final report

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Adaptation to Climate Change in the Southern Livestock Industries

(Victorian component)

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1. Executive Summary and Key Findings

Pasture growth across much of Victoria in 2030 will be characterised by increased winter production and an earlier, often reduced, spring peak, with models predicting annual pasture yield changes of +5% to -26% in the low rainfall zone and +6% to -20% in the high rainfall zone.

Earlier lambing may become more profitable for winter/spring lambing enterprises in the south west, but no trend was found for central/north east regions. Increased emphasis on meat production looks favourable as an adaptation for many wool enterprises.

Despite shorter springs across the high rainfall regions, the modelled profitability of prime lamb versus store lamb systems for winter lambing lamb enterprises did not show a clear trend in favour of one approach across regions.

Changing from autumn to spring calving in the high rainfall regions offers little improvement in gross margins. Similarly, no benefit was derived from adjustments to calving time within a season (e.g. earlier spring calving by up to 2 months or delaying autumn calving by several months).

Lucerne as a pasture base in the northern Victorian mixed sheep and crops zone offers the ability to double profits compared to annual pastures from the sheep enterprise under future climate scenarios. This finding is valid for the 360mm to 480mm year average rainfall areas. Lucerne pastures reduce seasonal risk as low winter and spring rainfall may be followed by summer storms that provide out of season green pasture. Three of the four GCM's indicated a reduction in winter-spring rain and an increase in summer rain.

Lucerne is of increasing interest elsewhere for its ability to plug feed gaps provided that winter pasture production is not jeopardised, especially where market stock need to be finished in traditional periods of feed shortage.

Optimising soil fertility, pasture production and utilisation (via increased stocking rate) offers major gains to livestock profitability, both now and in the future.

2. Statement against Objectives and Activities

a) Project objectives (as per contract)

Objective	Status at Project End
1. By 2011, a knowledge base will be established to underpin ongoing engagement with livestock producers in Victoria, and to facilitate further research, development and extension in climate change adaptation.	Achieved, in as far as the scope of the project allowed (i.e. limited number of case studies possible).
2. By 2012, 2000 livestock producers across Victoria will be aware of the key	Awareness as at 16/05/12 Direct engagement (face to face and telephone

Objective	Status at Project End
research outcomes of the program through a combination of field days, workshops and written material.	seminar) = 784 Awareness via communication products = 1280 **Total = 2064** <u>Expected awareness including post-contract activities to which we have a commitment</u> Direct engagement (face to face) = 854 Awareness via communication products = 1995 **Total = 2849**
3. By 2012, a program of on-farm trialling of key recommendations within each of the agro-climatic regions of southern Australia will be defined, for implementation during the period 2012-2015 via the MLA Producer Demonstration Sites (PDS) program and similar programs supported by other RDE providers.	Attainment of this objective is subject to decisions under consideration within DAFF's "Action on the Ground" program, for which expressions of interest have been submitted, and the "Extension and Outreach" program to be released in July 2012. DPI Vic currently has a proposal before DAFF for consideration as an Action On The Ground project.
4. An improved modelling capacity will be established across a range of industry RD&E providers that will assist industry in evaluating adaptation options in more detail across a range of agro-climatic regions.	DPI Victoria has increased its capability and capacity in the use of GrassGro from a low base (one or two staff with low level knowledge) to having three Meat and Wool extension staff competent in its use. An additional staff member who attained these skills retired during the final stages of this project, but is still a potential resource to the industry in a private capacity.

b) Project activities

Activity	Contracted requirement	Status at Project End
1. Regions modelled	3	3 regions modelled: NC Vic, NE Vic, SW Vic
2. Locations modelled	NA	NC Vic: Wedderburn, Tandarra, Yarrawalla NE Vic: Everton, Seymour SW Vic: Lismore, Penshurst
3. Enterprises modelled	NA	NC Vic: Low rainfall mixed cropping/sheep farm system NE Vic: High rainfall beef breeding enterprise Medium rainfall sheep enterprise SW Vic: High rainfall prime lamb (self replacing) enterprise High rainfall beef breeding enterprise
4. Producer workshops held	At least 6 (2 per region)	9 as at 16/05/12 Statewide: BetterBeef Telephone Seminar NC Vic: North Central Women in Agric Regional Forum, GSSA Pasture Workshop, Elmore Field Days NE Vic: EverGraze Grazing Field Day, GSSA Pasture Update, Upper Murray Agribusiness Group Farming Systems in Future Environments Expo SW Vic: Western Region Angus Breeder Seminar, FarmPlan21
5. Other awareness events held (e.g. BWBL & BB Group seminars)	At least 10	15 as at 16/05/12 NC Vic: Bestwool Bestlamb Groups: Loddon Valley, Coonooer Bridge, Campaspe, Maldon, Maryborough LandCare Groups: Mt Korong Landcare/TopCrop, Marong NE Vic: Bestwool Bestlamb Group: King Valley (Everton) EverGraze Supporting Site (Creightons Ck), Producer Networks (Seymour) SW Vic: Bestwool Bestlamb Groups: Western Plains, Shelford, Glenelg BetterBeef Groups: Ballarat/Colac, Hamilton
6. Producers directly engaged		784 as at 16/05/12

