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2007



# Modelling Sheep Population and Wool Production in Australia

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# Outline of presentation

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## Sheep and Wool industry

### Model development

- Approach
- Sensitivity analysis
- Correlation

### Two applications

- Forecasting cycle
- Adjusting ram choice to maintain the flock

### Benefits

# Background

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## Sheep & Wool industry (2006)

- 92 million sheep
- 420 million kg wool
- A\$2.5 billion per year

## Long supply chain

- Stages – Growers, Exporters, Processors, Retailers
- Duration – farm to fashion outlet >9 months

## Planning is crucial

- Production and price
- Wool quality

**Thus production forecasts are crucial!**

# Scoping study

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## Concluded there was an

“... industry driven need to enhance the capacity for forecasting and projection of sheep meat and wool supply in Australia”

### 1<sup>st</sup> generation model

“a quarterly demographic model of the sheep flock”

### 2<sup>nd</sup> generation model

“... will utilise Monte Carlo simulation techniques to both develop estimates and quantify uncertainty in final forecasts”

# Why Monte Carlo methods?

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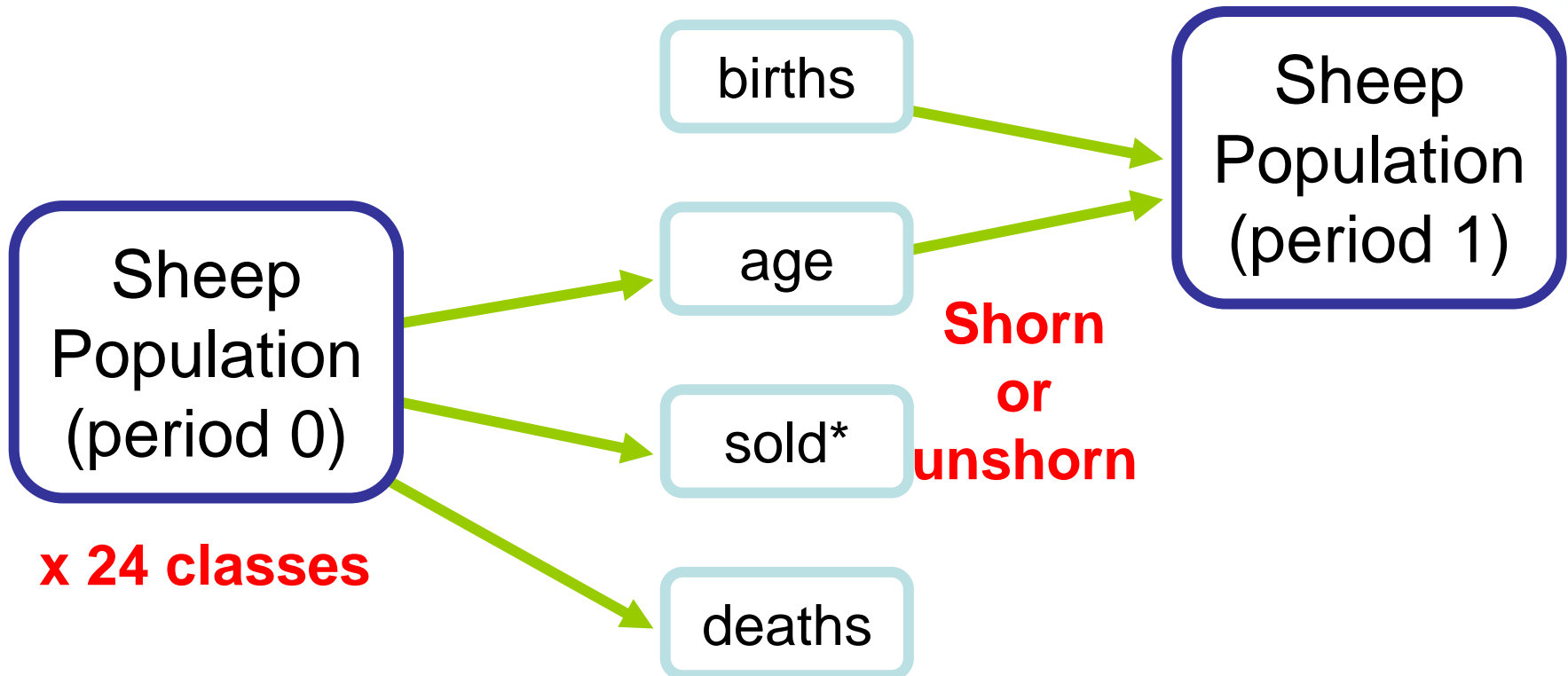
Unknown starting point

Need to estimate closing point

System is not at equilibrium

# Projection is easy ...

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**Project out 5 years**

$\text{sold}^* = \text{sales} - \text{purchases}$

# Matrix projection process

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	New Born	Immature	Mature
New Born		0.22	0.32
Immature	0.70		
Mature		0.95	0.80

	Start	Year 1	Year 2	Year 3	Year 4	Year 5
New Born	11.2	13.3	$13.3 = (11.2 * 1.18)$	$14.8 = (13.3 * 1.11)$	$16.5 = (14.8 * 1.05)$	$18.3 = (16.5 * 1.04)$
Immature	8.0	7.8	$7.8 = (8.0 * 0.97)$	$7.5 = (7.8 * 0.96)$	$7.2 = (7.5 * 0.95)$	$6.9 = (7.2 * 0.93)$
Mature	36.0	36.5	$36.7 = (36.0 * 1.02)$	$37.2 = (36.7 * 1.01)$	$37.7 = (37.2 * 1.01)$	$38.2 = (37.7 * 1.01)$
Total	55.2	57.6	59.4	61.4	63.6	65.7

# Forecasting time line

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Mar 2007  
1<sup>st</sup> forecast

**Survey: flock composition, 2007 intensions**  
**Progressive sheep sales/exports (ABS)**  
**Wool test data (season to date)**

Jun 2007

**2007 growing season underway**  
**Sheep population 2006 (ABS)**  
**Progressive sheep sales/exports (season to date)**  
**Wool test data (end of season)**

Sep 2007

**2007 growing season conditions**  
**Surveys: MLA lamb survey, Dept Agriculture**  
**Sheep sales/exports (previous season)**

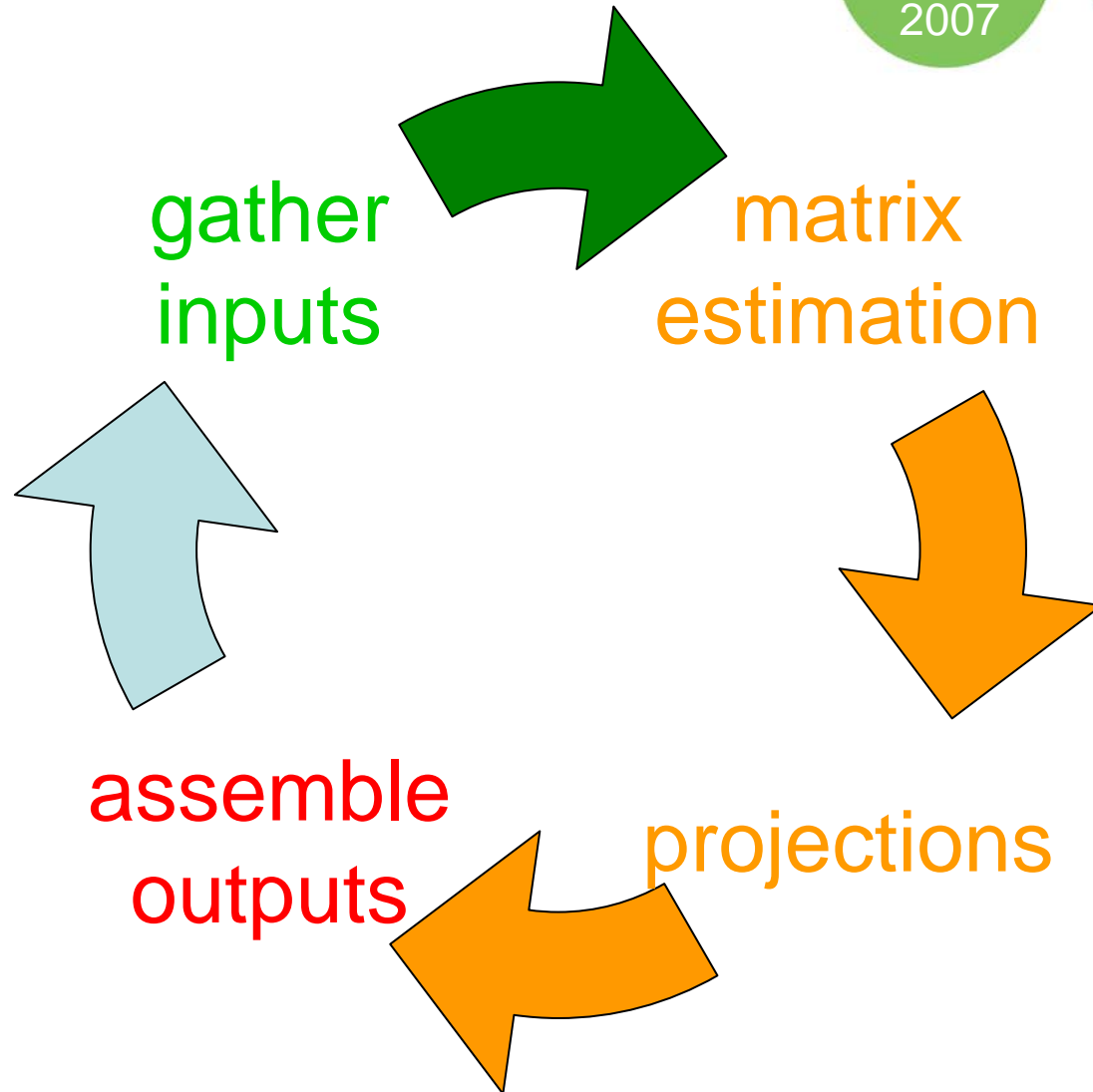
Mar 2008

**Survey: flock composition, 2007 intensions**  
**Progressive sheep sales/exports (season to date)**  
**Wool test data (season to date)**

Jun 2008

**2008 growing season underway**  
**Sheep population 2006 (ABS)**  
**Progressive sheep sales/exports (season to date)**  
**Wool test data (end of season)**

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# Model specifications

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## Flock size and composition

- 4 age groups
  - Lambs
  - Weaners
  - Hoggets
  - Adults
- 3 breeds
  - Merino
  - Merino first cross
  - Merino second cross/meat breeds
- 2 sexes
  - Ewes
  - Wethers

Time step of 6 months

Australia - single region

## Key Inputs

- Lambing rate (by breed)
- Ram choice
- Death rates
- Sales rates (net)
  
- Initial flock composition

# Initial flock composition

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## Population at 1<sup>st</sup> July 2006, millions

Initial flock composition	Ewes (no.)	Wethers (no.)	
Merino lambs	6.88	5.5	
Merino weaners	4.11	2.76	
Merino hoggets	6.05	3.32	
Merino adults	38.37	8.65	
Merino first cross lambs	2.11	1.59	
Merino first cross weaners	1.54	1.23	
Merino first cross hoggets	0.66	0.19	
Merino first cross adults	5.08	0.4	
Second cross or meat breed lambs	0.88	0.62	
Second cross or meat breed weaners	0.45	0.35	
Second cross or meat breed hoggets	0.12	0.06	
Second cross or meat breed adults	0.88	0.12	
<b>Initial sheep population</b>	<b>67.13</b>	<b>24.79</b>	<b>91.92</b>

# Input form

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Inputs for Australia	Jul-Dec 2006	Jan-Jun 2007
Wool production scalar	100%	100%
Sheep sales season scalar	100%	100%
Dew rate season scalar	100%	100%
Ram:ewe ratio		
Merino ewes x Merino rams	69%	69%
Merino 1st cross ewes x Merino rams	6%	5%
2nd cross & meat ewes x Merino rams	6%	5%
Wearing rates		
Merino lambs	80%	80%
Merino 1st cross lambs	86%	86%
2nd cross & meat breed lambs	94%	94%

# Wool production scalar (% of mean)

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## StatTools (Core Analysis Pack)

**Analysis:** One Variable Summary

**Performed By:** Kimbal Curtis

**Date:** Tuesday, 3 July 2007

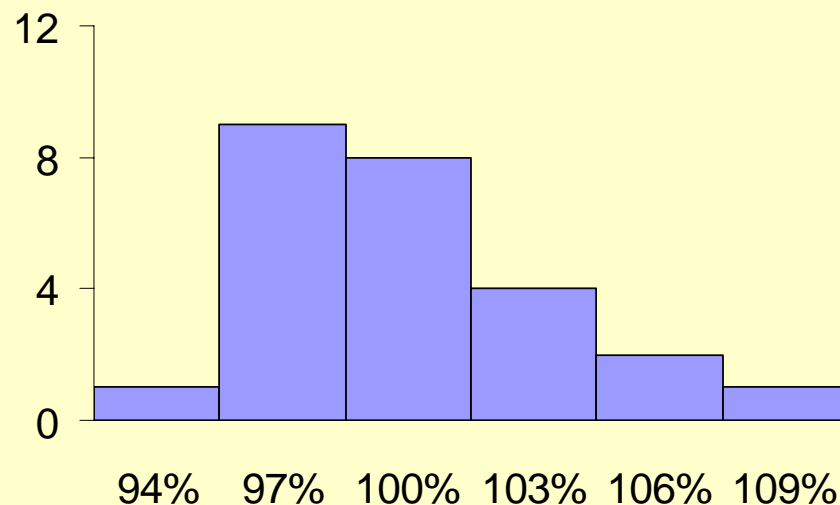
**Updating:** Static

### Relative wool cut per sheep (Australia) WoolProduction annual dataset

#### One Variable Summary

Mean	1.00000
Variance	0.00104
Std. Dev.	0.03227
Skewness	0.5275
Kurtosis	2.7317
Median	0.99703
Mean Abs. Dev.	0.02668
Minimum	0.94977
Maximum	1.07580
Range	0.12604
Count	25
Sum	25.00000
1st Quartile	0.97452
3rd Quartile	1.01954

