Research Report

National Economics Project
Corangamite Region

The role of Grazing Wheat in mixed farming systems:

A Whole-farm Analysis for the Corangamite Region of Victoria

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Acknowledgements

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Introduction

One of the major factors limiting the profitability of livestock production in southern Australia is perceived to be the autumn/winter feed gap, where pasture residues are of poor quality and pasture growth rates and availability of green feed are very low. During this period farmers typically provide supplementary grain to sheep to maintain liveweight at a high cost. Increasing interest in (and adoption of) summer active perennial species has tended to reduce the feed shortage during autumn, but this remains a problem during the cooler months of the year.

A number of strategies to reduce the impact of the feed gap on livestock profitability have been proposed over many years, including; gathering straw and feeding it with additives that improve digestibility, hay and silage production and lot feeding. In some regions of southern Australia cereal crops are sown as a fodder crop that can be grazed during winter, and is some cases provide a standing crop to improve liveweight gain over summer.

Recently there has been increased interest in using long season wheat varieties, to provide winter feed but also provide a harvestable yield of grain. Experiments have shown that long season varieties can provide good quantities of high quality feed, although grazing can reduce the grain yield. Trials over a number of years have shown that the loss in yield after grazing is variable, such that in 90% of cases yield changes after grazing of between have been between -30% and +30%. Losses in grain yield were observed more frequently than yield gains, after grazing in winter. (Feedbase Project Team, Grain & Graze, 2007).

However there are potential gains to the pasture enterprise by supplying higher quantities of good quality feed through winter. Increase feed supplies may provide good opportunity for farmers to increase the stocking rate of the farm. This can be partly achieved by reducing grazing pressure on pastures during winter by running stock on crop paddocks which will lead to an increase in pasture productivity through deferment.

In mixed systems introducing grazing wheat is likely to have broader implications for farm strategy, by altering the relative profitability of crop and pasture. The aim of this analysis is to determine the effect of the introduction of grazing cereals into the farming system on the optimal enterprise mix.

In southern Victoria there has also been increasing interest in the role of lucerne to provide feed over summer, particularly for prime lamb enterprises. However lucerne has not improved livestock production as anticipated. Growth rates of land have been lower than the expected given the measured digestibility of the pasture and low production over winter has limited the carrying capacity of farms.

Trials have shown that a special formulation of pelleted feed improves the condition of the rumen and improves digestion of the high quality pasture, thereby improving growth rates. The winter feed gap was addressed by the inclusion of companion cereal crops in

lucerne, to provide additional feed when the growth rate of lucerne is low. The limitation of this strategy is the potential impact on lucerne growth and the provision of feed during the same period as grazing cereal.

The aim of this study is to estimate the increase in farm profit that is likely to result from the adoption of strategies being examined by Grain & Graze in southern Victoria and assess the changes in farm strategies that are likely to be undertaken to maximise the benefits of these strategies

Method

Description of the region

The Corangamite and Glenelg/Hopkins catchments are situated in southern Victoria, to the West of Melbourne and East of the South Australian border.

The climate can be broadly described as Mediterranean, with a cool wet growing season during winter and spring, where rainfall exceeds evapotranspiration and warm relatively dry summers. The study region has annual rainfall of between 550 and 650 mm, 80% of which falls in the growing season and summer rain is a small proportion of the total. The break of the season is typically around late March, the season finish is in early December and the total the variability in rainfall is low compared with other agricultural regions of southern Australia

A basalt plain is the dominant land form in the study region. Within this plain there are areas of shallow, underdeveloped soils that are infertile, while others have developed over a longer period and are more fertile supporting high levels of production. Consecutive lava flows have also interrupted drainage lines, so much of the plain is poorly drained and subject to water logging and inundation. In some areas salinity levels also limit the production of many agricultural plants species.

Sedimentary soils formed by marine deposition make up a smaller proportion of the region. These are older soils and typically low in fertility with a sandy top soil and heavier subsoil. Old lake beds contain heavy clay soils including cracking clays. These are often sodic and poorly drained.

Sheep meat and wool has been the dominant enterprise until more recently, when there has been a marked increase in crop area, particularly in the eastern half of the region. Livestock are grazed on productive mixed pastures of mixed perennial and annual species. Dairy and beef enterprises are important to regional economies but are only minor in terms of total area in the study region. Cropping, horticulture, forestry and viticulture are also minor enterprises.

The model used in this analysis focuses in the area around Inverleigh which lies around 30km west of Geelong.

Description of the model

Overview

MIDAS (Model of an Integrated Dryland Agricultural System) is a suite of whole-farm models that describe the crop-livestock production systems in a number of regions of Southern Australia. It is an economic optimisation model that has a strong focus on the biological relationships of production, including the interactions between enterprises that are both spatial and temporal in nature.

Versions of the model have been developed for a number of different regions of Western Australian (Blennerhasset & Bathgate, 2000; Morrison *et al.*, 1986; Morrison & Young, 1991), south-west Victoria (Thompson & Young, 2000), the Central West Slopes (Bathgate & Hoque, 2007), Southern Slopes (Bathgate, Unpublished) and Coolamon Regions (Bathgate, 2008) of New South Wales and the Upper South East of South Australia (Bathgate, Unpublished).

Components of MIDAS

The model comprises a number of sub-matrices representing different components of the farming system. These are:

(i) Crop/ pasture rotations
Cropping history (or rotation) is represented by up to 70 different activities for each of six land management units described in the model.

(ii) Machinery
Represented by a single activity that describes the availability of machinery to sow crops and pasture during four periods after the break of the season. This constrains the area of crop that can be sown and the reductions in crop yield that occur as a result of delayed sowing.

