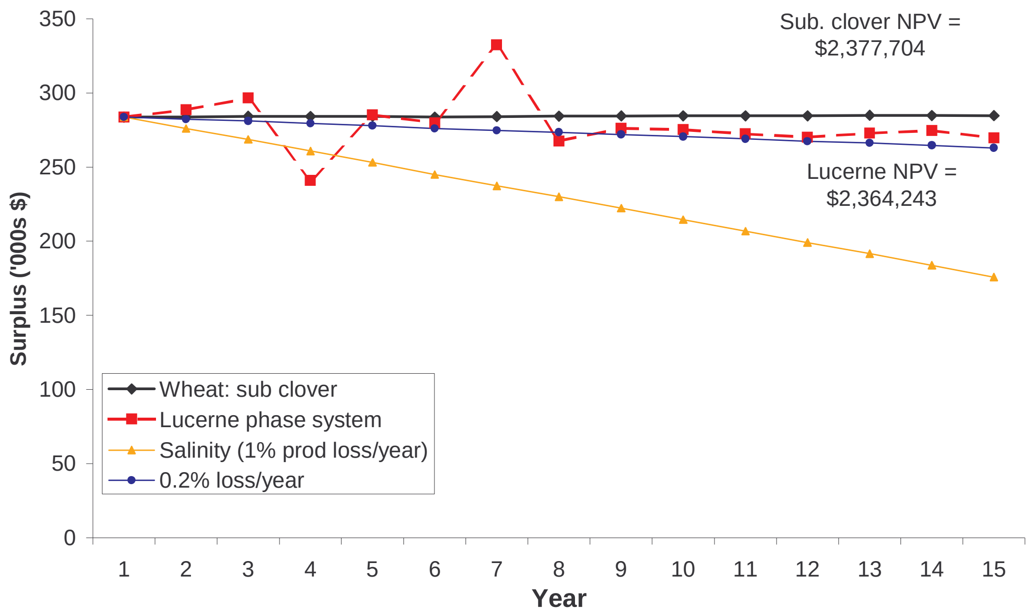


Figure 4: The lucerne phase system compared to a wheat: sub. clover system with 0%, 0.2% and 1% annual production loss.

4.1.4. Sensitivity analysis: Wickepin farm

All the sensitivity analyses in this study compare the cumulative net present value of surplus/deficit of each system over a 15 year period at a discount rate of 10%. Shaded cells in tables indicate the sub. clover system is more profitable, those cells not shaded indicate the lucerne system is more profitable. The number indicates by how much the preferred system is better than the other.

The comparative advantage of the lucerne system over the sub. clover system is strongly influenced by the yield of the cover crop of barley in the establishment year of lucerne. Table 2 compares the net present value of each system at seven different cover crop barley yields and four barley grain prices.

Table 2: Difference in net present value ($'000) of the lucerne and sub. clover systems for different yields of barley in the lucerne establishment year, and changes in barley price.

	Yield of Barley (t/ha)[a]						
Barley Price ($/t)	0	0.5	1.0	1.3	1.4	1.5	2.0
155	-331	-234	-136	-78	-58	-39	58
165	-319	-216	-112	-50	-29	-8	95
175	-307	-197	-88	-22	0.3	22	132
185	-296	-179	-63	6	30	53	169

[a] Shaded cells indicate that the wheat: sub. clover system is more profitable than the lucerne-based system

Table 2 shows the importance of barley yield in driving the relative profitability of the lucerne system. In this analysis a yield 1.5 tonnes per hectare or better for barley in the establishment year of lucerne is required to ensure as much, if not more money is made than in the sub. clover system.

The effect of wool and sheep sale price on system profitability was also examined. At low wool and sheep prices the lucerne system is the more profitable system (see Table 3). This is because the lucerne system generates less of its income from sheep that the sub. clover system.

Table 3: Difference in net present value ($'000) of the lucerne and sub. clover systems for different wool and sheep sale prices.