Wool production  
scalar



# Outputs

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Outputs for Australia	Year 2: 2007-08	
<b>Opening sheep number (millions) - 1 July</b>	<b>91.88</b>	0.0 (0.0%)
Number of sheep shorn (millions)	94.5	-1.1 (-1.2%)
Ratio of sheep shorn:opening number	103%	
<b>Shorn wool production (mkg greasy)</b>	<b>423</b>	-5.1 (-1.2%)
Wool cut per head (kg greasy)	4.47	0.0 (0.0%)
<b>Closing sheep number (millions) - 30 June</b>	<b>91.09</b>	-0.8 (-0.9%)
Sheep sold for slaughter (millions)		
lambs+weaners	17.9	2.3 (14.6%)
hoggets	1.8	-0.1 (-6.9%)
adults	11.9	0.2 (1.6%)
subtotal	31.6	2.3 (8.0%)
Deaths (millions)	4.9	-0.1 (-1.6%)

# Output series

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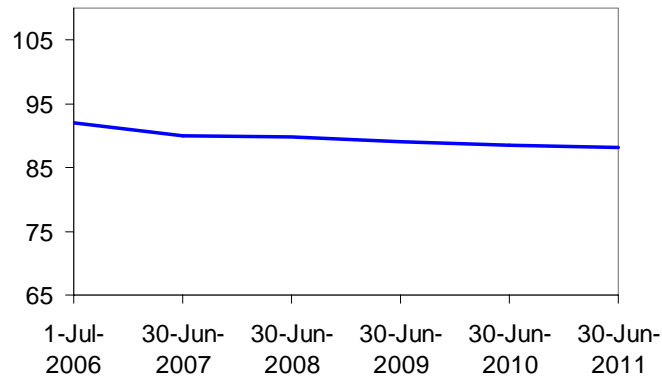
Outputs for Australia	Year 1: 2006-07	Year 2: 2007-08		Year 3: 2008-09	
<b>Opening sheep number (millions) - 1 July</b>	<b>91.92</b>	<b>91.88</b>	0.0 (0.0%)	<b>91.09</b>	-0.8 (-0.9%)
Number of sheep & lambs shorn (millions)	95.7	94.5	-1.1 (-1.2%)	93.8	-0.8 (-0.8%)
Ratio of sheep shorn:opening number	104%	103%		103%	
<b>Shorn wool production (mkg greasy)</b>	<b>428</b>	<b>423</b>	-5.1 (-1.2%)	<b>419</b>	-4.2 (-1.0%)
Wool cut per head (kg greasy)	4.47	4.47	0.0 (0.0%)	4.47	0.0 (-0.2%)
<b>Closing sheep number (millions) - 30 June</b>	<b>91.88</b>	<b>91.09</b>	-0.8 (-0.9%)	<b>90.16</b>	-0.9 (-1.0%)
Sheep sold for slaughter/live export (millions)					
lambs+weaners	15.6	17.9	2.3 (14.6%)	18.2	0.3 (1.5%)
hoggets	1.9	1.8	-0.1 (-6.9%)	1.7	-0.1 (-5.4%)
adults	11.7	11.9	0.2 (1.6%)	11.6	-0.2 (-2.1%)
subtotal	29.2	31.6	2.3 (8.0%)	31.5	-0.1 (-0.3%)
Deaths (millions)	5.0	4.9	-0.1 (-1.6%)	4.9	0.0 (-0.4%)

# Deterministic forecasts

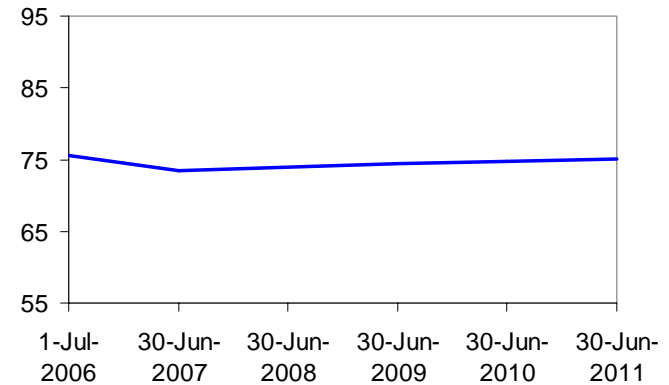
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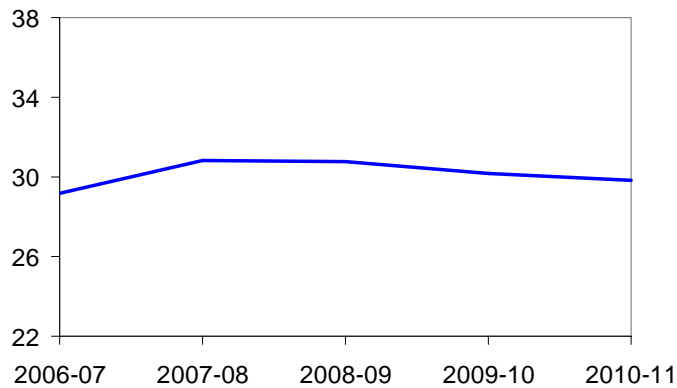
## Flock size



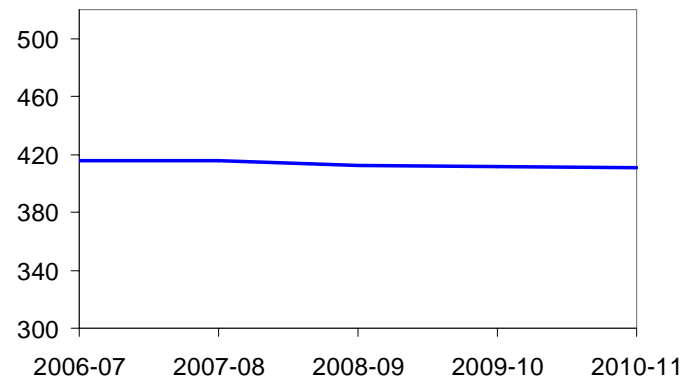
## Merino flock size



## Sheep sales



## Wool production

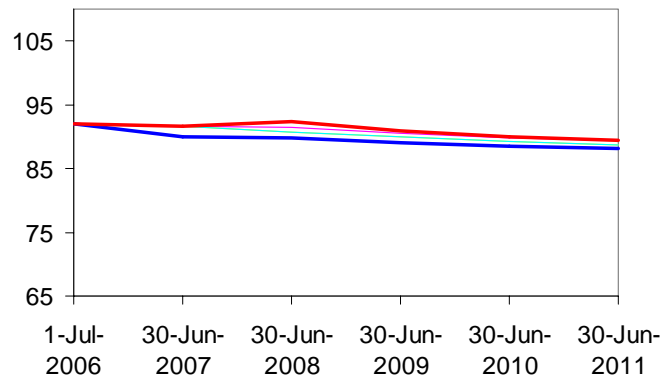


# Deterministic forecasts, updated quarterly

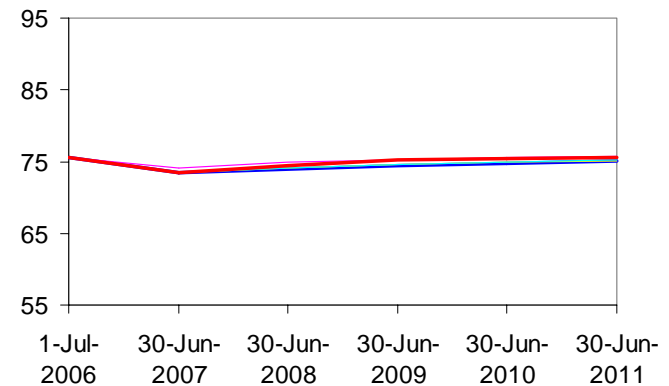
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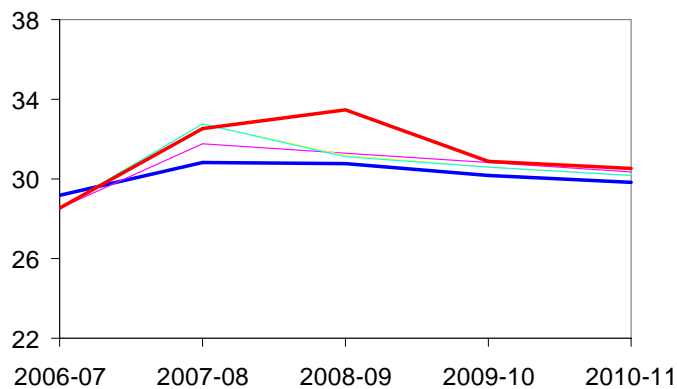
## Flock size



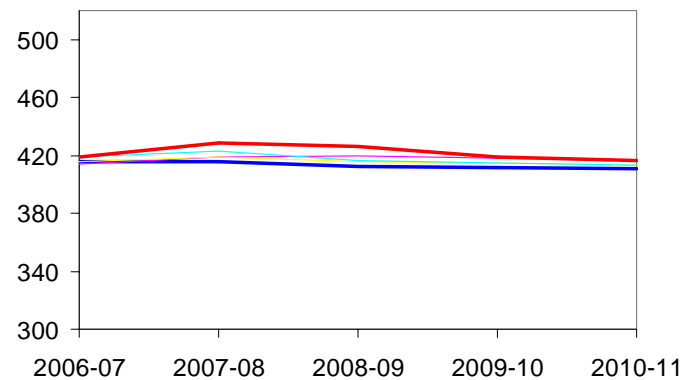
## Merino flock size



## Sheep sales



## Wool production

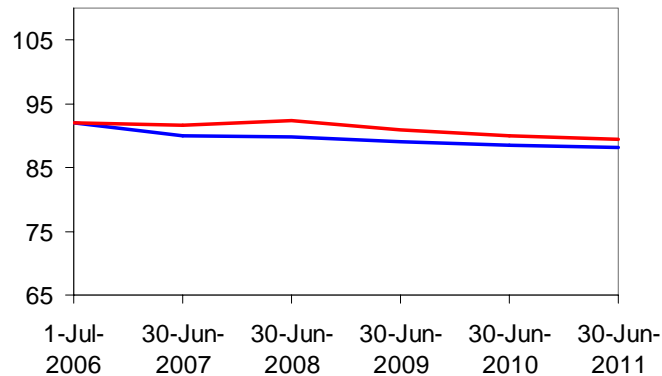


# Deterministic forecasts, 1<sup>st</sup> and last

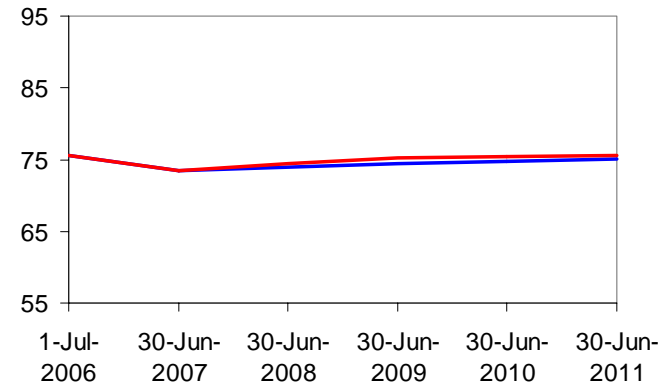
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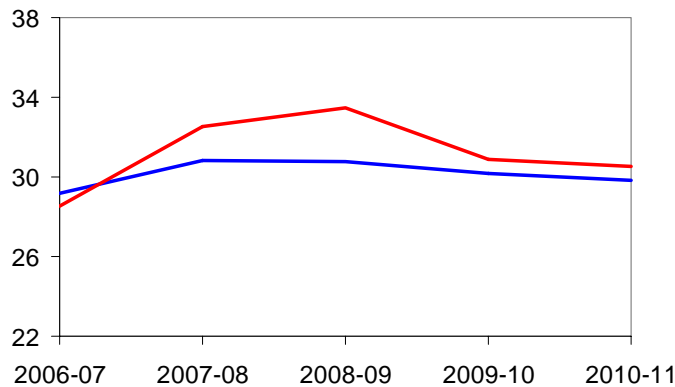
## Flock size



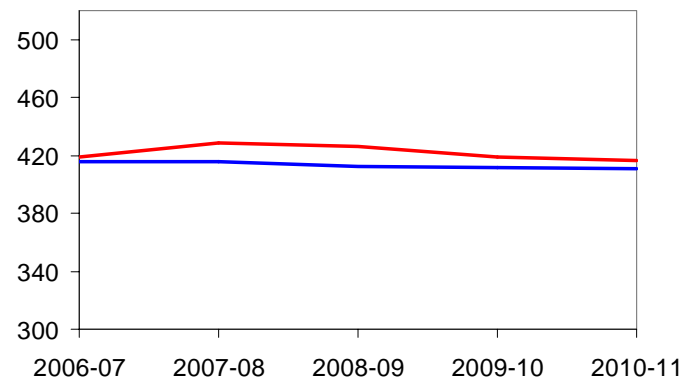
## Merino flock size



## Sheep sales



## Wool production



# Introducing variability

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- Identify most important inputs
- Define distributions
- Include correlations

