FUTURE FARM INDUSTRIES CRC

EverCrop Uniform Rainfall Zone

Assessing the impact of input costs on enterprise mix on crop-livestock farms in southern New South Wales

Michael Robertson, Andrew Bathgate, Michael Reynolds, Richard Hayes, Jeff McCormick, Guangdi Li, Geoff Casburn

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Future Farm Industries CRC aims to transform Australian agriculture and rural landscapes by developing and applying Profitable Perennials™ technologies to innovative farming systems and new regional industries.

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Scenario output based on MIDAS SNSW Model 10

Future Farm Industries CRC Technical Bulletin

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1 EXECUTIVE SUMMARY

Whole-farm bio-economic modelling is being used to assess the financial impacts of changes to the scale of use and management of perennials, as part of the EverCrop® project within the Future Farm Industries CRC. In the first report in a series (Bathgate et al. 2010) the MIDAS (Model of an Integrated Dryland Agricultural Systems) bio-economic model was used to quantify the change in farm profit and enterprise mix from incorporating lucerne, chicory or perennial grasses in the phased pasture-crop rotation of a typical farm located in the 450-500 mm rainfall zone in southern NSW. Adding lucerne to the rotation was estimated to increase farm profit by 30% compared to a system based on annual pastures only. Including either perennial grasses or chicory in addition to lucerne increased farm profit by an additional 4-5% and profit was maximised when all three perennial pasture species were used in the rotation. The optimum area of perennial pastures was 34% of the farm with annual pastures on 10% of the area. In this study, commodity prices and input costs typical of 2009 were assumed. The current report follows on from the Bathgate et al. study by exploring the impact that changing commodity prices and farm input prices has on pasture/crop rotations, livestock carrying capacity and cropping area on this model farm.

Overall, these results suggest that the crop-livestock mixed farm, typical of the uniform rainfall zone in southern NSW and northern Victoria is robust and does not change markedly in configuration in response to price and cost changes. Only when quite large changes in prices and costs were assumed did significant components of the system disappear from the profit-maximising set of crop-pasture sequences. The area of perennial pastures on the farm only varied between 160 and 400 ha out of the 1000 ha farm, across a wide range of cost and price assumptions. This is no doubt due to constraints on the area of soil types suitable for cropping and rotational constraints.

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3 INTRODUCTION

Whole-farm bio-economic modelling is being used to assess the financial impacts of changes to the scale of use and management of perennials, as part of the EverCrop® project within the Future Farm Industries CRC. In the first report in a series (Bathgate et al. 2010) the MIDAS (Model of an Integrated Dryland Agricultural Systems) bio-economic model was used to quantify the change in farm profit and enterprise mix from incorporating lucerne, chicory or perennial grasses in the phased pasture-crop rotation of a typical farm located in the 450-500 mm rainfall zone in southern NSW. Traditional rotations have utilised either annual pastures or lucerne (*Medicago sativa*) but the need to increase ground cover and overcome the animal health issues (red gut, bloat) associated with lucerne pastures has increased interest in using a greater range of perennials in the rotation. Estimated farm profit on a typical 1,000 ha property relying on an annual pasture-crop rotation was $147,000. Adding lucerne to the rotation was estimated to increase farm profit by 30% compared to a system based on annual pastures only. Including either perennial grasses or chicory in addition to lucerne increased farm profit by an additional 4-5% and profit was maximised at $207,000 when all three perennial pasture species were used in the rotation. The optimum area of perennial pastures was 34% of the farm with annual pastures on 10%. The area under crop declined only slightly from 70% in an annual pasture system to 57% when perennials were incorporated into the rotation. Perennials increased the average stocking rate by 28% and increased both the area of winter grazed crop and the amount of supplementary feeding required.

