ECONOMIC EVALUATION OF PHASE FARMING WITH LUCERNE ON THE ESPERANCE SANDPLAIN

Michael O'Connell

Regional Economist, Department of Agriculture, Western Australia

moconnell@agric.wa.gov.au

Abstract
This study examines the profitability of phase farming with lucerne for a farming system on the South Coast of Western Australia. Consistent with previous studies, lucerne appears promising within niches in the farming system. However, further improvements in the production and / or utilisation of lucerne are likely to be required before widespread adoption is financially attractive.

Several important conclusions emerge from this study:
• The profitability of lucerne is primarily due to savings on supplementary feed costs over summer and autumn. While lucerne does provide benefits to following crops, the net impact of lucerne on the profitability of a farmer's cropping programme is likely to be negligible.
• The profitability and optimal area of lucerne is likely to be significantly higher on farms where prime lamb production occurs. This will especially be the case where lambs are sold as carryover stock in mid-late summer.
• The economic value of lucerne diminishes as a larger area is established. The implication of this is that just because some lucerne is good, more may not necessarily be better.
• Lucerne appears able to provide some reduction in recharge without a loss in profit. However, for the farming district examined in this study, the dominance of high recharge soil groups creates particular challenges. Significant improvements in lucerne production and / or utilisation will be required before it will compete with current land uses on some of the major soil groups.

Introduction
Inclusion of lucerne in the farming system is seen by many as a means of addressing several important challenges facing agriculture on the South Coast of Western Australia. These challenges include:
- Dryland salinity caused by excess groundwater recharge.
- Herbicide resistant weed populations associated with intensive cropping rotations.
- Declining soil fertility, again associated with intensive cropping.
- Feed shortages in autumn and early winter due to the seasonal pattern of annual pasture production.

Trial results and farmer experience suggest a promising future for lucerne on the South Coast (e.g. Latta 2002). Despite this, many lucerne stands in the region are still in their first rotation, and cropping after lucerne is a new experience for most farmers. Furthermore, stands of lucerne established in recent years have benefited from a period of favourable wool and sheep prices. Few farmers have yet tested the profitability of lucerne under less favourable market conditions, e.g. such as those endured during much of the 1990s.

These and other issues related to lucerne on the South Coast were examined in detail by Bathgate and Pannell (2002). Their analyses indicated a profitable outcome for lucerne in certain niches in the farming system, and identified a range of important profit drivers including soil type mix, lucerne summer growth rates, and wool and sheep prices.

This study builds on the work of Bathgate and Pannell (2002) by addressing the following questions …
- What is the most profitable means of utilising lucerne for livestock production?
- What impact does lucerne have on the profitability of cropping?
- To what extent can lucerne be used to reduce groundwater recharge while still maintaining profit?

In addressing these questions, the objective of this paper is to provide information that will assist in prioritising a) extension messages and b) future research needs.

Methods
Study area
This study focuses on the 400 - 500 mm rainfall belt within the shire of Esperance on the South Coast of Western Australia. Sandy textured soils are dominant, and the area is generally referred to as the Esperance sandplain.

Typical farm size is 2,000 - 3,000 ha. Most farms produce a mix of grain, wool and meat. Typically 50 - 60% of arable land is sown to crop with the balance being pasture. Sheep are the dominant livestock enterprise, although cattle are important on some individual farms.

The traditional growing season for crops and pasture is May to October, with about two-thirds of annual rainfall falling over this period. A summer drought follows during which time the quality and quantity of feed available for livestock steadily declines, culminating in the "autumn feed gap". This feature of the farming system has important implications for the profitability of alternative feed sources (such as lucerne), in that the timing of feed supply can be just as important as the amount produced.

Analytical technique

The analysis was conducted using the South Coast version of MIDAS. The acronym MIDAS stands for "Model of an Integrated Dryland Agricultural System". The MIDAS approach has been described in detail by several authors (e.g. Kingwell and Pannell 1987, Bathgate 1999). Briefly, MIDAS is a mathematical programming model that represents the technical, physical, biological and managerial aspects of broadacre livestock and crop production systems. Crops, crop stubbles, pastures, sheep, grain feeding, machinery and finance are all represented to a high level of detail. In addition, the model is strongly based on soil types and rotations, with different production figures for each rotation on each soil type.