## Why?

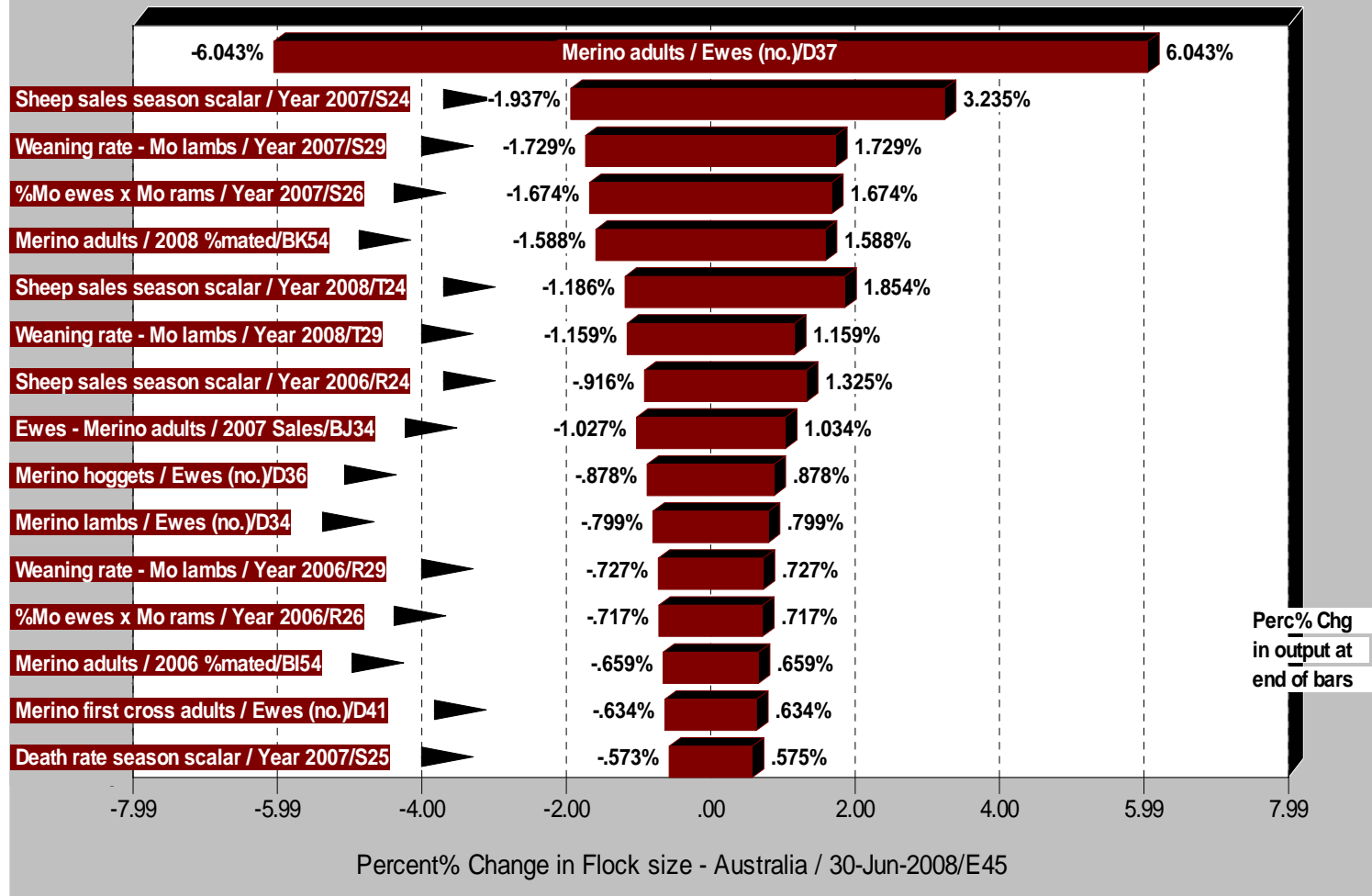
- Unknown starting point
- Future values have a range on possible values

# Sensitivity analysis - TopRank

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Tornado Graph for Flock size - Australia / 30-Jun-2008/E45



# Sensitivity analysis short and long term drivers

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Description	Period 1		Period 5	
	Max	Min	Max	Min
<b>Percent of flock that are Merino adult ewes</b>	<b>5.7%</b>	<b>-5.7%</b>	<b>6.4%</b>	<b>-6.4%</b>
<b>Weaning rate, Merino lambs</b>	<b>1.8%</b>	<b>-1.8%</b>	<b>6.4%</b>	<b>-6.2%</b>
<b>Weaning rate, first cross lambs</b>	<b>0.8%</b>	<b>-0.8%</b>	<b>1.1%</b>	<b>-1.1%</b>
<b>Percent of Merino adult ewes sold</b>	<b>0.8%</b>	<b>-0.8%</b>	<b>4.1%</b>	<b>-4.0%</b>
<b>Percent of flock that are Merino adult wethers</b>	<b>0.8%</b>	<b>-0.8%</b>		
<b>Percent of flock that are Merino ewe lambs</b>	<b>0.7%</b>	<b>-0.7%</b>	<b>0.9%</b>	<b>-0.9%</b>
Percent of flock that are Merino wether lambs	0.6%	-0.6%		
Percent of flock that are Merino ewe weaners	0.6%	-0.6%	0.9%	-0.9%
Weaning rate, second cross lambs			1.8%	-1.7%
Percent of Merino adult wethers sold			0.8%	-0.7%
Percent of flock that are 1X ewe adults			0.6%	-0.6%
Percent of flock that are 2X ewe adults			0.6%	-0.6%
<b>Death rate, adult ewes</b>			<b>2.0%</b>	<b>-2.0%</b>
<b>Percent of Merino ewes joined to non-Merino rams</b>			<b>3.4%</b>	<b>-3.4%</b>
Percent of first or second cross wether lambs sold			0.9%	-0.9%
Percent of first or second cross adult ewes sold			1.2%	-1.1%
Percent of first or second cross ewe lambs sold			1.5%	-1.5%

# Distributions and data requirements

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	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	100%	5.0%	90%	110%
<b>Sales {Triang}</b>	105%		75%	125%
<b>Deaths {Triang}</b>	100%		30%	170%
Mo x Mo {Triang}	69%		59%	79%
1X x Mo {Triang}	8%		0%	10%
2X x Mo {Triang}	8%		0%	10%
<b>Mo lambing {Norm}</b>	80%	3.3%		
1X lambing {Norm}	86%	3.6%		
2X lambing {Norm}	94%	3.9%		

# Correlated inputs

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## StatTools (Core Analysis Pack)

**Analysis:** Correlation and Covariance

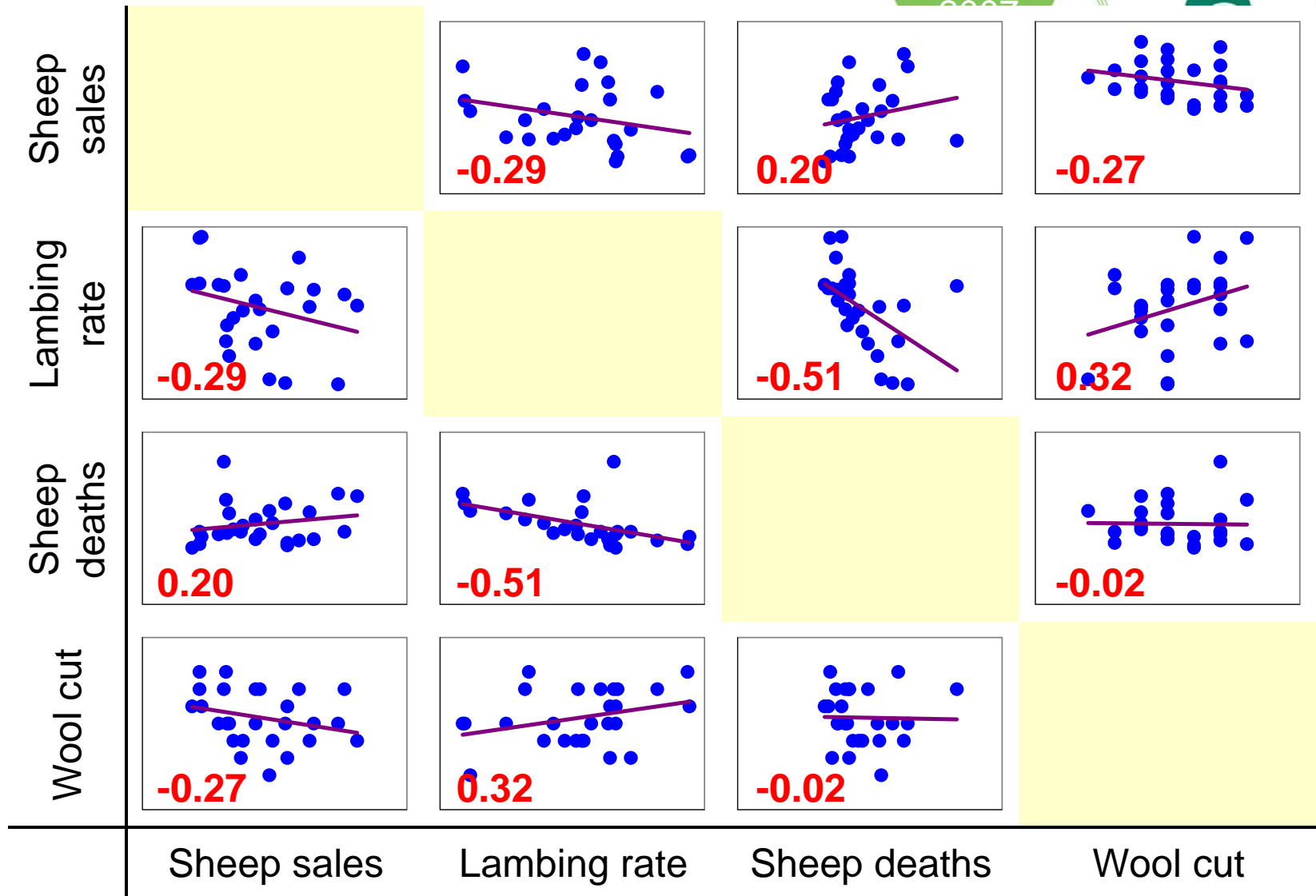
**Performed By:** Kimbal Curtis

**Date:** Tuesday, 3 July 2007

**Updating:** Static

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	ABARE sheep data (Australia)	ABARE sheep data (Australia)	ABARE sheep data (Australia)	ABARE sheep data (Australia)
<i>Correlation Table</i>	Sheep sales rate (%)	Lambing rate (%)	Sheep death rate (%)	Wool cut per sheep shorn (kg)
Sheep sales rate (%)	1.000	-0.293	0.204	-0.268
Lambing rate (%)	-0.293	1.000	-0.512	0.322
Sheep death rate (%)	0.204	-0.512	1.000	-0.021
Wool cut per sheep shorn (kg)	-0.268	0.322	-0.021	1.000



# Model now built

Let the fun begin ...

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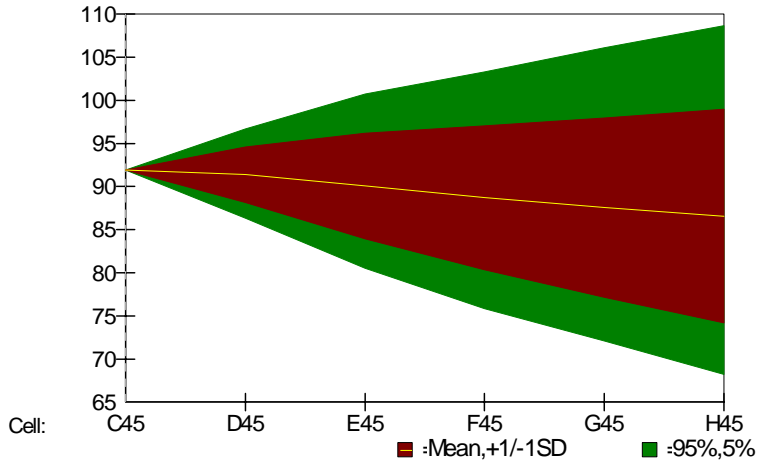
Demonstrate flock model

# Output bounds

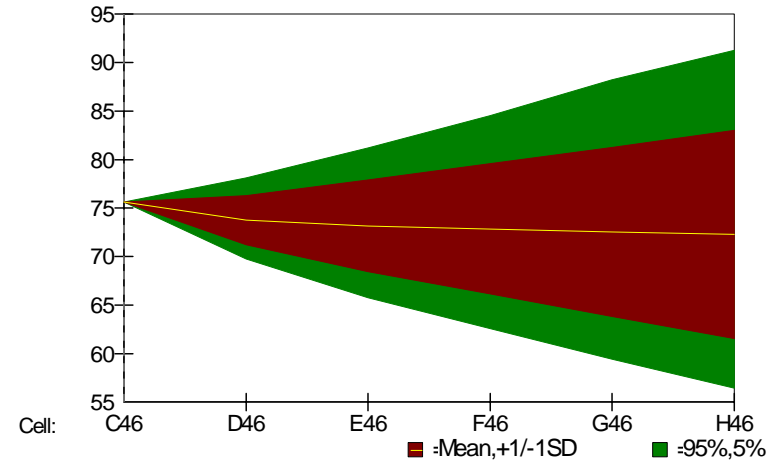
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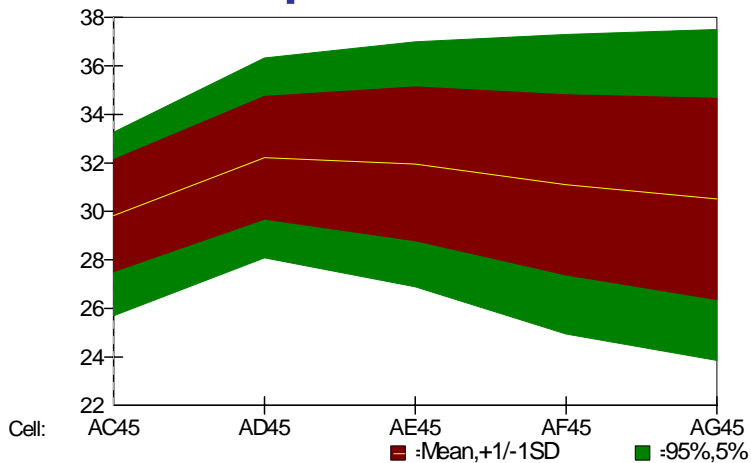
## Flock size



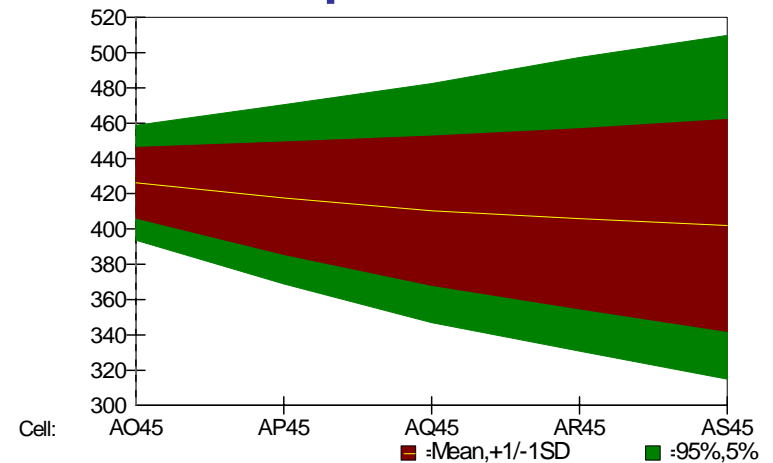
## Merino flock size



## Sheep sales



## Wool production



# Example 1: Forecasting

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Forecasts released quarterly  
Farmers surveyed twice a year

- 1100 in July, 1400 in February

## Industry data sources

- Australian Bureau of Statistics
- Australian Wool Testing Authority
- Meat and Livestock Australia

## State committee inputs

Forecasting 2007-08 wool production  
Sheep population at 30-June-2008

# Model set up

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Start with average conditions