In the first study, commodity prices and input costs typical of 2009 were assumed. However mixed farmers in Australia are exposed to considerable variation in commodity prices and input costs with implications for the profitability of crop and livestock enterprises and the profit-maximising mix on a farm. Hence, follow-up questions concern the impact of variation in farm input costs and prices on the profit maximising enterprise mix and whole farm profit benefits of perennials found by Bathgate et al. (2010) This technical report is the fourth in a series of reports that uses established benchmarks from the baseline report and explores the impact that changing commodity prices and farm input prices has on pasture/crop rotations, livestock carrying capacity and cropping area on this model farm. The key question this report addresses is: *"What changes occur to whole farm crop area, stocking rate and pasture/crop rotations by soil type in response to the changing commodity prices for wheat, canola and lamb, and the costs of inputs such as fertiliser and chemicals?".*

4 METHODS

A version of the MIDAS model that had previously been developed for the Coolamon region of southern NSW (MIDAS SNSW Model 10 v2t) was adapted to include chicory and winter-active perennial grasses as potential pasture options. A full description of the model assumptions is given in Bathgate et al. (2010). Pasture production curves for the annual pastures and lucerne were based on output from the GrassGro® plant-growth model (Donnelly et al. 2002) using long-term average climatic conditions for the 450-500 mm rainfall zone of southern NSW, whereas pasture production and quality curves for chicory and winter-active perennial grasses were based on local experimental data (Hayes *et al*. 2010; Li *et al*. 2012; and unpublished data). Four possible land-management units (soil types) were selected and combined to represent soils commonly found on typical farms in southern NSW. These units were 100 ha of non-arable tenosols, 50 ha of grey vertisols, 200 ha of red kandosols and 650 ha of red chromosols. Crop and pasture yields were adjusted to account for their different production potentials on the various soils. The model was run assuming a 1000 ha farm with crop and pasture rotations involving wheat, barley, lupins, canola, field peas, mixed annual pasture (based on subterranean clover) and perennial pasture species adapted to the region (lucerne, chicory, phalaris and cocksfoot). A livestock enterprise based on prime-lamb production was assumed. Commodity prices and input costs typical of 2009 were assumed as the baseline and then varied to determine the:

1. Impact of grain prices on area under crop and farm stocking rate
2. Impact on rotations of changing grain prices
3. Impact on rotations of changing relativities between wheat, meat and wool prices
4. Impact on rotations of changing fertiliser and chemical costs

5 Results

5.1 Impact of grain prices on area under crop and farm stocking rate

The results of the baseline runs (Table 1, taken from Bathgate et al. 2010) indicated that option 5, including lucerne, chicory and perennial grasses, was the most profitable system. This option was then subjected to variation in the price of both wheat and canola. The baseline commodity prices of wheat ($220/t) and canola ($440/t) gives an annual farm profit of $207,000 with a total area of crop of 565 ha, and area of perennials of 336 ha.

Table 1: ***Changes in farm profit and key criteria from inclusion of perennial pastures into the pasture crop rotation on 1000 ha farm.***

Key statistics	Option 1	Option 2	Option 3	Option 4	Option 5
	Traditional Annual pasture	**Annual +lucerne**	**Annual +lucerne + chicory**	**Annual+ lucerne + per grass**	**Annual+ lucerne+ chicory + per grass**
Farm profit	$147,000	$191,000	$200,00	$198,000	$207,000
Total area pasture (ha)	300	403	433	440	436
Lucerne	-	281	267	272	246
Chicory	-	-	44	-	24
Perennial grasses	-	-	-	68	66
Annual pastures	300	122	122	100	100
Total area of crop (ha)	700	596	566	560	565
Wheat	250	228	227	232	234
Canola	150	123	113	116	117
Barley	150	123	113	116	117
Pulse	138	122	113	96	97
% Farm under crop	70%	60%	57%	56%	57%
Av stocking rate per grazed ha (DSE)	10	13.5	12.8	14	13.8
Stocking rate whole farm (DSE)	3	5.4	5.5	6.7	5.9
Area grazed crop (ha)	100	106	113	116	117
Supp feed (Tonnes)	127	113	120	139	140

Variation of the wheat price from $160/t to $320/t and canola prices from $340/t to $640/t (Table 2a) generated a fairly small variation in area of cropping from 505 to 661 ha, due to constraints on the area of soil types suitable for cropping and rotation constraints. Area under crop was more responsive to the price of canola than wheat. At low commodity prices, wheat dominated the area under crop, while at high canola prices, canola comprises one-third to one-half of the area under crop. When canola prices were similar to those for wheat, canola dropped out of the rotation altogether.