Activity	Contracted requirement	Status at Project End
7. Communication products produced	NA	5 products have been produced as at 16/5/12. Commitment has been given by DPI and various organisations for publication of a further 5 products over the course of 2012, with the process also underway to submit an additional journal paper. See Section 7 for full list.
8. Producers aware of the key project findings?		2064 as at 16/5/12 Note: This figure will grow to an anticipated 2,849 (approx), taking into account committed future delivery of further producer workshops / group seminars to June 2012 (+70) and communication products to October 2012 (+715).
9. **Adaptations modelled**	NA	NC Vic: Mixed Crop/Livestock System – Replacement of annual pasture with lucerne, Increased livestock emphasis. NE Vic: Wool Sheep System – Dual Purpose, Increase Lambing %, Addition of Lucerne. Beef Breeding System – Calving Time, Stocking Rate, selling at 16 months.. SW Vic: Prime Lamb System – Stocking rate, Time of Lambing, Store Lamb Production. Beef Breeding System – Time of Calving, Increased Fertility & Stocking Rate, Addition of Lucerne.

3. Methodology

Please identify the research questions being addressed, methodology employed to address them.

Regions please ensure you include a matrix of (example only - adjust as you need to)

Location	Baseline Enterprise	Research Questions	Methodology
North Central Victoria – Tandarra	Merino ewes joined to terminal sires for prime lamb production on a mixed sheep and crops farm with an annual	Can the performance of a traditional mixed 60/40 livestock and cropping system be improved under a future climate by reducing sheep numbers (same management) and increasing the cropping intensity, or replacing the annual pastures with lucerne based pastures (and breeding own replacement ewes)?	GrassGro was used to model two sheep enterprises: a. Merinos on annual pastures with ewes joined to terminal sires and ewe replacements purchased b. Merinos on lucerne pastures with ewes joined to merino and terminal sires and ewe replacements bred on farm

Location	Baseline Enterprise	Research Questions	Methodology
	pasture base and purchased ewe replacements.		The three crop/livestock systems were then compared using the GrassGro outputs for the livestock enterprise. The cropping enterprise was modelled using typical management and yields for the study period (1998 – 2009). The baseline 'Annual pasture and crop' system comprised 60% of the farm area under annual pastures supporting a sheep enterprise, with the remaining 40% under crops. The 'Intensive crop' system comprised 80% of the farm cropped, with the remaining 20% under annual pastures supporting a sheep enterprise. The 'Lucerne pasture and crop' system comprised 60% of the farm area under lucerne based pastures supporting a self-replacing sheep enterprise, with the remaining 40% under crop.
North Central Victoria – Wedderburn	As for Tandarra (above)	As for Tandarra (above)	As for Tandarra (above)
North Central Victoria – Yarrawalla	As for Tandarra (above)	As for Tandarra (above)	As for Tandarra (above)
North East Victoria - Everton	Beef Breeding	Can the expected performance of existing autumn calving beef breeding systems improve in profitability and reduce risk by calving in February rather than April? Is calving in spring a better profit and risk management option?	Grassgro was used to model a baseline April-calving self-replacing Hereford breeding system, selling surplus heifers at 21 months and steers at 51 weeks. Using a 2030 climate, the system was then tested for the following adaptations: • February calving (selling calves at same age as currently) • August calving, selling calves at 12 months • August calving system, selling steers at 16 months after their second spring
North East	Merino	Can the expected performance	Grassgro was used to model a