Same for all years

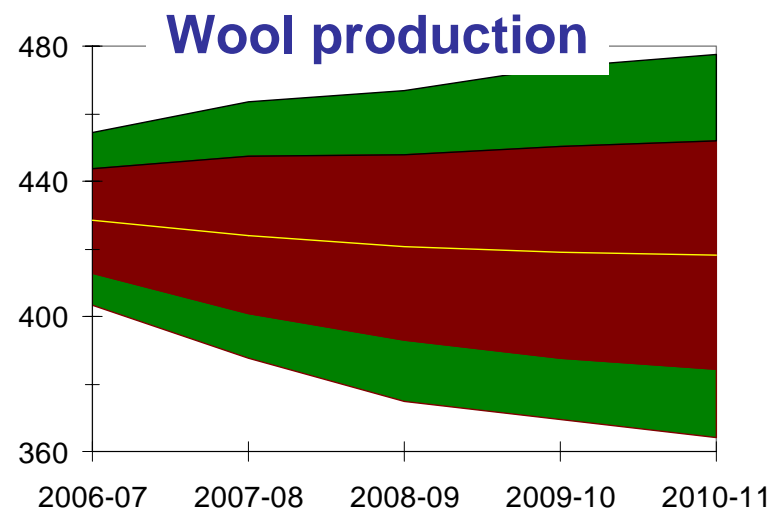
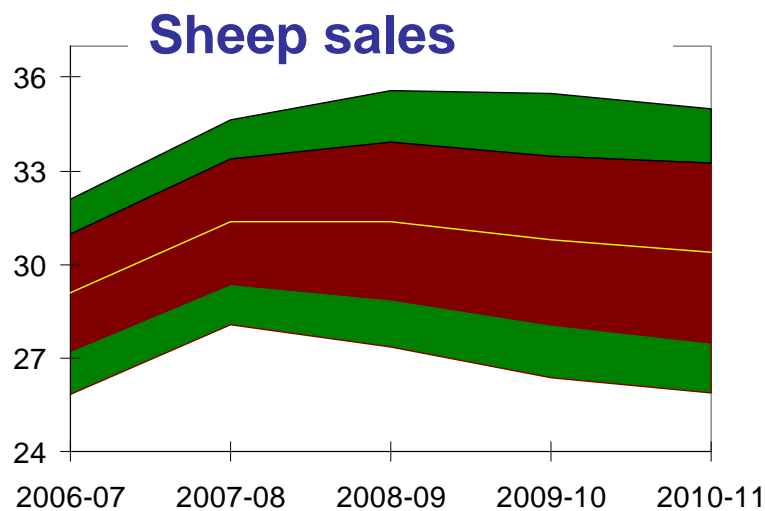
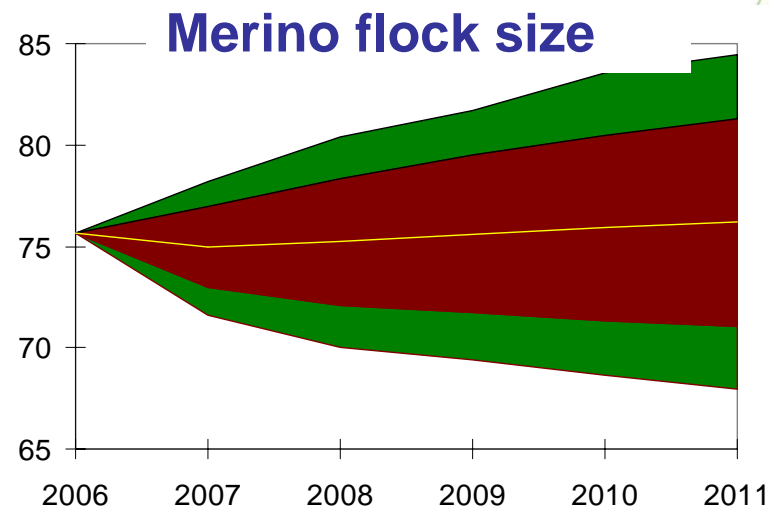
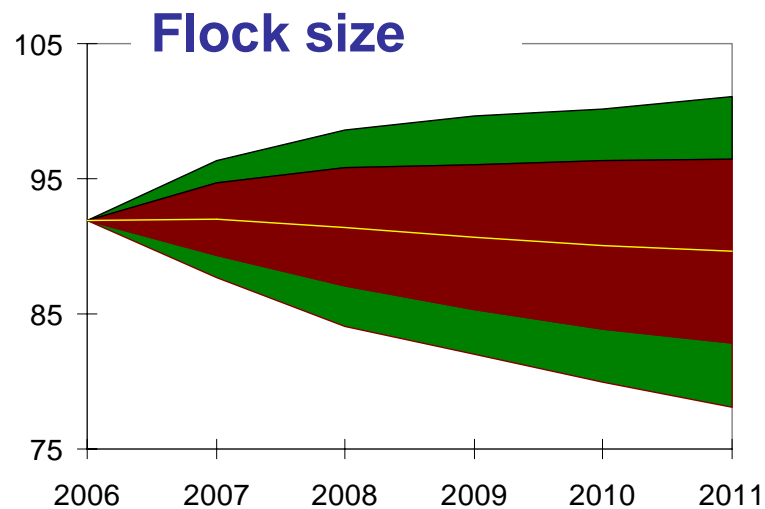
Initialise at July 2006

## Risk parameters for Year 2006

	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	100%	5.0%	90%	110%
<b>Sales {Triang}</b>	100%		75%	125%
<b>Deaths {Triang}</b>	100%		30%	170%
Mo x Mo {Triang}	69%		59%	79%
1X x Mo {Triang}	8%		0%	10%
2X x Mo {Triang}	8%		0%	10%
<b>Mo lambing {Norm}</b>	80%	3.3%		
1X lambing {Norm}	86%	3.6%		
2X lambing {Norm}	94%	3.9%		

# Projection based on average conditions

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# 1<sup>st</sup> forecast (March 2007)

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## Poorer conditions than average in 2006

- Lower wool cut, lambing rates
- Higher sales and deaths

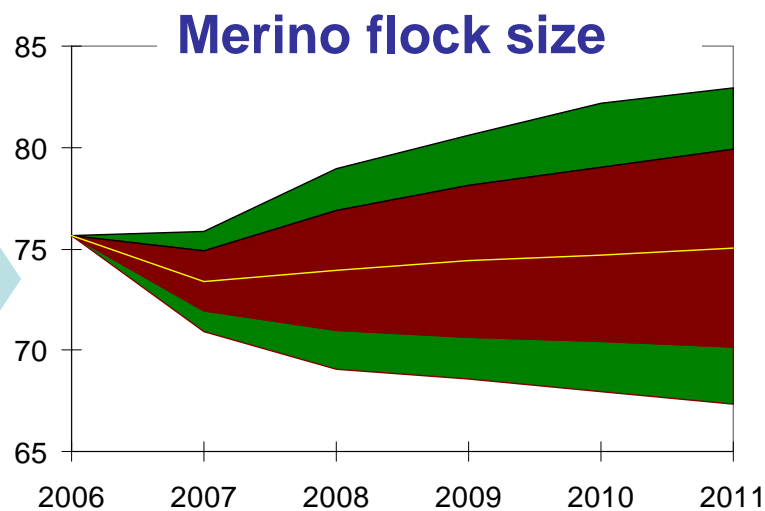
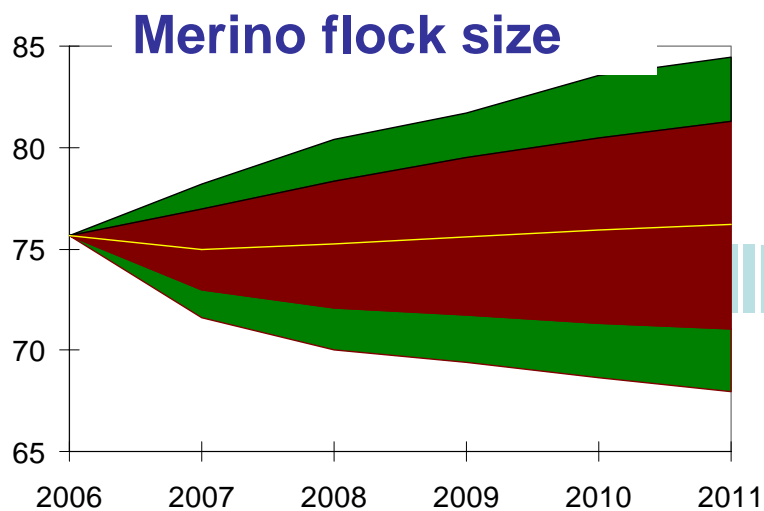
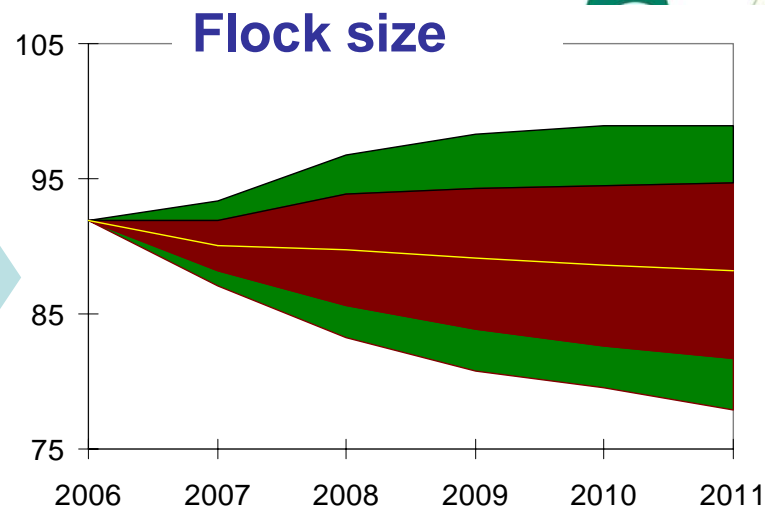
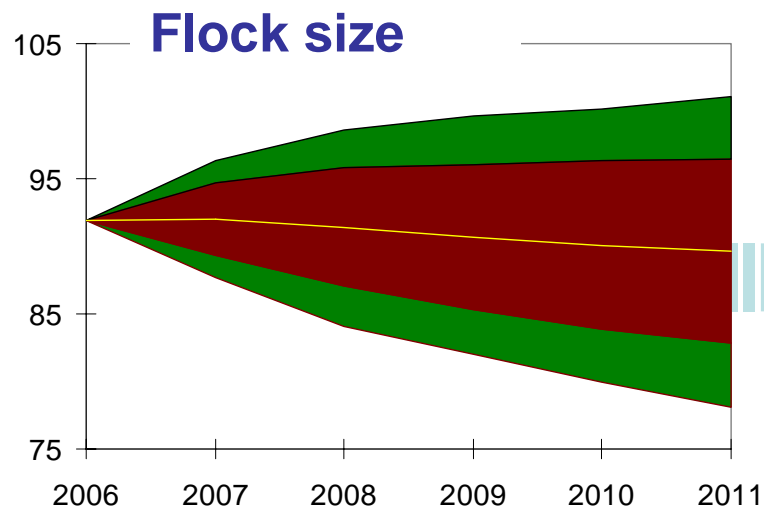
## Average conditions for 2007

### Risk parameters for Year 2006

	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	97%	2.0%	90%	110%
<b>Sales {Triang}</b>	105%		100%	110%
<b>Deaths {Triang}</b>	110%		100%	120%
Mo x Mo {Triang}	69%		65%	74%
1X x Mo {Triang}	8%		6%	10%
2X x Mo {Triang}	8%		6%	10%
<b>Mo lambing {Norm}</b>	70%	0.1%		
1X lambing {Norm}	80%	0.1%		
2X lambing {Norm}	94%	0.1%		

# Average to Mar-2007 forecast

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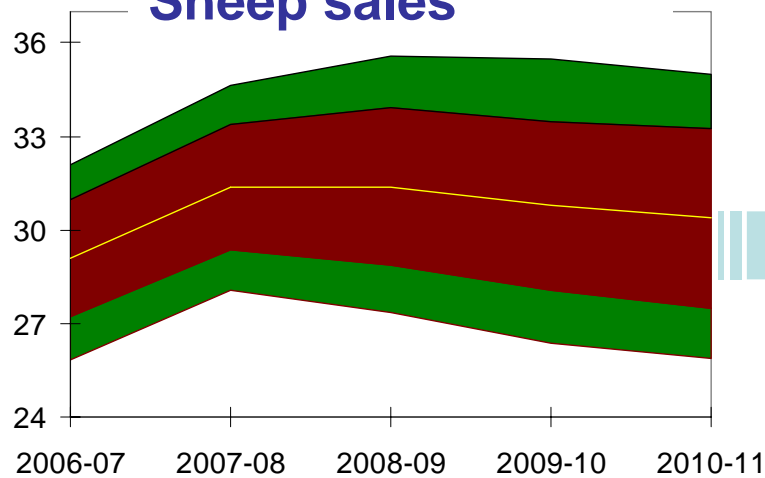


# Average to Mar-2007 forecast

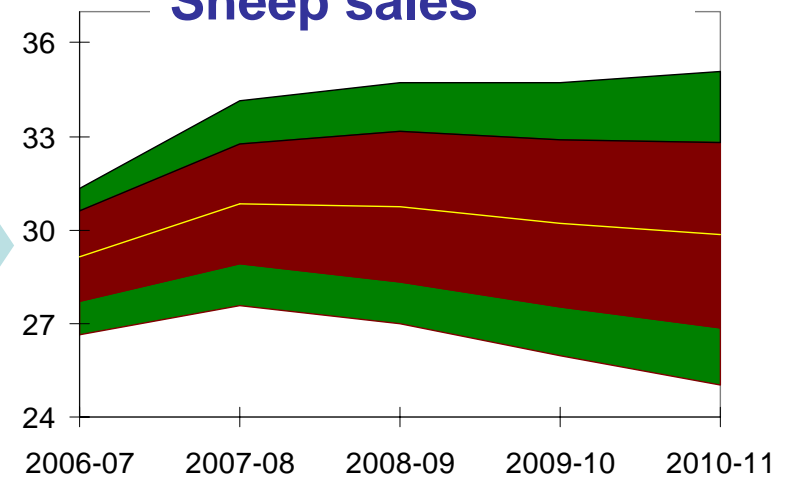
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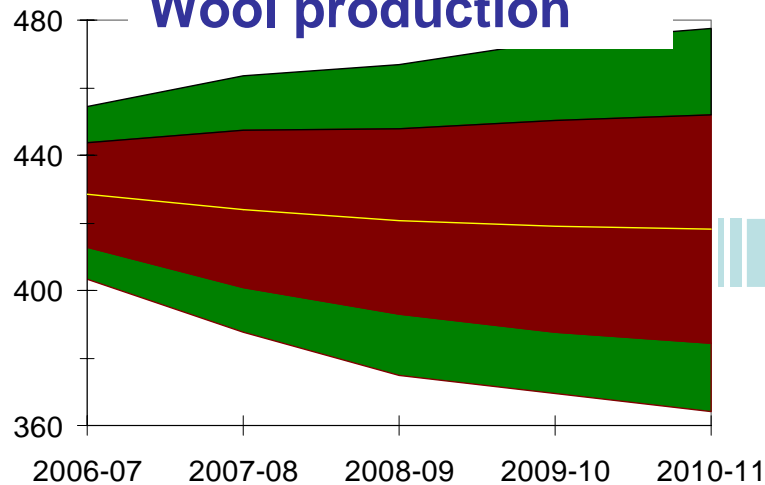
## Sheep sales