Wool price (c/kg greasy)	300	400	500	600	700
NPV difference ($'000)	81	51	21	-8	-38
Sheep sale price ($/hd)	35	45	55	65	
NPV difference ($'000)	1	-4	-8	-13	

Lambs grazed on lucerne are known to have higher liveweights over their sub. clover grazed counterparts. Table 27 gives a sensitivity analysis of the two systems when lambs grazed on lucerne attract a higher premium. Sub. clover lambs sell at a constant ($55/hd). With premiums for lambs grazed on lucerne, the lucerne system is more profitable than the sub. clover system.

Table 4: Difference in net present value ($'000) of the lucerne and sub. clover systems when lambs grazed on lucerne attract a higher price.

Lamb price ($/hd)	55	60	65	70	75
NPV difference ($'000)	-8	6	19	33	47

Wheat price was also considered in this study. The results showed that as wheat price increased, the lucerne system is increasingly less profitable when compared to the sub. clover system. Although Table 1 shows more income being generated by crops in the new system, there are fewer years of wheat. Therefore the lucerne system is less sensitive to wheat price than the sub. clover system.

4.1.5. Constraints to adopting lucerne: Wickepin farm

A main impediment to adopting the lucerne system was the impact of the establishment year for lucerne and the greater emphasis on cropping that caused a reduction in sheep numbers. One third of the property was changed to the new rotation, which resulted in a reduction of 1360 DSE/ha in carrying capacity per year. Such a reduction in stock numbers and a shift toward cropping, with its higher input requirements and greater variability of returns, was a disincentive for adoption.

The new rotation is not more profitable than remaining in the initial rotation therefore a change to the new lucerne phase rotation would only be initiated as production losses due to water-logging and salinity became more evident.

4.1.6. Conclusion for lucerne: Wickepin farm

For this case study, a lucerne-based rotation replaced a wheat:sub. clover rotation on approximately a third of the farm. The major cost and impediment of the lucerne system is the impact of a reduced flock size and the introduction of new crops whose profitability does not match that of the wheat crops they replace. However, as shown in

Table 5, there is only a small difference in the profitability per hectare of the lucerne and the wheat: sub clover rotation. Small improvements in production benefits (salinity losses avoided) from introducing lucerne are all that is required to ensure that lucerne generates superior returns.

Table 5: A summary of the profitability of the lucerne phase system for salinity management ($/ha/yr on a whole farm basis)

Profit at full equity ($/ha/yr)						Farm area	Proportion of farm subject to lucerne phase system
25th percentile		Average		75th percentile			
without	with	without	with	without	with	(ha)	(%)
18.0	17.7	76.4	72.2	106.9	103.9	3130	38

The information in this case study is likely to apply to farms with a similar livestock and cropping production system in the following parts of the GRDC Central zone: Meckering, Quairading and Wickepin; the western portion the Dumbleyung, Kulin, Corrigin, Tammin, and Dowerin shires; the southern portion of the Goomalling and Dowerin shires and the eastern portion of the Northam, York, Beverley, Brookton, Pingelly, Cuballing, Narrogin and Wagin shires.

4.1.7. Knowledge gaps for lucerne: Wickepin farm

As stated previously the environmental benefits of lucerne have not been captured in the financial analysis. The farmer has been growing lucerne for two years, which have both been drier than usual, so there has been poor lucerne establishment and production. Hence, the full potential of the lucerne is yet to be realised and so estimates of profitability have been limited. Future years should enable better identification and quantification of the water use and soil health benefits of lucerne in this system.

4.2. Case Study 2: Incorporating lucerne using precision agriculture

4.2.1. The farming system

The case study farm is located near the town of Buntine in the shire of Dalwallinu. Annual rainfall for the shire is 270 mm. A challenge for lucerne is its expansion into low rainfall cropping systems as typified in this case study.

The farming systems in this area are dominated by cropping with a lupin:wheat rotation typical on sandplain soils, especially where land use on those soils is yet to experience herbicide resistant weed problems. Most farmers run some sheep but the low wool prices of 1990 resulted in many farmers switching into cropping. The case study farm is diversified with livestock and crop production systems, including utilising excess grain in a sheep feedlot. Lucerne is being trialled in two paddocks over an area of 200 hectares. The following analysis is for these paddocks only.