The South Coast MIDAS represents a farm of 2,500 hectares in the 400 - 500 mm rainfall zone of the South Coast. Several mixes of soil type are included in the model to allow for sub-regional differences. The soil mix used in this analysis represents a typical mix for the Esperance sandplain and is summarised in Table 1.

Table 1. Summary of soil type mix assumed for the Esperance sandplain sub-region of the South Coast.

Soil group	Brief description	Area (hectares)
Deep sands	Generally more than 80cm to clay. Not susceptible to waterlogging and therefore able to be used for high yield cropping or tagasaste.	500
Waterlogging prone duplex	Sand over clay (with or without gravel) within 30cm. Slope<3%. Subject to waterlogging, leading to greatly reduced cereal yields and delayed pasture growth. Most severe water-logging occurs in drainage lines and depressions.	750
Medium depth sandplain duplex	Sand over clay at 30 to 80cm, often with a gravel layer above the clay. May be waterlogged in wet years. High yielding cereal and lupin crops are possible in some years. Susceptible to wind erosion and water repellence.	1000
Saline soils	Not necessarily bare salt scalds; can be productive if fertilised.	250
Total area		2500

Representation of lucerne in MIDAS

Lucerne is assumed to be sown in August and first grazed in November of the same year. From then on grazing is rotational with 6 week breaks, so as to ensure that overgrazing does not occur. The lucerne based pasture is assumed to be a mix sward that includes a range of annual species (i.e. much the same mix of grasses and herbs as would be found in a sub-clover based pasture). Costs associated with lucerne are summarised in Table 2.

Table 2. Costs of lucerne establishment, maintenance and removal

	Establishment year ($/ha)	Annual maintenance ($/ha)	Removal ($/ha)
Machinery costs	12	-	-
Seed costs	28	-	-
Fertiliser	45	45	-
Chemicals	50	10	30

Totals	135	55	30

During the May - October growing season lucerne is assumed to grow at the same rate as annual pastures. From November to April there is no growth of annual pasture, although it remains available as a source of dry feed. By contrast, the lucerne continues to grow over the dry months, albeit at a reduced rate. Indicative annual pasture and lucerne growth rates are provided in Table 3 (note: actual growth rates represented in the model vary according to soil type and rotation).

Table 3. Indicative growth rates for annual and lucerne based pastures (these figures are for the medium-depth duplex soil group).

	Indicative growth rates (kg / ha / day)	
Month	Annual pasture	Lucerne
January	0	4
February	0	0
March	0	0
April	13	13
May	10	10
June	15	15
July	20	20
August	30	30
September	40	40
October	50	50
November	0	10
December	0	6

Lucerne phases of two, three and four years are represented in the model. Lucerne is assumed to provide yield and nitrogen benefits to the first two years of crop coming out of the lucerne phase. Lucerne rotations included in the model are as follows:

- 2 years of lucerne followed by wheat
- 2 years of lucerne followed by - wheat - barley
- 2 years of lucerne followed by wheat - canola - wheat - barley
- 2 years of lucerne followed by wheat - canola - barley - grain legume - wheat
- 3 years of lucerne followed by wheat - canola - barley
- 3 years of lucerne followed by wheat - canola - wheat - barley
- 4 years of lucerne followed by wheat
- 4 years of lucerne followed by wheat - canola - wheat - barley
- 4 years of lucerne followed by wheat - canola - barley - grain legume - wheat

These lucerne rotations are available on all soil groups except the saline soils. In addition the model includes continuous pasture, pasture - crop rotations, continuous crop rotations and green manure options. In total there are over 90 different rotational combinations available for each soil group.

Lucerne is assumed to be removed in the spring of the year prior to cropping. Autumn removal just prior to crop seeding would be preferable from a grazing perspective, but is a risky strategy because of the difficulties of killing lucerne at a time when it is unlikely to be actively growing.

Price assumptions

Table 4 lists the price assumptions for this analysis. These prices are based on a range of sources including ABARE, futures markets and forward contracts. They are intended to represent medium term estimates, and so may not directly correspond to prices received this year.

Table 4. Price assumptions.