The area of perennial pastures only varied between 239 and 395 ha for the same range of wheat and canola prices (Table 2b), compared to the baseline area of 336 ha under the standard assumptions of wheat at $220/t and canola at $440/t.

Table 2: ***(a) Area of the farm cropped, with area of canola is given in brackets (ha), and (b) area sown to perennial pasture in response to variation in wheat and canola price ($/t).***

	Canola Price ($/t)			
(a) Crop area				
Wheat price ($/t)	**340**	**440**	**540**	**640**
160	505 (96)	513 (105)	645 (121)	628 (280)
200	511 (6)	552 (114)	549 (213)	594 (254)
240	526 (6)	585 (115)	612 (130)	634 (277)
280	571 (0)	551 (29)	661 (142)	661 (243)
320	571 (0)	571 (21)	614 (153)	661 (243)
(b) Perennial area				
160	395	387	255	272
200	389	348	351	306
240	374	315	288	266
280	329	349	239	239
320	329	329	286	239

Table 3 shows that a 2-fold variation in the area under canola due to price variation is associated with a 30% change in farm stocking rate. A decrease in farm stocking rate by approximately 1 DSE was associated with an increase in the canola area of up to 80 hectares (data not shown).

Table 3: ***Farm stocking rate (Dry sheep equivalents, DSE) in response to variation in wheat and canola price ($/t).***

	Canola price ($/t)			
Wheat price ($/t)	**340**	**440**	**540**	**640**
160	6.4	6.3	4.9	5.2
200	6.4	6.0	6.0	5.6
240	6.3	5.9	5.3	5.1
280	5.8	6.2	4.8	4.8
320	5.8	5.8	5.5	4.8

5.2 Impact on rotations of changing grain prices

The rotations selected on each land management unit (LMU) on the farm for the profit-maximising option 5 (Table 1) are listed in Table 4, together with results where combinations of low and high wheat and canola prices were used. Appendix 1 describes the land management units and appendix 2 lists crop-pasture sequences available for selection by the model.

Table 4: ***Impact of Wheat and Canola Prices on pasture/crop sequences***.

Codes: numeral = Pasture Years, PA =Permanent Pasture, Y = Chicory, U = Lucerne, H =Perennial Winter Grass, W = Wheat, C = Canola, B = Barley, L = Lupins, P = Annual Pasture

Wheat/canola prices ($/t)	LMU1	LMU2	LMU3	LMU4
220/440 Baseline	Annual pasture	5HWCWB	4UWCWB 4YWCWLB 4HWCWB	4UWCWLB 3YWCWLB
160/340	Annual pasture	5HWCWB	4UWWLB, 4YWCWLB, 4HWCWB	5UWCWLB
160/640	Annual pasture	5HWCWB	3UWCWC, WCBL	3UWCWC, 3YWCWC
320/340	Annual pasture	4HWWB	WWBL	4UWWB, 3YWWLB
320/640	Annual pasture	5HWCWB	3UWCWCB, 3HWCWB, WCBL	3UWCWCB, 3YWCWCB

Low wheat and canola prices indicate very little change in pasture crop sequences from the baseline sequences. It shows that even when prices are relatively low there is still a strong need for well structured rotations, with a four- to five- year pasture phase and a similar length for the cropping phase.

As the price of canola increases and wheat stays at a relatively low price, there is an indication that the pasture phase may shorten on the better cropping soils (LMU 3 and 4) to take advantage of high prices, and two canola crops in the one cropping phase becomes the preferred option. At the same time a continuous cropping phase on the light red kandosol (LMU3) also becomes an option

High wheat prices and relatively low canola prices also indicates a move towards a continuous cropping option on the light red soils (LMU3), with canola being replaced with a double wheat sequence to take advantage of relatively higher wheat prices. High wheat and canola prices tend to shorten the pasture sequence to a three year option. The crop legume (lupins) is replaced with a second canola crop in the five year crop sequence.