4.2.2. The introduction of lucerne

Lucerne is established as semi-permanent one-metre spaced rows within crop phases. Complementary cropping of cereals or lupins occurs in the interrows. Crops are harvested with the straw remaining in header rows. Approximately two-thirds of the header rows are collected to make hay, which includes cereal straw and lucerne leaf and stem material slashed by the harvesting process. Sheep graze residues in the paddock over summer. When the paddock is in the lupin phase no lucerne:lupin stubble hay is produced. The lucerne stand is expected to last for at least 5 years.

The farm runs a self-replacing merino flock. To utilise the extra feed available from lucerne over summer, 3 to 4 year old ewes are transferred into the paddocks for 4 months after harvest and then transferred out. A third of the wool clip of the grazing sheep is attributed to the feed available in those paddocks. Whilst the lucerne phase includes hay production from the cereal residues, the stocking rate over summer in the paddocks is not reduced. The exceptions to this are the lucerne establishment year, when paddocks were not stocked over summer, and the lupin year in which the stocking rate increased by one DSE per hectare, as hay was not produced.

The lucerne fulfils two roles in the cropping system, improving the nitrogen supply and reducing water tables. Whilst it has been established that the nitrogen supply is improved, the reduction in leakage has only been imputed from water use calculations.

Management and equipment factors are important components of lucerne and crop production in this farming system. The farmer uses precision farming equipment. This allows the precise cultivation of the crop between the lucerne rows and spray boots allow control of broadleaf weeds in the cereal crops between the lucerne rows, saving on herbicide costs.

4.2.3. The profitability of lucerne using district average information

An analysis was performed using district average information available from the Bankwest benchmarks.

The case study analysis has an initial three years of steady state wheat:lupin rotation that then changes to incorporate lucerne in the fourth year, followed by a further three years of production based on lucerne as a component of the rotation in the two paddocks. Hence, year seven in the following figures is the extent of the farmer's current planning horizon for management of these two paddocks. Table 6 shows the sequence of crops for both rotations.

Table 6: Sequence of crops in the two rotations

	Cropping component						
Rotation	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Lupin: Wheat	Lupin	Wheat	Lupin	Wheat	Lupin	Wheat	Lupin
Lucerne interrows	Lupin	Wheat	Lupin	Lucerne establish/ Barley	Lucerne/ Lupin	Lucerne/ Wheat	Lucerne/ Barley

Four years of Bankwest benchmark data for the Dalwallinu district were available. The analysis used the farmer's production scenario (including input levels) and then superimposed the "top 25%" Bankwest grain and wool yield data. All analyses used the same yield information for the full seven years of the analysis, (for example the 1999/00 analysis used 1999/00 yields in each rotational year). Figure 5 shows a sample of two years of superimposed benchmark data and illustrates how the relative profitability of the lucerne rotation changes with the yield information used. The main cause of the discrepancies between the years is the relative yields of each of the grain species. For example in 2000/01 the yield of barley was comparable to the yield of lupins and much less than wheat; hence the discrepancy in income seen in year 4 where the lucerne system is in the barley phase whereas the lupin:wheat rotation is in the wheat phase.

The analysis of the steady state wheat:lupin rotation is strongly influenced by the yield and price differences between wheat and lupins. The returns from the wheat:lupin rotation usually show a saw-tooth pattern of surplus through time due to the greater profits generated by the wheat phase of the rotation as shown in Figure 5. Incorporating lucerne into the wheat:lupin system reduces the surplus per hectare in the first year due to the cost of establishing the lucerne, with no off-setting additional income. In subsequent years there is an increase in the surplus due to additional income from the hay production and in the final year there is a change to barley, a more profitable crop species than lupins.

Introducing lucerne into the rotational management of the two paddocks generates additional income through the reduced frequency of lupins in the rotation sequence and through production of lucerne:cereal stubble hay. The rotation sequence shifts from wheat:lupin to the lucerne interrows rotation described in Table 6. Reducing the frequency of lupins in the rotation increases profit as lupins, in spite of its rotational advantages for following cereals, is relatively less profitable than cereals, given current costs, prices and yields. Further, hay production based on utilising header straw that incorporates lucerne is a valuable additional source of revenue, although a conservative 0.5 tonnes per hectare hay yield is assumed. When hay is not produced, the stocking rate attributable to the introduction of lucerne over summer does not compensate for the reduction in crop yield expected by the replacement of the cereal and lupin area by lucerne interrows. Also, reducing the prices and/or yield of the hay production reduces the superior profit margin of the hay enterprise. As shown in year seven of Figure 5, reducing the frequency of lupins allows much greater profits to be generated in that year which ordinarily would have been sown to lupins.