Commodity	Price	Basis of quotation
APW 10% wheat	200	$/t pool return GST exc.
Malting barley	205	$/t pool return GST exc.
Feed barley	170	$/t pool return GST exc.
Oats	150	$/t delivered Perth GST exc.

Canola	375	$/t pool return GST exc.
Lupins	210	$/t pool return GST exc.
Field peas	300	$/t delivered Perth GST exc.
Wool	900	c/kg clean Western Market Indicator
Lambs	320	c/kg dress weight
Mutton	200	c/kg dress weight
Shippers	55	$/hd liveweight

Results and discussion

Changes in whole-farm strategy when lucerne is included in the system

Patterns of feed supply are altered markedly by the inclusion of lucerne in the farming system. This has important implications for the diet of livestock, particularly “out of season”, i.e. November to April. Changes in the November - April diet composition selected by MIDAS are highlighted in Figure 1.

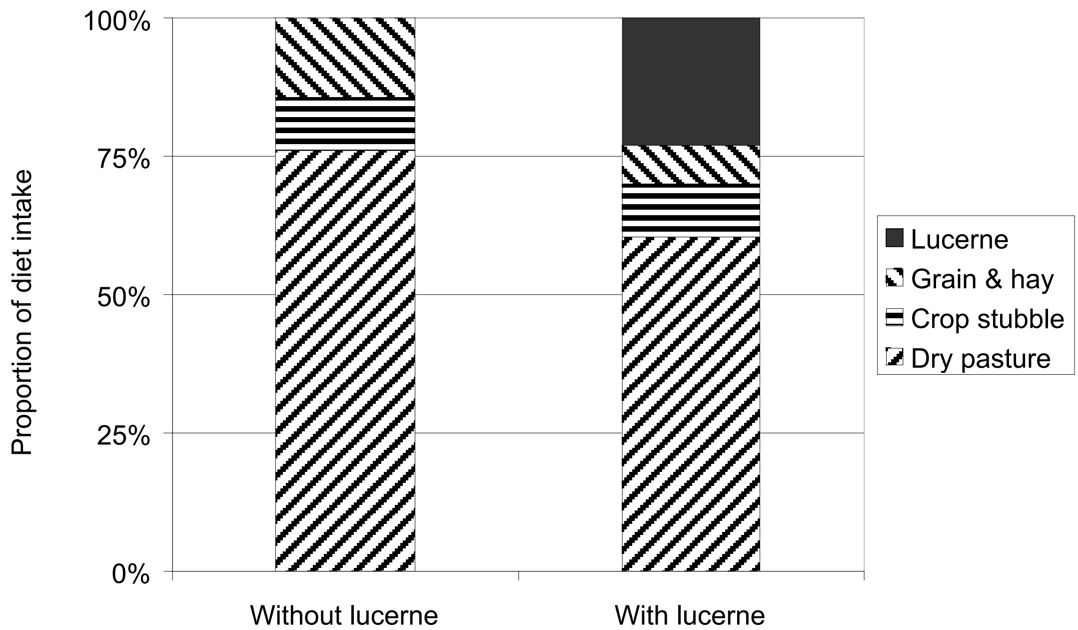

Figure 1. Impact of lucerne on diet composition over the November - April out of growing season period.

By contrast, inclusion of lucerne in the system has minimal impact on the area of crop selected by MIDAS. However, important shifts in cropping rotation may be required to accommodate lucerne. These shifts can be summarised as follows:

- On the soil types where lucerne is grown there is likely to be an overall reduction in crop area, especially if lucerne is established in place of a continuous cropping rotation.
- This reduction in crop area will generally be compensated for by an increase in crop area on other land management units.

An example of these changes in cropping rotation due to inclusion of lucerne is illustrated in Table 5. Lucerne has displaced crop on the medium-depth duplex and to compensate for this change there has been a shift in rotation on the deep sands, even though lucerne is not grown on this soil group.

Table 5. Summary of enterprise mix by soil group with and without lucerne.