Location	Baseline Enterprise	Research Questions	Methodology
Victoria – Seymour		of existing winter lambing merino-based wool production systems under a 2030 climate be optimised by an increased emphasis on meat production by selling store or prime lambs? Does the inclusion of a summer growing pastures species (lucerne) to extend the growing season improve profitability and reduce risk?	baseline self-replacing Merino flock lambing in July. Using a 2030 climate, the system was then tested for the following adaptations: • 30% of ewes joined to Terminal sires and stocked at 7 ewes/ha, with 1st Cross lambs sold at weaning in October • Reduce stocking rate to 5.5 ewes/ha, finishing 1st Cross lambs to 48 kg • Reduce stocking rate to 5.5 ewes/ha, finishing 1st Cross lambs to 48 kg, with the addition of lucerne to the system
South West Victoria – Lismore	Self Replacing Prime Lamb	Can the expected performance of existing spring lambing prime lamb finishing systems under a 2030 climate be improved by changing stocking rate or lambing time or selling all lambs at weaning instead of focusing on finished lambs?	Grassgro was used to model a baseline self replacing, spring lambing prime lamb system that finishes lambs for slaughter at 45kg. Using a 2030 climate, the system was then tested for the following adaptations: • A range of stocking rates • A range of earlier lambing times • Selling all lambs at weaning as a mixture of prime and store lambs
South West Victoria - Penshurst	Beef Breeding	Can the expected performance of existing autumn calving beef breeding systems under a 2030 climate be improved by changing calving time, increasing soil fertility and stocking rate or adding lucerne to the feedbase?	Grassgro was used to model a baseline autumn calving beef breeding system that turns off 320 – 360 kg weaners in late summer. Using a 2030 climate, the system was then tested for the following adaptations: • Spring calving • A range of calving dates within spring • Increased soil fertility and stocking rate • The substitution of lucerne for perennial ryegrass pastures at up to 40% of the grazed area.

4. Key results

a) Overview - summary of the key findings

- Pasture growth across much of Victoria in 2030 will be characterised by increased winter production and a shorter spring, with models predicting annual pasture yield changes of +5% to -26% in the low rainfall zone and +6% to -20% in the high rainfall zone.
- Earlier lambing may become more profitable for winter/spring lambing enterprises in the south west, but no trend was found for central/north east regions.
- Increased emphasis on meat production looks favourable as an adaptation for many wool enterprises.
- Despite shorter springs across the high rainfall regions, the modelled profitability of prime lamb versus store lamb systems for winter lambing lamb enterprises did not show a clear trend in favour of one approach across regions.
- Lucerne as a pasture base in the northern Victorian mixed sheep and crops zone offers the ability to double profits compared to annual pastures from the sheep enterprise under future climate scenarios. This finding is valid for the 360mm to 480mm year average rainfall areas. Lucerne pastures reduce seasonal risk as low winter and spring rainfall may be followed by summer storms that provide out of season green pasture. Three of the four GCM's indicated a reduction in winter-spring rain and an increase in summer rain.
- Changing from autumn to spring calving in the high rainfall regions offers little improvement in gross margins.
- Similarly, no benefit was derived from adjustments to calving time within a season (e.g. earlier spring calving by up to 2 months or delaying autumn calving by several months).
- Optimising soil fertility, pasture production and utilisation (via increased stocking rate) offers major gains to livestock profitability, both now and in the future
- Lucerne is of increasing interest across all regions studied for its ability to plug feed gaps provided that winter pasture production is not jeopardised, especially where market stock need to be finished in traditional periods of feed shortage.

b) Specific results

Location Tandarra, North Central Vic
Enterprise Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble
Soil Type Riverine plains - red loams over clay

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	430	399	417	-3%	400	-7%	358	-17%	438	2%
Temperature (°C average)	15.4	15.5	16.5	7%	16.5	7%	16.4	6%	16.3	6%
Pasture (kg DM/ha/yr)	4660	4310	4380	-6%	4320	-7%	3570	-23%	4780	3%
Stock Rate (DSE/ha)	5.8	5.8	5.8	0%	5.8	0%	5.8	0%	5.8	0%
Gross Margin ($/ha)	105	81	108		58		25		135	
Gross Margin change compared to 1970 - 1999	na	-23%	3%		-45%		-76%		29%	
Gross Margin change compared to 2000 - 2009	na	na	33%		-28%		-69%		67%	

Location **Wedderburn, North Central Victoria**
Enterprise **Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble**
Soil Type **Riverine plains - red loams over clay**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	488	431	499	2%	469	-4%	403	-17%	492	1%
Temperature (°C average)	15	15.3	16.1	7%	16.1	7%	16	7%	15.9	6%
Pasture (kg DM/ha/yr)	5380	4720	5270	-2%	4750	-12%	3980	-26%	5540	3%
Stock Rate (DSE/ha)	7.1	7.1	7.1	0%	7.1	0%	7.1	0%	7.1	0%
Gross Margin ($/ha)	124	105	129		92		27		138	
Gross Margin change compared to 1970 - 1999	na	-15%	4%		-26%		-78%		11%	
Gross Margin change compared to 2000 - 2009	na	na	23%		-12%		-74%		31%	