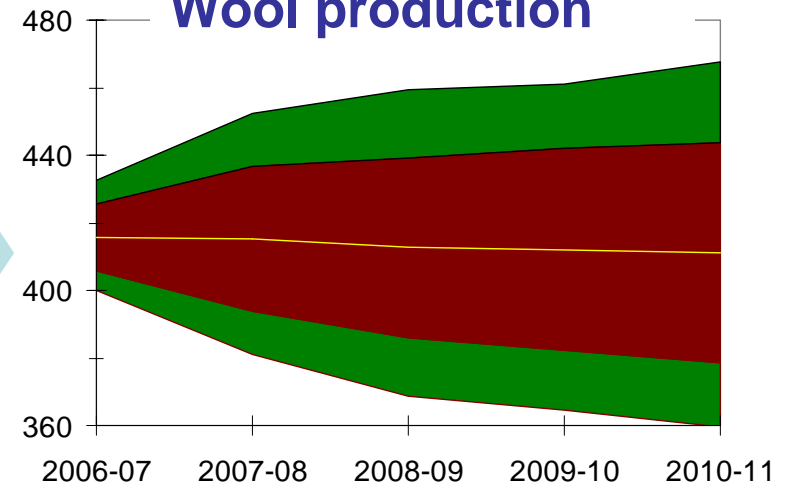
## Sheep sales



## Wool production



## Wool production



# 2<sup>nd</sup> forecast (July 2007)

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## Risk parameters for Year 2006

Wool {NormTrunc}  
Sales {Triang}  
Deaths {Triang}  
Mo x Mo {Triang}  
1X x Mo {Triang}  
2X x Mo {Triang}  
Mo lambing {Norm}  
1X lambing {Norm}  
2X lambing {Norm}

	Average	Stdev	Min	Max
Wool {NormTrunc}	97%	2.0%	90%	110%
Sales {Triang}	105%		100%	110%
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1X lambing {Norm}	80%	0.1%		
2X lambing {Norm}	94%	0.1%		

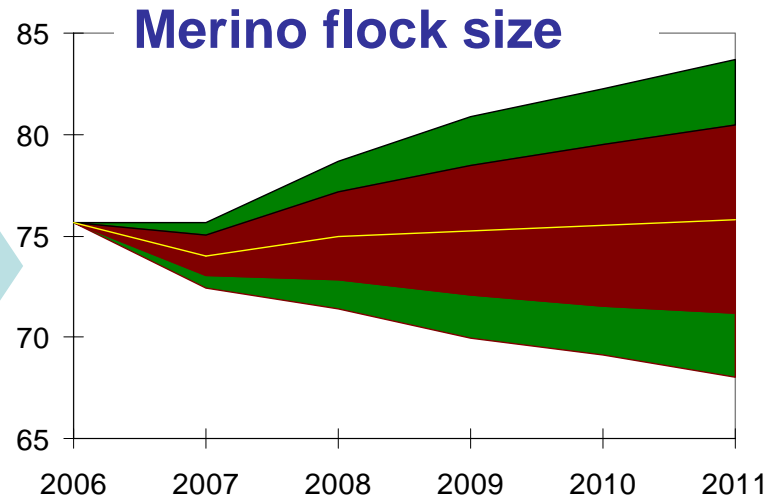
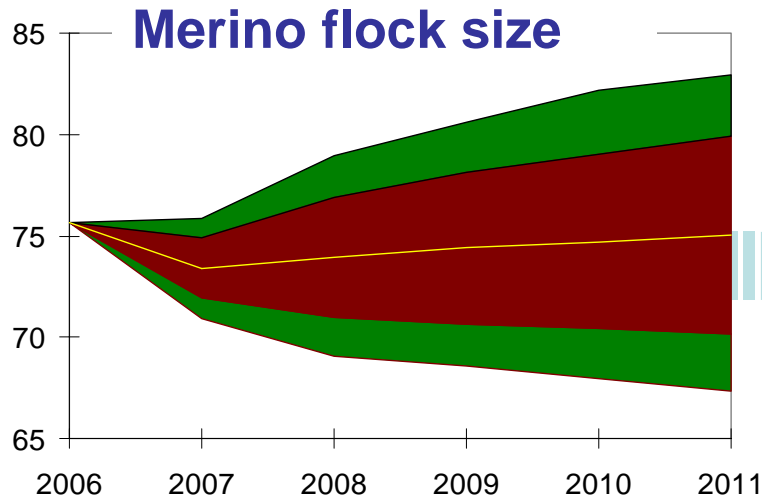
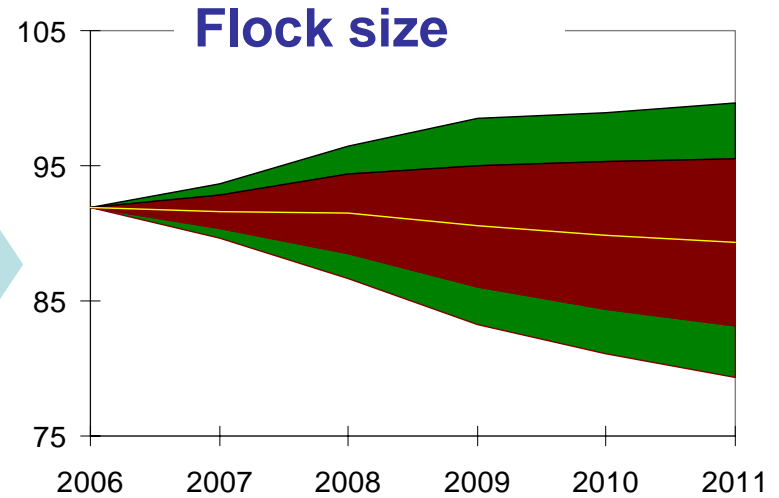
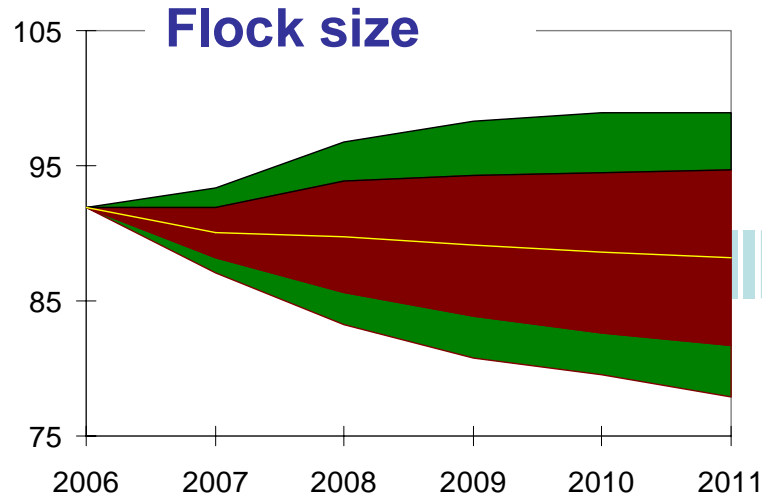
## Risk parameters for Year 2007

Wool {NormTrunc}  
Sales {Triang}  
Deaths {Triang}  
Mo x Mo {Triang}  
1X x Mo {Triang}  
2X x Mo {Triang}  
Mo lambing {Norm}  
1X lambing {Norm}  
2X lambing {Norm}

	Average	Stdev	Min	Max
Wool {NormTrunc}	99%	4.0%	90%	110%
Sales {Triang}	95%		80%	110%
Deaths {Triang}	100%		60%	140%
Mo x Mo {Triang}	69%		59%	79%
1X x Mo {Triang}	8%		0%	10%
2X x Mo {Triang}	8%		0%	10%
Mo lambing {Norm}	82%	2.0%		
1X lambing {Norm}	93%	2.0%		
2X lambing {Norm}	105%	2.0%		

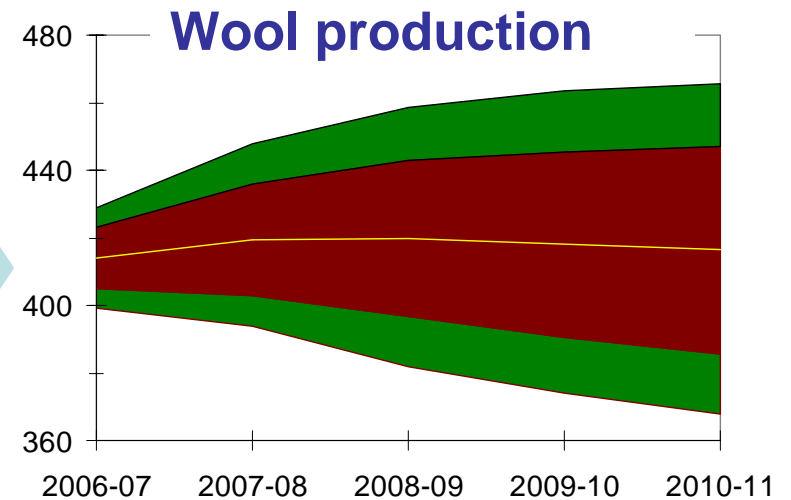
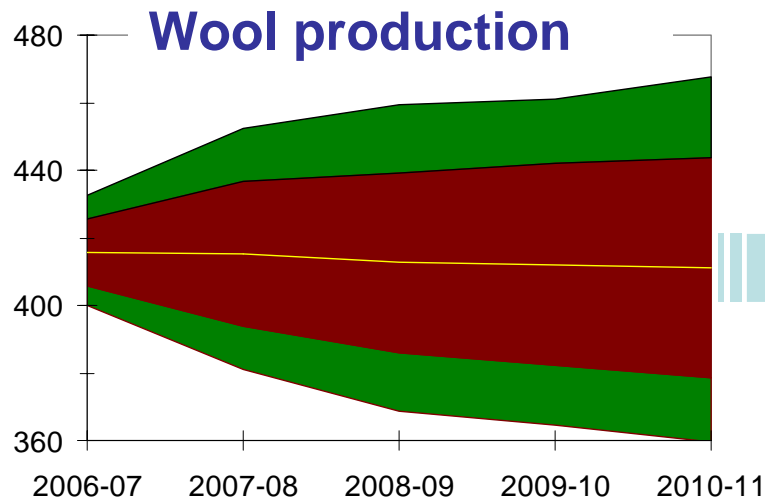
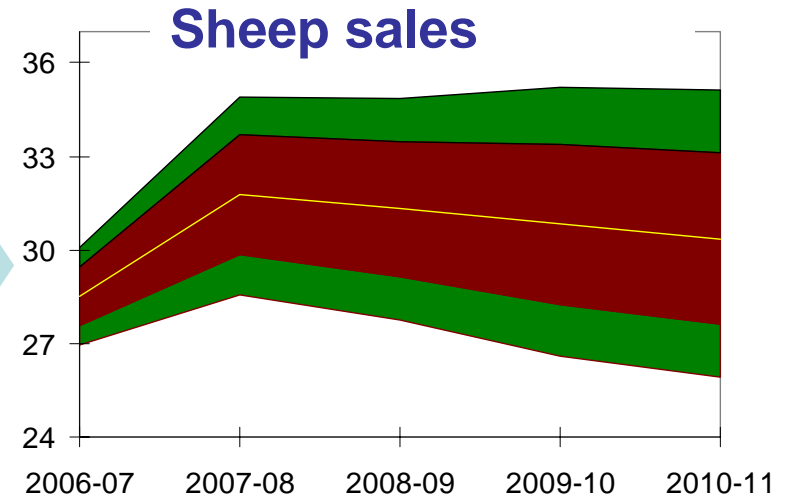
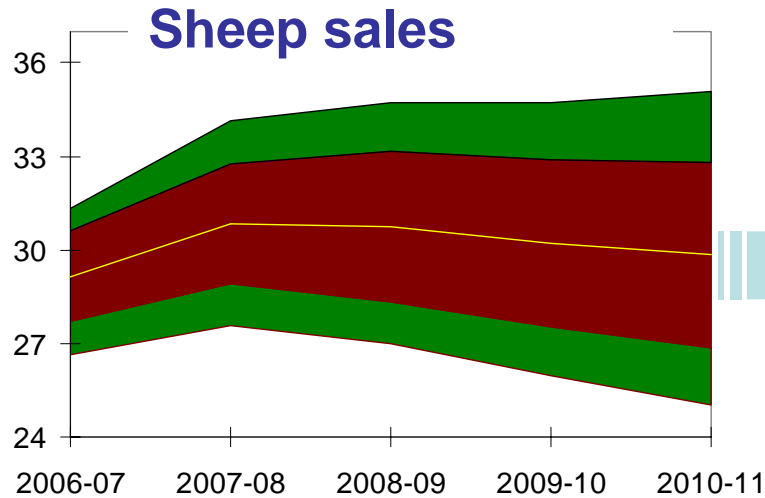
# Mar-2007 to Jul-2007 forecasts