(iii) Time of sowing penalties
On average, maximum crop yield is achieved when crops are sown within a narrow window after the break of season. Crop sown outside this window have reduced yields. This sub-matrix describes the relationship between yield reduction and areas of crop sown, based on the availability of machinery.

(iv) Grain, wool and livestock selling
Selling activities in the model link the physical output of the model with the cashflow and objective function.

(v) Pasture production
The season is divided into 10 periods of varying length depending on the growth rate of pasture. There are 7 periods of growth and 3 periods of senescence and pasture decline.

(vi) Livestock production
A large number of livestock classes are describe sheep and cattle production. These differ in the demand for energy and the levels of production.

(vii) Supplementary feeding
Alternative sources of supplementary feed are available to ensure adequate supply of energy over the summer drought.

(viii) Stubble grazing
Crop residues provide an additional source of feed for livestock during the summer drought. The quality and quantity of stubble available for grazing deteriorates with time and with grazing.

(ix) Finance
Income and expenditure associated with each activity are described in the cashflow section of the model. Overheads and depreciation are subtracted from the net cashflow to calculate farm profit.

Soil Classes

Three land management units (LMU) are an aggregation of soil types that have the same production levels for a given level of inputs and management. It is implied that all soils within an LMU have similar chemical and physical characteristics. Therefore the proportion of excess water that runs off into water courses and recharges the water table will be the same within each LMU.

The three units described are the lunette soils, brown sandy loams and the clay loam duplex. The latter two constitute the majority of the farm area making 94% of the total in equal proportions. The duplex soils are most prone to waterlogging, although it has been demonstrated they are very productive with appropriate drainage. The lunette soils are the most productive for both pastures and crops but only constitute around 6% of the total area.

Crop production

Different crop and pasture sequences (or rotations) are represented as single activities These are associated with specific crop yields, pasture growth and inputs levels that depend on the sequence. Pulse crops reduce the carryover of cereal diseases and fix soil nitrogen, for example. This affects potential cereal yield and optimum nitrogen rate. The number of continuous years of crop affects the ability of pastures to regenerate naturally and thus the number of livestock that can be grazed profitability is affected.

Six crop and pasture types are included in these activities. These are:
  i. Wheat
  ii. Barley
  iii. Canola
  iv. Oats
  v. Field peas
  vi. Annual pastures (mixed sward)
  vii. Perennial pasture

Annual pasture production

An annual pasture is a mixed sward of grasses and legumes. The quality and quantity of feed is the average of the sward for each period. Periods 1 to 7 represent the growing season (see Table 2). Each period varies in length according to growth rate and pasture quality (digestibility). Pasture is assumed to germinate in Period 1.

Germination is dependent on soil class and crop/pasture sequence. Growth rate in subsequent periods is a function of feed on offer (kg of dry matter per ha), and is approximated by linear segments. Feed on offer (FOO) is a function of FOO at the beginning of period, the amount of pasture grazed by livestock during the period and the rate of physical deterioration and trampling by livestock (Bathgate & Blennerhasset, 2000).

Pasture quality and quantity decline rapidly after senescence (Periods 8–10). This is represented by individual grazing activities for each period. Conservation constraints prevent over grazing.

Lucerne production

Lucerne is modelled differently to annual pasture. Annual pastures can be managed flexibly to optimise the supply of feed to livestock that have changing demands. Paddocks can be subject to a high grazing pressure when demand for energy is high, at the expense of future pasture growth. Alternatively annual pasture may be deferred to improve growth rate and future feed availability. The method of modelling annual pasture provides this flexibility.

Lucerne, on the other hand, requires a rigid management regime. Prolonged high grazing pressures will damage individual plants leading to a reduction in plant density. This will compromise the productivity of the lucerne stand. On the other hand prolonged deferment of pastures will lead to a decline in the quality of the feed (Stockdale & King, 1985). Lucerne is typically grazed for a period and then the livestock are excluded to encourage re-growth. In this model, the implied grazing regime is 2 weeks of grazing followed by a 6 week period of grazing rest. Sheep are removed from the lucerne stand once the feed on offer is reduced to a certain level. While this reduces flexibility of grazing management, previous studies have shown that the profitability of lucerne depends on its ability to provide good quality feed during this period (eg Bathgate & Pannell, 2002).

This rigid grazing regime enables lucerne to be modelled more simply. As the feed on offer at the end of each grazing period is known, the growth rate for the next period can be estimated prior to solving the model and can be used to determine the total feed available for that grazing period.

Stubble grazing

Crop residues can be a source of high quality feed for livestock after harvest. Sheep preferentially graze the high quality components of the stubble so the quality of stubble declines as it is grazed. There are three stubble grazing activities for each crop representing this decline. Transfer activities ensure the higher quality components are grazed prior to lower quality components. This prevents the model allocating the low quality pasture first and deferring the high quality portion of the stubble to late summer/autumn where the marginal value of feed is highest. Conservation constraints limit the total amount of dry matter available for grazing.

Livestock

Sheep production

A self-replacing merino flock is described in the model. Three different enterprises can be represented. They include a wool only enterprise, a wool and merino prime lamb enterprise, or a cross-bred prime lamb enterprise. Different classes of sheep are described, based on age, times of sale and gender. Ewes are culled after five or six years. Death rates, annual wool growth and hauter are a function of the liveweight of each sheep

class. Liveweight of ewes also affects lambing rates. Liveweights of animals are a function of the availability and quality of feed.