Location **Yarrawalla, North Central Victoria**
Enterprise **Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble**
Soil Type **Riverine plains - red loams over clay**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	365	352	361	-1%	352	-4%	338	-7%	373	2%
Temperature (°C average)	15.5	15.8	16.5	6%	16.5	6%	16.4	6%	16.3	5%
Pasture (kg DM/ha/yr)	3590	2980	3420	-5%	3150	-12%	2750	-23%	3780	5%
Stock Rate (DSE/ha)	4.7	4.7	4.7	0%	4.7	0%	4.7	0%	4.7	0%
Gross Margin ($/ha)	65	58	63		44		38		67	
Gross Margin change compared to 1970 - 1999	na	-11%	-3%		-32%		-42%		3%	
Gross Margin change compared to 2000 - 2009	na	na	9%		-24%		-34%		16%	

Note: The North Central Victorian case studies were evaluated in a whole farm context which included an associated cropping enterprise on a farm of 1000 ha (total area). The baseline livestock enterprise was a Terminal Sire x Merino operation (not self-replacing) grazing annual pastures plus crop stubble. This enterprise was analysed as either 60% or 20% of farm area. The adaptation to a 2030 climate was based on changing the pasture base to lucerne and changing the merinos to a self-replacing flock with surplus ewes joined to terminal sire rams. The whole farm systems are described in Table 1.

Table 1. Farm details of the three systems tested. Each farm is 1000ha with the same environment, management skill base and cost structure.

	'Lucerne pasture and crop' system	'Annual pasture and crop' system	'Intensive crop' system
Pasture area	60% of farm area, lucerne based.	60% of farm area, annuals based.	20% of farm area, short annual pasture phase between crops.
Crop area	40% of farm area	40% of farm area	80% of farm area
Sheep flock structure	Self replacing merino flock, wethers sold as prime merino wether lambs. Surplus ewes to terminal sires for prime lambs.	Merino ewes joined to terminal sires for prime lambs. Replacement ewes purchased	Merino ewes joined to terminal sires for prime lambs. Replacement ewes purchased
Sheep flock size and stocking rate	Lucerne pasture stocking rate 8.8 DSE/ha, plus stubble and winter cereal grazing.	Annual pasture stocking rate 5.8 DSE/ha plus stubble and winter cereal grazing.	Annual pasture stocking rate 6.9 DSE/ha plus stubble and winter cereal grazing.

	'Lucerne pasture and crop' system	'Annual pasture and crop' system	'Intensive crop' system
Crop sequence, type and typical yield WUE*	1. Wheat after lucerne pasture. WUE* 14kg/ha/mm. 2. Wheat after wheat. WUE normally 16 kg/ha/mm 3. Lupins under-sown to lucerne. WUE normally 8kg/ha/mm 4. Barley intercropped. WUE normally 14kg/ha/mm.	1. Wheat after canola. WUE normally 18kg/ha/mm. 2. Wheat after wheat. WUE normally 15kg/ha/mm 3. Barley after wheat. WUE normally 18 kg/ha/mm 4. Canola. WUE normally 8kg/ha/mm	1. Wheat after canola. WUE 18kg/ha/mm. 2. Wheat after wheat. WUE normally 15kg/ha/mm 3. Barley after wheat. WUE normally 18 kg/ha/mm 4. Canola. WUE normally 8kg/ha/mm

* WUE – water use efficiency, kg/ha/mm growing season rainfall; # DSE – dry sheep equivalent

Location **Everton, North East Victoria**
Enterprise **Beef Breeding (April Calving, 0.8 cows/ha)**

Soil Type **Clay loam (70% arable plus 30% stoney, shallow non-arable)**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	719	579	639	-11%	611	-15%	564	-22%	697	-3%
Temperature (°C average)	21.0	22.0	22.4	7%	22.6	8%	22.6	8%	22.0	5%
Pasture (kg DM/ha/yr)	7807	6731	7720	-1%	6988	-10%	6392	-18%	7852	1%
Stock Rate (DSE/ha)	10	9.6	9	-10%	na	na	na	na	na	na
Gross Margin ($/ha)	175	129	165		129		118		179	
Gross Margin change compared to 1970 - 1999	na	-26%	-6%		-26%		-33%		2%	
Gross Margin change compared to 2000 - 2009	na	na	28%		0%		-9%		39%	

Location **Seymour, North East Victoria**
Enterprise **Merino Sheep, 6 ewes/ha**

Soil Type **Clay loam (70% arable plus 30% stoney, shallow non-arable)**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	631	507	622	-1%	533	-16%	627	-1%	607	-4%
Temperature (°C average)	20.2	21	21.5	6%	21.8	8%	21.4	6%	21.2	5%
Pasture (kg DM/ha/yr)	7500	6300	8100	8%	6500	-13%	7700	3%	7600	1%
Stock Rate (DSE/ha)	12.0	10.8	12.6	5%	9.7	-19%	11.5	-4%	11.4	-5%
Gross Margin ($/ha)	188	146	199		137		179		176	
Gross Margin change compared to 1970 - 1999	na	-22%	6%		-27%		-5%		-6%	
Gross Margin change compared to 2000 - 2009	na	na	36%		-6%		23%		21%	