Soil group	**Without lucerne**	**With lucerne**
Deep sands	400 ha crop, 100 ha pasture	450 ha crop, 50 ha pasture
Waterlogging prone duplex	350 ha crop, 400 ha pasture	350 ha crop, 400 ha pasture
Medium depth sandplain duplex	850 ha crop, 150 ha pasture	800 ha crop, **200 ha lucerne**

		lucerne
Saline soils	250 ha pasture	250 ha pasture
Total crop **Total pasture + lucerne**	**1600 ha** **900 ha**	**1600 ha** **900 ha**

Impact of lucerne on whole-farm profit

Inclusion of lucerne in the farming system improved MIDAS whole farm profit, with the dollar value of lucerne being highly sensitive to several key assumptions. For example, under current wool and sheep prices the average value of each hectare of lucerne was approximately $30-40. Inclusion of prime lambs increased this figure by a further $10-20/ha, especially where lambs were carried over summer and sold in January. The majority of these benefits relate to savings on supplementary feed costs. This is because lucerne reduces the requirement for grain and hay feeding (see Figure 1).

Importantly, gains from lucerne diminish as a greater area is sown. That is, each additional hectare sown is worth less than the previous hectare. Eventually a point will be reached where sowing additional lucerne actually reduces profit. This principal is demonstrated in Figure 2, where the marginal value of lucerne is graphed for scenarios with and without prime lamb production. The optimal area of lucerne is at the point where marginal value is $0, i.e. the point where there are no further gains to be had from increasing the area of lucerne.

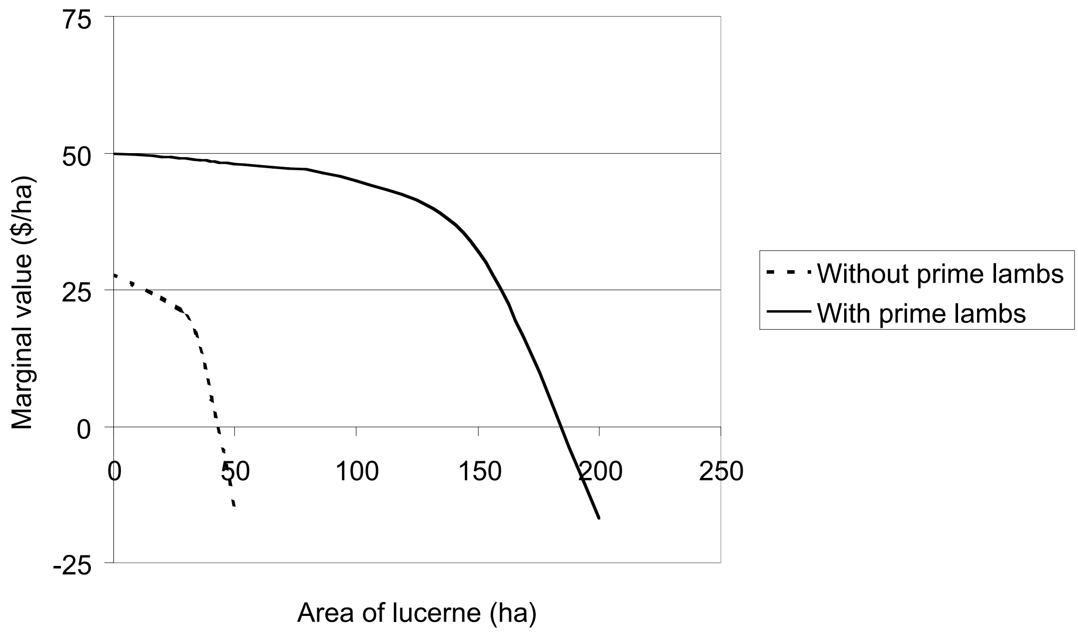

Figure 2. Marginal value of lucerne with and without inclusion of prime lambs in the enterprise mix.

In practice it is not so critical to precisely identify the "optimal" area of lucerne. However it is important to recognise that just because some lucerne is good, more will not necessarily be better. Reasons for the pattern of diminishing returns include:

- Additional lucerne evens out the supply of feed through the year. This reduces the scarcity of feed in the summer and autumn (and hence the economic value of additional feed).
- Additional lucerne will often have to be sown on soil types where it is not well suited.
- Additional lucerne may displace high value crops, thereby incurring a heavy opportunity cost.

Does lucerne improve the profitability of cropping?