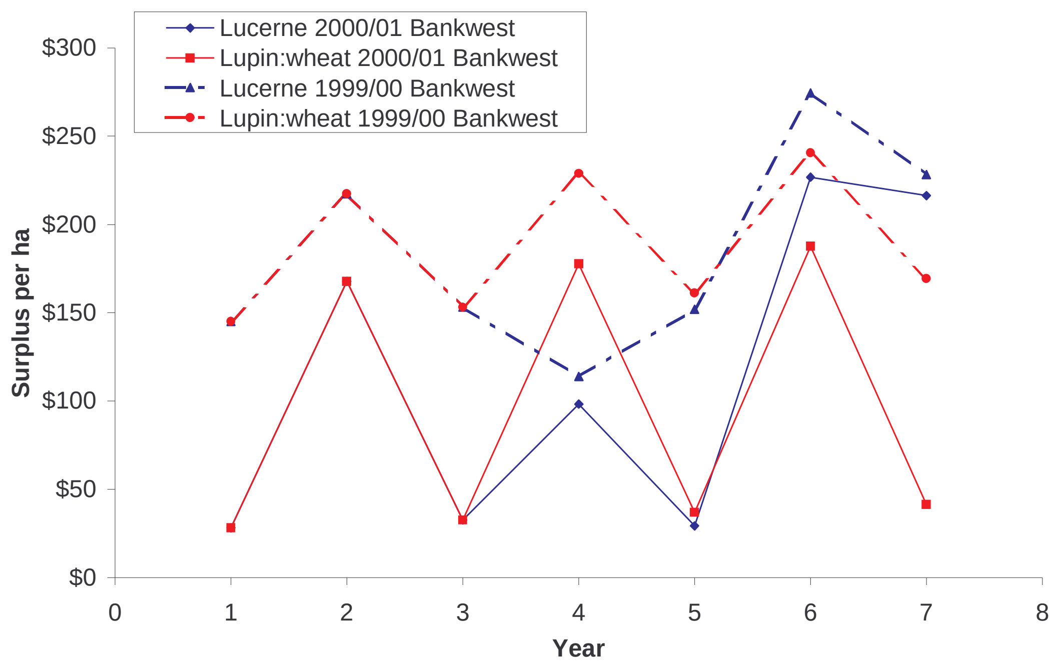


Figure 5: Surplus from lupin:wheat rotation versus introducing lucerne; based on Bankwest benchmark district data

4.2.4. Continuing the system for a further 8 years

The cumulative benefits from the lucerne system are marginal when analysed over the farmer's 7-year planning horizon. The analysis is extended out to 15 years to determine the long-term profitability of the new system. An analysis is also done to determine how significant the change to a lupin:wheat:barley rotation is in the profitability of the lucerne system. In each of these analyses the lumpiness was removed from the output by taking the two paddocks out of phase such that lupins would be in one paddock while wheat would be in the other. This also resulted in the change to the lucerne system occurring over two years instead of one.

In Figure 6 using the farmer's expected yields the simple change to the lupin:wheat:barley rotation was the most profitable without incorporating the lucerne rows. Figure 7 shows the same information using the 1999/00 Dalwallinu Bankwest benchmark yields.

When barley yields exceed wheat yields the change to the barley rotation is more profitable than the lucerne system, however when barley yields are less than the wheat yields the lucerne system is the more profitable due to the added benefits from hay production.

4.2.5. Seasonal effects

The short term Bankwest benchmark analysis was extended to account for four years of available benchmark data, 1997/98 to 2000/01. Unlike the previous analysis this used the high production cost information and the average yield information from the benchmarks for the Dalwallinu area. Since the yield relativities of each year have an impact on the relative profitability of the lucerne rotation, it was decided to use each of the Bankwest benchmark years as an indication of seasonal variability.