Location **Lismore, South West Victoria**
Enterprise **Prime Lamb Breeding (Self replacing composites, mid-July lambing, 45kg prime lambs)**

Soil Type **Clay loam duplex with lighter banks**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	652	575	579	-11%	587	-10%	595	-9%	654	0%
Temperature (°C average)	13.7	13.4	14.8	7%	14.8	7%	14.5	6%	14.8	7%
Pasture (kg DM/ha/yr)	8495	7244	7587	-11%	6776	-20%	7016	-17%	8641	2%
Stock Rate (DSE/ha)	13.2	12.8	12.4	-6%	12.2	-8%	12.0	-9%	12.9	-2%
Gross Margin ($/ha)	316	256	187		173		146		257	
Gross Margin change compared to 1970 - 1999	na	-19%	-41%		-45%		-54%		-19%	
Gross Margin change compared to 2000 - 2009	na	na	-27%		-32%		-43%		0%	

Location **Penshurst, South West Victoria**
Enterprise **Beef Breeding (Autumn calving, 0.9 cows/ha, sell 340kg weaners @ 9 months)**

Soil Type **Clay loam with stoney rises**

	1970 - 1999	2000 - 2009	CCSM		GFDL		ECHAM		HAD	
			2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)	2030 Climate	(% change)
Rainfall (mm/yr)	743	660	675	-9%	656	-12%	659	-11%	744	0%
Temperature (°C average)	13.0	13.4	14.1	8%	14.0	8%	13.8	6%	14.1	8%
Pasture (kg DM/ha/yr)	8437	8535	7896	-6%	7751	-8%	7598	-10%	8941	6%
Stock Rate (DSE/ha)	12.4	12.4	12.4	0%	12.4	0%	12.4	0%	12.4	0%
Gross Margin ($/ha)	252	264	213		220		203		235	
Gross Margin change compared to 1970 - 1999	na	5%	-15%		-13%		-19%		-7%	
Gross Margin change compared to 2000 - 2009	na	na	-19%		-17%		-23%		-11%	

c) Summary of adaptations examined and potential impact / benefit

Location **Tandarra, North Central Vic**
Enterprise **Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble**
Soil Type **Riverine plains - red loams over clay**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual - Annual pastures, prime lambs from merino ewes, June lambing, prime lambs sold Nov - Feb, stocking rate 5.8 DSE/ha	105	81	108	58	25	135
Business as usual but reduce stocking rate to 4.7 DSE/ha	na	75	100	54	23	126
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 8.8 DSE/ha	na	221	250	214	178	272
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 7.1 DSE/ha	na	190	215	184	153	234

Location **Wedderburn, North Central Victoria**
Enterprise **Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble**
Soil Type **Riverine plains - red loams over clay**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual - Annual pastures, prime lambs from merino ewes, June lambing, prime lambs sold Nov - Feb, stocking rate 5.8 DSE/ha	124	105	129	92	27	138
Business as usual but reduce stocking rate to 4.7 DSE/ha	na	96	118	85	25	127
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 8.8 DSE/ha	na	215	244	203	161	248
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 7.1 DSE/ha	na	185	209	175	138	213

Location **Yarrawalla, North Central Victoria**
Enterprise **Dual Purpose Terminal Sire x Merino operation (not self-replacing), grazing annual pastures plus crop stubble**
Soil Type **Riverine plains - red loams over clay**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual - Annual pastures, prime lambs from merino ewes, June lambing, prime lambs sold Nov - Feb, stocking rate 4.7 DSE/ha	65	58	63	44	38	67
Business as usual but reduce stocking rate to 3.6 DSE/ha	na	54	59	41	36	63
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 7.3 DSE/ha	na	154	138	152	116	168
Change pasture base to lucerne, change to self-replacing flock joining surplus ewes to terminal sire. July lambing with crossbred lambs sold in Feb, merino wether lambs sold in June, stocking rate 5.7 DSE/ha	na	134	121	131	101	144

Note: The North Central Victorian case study adaptations included an analysis of the whole mixed sheep/cropping farm system, conducted over a period of 13 “dry” years that have similarities to 2030 predictions by some of the climate models. While varying considerably in their predictions, the four climate models used to generate a 2030 climate in similar studies across southern Australia predict reductions of up to 17 percent in annual rainfall and up to 24% in growing season (April – October) rainfall for this region. For example, during the period of this study, Wedderburn experienced average reductions of 12% and 17% in annual and growing season rainfall respectively.

Financial performance was analysed via cumulative cash flow for each of the systems described previously. Over the 13 year period of this study the cumulative cash flow of the ‘Lucerne pasture and crop’ farm was $864,000 compared to $591,000 for the ‘Intensive crop’ farm. The cumulative cash flow of the ‘Annual pasture and crop’ system was $281,000, less than half that of the ‘Intensive crop’ farm.