<u>Cattle production</u>
A self-replacing cattle herd is also included in the model. Two different calving times can be represented. September born calves sold at 16 months of age in January and March born calves sold at 10 months of age as weaners in January. As with the sheep flock, different liveweight patterns of cows and the progeny are included which influence the nutritional demand, calving rates and sale prices.

The relationships used to estimate production and energy requirements of the cattle are based on a feed budget programme developed by Andrew Moore (*pers comm.*) that is based on the GrazFeed and GrassGro models.

Finance

Cash payments for inputs and cash received are described as a bi-monthly cashflow. Provision has been made to enable an overdraft. Interest is paid on bimonthly deficits and earned on surpluses. The objective function is equal to the net cashflow at the end of the year, less depreciation of machinery and infrastructure, less the opportunity cost of non-land assets.

Model data

Crop and pasture production achieved and the inputs applied assume a good level of management. Management skill in the top 3rd decile is assumed.

The Inverleigh Model assumes annual average rainfall is around 600-650 mm and a typical farm is 900 hectare in total arable area. The soils and average crop yields are shown below in Table 1.

The season is divided into 10 periods, according to growth rate and quality of pasture. The first seven periods represent the growing season for annual pasture species and three the summer 'drought'. Demand for energy by livestock varies between periods, depending on the change in liveweight and the stage of the reproductive cycle.

Whilst the standard model assumptions reflect the parameter values of an expected season the conclusions are never based solely on model runs based on the standard assumptions. Sensitivity analysis is used to examine the influence of parameter values on farm profit. Conclusions of the analysis are reliant on the outcome of the sensitivity analysis.

Table 1: Crop and pasture production on each LMU for a farm representative of Inverleigh assuming good management. The most yields and growth rates of the most productive phases of the best rotations are described are shown.

	LMU1 Brown sandy loams	LMU2 Clay loam duplex	LMU3 Lunette
Area (ha)	425	425	50
Wheat (t/ha)	4.5	4.5	5.4
Barley (t/ha)	4.0	4.0	4.9
Oats	3.6	3.6	4.3
Canola (t/ha)	1.5	1.5	1.8
Field peas (t/ha)	1.8	1.8	2.2
Pasture (t/ha)			
P1	100%	80%	100%
P2	100%	80%	100%
P3	100%	80%	100%
P4	100%	80%	100%
P5	100%	100%	100%
P6	100%	100%	100%
P7	100%	200%	100%

Table 2: Start dates for pasture periods

Period	Start date
1	29-Mar
2	3-May
3	31-May
4	6-Jul
5	10-Aug
6	14-Sep
7	26-Oct
8	23-Nov
9	21-Jan
10	1-Mar

Analysis

The model was used to examine the profitability of a cattle based system compared to a sheep meat & wool based enterprise. A sensitivity was carried out to determine the price at which cattle and sheep breakeven.

The model was also run for a range of grain and wool prices, whilst constraining the area of crop and pasture to predetermined limits, to examine the responsiveness of farm profit to changes in the enterprise mix, with and without the innovations being assessed by Grain & Graze. This analysis was repeated at three levels of crop yield to provide some insight into how each innovation might influence farm profit under different seasonal conditions.

The innovations assessed were:
1.   Grazing cereal,
2.   Lucerne,
3.   Lucerne with supplementary pellets for lambs,
4.   Companion cereal in lucerne and,
5.   Integrated pest management

The price for each of the five sets of runs undertaken are shown in Table 3.

Table 3: Price assumptions for each set of runs

Commodity	Price	units
Wheat	300	$/t
Barley	300	$/t
Canola	560	$/t
Wool	900	c/kg clean
Prime lamb	350	c/kg dressed
Hiefers	160	c/kg liveweight
Steers	170	c/kg liveweight
Cows	125	c/kg liveweight

An important assumption of this analysis is that the long season wheat varieties grown by farmers achieve the same quality standards as the wheat varieties they replace. That is, the second year of wheat after a lucerne or annual pasture phase is assumed to be ASW grade and this is reflected in the prices and yields assumed.