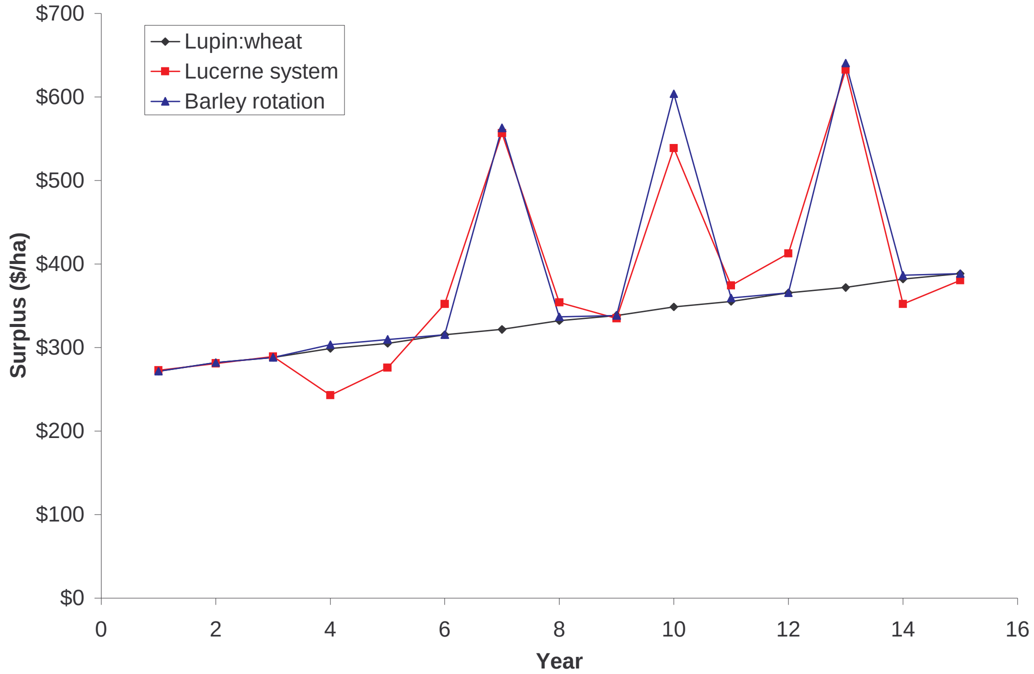


Figure 6: Surpluses from three different land use strategies: (i) lupin:wheat rotation, (ii) introduction of barley and (iii) introduction of lucerne, based on the farmer's inputs and yields.