Location **Everton, North East Victoria**
Enterprise **Beef Breeding (April Calving, 0.8 cows/ha)**

Soil Type **Clay loam (70% arable plus 30% stoney, shallow non-arable)**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual	175	129	165	129	118	179
February Calving, 0.8 cows/ha	192	148	187	153	135	217
April Calving, 0.9 cows/ha	1854	138	na	149	na	na
August Calving, sell steers @ 12 mth	196	150	na	164	na	na
August Calving, sell steers @ 16 mth	239	193	na	181	na	na
August calving, sell steers @ 16mths, 0.7 cows/ha	217	178	na	173	na	na

Location **Seymour, North East Victoria**
Enterprise **Merino Sheep, 6 ewes/ha**

Soil Type **Clay loam (70% arable plus 30% stoney, shallow non-arable)**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual	188	146	199	137	179	176
30% of Merinos joined to Terminal Sire and run at 7ewes/ha, sell store lambs at weaning.	336	274	370	277	337	332
Finish 1st cross lambs to 48kg, 5.5 ewes/ha	320	257	343	256	308	303
Finish 1st cross lambs to 48kg include lucerne, 5.5 ewes/ha	334	262	357	271	330	326

Location **Lismore, South West Victoria**
Enterprise **Prime Lamb Breeding (Self replacing composites, mid-July lambing, 45kg prime lambs)**
Soil Type **Clay loam duplex with lighter banks**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual	316	256	187	173	146	257
Reduced stocking rate (5 ewes/ha)	291	na	183	171	162	247
Reduced stocking rate (4 ewes/ha)	239	na	166	157	172	214
Lambing @ 1-July (2 wk earlier)	325	na	243	184	153	264
Lambing @ 18-June (4 wk earlier)	322	na	265	193	168	273
Lambing @ 4-June (6 wk earlier)	316	na	231	190	173	278
Sell all lambs @ weaning (1-Dec) as prime and/or stores	210	na	159	100	79	166

Location **Penshurst, South West Victoria**
Enterprise **Beef Breeding (Autumn calving, 0.9 cows/ha, sell 340kg weaners @ 9 months)**
Soil Type **Clay loam with stoney rises**

Adaptations modelled	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)	Gross Margin ($/ha)
	1970 - 1999	2000 - 2009	2030	2030	2030	2030
			CSSM	GFDL	ECHAM	HAD
Business as usual	252	264	213	220	203	235
Spring Calving (September)	267	na	233	243	225	255
Spring Calving (August)	259	na	224	240	220	243
Spring Calving (July)	257	na	220	243	213	239
Increase soil fertility (11.2 tDM/ha/yr) & stocking rate (18 dse/ha)	387	na	351	337	335	372
Convert 20% pasture to lucerne	264	na	239	247	237	257
Convert 30% pasture to lucerne	275	na	252	257	250	274
Convert 40% pasture to lucerne	277	na	258	268	260	280

5. Implications of project findings

Key implications and limitations of the results obtained

Mixed livestock/cropping farms in North Central Victoria:

It is sometimes claimed that the main role of sheep on a mixed farm is to prevent large financial losses in droughts. This is true on mixed farms when sheep are regarded merely as 'stubble munchers and weed controllers', but this also limits the profit potential in good years. However the figures calculated in the whole farm analysis for these case studies indicate lucerne-based sheep enterprises offer increased profitability. They do not just prevent financial losses when crops fail, but can generate positive cash flow during droughts, while neighbouring cropping farms are subject to financial stress. The annual pasture based sheep systems generated smaller profits than the lucerne based system; a key feature is that they prevent large losses on cropping farms during droughts. Additional crop yield sensitivity analyses indicate that cereal crops required yields of 18 kg/ha/mm of effective rainfall to financially outperform the 'Lucerne pasture and crop' system as used on the case study farms. Crop yield benchmarking information indicates crop yields average around 15 kg/ha/mm on many well managed farms.

The benefits of the 'Lucerne pasture and crop' system in the years of the study offer potential adaptations to future climate change for the mixed farming enterprises in northern Victoria.

Over recent years, many farmers in the traditional mixed farming zone have reduced sheep numbers and increased the area under crop, resulting in costly supplementary feeding of sheep in droughts and the questions about the labour required to manage a sheep enterprise that is often viewed as unprofitable. Many of these farms now have zero or a token number of sheep. A challenge to the sheep industry is the continuous innovation in the grains industry compared to sheep systems that have changed little in 40 years. Sheep farming must adapt to survive future climate challenges of increasing variability, lower winter-spring rains and increased frequency of summer storms for northern Victoria while increasing its total factor productivity to match the productivity gains of the grains industry. The sheep industry innovations shown on these few case study lucerne based farms indicate future directions to enable the sheep industry to prosper in the climate challenges of the future.