Results

Cattle

A self replacing cattle enterprise based on selling steers at 15 months is less profitable than a sheep meat and wool enterprise mating surplus merino ewes to a terminal sire (Figure 1). With current prices and a cattle based enterprise the optimum area of crop is higher than for a sheep based enterprise, this is because of the lower profitability of the pasture phase on a cattle property.
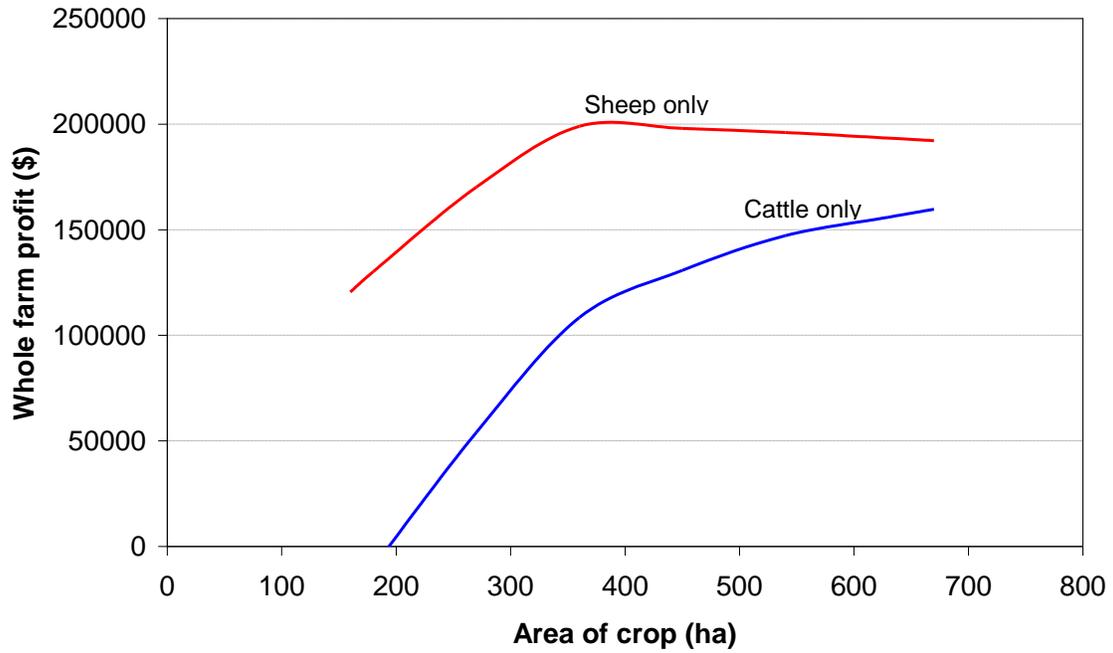
Figure 1: **Responses of farm profit to area of crop for a sheep enterprise and a cattle enterprise operating on a property without lucerne and without grazing wheat. Wheat price $300/t, barley price $300/t, canola price $560/t, Wool price 900 c/kg clean (Market indicator), Steer price 170c/kg live.**
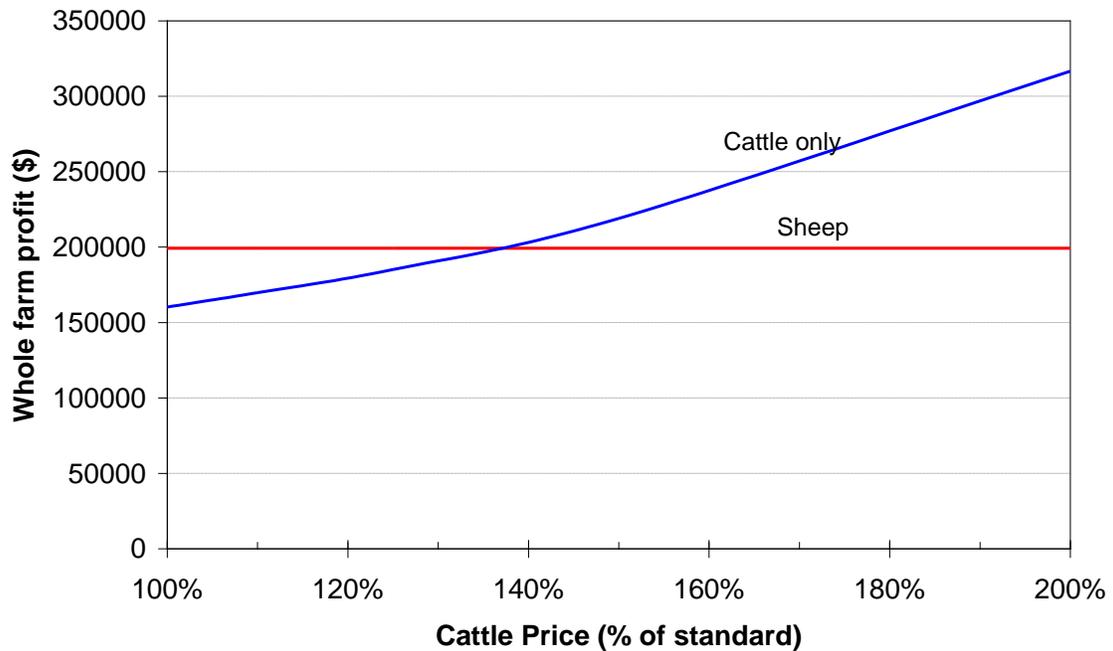

Figure 2: **Relative profitability of a sheep and a cattle enterprise with changes in the price received for beef. Standard prices are Steers 170c/kg live, heifers 160c/kg live and cow 125c/kg live.**

For a cattle based property to breakeven with a sheep based property the price of beef would need to be approximately 40% higher than current while the price of lamb and wool remain at their current levels (wool 900c/kg MI and lamb $3.50/kg DW). A 40% increase in cattle price lifts the steers to $2.35/kg live and the cows to $1.75/kg.

Landuse

A comparison of the 'optimal' farm enterprise mix for a "conventional" farm and farms with lucerne and grazing cereal are shown in Table 4.

Table 4: Brief summary of the optimal farm strategy for a standard farm, a lucerne farm and a grazing wheat farm.

Grazing cereal	Lucerne	Wheat	Barley	Canola	Past.	Luc.	DSE	Profit ($)
				Area (ha)				
Without	Without	113	113	113	559	-	6493	199,000
With	Without	152	152	152	444	-	6490	229,000
With	With	142	142	142	313	160	5786	244,000

The optimal crop area is around 38% where cereal is not grazed and lucerne is not grown. The optimal winter stocking rate is around 12 dry sheep equivalents per hectare. The selected rotations include long phases of annual legume based pasture of 12-15 years and long phases of crop up to nine years. Profit estimates are based on current grain and wool prices, and recent fertiliser and chemical prices.

Introducing grazing cereal leads to change in the optimal farm strategy and a substantial increase in farm profit. However the profit estimates assume that there is no yield reduction after grazing. Previous analysis for southern NSW indicate that small reductions in cereal yield after grazing has a significant adverse effect on the net benefit of grazing.

Crop area is increased whilst the area of pasture is reduced. This is achieved by reducing the length of pasture phase from 15 to three years, whilst maintaining the same length of crop phase, on a proportion of LMU 1 and LMU 2.