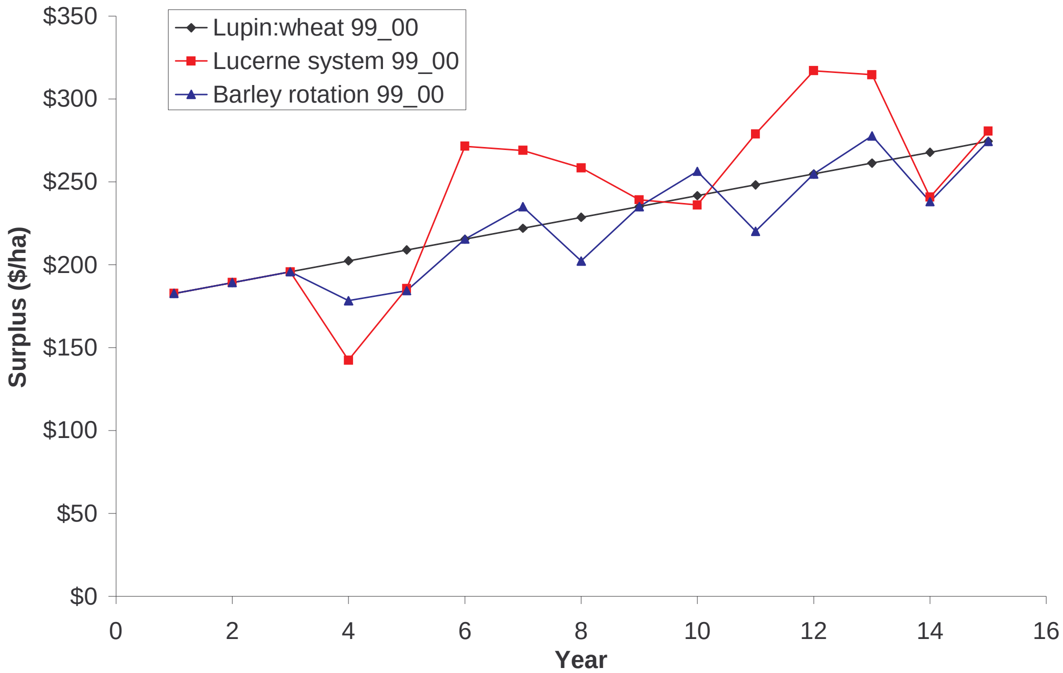


Figure 7: Surpluses from three different land use strategies: (i) lupin:wheat rotation, (ii) introduction of barley and (iii) introduction of lucerne, based on the farmer's inputs and Bankwest Benchmark yields for 1999/00.

After completing this series of runs the aim was to generate profit distributions for the lupin:wheat and lucerne-based rotation alternatives. The first three years of the analysis were unchanged and all used 1998/99 information. Then each transitional year was allocated to an actual year of Bankwest yield data. Table 7 gives an example.

Table 7: Example of how bankwest yeild data was allocated (Shading is used to indicate the Bankwest year)

Run #	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Run 1	1998/99	1998/99	1998/99	1997/98	1998/99	1999/00	2000/01
Run 2	1998/99	1998/99	1998/99	1997/98	1998/99	2000/01	1999/00
Run 3	1998/99	1998/99	1998/99	1997/98	1999/00	2000/01	1998/99
..	..	..	..	..	..	..	..
Run 24	1998/99	1998/99	1998/99	2000/01	1998/99	1999/00	1997/98

Altogether 24 (=4*3*2*1) year combinations across years 4 to 7 were feasible. All were analysed and then distributions of discounted profits were generated. Despite incorporating yield variation across the various seasons, commodity prices were fixed. Figure 8 compares the discounted cash operating surpluses of the lupin:wheat versus lucerne-based rotations for the four transitional years (i.e. the common 3 years of steady state lupin:wheat rotation are excluded). In this analysis the profitability of the lucerne-based rotation was often less than the lupin:wheat rotation. The lucerne rotation is also slightly less reliable with a coefficient of variation of 11% compared to 9% for the lupin:wheat rotation.

4.2.6. Qualifiers

Several factors were not considered in the above analysis:

- All years experienced standard prices so only crop production risk was examined.
- There was no change to the hay yield with changes in crop yield, this is unrealistic because the hay yield is directly affected by season and grain yield. However the assumed hay yield is set conservatively and so any change would only represent a further gain in profit.

Figure 9 takes the information from Figure 8 and shows how the distributions relate to each other.

The distribution in Figure 9 shows that the increase in profit from the lucerne rotation, for the yield and price conditions assumed, ranges from -$150 per ha to $140 per ha. In more than 65 percent of simulated cases the farmer is better off remaining with his initial lupin:wheat rotation. Although when the farmer's prices and yields are used the analysis is much more positive with increased profit from the lucerne being anticipated. This is also true when the analysis is extended to 15 years and the paddocks are changed into the lucerne system over a period of two years instead of both in the same year.