Palisade  
Sydney



# Mar-2007 to Jul-2007 forecasts

Palisade  
Sydney



# 3<sup>rd</sup> forecast (September 2007)

Palisade  
Sydney  
2007



## Improving conditions across 2007

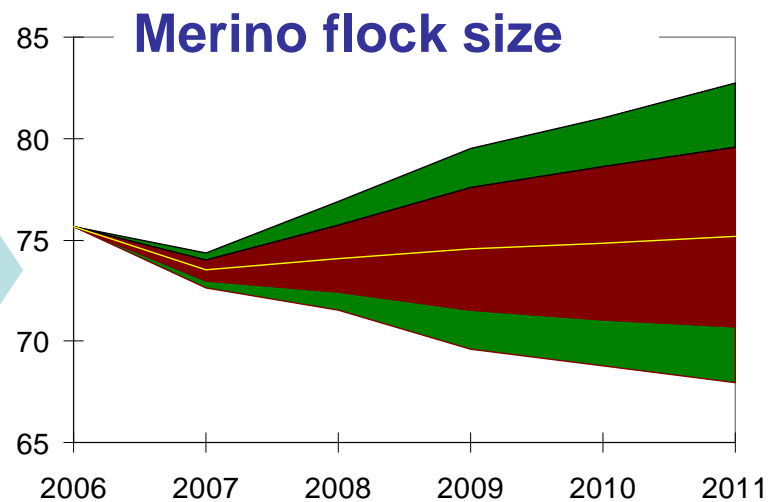
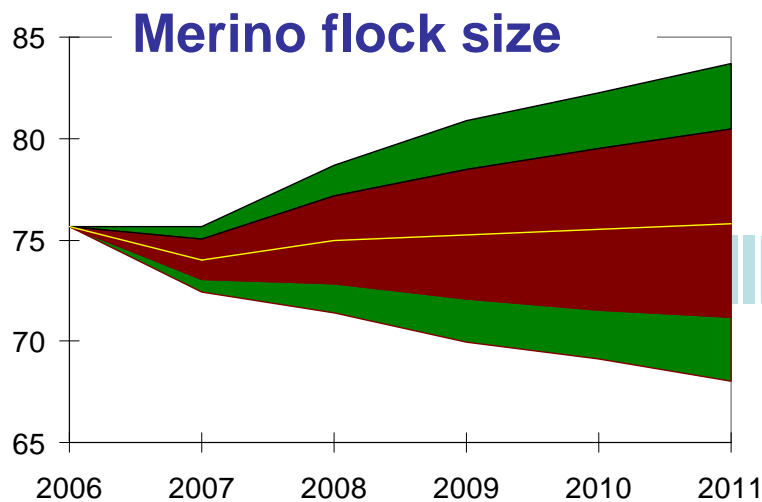
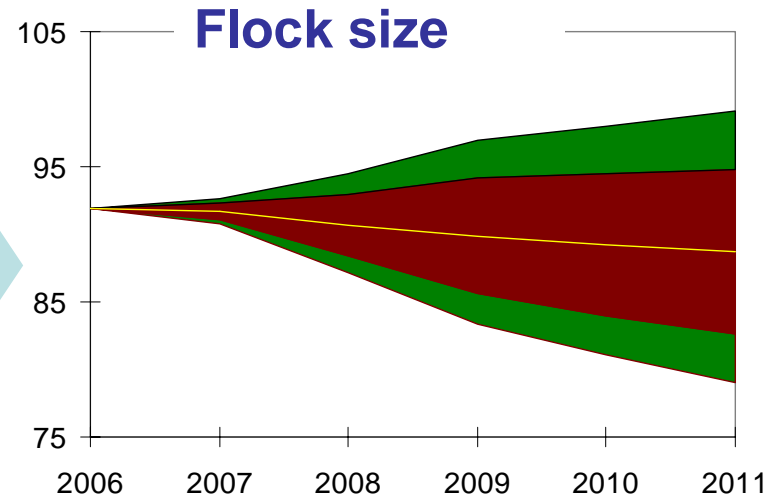
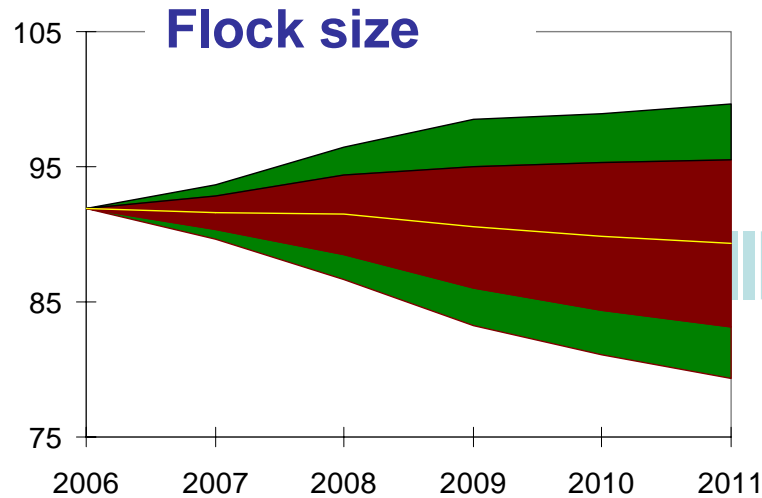
- Average wool cut per sheep
- Better lambing rates
- Reduced sales (re-building)

### Risk parameters for Year 2007

	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	100%	2.0%	90%	110%
<b>Sales {Triang}</b>	95%		90%	100%
<b>Deaths {Triang}</b>	100%		85%	115%
<b>Mo x Mo {Triang}</b>	65%		60%	70%
<b>1X x Mo {Triang}</b>	8%		4%	10%
<b>2X x Mo {Triang}</b>	8%		4%	10%
<b>Mo lambing {Norm}</b>	82%	1.5%		
<b>1X lambing {Norm}</b>	93%	1.5%		
<b>2X lambing {Norm}</b>	105%	1.5%		

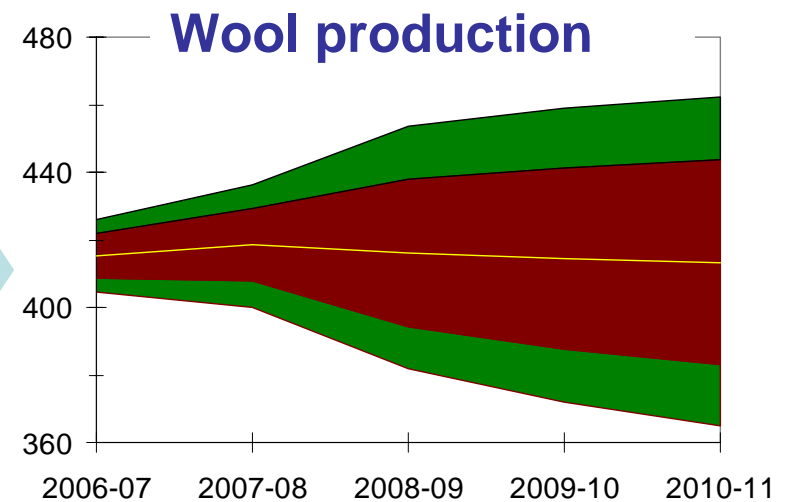
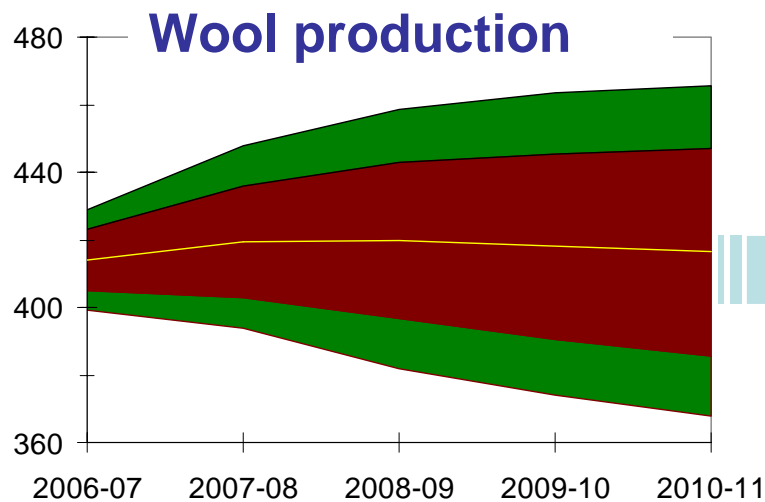
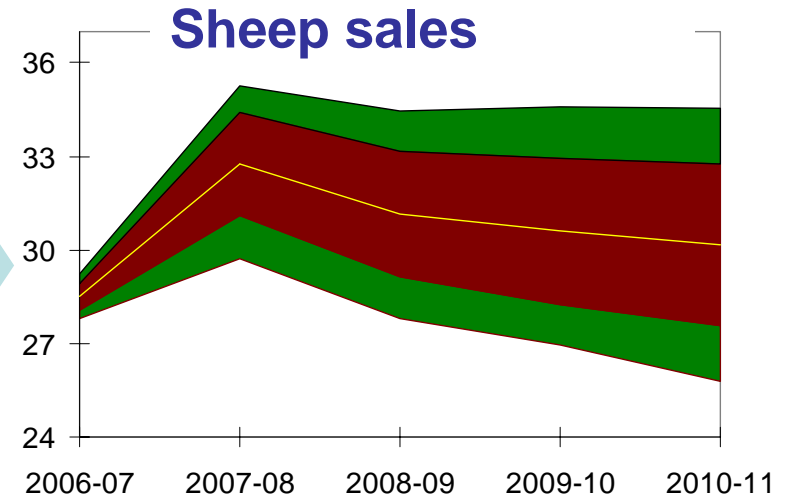
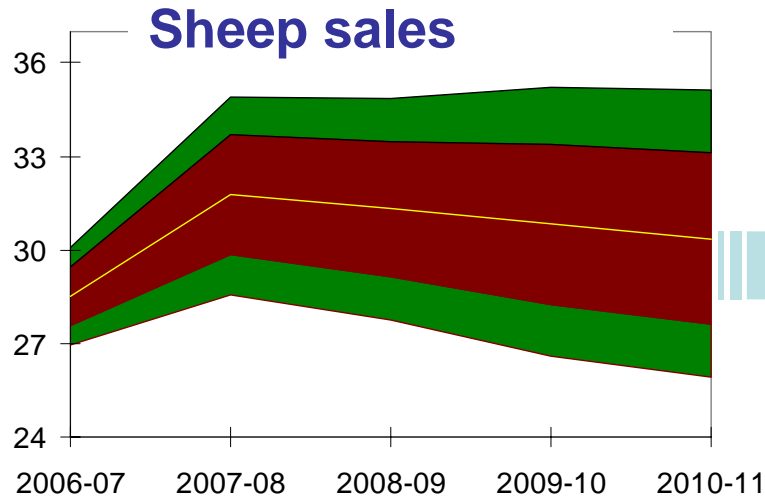
# Jul-2007 to Sep-2007 forecasts

Palisade  
Sydney



# Jul-2007 to Sep-2007 forecasts

Palisade  
Sydney



# 5<sup>th</sup> forecast (March 2008)

Palisade  
Sydney  
2007



## Good finishing conditions for 2007

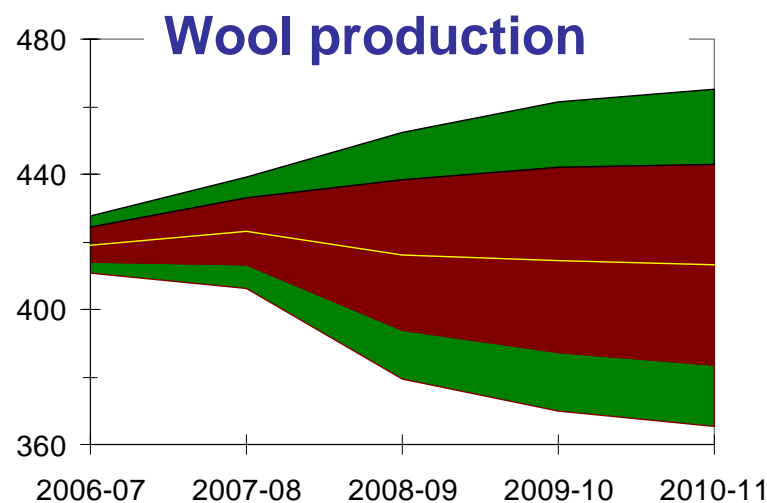
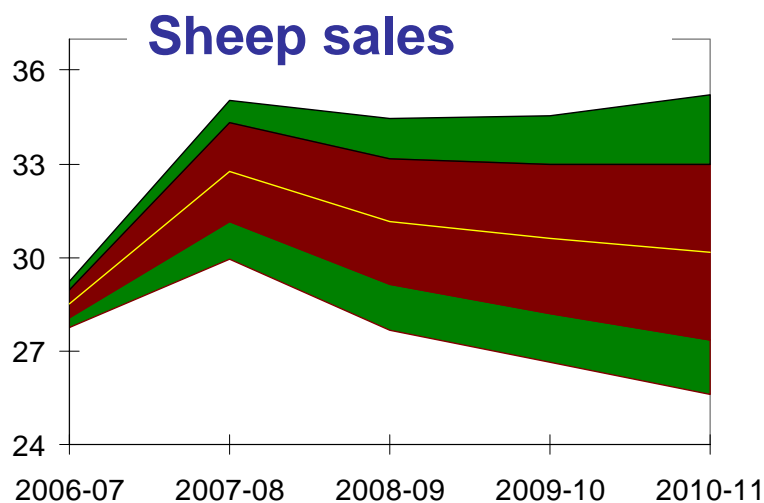
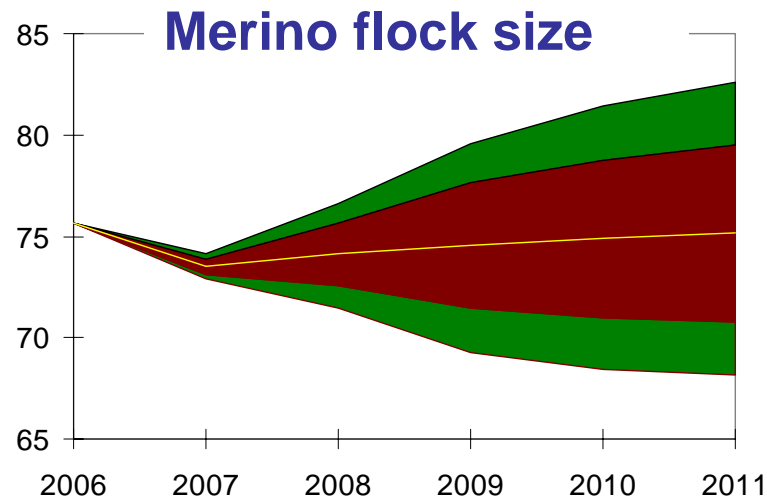
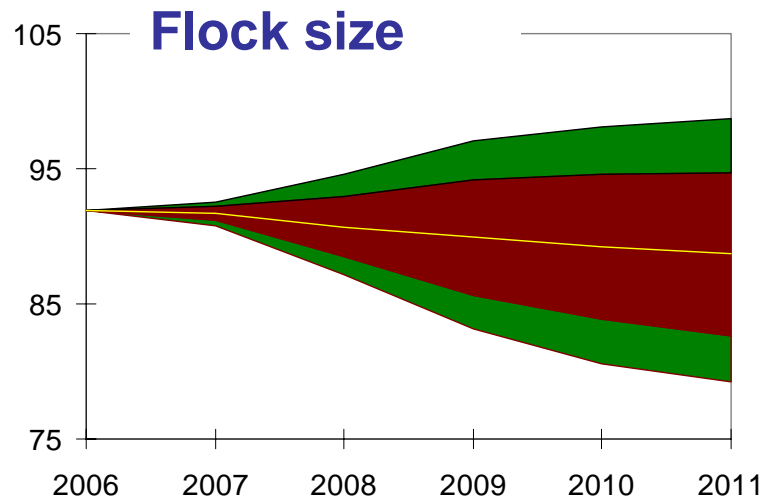
- Better wool cut
- Better lambing rates in 2008