Cereals sown directly after a lucerne phase often show increases in yield and protein relative to cereals sown after annual pasture. For example, Latta et al. (2001) report trial results where wheat yield and protein after lucerne were 10% and 1% higher than wheat grown after annual pasture. Despite such impressive yield and protein benefits, results from this economic analysis suggest that the net impact of lucerne on the profitability of a farmer's cropping programme will generally be small, sometimes nil, and occasionally negative. This is due a combination of reasons.

Firstly, the length of most lucerne rotations means that benefits to following crops can only be realised occasionally. For example, a one-off yield boost of 250 kg/ha (worth say $40) in an 8 year lucerne / crop rotation is actually only worth $5/ha when averaged out over the rotation.

Secondly, the drying effect that lucerne has on the soil profile can actually cause yield decreases in following crops in situations where growing season rainfall is low (e.g. Latta and Devenish 2002). The reverse of this argument is that the drying effect of lucerne could be beneficial to following crops in very wet years due to reduced waterlogging, although realisation of this benefit would require that lucerne be sown into waterlogging prone areas.

Finally, as shown in Table 5, the inclusion of lucerne will typically displace some crop, most probably on a soil type where crops grow particularly well. In order to compensate for this loss of crop area, more crop will be sown on soil types where crops may be less productive and less profitable.

The relatively minor impact that cropping benefits have on the profitability of lucerne is emphasised in Figure 3. Even with a 25% yield boost in the first cereal after lucerne (relative to cereal after pasture), the average value of lucerne is only slightly increased. The change in optimal area of lucerne is likewise small.

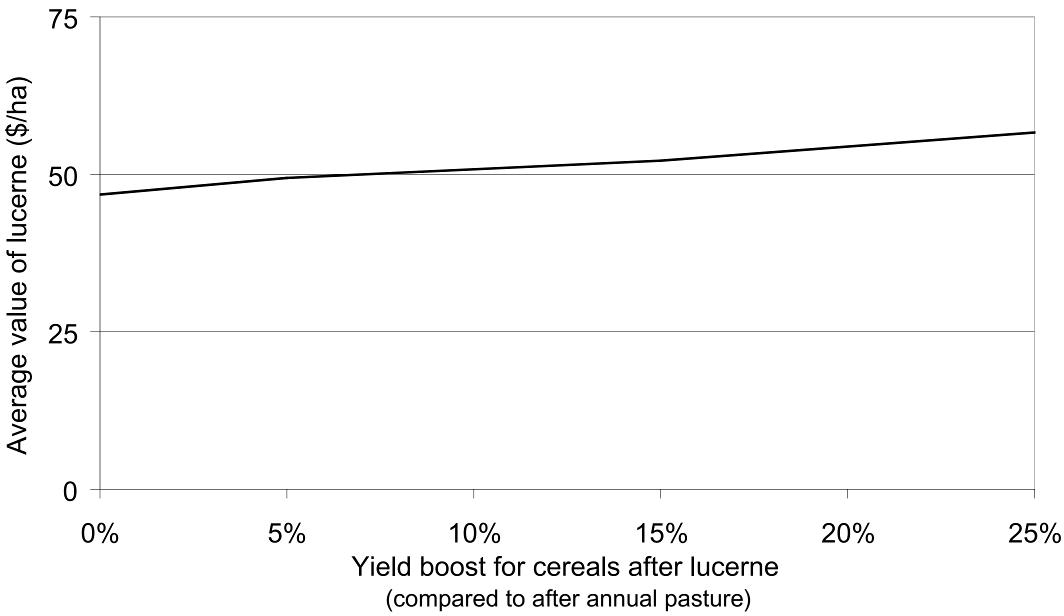

Figure 3. Impact of yield boost to following cereal crops on the increase in profit from adopting lucerne.

Lucerne, profit and groundwater recharge

On any given farm the amount of recharge occurring across the landscape varies considerably according to soil type. The extent to which lucerne can be used to reduce recharge is therefore dependent on its profitability on high recharge soil types.

Indicative recharge figures for the soil groups used in this analysis are also provided in Table 6. These recharge figures assume an average annual rainfall of 450 mm.

Table 6. Indicative recharge figures under annual-based agriculture for each of the soil groups used in this analysis.