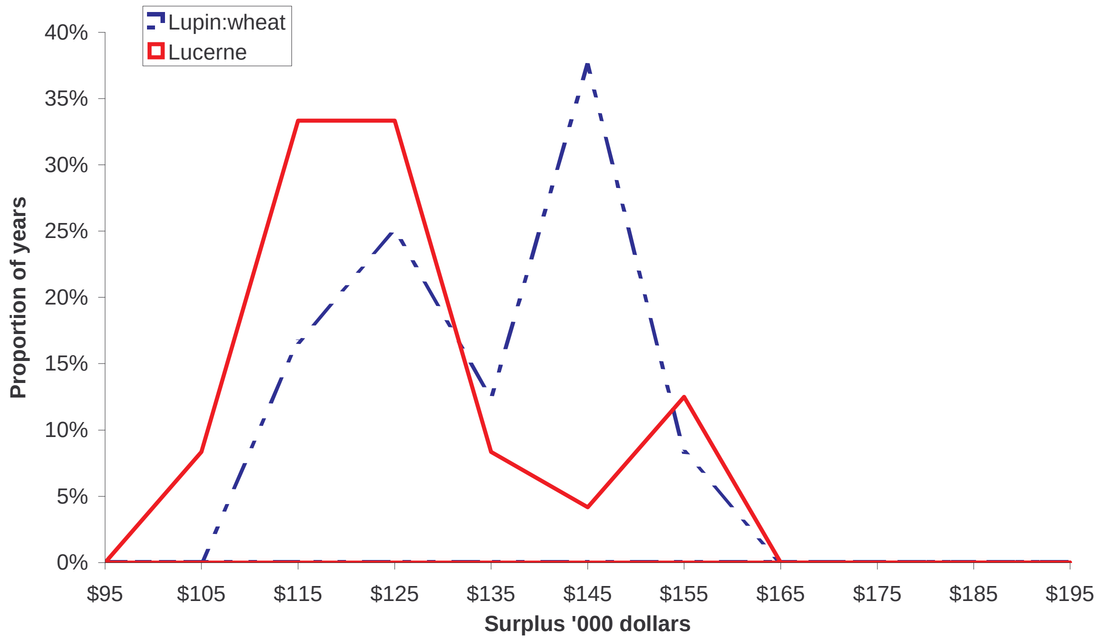


Figure 8: Discounted profit distributions of lupin:wheat versus lucerne-based rotations, applying transition years based on Bankwest benchmark district crop yields

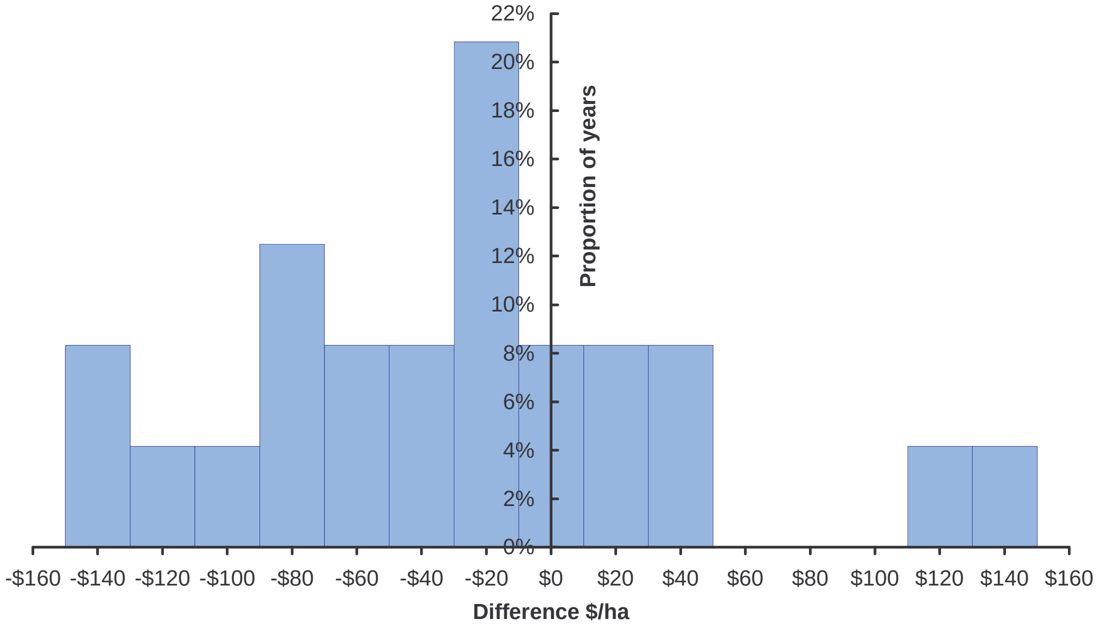


Figure 9: Difference in discounted net profit of introducing lucerne versus maintaining a lupin:wheat rotation, based on transition years using Bankwest benchmark district crop yield data

Although this case study identifies lucerne to be a marginally profitable addition to the farming system for this Buntine farmer, extrapolating findings to other farms in the region is not without hazard. For example, if several farmers commenced production of lucerne:crop stubble hay then the market could quickly become saturated, lessening its price and eroding profits from hay production. It appears that altering the paddocks to bring them into the lucerne phase over two years will be more profitable. Not all farmers may have the capacity to delay changing to the new system, paddocks suited to lucerne production or the facilities to run additional sheep. Emergence of higher yielding lupin varieties or new chemicals to better control weeds in the wheat:lupin rotation may emerge to further lessen the profitability of switching away from the wheat:lupin rotation.