5.3 Impact on rotations of changing relativities between wheat and lamb prices

Relatively low lamb and wheat prices generated little change in the pasture crop sequence (Table 5). As lamb prices rise and wheat prices remain low there is no substantial change in the length of the pasture/crop sequence and sequence cropping mix. However, when the price of wheat and lamb are both high, canola is replaced by a double wheat sequence, with the second wheat being grazed.

Table 5: ***Impact of wheat and lamb prices on pasture/crop sequences.*** *See Table 5 for sequence codes.*

Prices of wheat ($/t)/ lamb ($/kg)	LMU1	LMU2	LMU3	LMU4
220/3.0 Baseline	Annual pasture	5HWCWB	4UWCWB 4YWCWLB 4HWCWB	4UWCWLB 3YWCWLB
160/2.5	Annual pasture	5HWCWB	4UWCWLB	4UWCWLB, 3YWCWLB
160/5.5	Annual pasture	5HWCWB	4YWCWLB, 4HWCWB	5UWCWLB, 4YWCWLB
320/2.5	Annual pasture	4HWWB	4UWWB, WWBL	3UWCWB, 3YWCWB
320/5.5	Annual pasture	4HWWB	4YWWB, 3HWCWB, WWBL	4UWWB, 3YWWLB

In contrast to the lack of sensitivity of area under perennial pasture associated with variation in grain prices, perennial area responded more to variation in wool and grain prices (Table 6). At the extremes of high wool price and low grain price, perennial area was around 400 ha, but when the wheat price was high and wool price low the area dropped to 164 ha.

Table 6: Change in area sown to perennial pasture ***in response to variation in wheat ($/t) and wool price ($/kg).***

Wheat Price ($/t)	Wool Price ($/kg)			
	2.5	3.5	4.5	5.5
160	333	345	372	395
200	311	331	348	351
240	286	270	349	414
280	293	247	385	414
320	164	257	361	403

5.4 Impact on rotations of changing fertiliser and chemical costs

Table 7 shows the impact of high and low fertiliser prices on pasture-crop sequences.

A decrease or increase in the price of fertiliser has little impact on the pasture crop sequences chosen to maximise profit. Lupins appear to be a viable option at both low and high fertiliser prices and the length of the sequence remains unchanged. As fertiliser N prices rise above $1000/t the option of chicory as a pasture phase on LMU4 is not selected and lucerne remains the most viable option. Note that no N fertiliser was applied to perennial grasses because it was assumed that there were companion clovers growing with the grasses.

A similar trend is evident in the impact of variation in chemical costs with little impact on the pasture/crop sequences selected (Table 8).

Table 7: ***Impact of high and low fertiliser prices on pasture/crop sequences. Baseline costs were $520/t for N fertiliser and $235/t for P fertiliser.*** *See Table 5 for sequence codes. 100% indicates the baseline price used for fertiliser*

Relative fertiliser prices	LMU1	LMU2	LMU3	LMU4
25%	Annual pasture	5HWCWB	3UWCWLB, 3HWNB	3UWCWLB, 3YWCWLB
100%	Annual pasture	5HWCWB	3UWCWLB, 4YWCWLB, 4HWCWB	4UWCWLB, 3YWCWLB
200%	Annual pasture	4HWWB	4UWCWLB, 4YWCWLB, 4HWCWB	4UWCWLB

Table 8: Impact of high and low chemical prices on pasture/crop sequences. *See Table 5 for sequence codes. 100% indicates the baseline price used for chemicals.*

Relative chemical prices	LMU1	LMU2	LMU3	LMU4
25%	Annual past	5HWCWB	3UWCWLB, 3YWCWLB, 3HWCWB	4UWCWLB, 3UWCWLB, 3YWCWLB
100%	Annual past	5HWCWB	3UWCWLB, 4YWCWLB, 4HWCWB	4UWCWLB, 3YWCWLB
200%	Annual past	4HWWB	4YWCWLB, 4HWCWB	4UWCWLB, 4YWCWLB

When fertiliser, herbicide and fuel costs vary in concert (Table 9) perennial area was remarkably stable at around 330 ha. Only when fertiliser drops to 0.25 of the standard assumption does the area of perennial respond much.