Mixed lucerne pasture and crop farming systems can reduce price risk through the production of three commodities; meat, wool and grains. They also reduce the seasonal risk of reliance on winter-spring rains by profitably utilising summer rain storms. They are widely applicable over much of northern Victoria and the cropping areas of New South Wales where winter-spring rains are unreliable and climate models predict increasing variability, lower winter-spring rains and increased frequency of summer storms.

North East Victoria Case Studies:

For much of north east Victoria, the 2000 - 2009 period was characterised by shorter growing seasons with late breaks and shorter springs but increased pasture growth in winter. A similar trend towards shorter springs and better winters was revealed in the models for 2030, but with a generally reduced impact compared with 2000 - 2009. Modelling also revealed significant increases in winter pasture growth in higher altitudes with cold winter environments, which can compensate somewhat for a shorter spring.

Three of the four 2030 climate scenarios indicate that current best practice management will also optimise profitability in the future. There was no impact of changing lambing times (earlier or later) for either a wool or dual purpose enterprise and potential stocking rates were similar, however the most pessimistic 2030 scenario predicts that optimal stocking rates would be much lower, questioning the viability of some operations.

Whilst finishing lambs on pasture and/or supplements was never a profitable option in the Seymour case study, the inclusion of lucerne or a similar alternative may become a viable option to increase the growing season if winter pasture production is not jeopardised.

The optimal long term stocking rates for the Seymour case study, as analysed by GrassGro, fall short of estimated potential when calculated as DSE/100mm rainfall. This is believed to be due to the variability of land class and soil type which reduces both the ability to grow improved grasses and the growing season. However wool production per hectare on this farm was close to that produced by the top 20% sheep farmers in benchmarking studies, indicating the potential of improved genetics to generate profit.

For a beef breeding system where weaners are sold at around 12 months, changing calving time from February to April (a strategy recently adopted by some producers to mitigate the risk of late autumn breaks) was revealed to be a maladaptation with greater pressure placed on summer feeding.

Spring (August) calving provides no advantage over February unless steers are retained over a second spring for sale at 16 months. This system also reduces variability.

South West Victoria Case Studies:

Gross margin analysis indicated that the typical prime lamb system modelled is operating at a sub-optimal stocking rate (6 ewes/ha, 15.3 DSE/ha). The gross margin is maximised at 8 ewes/ha but this is associated with an 80 per cent increase in variability. Maintaining current stocking rates into 2030 sees gross margin reductions of up to 54 per cent, with most models indicating no benefit to be gained from increasing stocking rate at that time.

There was reasonably strong agreement between climate models that earlier lambing may become more profitable in the future, but strong evidence that finishing lambs to prime condition will still be more profitable than selling all lambs at weaning regardless of their condition (under current input cost and product price assumptions).

For beef breeding systems, changing from autumn to spring calving offers minor gross margin improvements both now and in the future, with minor gains also realised by calving in September versus August or July.

The biggest gains, both now and in future, come from increasing soil fertility and hence pasture grown, enabling major gains in stocking rate. Under this scenario, beef gross margins in 2030 could exceed current gross margins in the 700mm rainfall zone (Penshurst study). This region was largely unaffected in gross margins during the dry 2000 – 2009 decade.

Lucerne offers the ability to overcome feed gaps and offer gross margin improvements in the future. The increase in gross margins is not substantial for 2030, but a consistent trend was evidenced that

related gross margin to area of the farm under lucerne, and reduced the financial impact of the poorest years.

Limitations to case study analysis approach:

The nature and size of this project mean that the case studies did not and cannot cover a broad enough range of enterprises to be specifically relevant to the majority of producers.

The future projections were conducted using existing prices and costs, with price sensitivity analysis being beyond the scope of the project.

GrassGro as a model has limitations that restrict its use and/or the confidence in its outputs. Difficulties experienced in modelling existing systems included the use of old pasture species parameters, the inability to test new varieties of existing species that might extend seasonality, and the inability of GrassGro to model animal performance that in reality is adversely affected by animal health issues (e.g. parasites) that act to retard animal performance.

Analysis of the livestock enterprise in isolation can be misleading when in reality it is the whole farm system that must adapt to climate change. Such an analysis was undertaken in the North Central Victorian case studies and acts as a good example of where this project could be taken in a future incarnation. Whole farm adaptive analysis could examine the role of multiple enterprises and their interactions – e.g. grazing cereals, new enterprise mixes.