Stock numbers are not altered, however and this leads to a increase in the optimal stocking rate to 14.5 dse per hectare. To accommodate the increased grazing pressure the total supplementary grain fed to the sheep flock increases by 15 tonnes during Period 1 of the growing season.

The shifts in farm strategy, particularly on the livestock side of the business contrast with the changes when lucerne is introduced. The area of crop in increased compared to the standard farm, but to a lesser extent than the increase that occurs under grazing cereal. Pasture area is decreased compared to the standard while stocking rate is only increased by around 0.5 dse per hectare rather than the increase of 3 dse per hectare under grazing cereal. However the increase in profit is substantially higher under lucerne, despite the

lower stocking rate compared to grazing cereal. The higher profitability from lucerne results from the large decline in requirements for supplementary feeding over summer.

Companion crop is not selected as part of the optimal strategy, primarily due to the costs of establishment.

Affect of crop area on farm profit

Figure 3 shows the effect of changing the area of crop on whole farm profit, at three different yield levels. High yields reflect the average yield achieved by farmers in the top 30% of managers. Mid yields are 75% of the high yields while low yields are 50%.
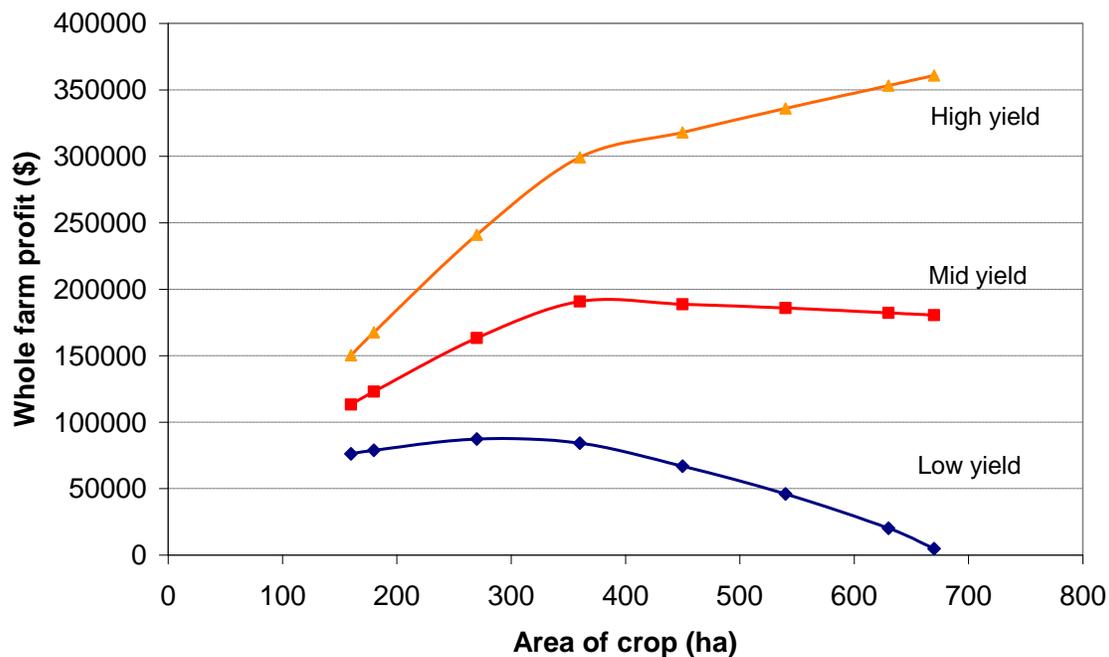

Figure 3:   Responses of farm profit to area of crop, and different relative yields (100% of standard, 75% and 50%).. Wheat price $300/t, barley price $300/t, canola price $560/t, Wool price 900 c/kg clean (Market indicator).

The results show that yield levels have a significant impact on the optimal enterprise mix. At high yields profit is maximised when the majority of the farm is in crop. Data points greater than 670 hectares are not shown because the suite of rotational options limits the crop area to 70% of the farm.

A 25% yield reduction reduces the optimal area below 50% of the farm. However the response curve is very flat from 350 hectares up to 670 hectares, such that the differences in profit over this range of cropped area is not significant. Figure 3 also shows that the optimal range of cropped area is reduced to between 150 and 400 hectares where crop yield are 50% of the standard assumptions and there is a significant reduction in profit if crop area is increased above this range.

A striking feature of the results is the variation in profit as crop area increases. Whilst large profits can be achieved in good seasons and by good managers the profits are much lower in poorer seasons, compared to the situation where crop area is low. This indicates that that risk of crop dominant program is substantially higher in comparison to a pasture dominant program where the variation in profit much lower.