4.2.7. Conclusion

For this case study farm, a lucerne-based rotation replaced a wheat:lupin rotation on 200 hectares. The frequency of the less profitable lupin phase was reduced in the new lucerne-based rotation and production of lucerne:cereal stubble hay commenced. Profit from the production of lucerne hay was often sufficient to offset the loss of grain production in the paddocks where the area of crop was reduced to accommodate lucerne. The major sources of gain in profit were the reduced frequency of the relatively less profitable lupin phase and extra revenue generated by production of the lucerne:cereal stubble hay.

The first year of the lucerne rotation was uniformly less profitable than the wheat:lupin rotation due to the establishment costs for lucerne. The level of loss experienced in this first year depended on the relative yields and prices between barley and wheat. Using Bankwest regional data, barley yield was less than wheat yield. However, in cases where barley yields outstrip wheat yields then it is more likely that a net gain in profit could be generated even in the first year of introducing lucerne. The short analysis time frame also limited the profitability of the lucerne system and staggering the change to the lucerne system also proved beneficial.

A range of crop yield scenarios and sequences was examined, for this case study farm the introduction of a lucerne-based rotation could be either profitable and unprofitable largely due to price and yield relativities and the management of the paddocks and the lucerne system transition. The increase in profits did not include the additional environmental benefits of increased water use by lucerne that could lessen the rise in the water table and delay any onset of salinisation. A summary of findings is presented in Table 8 that lists the mean profits, as well as 25th and 75th percentile profits, under various data assumptions for the case study farm.

Table 8: A summary of the profitability of the lucerne option for the WA Northern zone case study farm

	Profit at full equity ($/ha/yr)					
Data source	**25th percentile**		**Mean**		**75th percentile**	
	without	***with***	***without***	***with***	***without***	***with***
Farmer's expected yields	**52**	**58**	**155**	**188**	**137**	**99**
Bankwest (+100kg yield deficit)[a]	**125**	**129**	**135**	**137**	**145**	**142**
Bankwest (% yield deficit)[a]	**125**	**116**	**135**	**126**	**145**	**130**
Bankwest data extended to 15 years	**78**	**94**	**114**	**127**	**138**	**146**

[a] Each hectare of wheat or lupin includes widely spaced rows of lucerne. Hence, wheat and lupin yields, when expressed on a per hectare basis, need to be reduced to account for space occupied by the lucerne. Two different approaches are used to account for the foregone grain production.

The greatest influences on profitability in the new lucerne interrows system appear to be:

a. The extent of the crop yield reduction from lucerne displacement and competition. In the analysis the crop yield reduction from displacement of crop area is the only yield reduction considered. However, there is the possibility that the lucerne could be so efficient in removing water from the soil that it induces drought conditions in the crop. Conversely there is also no allowance for the yield benefit of the drying effect of the lucerne in wet years when waterlogging would be avoided.

b. The amount and price of the hay produced from the cereal and lucerne stubble. The new innovation gains from the production of lucerne:cereal stubble hay for feeding in a feedlot. The level of production of the hay and the price of the hay will determine whether the innovation can overcome the deficit from displacing crop area with lucerne.

c. The change in rotation to reduce the frequency of the less profitable lupin phase years. In general lupin production is less profitable than cereal production. Introducing lucerne also coincided with a shift from a lupin:wheat rotation to a barley:lupin:wheat rotation reducing the frequency of lupin years and hence improving overall profitability. Further analysis showed that the change to the barley:lupin:wheat rotation was more profitable but it was very dependant on the yield relativities of lupins, wheat and barley. Where barley yield exceeded lupin yield, which is not unexpected, the change to the barley:lupin:wheat rotation was a profitable move. It is expected that the nitrogen and water-use benefits, whilst not specifically captured by this analysis, are an attractive reason to include lucerne in the rotation.