### Risk parameters for Year 2007

	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	102%	1.0%	90%	110%
<b>Sales {Triang}</b>	95%		90%	100%
<b>Deaths {Triang}</b>	100%		85%	115%
<b>Mo x Mo {Triang}</b>	65%		63%	67%
<b>1X x Mo {Triang}</b>	8%		7%	9%
<b>2X x Mo {Triang}</b>	8%		7%	9%
<b>Mo lambing {Norm}</b>	82%	0.5%		
<b>1X lambing {Norm}</b>	93%	0.5%		
<b>2X lambing {Norm}</b>	105%	0.5%		

# 5<sup>th</sup> forecast (March 2008)

Palisade  
Sydney



# 6<sup>th</sup> forecast (July 2008)

Palisade  
Sydney  
2007



## Good finishing conditions for 2007

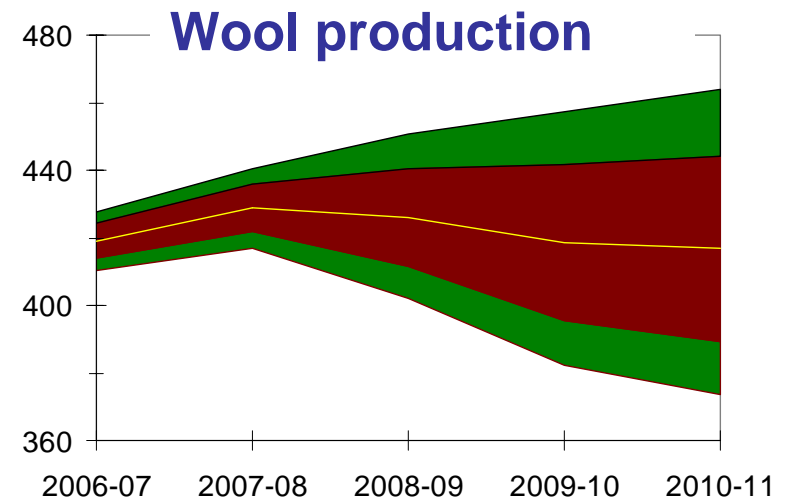
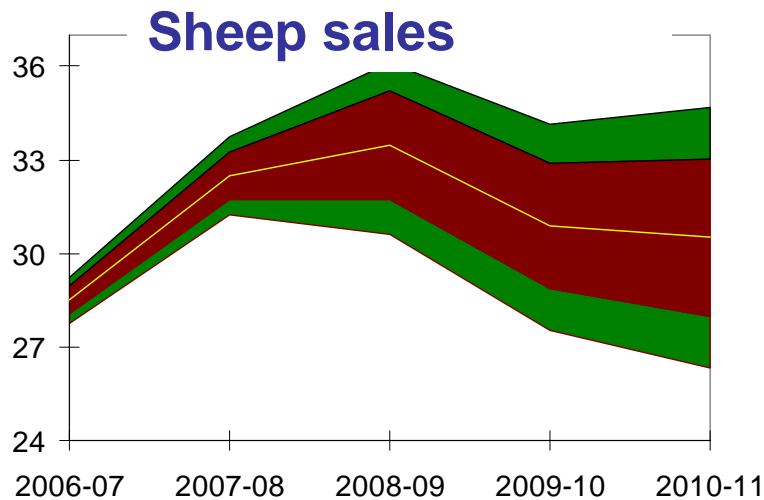
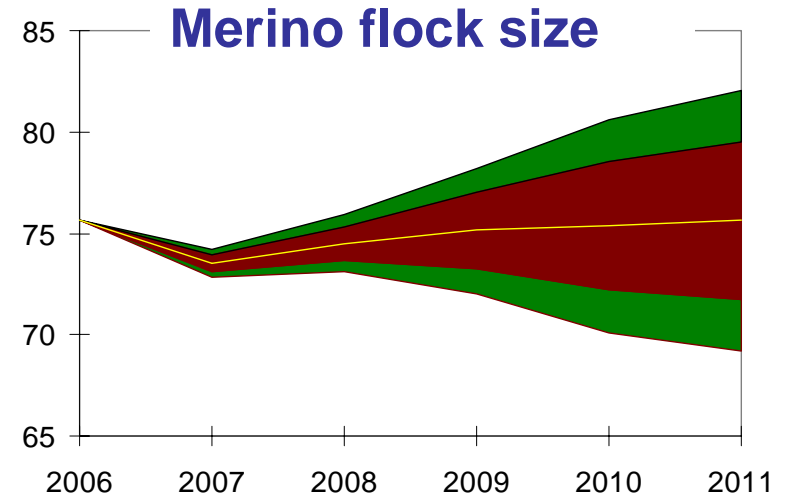
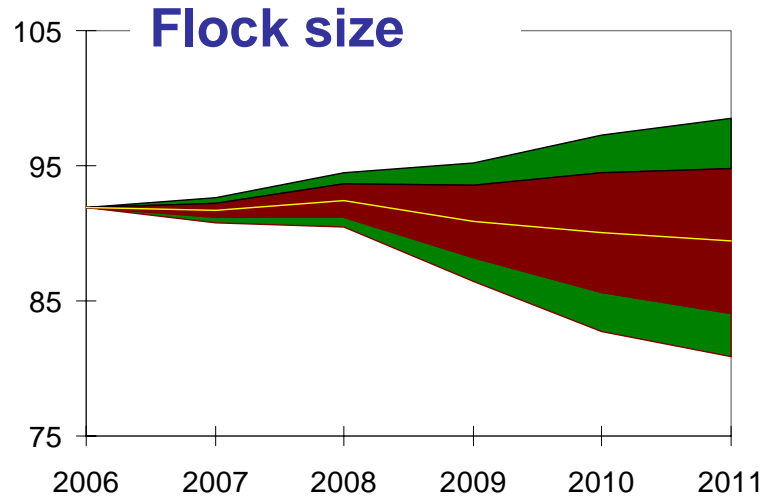
- Better wool cut
- Better lambing rates in 2008

### Risk parameters for Year 2008

	Average	Stdev	Min	Max
<b>Wool {NormTrunc}</b>	103%	3.0%	90%	110%
<b>Sales {Triang}</b>	98%		88%	108%
<b>Deaths {Triang}</b>	100%		75%	125%
<b>Mo x Mo {Triang}</b>	66%		61%	71%
<b>1X x Mo {Triang}</b>	8%		6%	10%
<b>2X x Mo {Triang}</b>	8%		6%	10%
<b>Mo lambing {Norm}</b>	85%	2.0%		
<b>1X lambing {Norm}</b>	95%	2.0%		
<b>2X lambing {Norm}</b>	105%	2.0%		

# 6<sup>th</sup> forecast (July 2008)

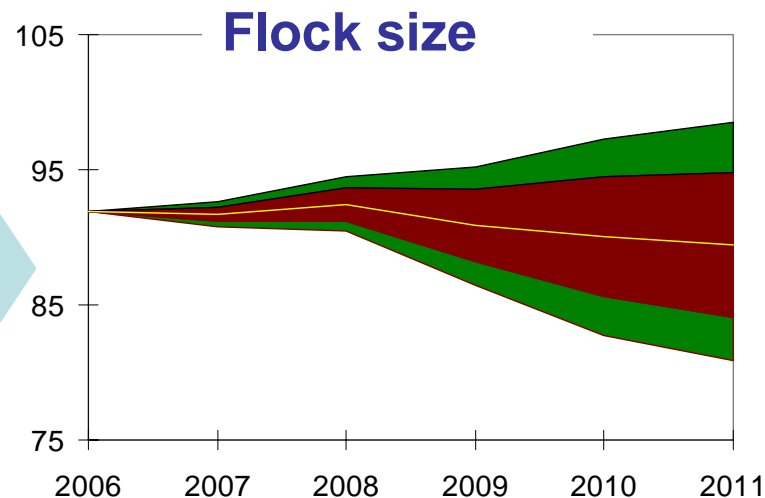
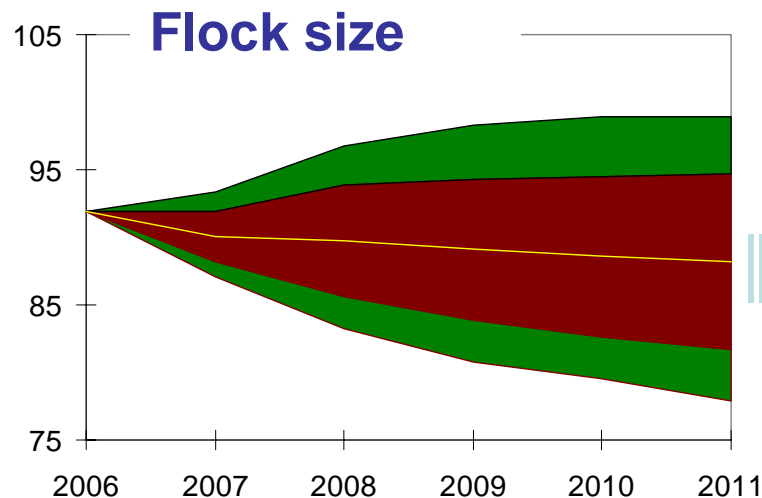
Palisade  
Sydney



# Comparing 1<sup>st</sup> & last forecasts

## Flock size

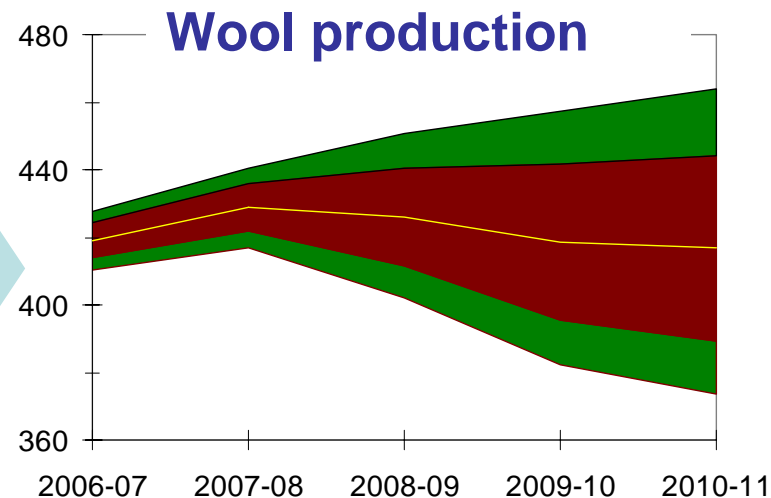
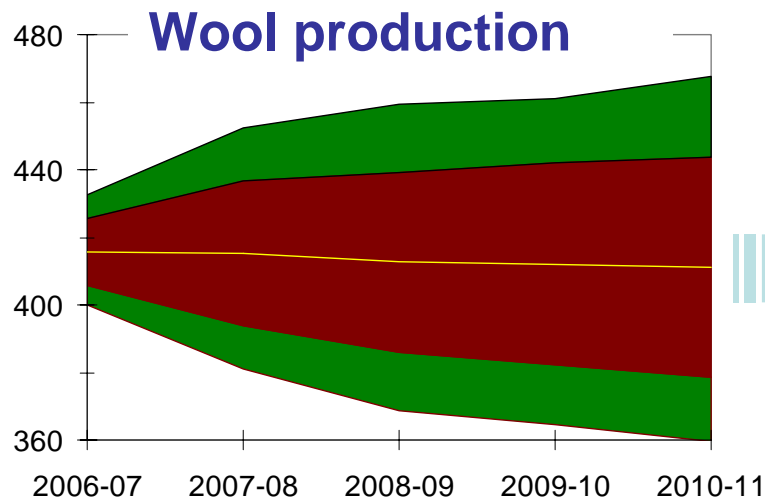
Palisade  
Sydney



	First forecast (made March 2007)	Last forecast (made July 2008)
30 June 2007	90.0 (87.1-93.2)	91.7 (90.9 - 92.5)
30 June 2008	89.8 (83.4 - 96.4)	92.4 (90.5 - 94.5)

# Comparing 1<sup>st</sup> & last forecasts Wool production

Palisade  
Sydney



	First forecast (made March 2007)	Last forecast (made July 2008)
2006-2007	416 (399 - 432)	419 (410 - 427)
2007-2008	415 (382 - 449)	429 (416 - 441)