Affect of grazing cereal on farm profit

Figure 4 shows the increase in whole farm profit that results from the introduction of grazing cereal at different proportions of the farm in crop and pasture. The results shows that the profitability of grazing cereal in pasture dominant enterprises is much lower in comparison to enterprises that have a more even mix of enterprise, or are crop dominant. At the optimal crop area of around 450 hectares, cereals on 130 hectares are grazed, leading to an increase in whole farm profit of around $30,000 or 15%. This equates to an increase of around $230 per hectare of grazing cereal. The increase in profit is large because grazing cereal enables the stocking rate of the whole pasture area to be lifted by around three dse per hectare. It must be emphasised that this analysis assumed that there is no yield reduction in the cereals subsequent to grazing.
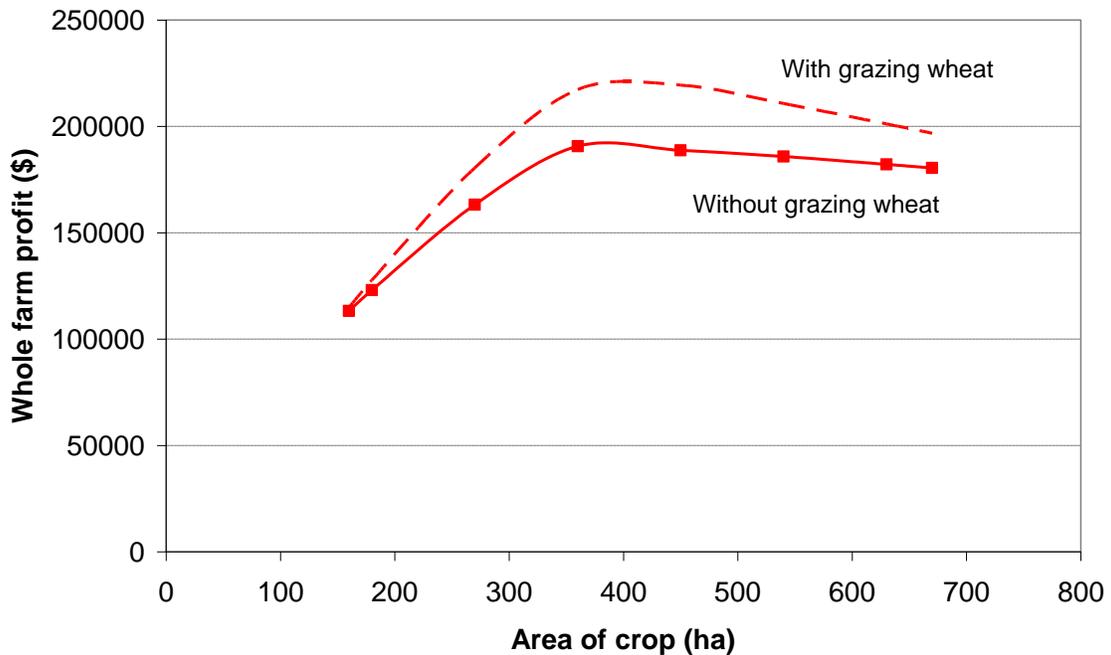

Figure 4: Whole farm profit at different areas of crop with and without grazing cereal, in the absence of lucerne. Wheat price $300/t and canola price $560/t (farm gate), Wool price 900 c/kg clean (market indicator)

Affect of lucerne on farm profit

Figure 5 shows the profit response to area of crop for the standard assumptions and after the introduction of grazing cereal and introduction of lucerne into the farming systems. The whole farm benefits of lucerne and grazing cereal are the same for area of crop over

300 hectares. However below 300 hectares of crop lucerne leads to larger increases in profit in comparison to grazing cereal.   This occurs for the same reason discussed above. That is, the requirement for supplementary feeding is much greater without lucerne pasture being available in summer. This limits the capacity to increase stocking rate when the area of pasture is high (and the area of grazing cereal low). As the area of crop increases, and hence the area og grazing cereal stocking rate can be increased at a greater rate, improving profit in line the increases that result for lucerne production.
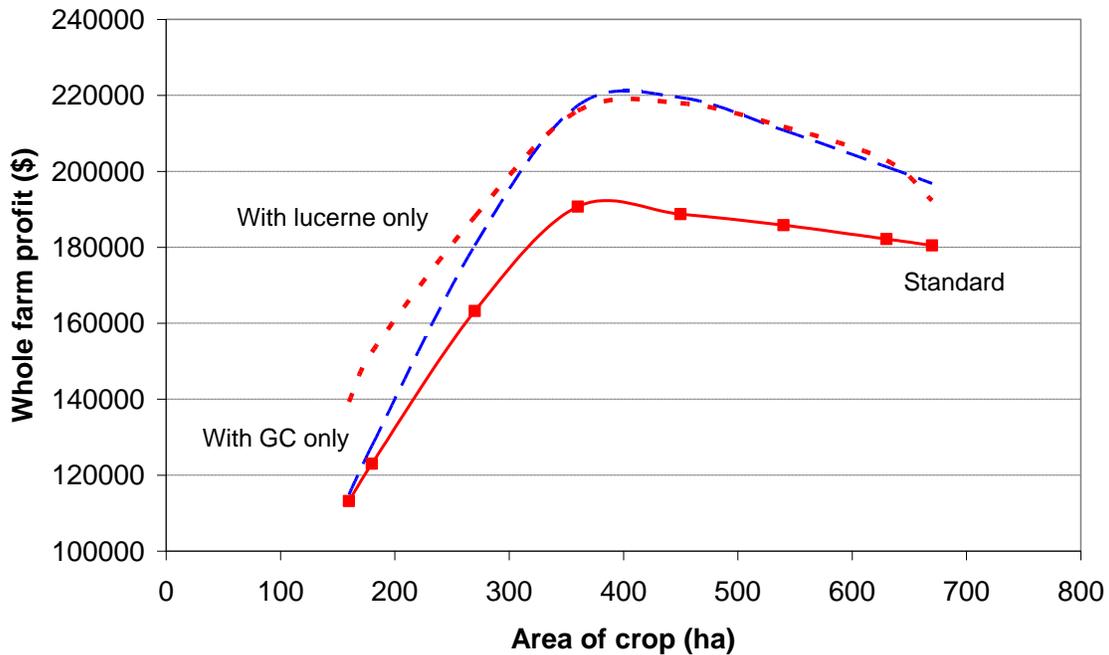

Figure 5:   Response of whole farm profit to area of crop, with and without lucerne. Wheat price $300/t and canola price $560/t (farm gate), Wool price 900 c/kg clean (market indicator). Note: the scale has been adjusted compared with Figure 4.