Table 9: ***Impact of relative prices for fertiliser, herbicide and fuel on the area of perennials on farm***.

Relative change	Fertiliser	Herbicide	Fuel
0.25	272	313	336
0.5	315	316	336
0.75	328	328	336
1	336	336	336
1.25	348	348	336
1.5	348	348	336
1.75	348	348	336
2	347	348	336

6 DISCUSSION

Overall, these results suggest that the crop-livestock mixed farm, typical of the uniform rainfall zone in southern NSW and northern Victoria is robust and does not change markedly in configuration in response to price and cost changes. Only when quite large changes in prices and costs were assumed did significant components of the system disappear from the profit-maximising set of crop-pasture sequences. Perennial area was remarkably stable over a wide range of cost and price settings, at around 300 ha (out of a farm area of 1000 ha) and only increased significantly above or below this at extreme combinations of costs and prices. This is no doubt due to due to constraints on the area of soil types suitable for cropping and rotational constraints. Some of these changes included:

- The area of cropping does not vary greatly and is mainly influenced by changes in the area of canola. Canola may substitute for pastures and crop legumes under conditions that favour canola profitability.
- At high wheat and livestock prices canola is replaced in sequences by dual-purpose wheat.
- Large variations in fertiliser and chemical costs were required to effect changes in crop-pasture sequences

The results reported in Bathgate et al. (2010) therefore are robust and the conclusions broadly applicable under a wide range of financial settings.

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8 APPENDIX 1

Management units (LMUs) in the Coolamon model, associated soil type description and the wheat yield potential expressed as a percentage of the best soil type.

LMU	Soil Type	Description	Area (ha)	Relative yield potential (%)
1	Non-arable Tenosols	Skeletal soils, shallow or rocky, often steeply sloping, can also include low lying areas not suitable for cultivation.	100	0
2	Grey Vertosols	Sodic grey clays, heavy textured cracking soils, poorly drained, low infiltration rates, subsoil constraints to root growth, can be saline at depth, can have gilgai present, often present on floodplains of inland steams, parent material alluvial or sedimentary	50	60
3	Light Red Kandosols	Acidic gradational soils, lack clear or abrupt B horizon, heavy sandy loams, includes red earths. Assume soil is limed to pH>5.0 ($CaCl_2$) and no subsoil acidity	200	90
4	Red Chromosols	Duplex soils, generally not strongly acidic, acid trend with depth, includes red brown earths and podzolic soils, generally favourable physical properties. Assume soil is limed to pH>5.0 ($CaCl_2$) and no subsoil acidity.	650	100

9 APPENDIX 2

Descriptions of crop sequences in combination with different lengths of key pasture phase for lucerne, chicory, winter annual perennial pastures (phalaris and cocksfoot) and mixed annual pasture.

Lucerne	Per grass	Annual	Chicory	Crop sequences	Code
5 years	5 years	5 years	5 years	Canola, wheat, lupins, wheat, barley	CWLWB
4 years	4 years	4 years	4 years	Canola, wheat, canola, wheat	CWCW
3 years	3 years	3 years	3 years	Canola, wheat, wheat, barley	CWWB
				Canola, wheat, canola, barley	WCWCB
				Canola, wheat, lupins, barley	WCWLB
				Wheat, canola, wheat, canola	WCWC
				Wheat, canola, wheat, barley	WCWB
				Wheat, wheat, lupin, wheat	WWLW
				Canola, wheat, canola, wheat Wheat, wheat, barley	WWLB WWB