# Example 2: Merino rams

Palisade  
Sydney  
2007



## Ram choice impacts on

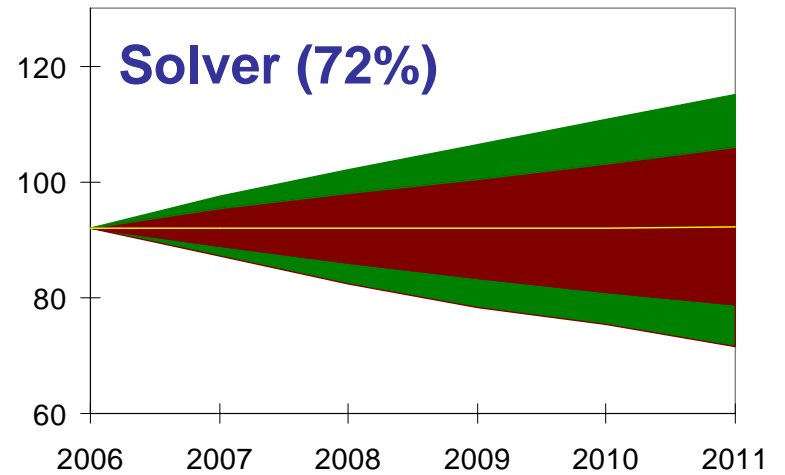
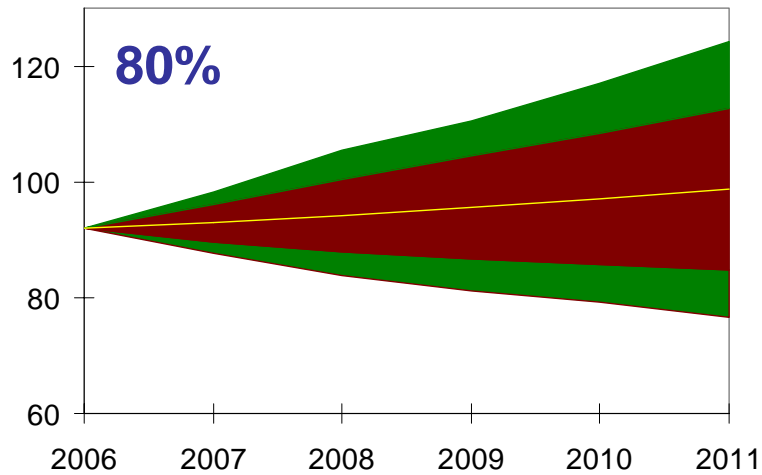
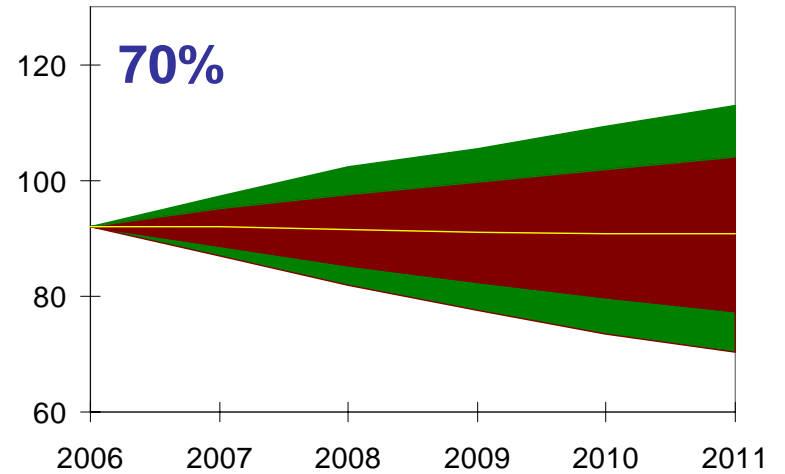
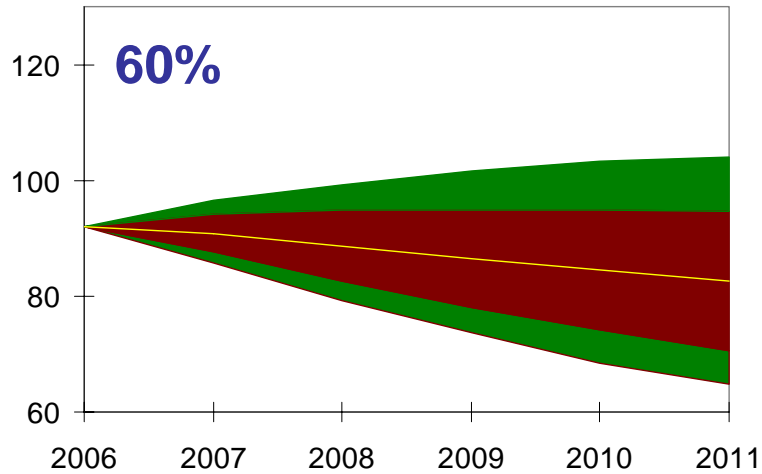
- Future flock composition
- Sheep turn off for meat
- Wool production

## Tipping point for flock

- At what level is the flock in balance!

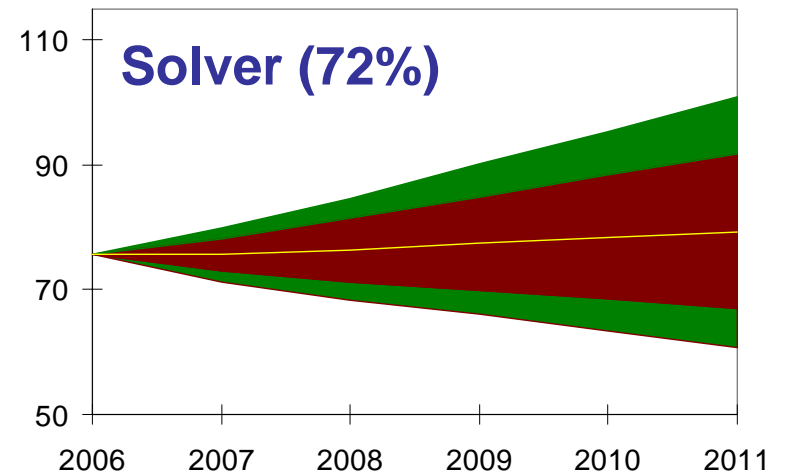
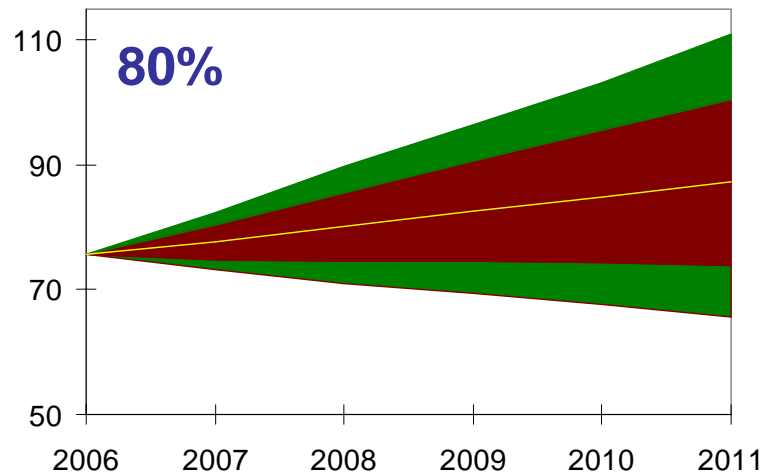
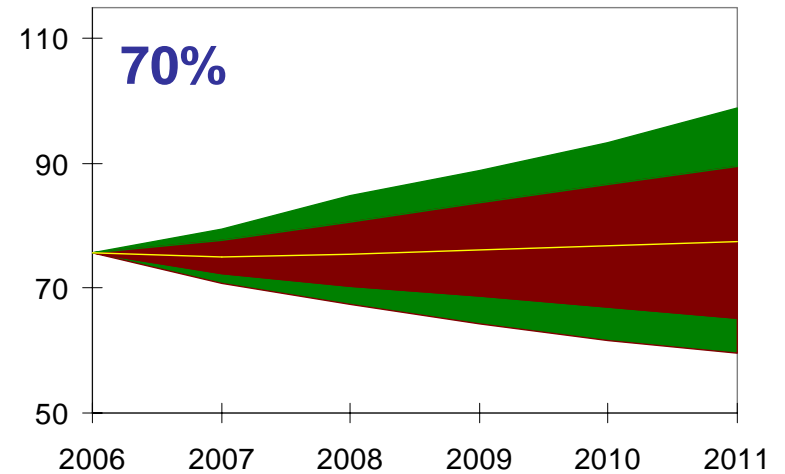
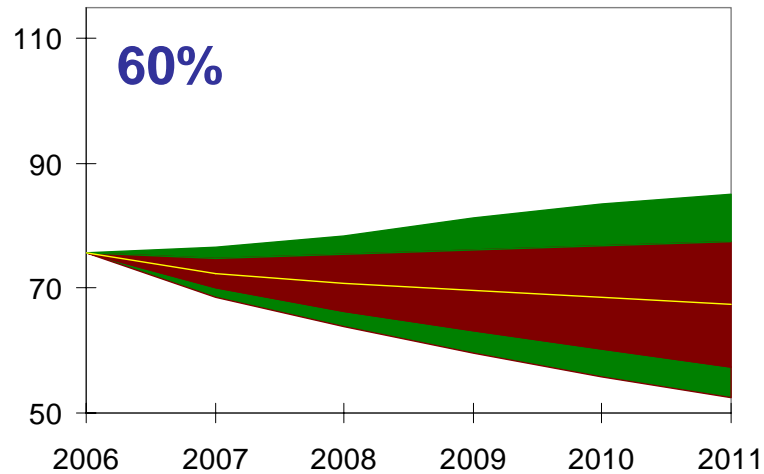
# Ram choice impact on flock

Palisade  
Sydney



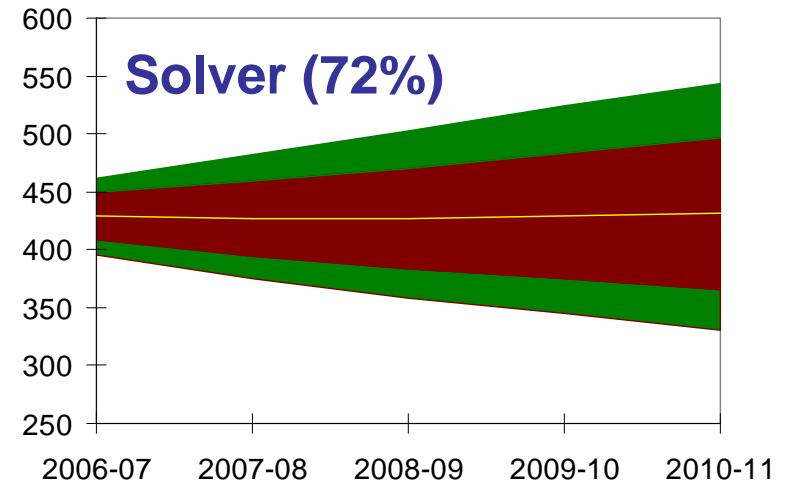
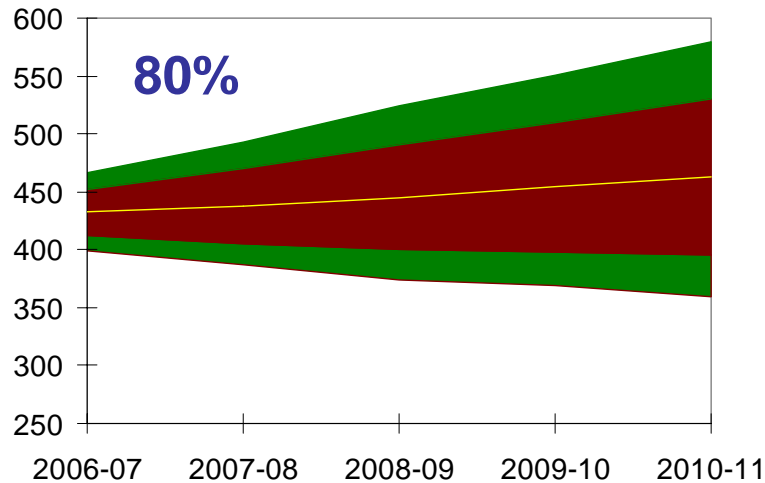
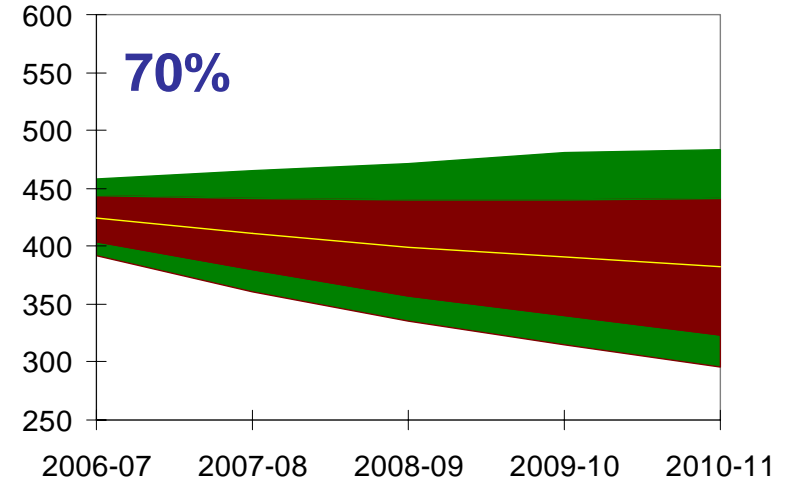
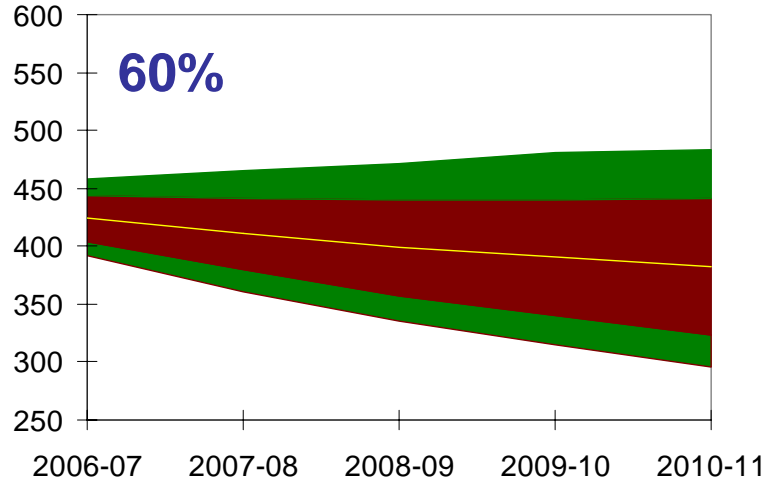
# Ram choice impact on Merinos

Palisade  
Sydney  
2007



# Ram choice on impact on wool

Palisade  
Sydney



# Benefits

Palisade  
Sydney  
2007



Assign confidence limits

Projections from uncertain inputs

Rapidly assess a wide range of inputs

Sensitivity analysis

Education

# Future work

Palisade  
Sydney  
2007



## Implement by State

## Distributions for

- Sales, Deaths, weaning rates
- Breeding decisions

## Incorporate into forecasting process

- Use in meetings
- Publication of ranges

# Acknowledgements

Palisade  
Sydney  
2007



## Scoping study

- Anthony Clark, David James

## Model development

- Anthony Clark, Greg Hood

## Review and implementation

- Paul Deane, Chris Wilcox

## Project management

- George Waldthausen

The model reported here is based on a model developed for and funded by Australian Wool Innovation.

• **australian wool**  
**innovation**  
• limited