Figure 6 shows that the benefit of lucerne is reduced to some extent where crop yield are high. However the benefits of lucerne production remain very high at around $25,000 for the whole farm, compared to $28,000 where crop yield s are low. As with previous results there is a small shift in the optimal cropping range where crop yields are low, however there is no change for the mid and high yield response curves. This implies that the optimal enterprise mix is not greatly affected by lucerne production across a range of crop yields. As with grazing cereals, the main shifts in farm strategy realte to the livestock enterprise, both in terms of stocking rate and level of supplementary feeding required.

This is also shown in Figure 7 which illustrates the impact of cross-bred lamb production with lucerne and the addition of pellets that improve the growth rates of lambs that are grazing lucerne. The "Standard" and "Lucerne" response curves correspond to the "Mid Yield" response curves of Figure 6. The "XB lucerne" response curve shows the whole-

farm profit when a cross-bred prime lamb enterprise is run. Cross-bred prime lambs improve farm profit by $5,000 -$20,000, depending the mix of crop and pasture.
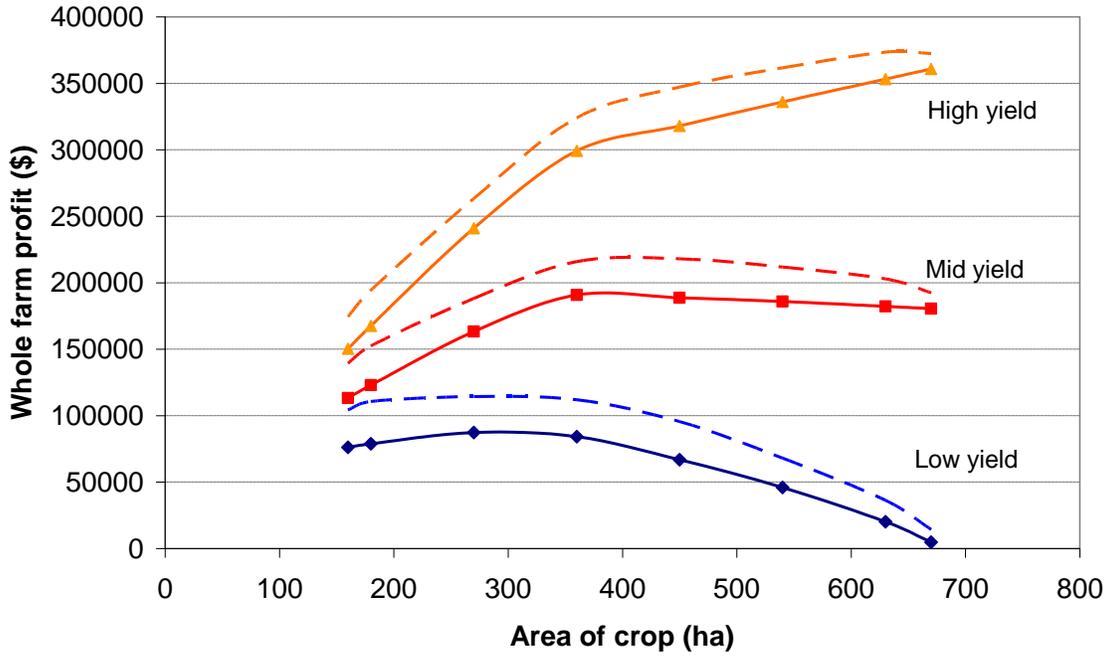

Figure 6: Response of whole farm profit to area of crop, with and without lucerne at three yield levels. Wheat price $300/t and canola price $560/t (farm gate), Wool price 900 c/kg clean (market indicator).
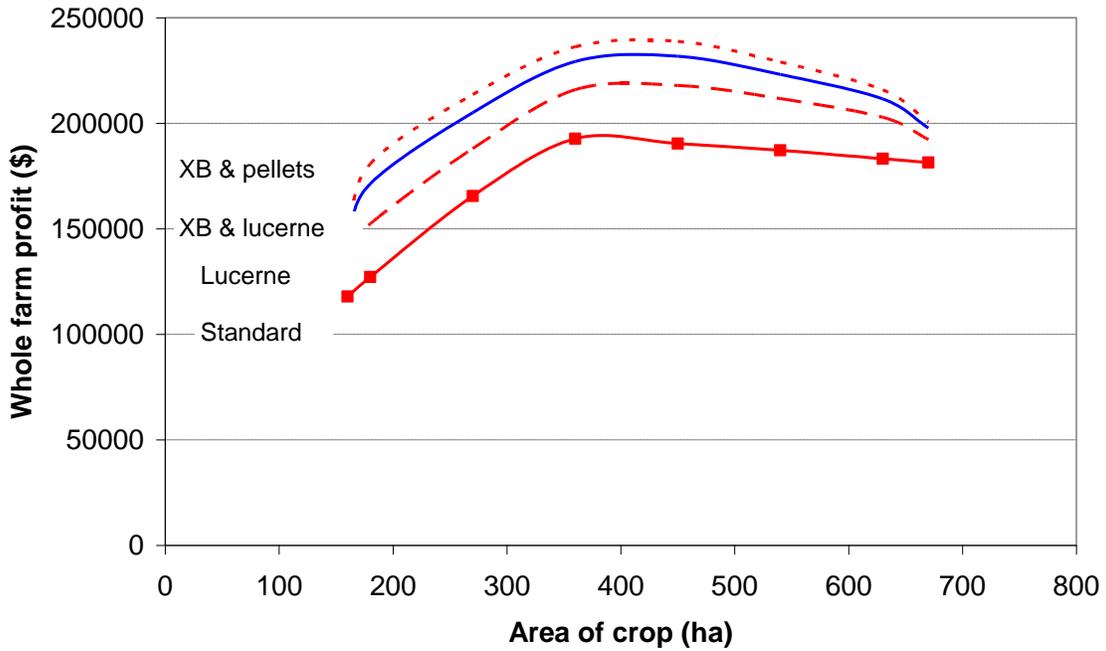