Producer Awareness and Attitudes

Evaluation at direct engagement events elicited a total of 277 responses across the three case studies from a total attendance of 630 where evaluation was able to be conducted (a 44% response rate). Of this sample, the responses to the following questions indicate that the overwhelming majority picked up new information and would attend a similar event and/or recommend it to others. This was translated into a significant increase in confidence about managing their livestock enterprise into the future. Over half of the respondents indicated that the project findings reinforced what they already knew, while a smaller but sizeable contingent revealed that the findings had changed their opinions about possible climate change impacts.

Response rates to the attitudinal evaluation questions about using information from seminars and workshops:

Learnt something new	93%
Reinforced things I already knew	58%
Information today has changed my opinion about possible impacts of climate change	38%
Workshop has given me greater confidence	71%
I would be keen to attend a similar workshop at a later date	87%

Whilst producers attending events were exposed to the project findings, the main interest in the North East was in the discussion of systems that work now (e.g. calving time/system and lamb finishing) rather than future climate.

6. Future RD&E needs

Further work is needed to fill in the geographical gaps existing in this work throughout Victoria, where just six studies were conducted in an attempt to sample the breadth of sheep and beef enterprises across regions that vary widely in their production systems, both between and within regions. The case study approach provided very specific information over few sites and would be more useful to the industry if the case studies were more exhaustive and could therefore enable general recommendations to be made for a region. For example, lucerne is likely to be an increasingly profitable addition to the feedbase in future, but for what regional enterprises and under what conditions?

Whole farm systems, not just enterprises, should be the basis of future climate change adaptation strategies. Considering enterprises in isolation may provide misleading information as optimisation of one enterprise may hinder adaptation at the whole farm level. A significant number of whole farm case studies in all farming zones should be used to identify whole farm systems that are profitable and sustainable into the future. This is not small-plot or paddock-scale research but rather modelling of whole farm systems using real life case studies or simulations done on them as per this project.

The capacity of computer modelling to simulate a range of livestock systems was found to be limiting, and investment in enhanced models would offer the ability for them to be more useful in analysing the research questions posed for climate change adaptation.

Computer model enhancement and testing, together with the expansion of the modelling approach to the whole farm level, should be high priority areas for future adaptation projects.

A number of shortcomings inherent in the GrassGro model itself hindered the progress of work in this project and/or compromised the confidence in modelling outputs, such as:

- Cow liveweight changes, particularly during autumn, post-calving – leading to supplementary feeding patterns that are unrealistic
- Ability to accurately model lucerne production
- Ability to accurately model recent or emerging plant cultivars that offer different seasonal growth responses
- Livestock performance that does not take into account adverse influences such as internal parasites that reduce lamb growth rates
- The ability to model genetic improvements (e.g. ASBVs for growth)

The livestock growth rate issue, which has implications for modelling animal health and genetics impacts, could perhaps be fixed by providing a scalar in the model, in the same way that soil fertility can be ramped up and down to model observed pasture growth rates.

These issues (and possibly others identified by other project modellers) require attention (and funding if necessary) if greater reliance is to be placed on modelling to generate adaptive ability within the livestock production sector.

7. Published papers and extension communication products

Communication products published as at 18/05/12

- Grassland Society of Southern Australia, Conference Proceedings 2010: "Managing The Key Risks Of Farming - Climate and Commodity Price Variability" (paper, based on North Central Victoria Case Study)
- Grassland Society of Southern Australia, Newsletter No.292 (August 2011): "Effect of Climate on the Time of Calving"
- DPI Sheep Notes (Spring 2011): "Sheep Farming Systems for the Future"
- Kondinin Group "Ag In Focus, Victoria" Newsletter (Summer 2011): "Spreading Risk to Manage Climate Variability"
- DPI Sheep Notes newsletter (Autumn 2012): "The Changing Shape of the Pasture Curve In Northern Victoria"

Communication products to be published post-18/05/12 (commitment received)

- Grassland Society of Southern Australia Newsletter, June 2012 - SW Vic Beef Case Study Outcomes (Beef)
- Grassland Society of Southern Australia Newsletter, August 2012 - SW Vic Beef Case Study Outcomes (Prime Lamb)
- Grassland Society of Southern Australia Conference - Poster Series re climate modelling and Victorian case study findings
- DPI Sheep Notes newsletter, Spring 2012 - Outcomes of SW Vic Beef and Prime Lamb Case Studies
- Australian Society of Agronomy Conference Proceedings - "Managing The Key Risks Of Farming - Climate and Commodity Price Variability" (refereed paper, based on North Central Victoria Case Study)

Communication products to be published post-18/05/12 (commitment yet to be received)

- Australian Farm Business Management Journal, Charles Sturt University - "Managing The Key Risks Of Farming - Climate and Commodity Price Variability" (refereed paper, based on North Central Victoria Case Study)