Soil group	**Indicative recharge (mm/year)**
Deep sands	80
Waterlogging prone duplex	55
Medium depth sandplain duplex	75
Saline soils	0 (discharge area)

From Table 6 it is evident that for the Esperance sandplain recharge is quite high for all of the major soil groups. Therefore, in order for lucerne to have a significant impact on recharge it must compete profitably on each of these soil groups. This is a far more challenging proposition than farmers in many other regions will face; most other regions have a broader mix of soils and recharge rates across the landscape.

Results from this analysis (see Table 5) suggest that lucerne is profitable to some extent on the medium depth duplex soil, but unlikely to compete on either the deep sand or waterlogging prone duplex. In the case of the deep sands, continuous cropping is more profitable than lucerne, while on the waterlogging prone duplex the growth of lucerne is insufficient to compete with annual pastures and cereals. Consequently, the prospects for reducing recharge on these parts of the landscape using lucerne are somewhat diminished. Improvements in the production and / or utilisation of lucerne on these soil groups will be needed before widespread adoption will be financially attractive to farmers.

Sensitivity analysis provides clues as to the kinds of improvements that might make lucerne profitable across more of the landscape. Figure 4 presents results of sensitivity analysis examining the impact of flock type and lucerne growth rates on the extent to which lucerne can be used to profitably reduce recharge. The "improved lucerne" shown in Figure 4 represents a hypothetical case where lucerne is equally productive across all of the non-saline soil types, and so is better able to compete with current land uses on deep sands and waterlogging prone duplexes.

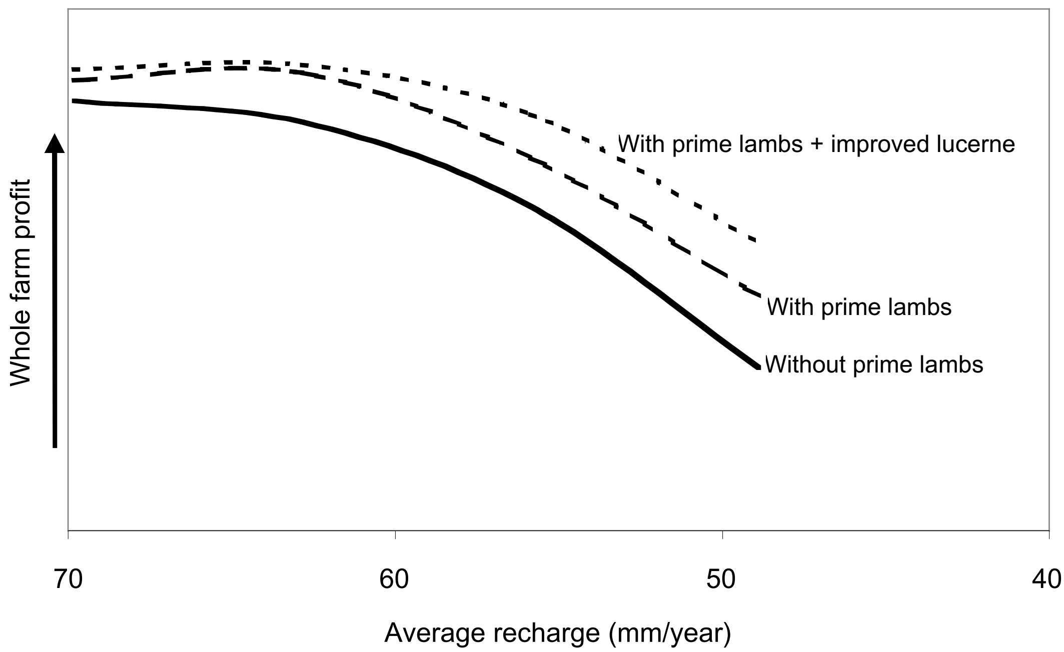

Figure 4. Trade-off between recharge reduction using lucerne and whole farm profit for a range of scenarios.

The results in Figure 4 further highlight how inclusion of prime lambs in the farming system is likely to improve the profitability of lucerne, and enhance the prospects for reducing recharge. Additional improvements in profitability and recharge reduction will be realised through the development of lucerne varieties and / or management packages that are better able to compete with existing enterprises on the deep sands and waterlogging prone duplex soil groups.

Acknowledgements

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