Figure 7: Response of whole farm profit to area of crop with and without lucerne and feeding pellets to lambs to improve growth rates. Wheat price $300/t and canola price $560/t (farm gate), Wool price 900 c/kg clean (market indicator)

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Using the formulated pellets with lucerne as was trialled by the Grain & Graze project leads to slight increases in profit, due to higher prices of lambs that were obtained for heavier lambs. This is shown by the response curve; "XB & pellets". The total estimated increase in profit from pellets and lucerne is over $40,000. This equates to a 20% increase, which is well in excess of the targets of the Grain & Graze Program.

However it must be emphasised that the increase in profit is contingent on farmers achieving assumed production levels of crops and pasture, and the growth rates assumed for livestock. Further analysis is required to explore the impact of changes in the assumptions and determine the affect on farm profit. This will help determine whether the proposed practices are robust under a range of economic and production conditions. The importance of undertaking further sensitivity analyses is highlighted by analyses conducted by the National Economics Project for other regions, where small changes in feed quality were shown to result in significant changes to the increase in farm profit.

Affect of integrated pest management on farm profit

Figure 8 shows the increase in farm profit that results from the adoption of integrated pest management. The analysis assumed that there were no differences in production of crops and pastures. The benefit was purely derived from the changes in chemical costs that result from a reduced need to apply pesticides. It is important to note that increased effort is required to monitor the crop and thee costs have not been considered.
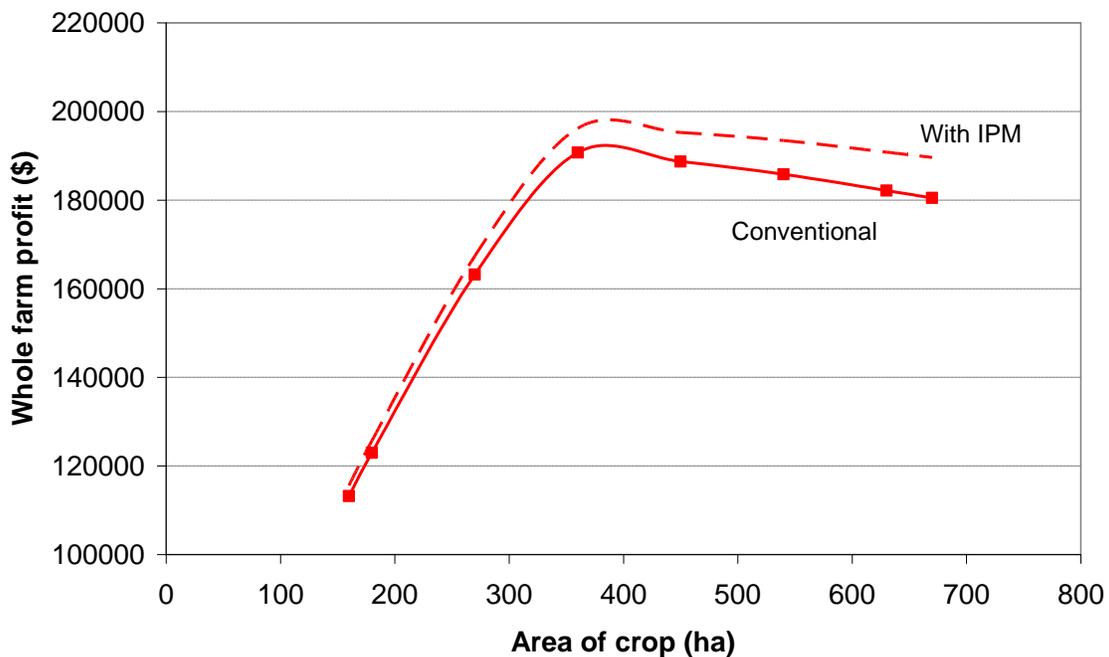

Figure 8:   Response of whole-farm profit to the area of crop after the adoption of integrated pest management. Wheat price $300/t and canola price $560/t (farm gate), Wool price 900 c/kg clean (market indicator)

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Conclusions

Innovations proposed by the Corangamite - Glenelg/Hopkins regional project of the Grain & Graze program are likely to lead to substantial increases in farm profitability. It was estimated that grazing cereal and lucerne production led to the greatest increase in whole-farm profit. Increases in profit were a result of the increase in optimal stocking through grazing cereal and the decreased requirement for supplementary feed over summer with the adoption of lucerne.

Whilst the optimal crop and pasture areas were altered by the introduction of these strategies the optimal range was not affected in most instances. That implies that there is little incentive to alter enterprise mix where these strategies are adopted.

These strategies were most profitable for a cross-bred prime lamb enterprise, whilst pellet supplement resulted in a marginal increase in profit as a result of improved growth rates of lambs.

A cattle based enterprise was less profitable than a sheep based enterprise. For a cattle enterprise to be equally profitable with a sheep enterprise the price of beef at the saleyards would need to increase by about 40%.

Further analysis is required to ensure the strategies assessed are robust under arrange of production and economic conditions. This will provide information to that will help define the role of the strategies in southern Victorian farming systems.

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