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Economic assessment of the impact of Wild Endophyte-Infected Perennial Ryegrass (Lolium perenne) on the productivity of sheep and cattle and the profitability of Australian livestock enterprises

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Abstract

An estimate of the cost of Perennial Ryegrass Toxicosis (PRGT) to the Australian sheep and beef cattle industries was undertaken. This was done by modelling the cost at the flock and herd level with outbreaks of varying severities and frequencies. Estimates of production effects were based on published literature and the opinion of those who have observed PRGT outbreaks. Costs were then applied to the number of sheep and cattle at risk of PRGT based on 2001 ABS data. Approximately 26.5M sheep and 1.5M cattle are at risk of PRGT. The total estimated annual cost for sheep was $63.6M and for beef cattle $8.7M. The cost of a severe outbreak was estimated to be $12.15 per head for merino sheep flock which when allowing for the frequency of PRGT outbreaks, results in an annual average cost of $4.78 per head. The cost of a severe outbreak in a prime lamb flock is $20.86 per head which equates to an annual average cost of $4.90 per head.

The cost of an outbreak in beef herds which tend to be less severely than sheep flocks is estimated to be $4.98 per head which translates to an annual average cost of $1.00 per head for cattle. The economic estimates do not take into account welfare issues of either the affected livestock or those that manage the stock. Both of these are major issues that need to be considered when determining future research strategies for PRGT.

A number of non-pasture and pasture improvement strategies exist to minimise the impact of PRGT. Pasture improvements include use of low endophyte PRG, novel endophyte PRG and establishment of alternative perennial grasses. Of these options, alternative perennial pastures (which include beneficial endophyte varieties of PRG) are likely to provide the best option and will result in improved flock profitability on farms that have moderate and high PRGT risk. If novel endophyte PRG persists it may also provide a good alternative.

A number of extension and research areas are proposed to reduce the impact of PRGT on Australian sheep flocks and beef herds.

Executive Summary

- Approximately 26.5M sheep (25% of the national flock) are at risk of PRGT, the majority of which run in the temperate south eastern part of Australia, with a small proportion in south west WA. Of these 26.5 million, 12.4 million are considered to have a high risk of PRGT, 1.6 million have a moderate risk and 12.5 million have a low risk.

- Approximately 1.5M beef cattle (6% of the national herd) are at risk of PRGT.

- The national cost of PRGT was estimated using flock and herd models in which a range of production parameters such as fleece weight, sale weights, and death rates can be varied and the economic estimates determined. Production losses were determined by a combination of literature review and expert opinion.

- The annual average cost of PRGT to the Australian sheep industry is estimated to be $63.6M. A severe outbreak is estimated to cost $12.15 per head in a merino flock and $20.86 per head in a prime lamb flock. Of the total cost, $33.6M is due to a decrease in income associated with deaths (and hence fewer sale sheep), reduced flock fertility and reduced wool quality. The balance of the cost relates to an increase in expenditure associated predominantly with additional labour and supplementary feed.

- The annual average cost of PRGT to the Australian beef cattle industry is estimated to be $1.5M. The cost of an outbreak is estimated to be $4.98 per head, giving an annual average cost of $1.00 per head. The cost is substantially lower than for sheep because cattle appear to be less severely affected in PRGT outbreaks.

- A number of strategies for the prevention of PRGT were investigated. In high and moderate risk areas the replacement of wild endophyte infected PRG with alternative perennial grasses (which include beneficial endophyte infected PRG) offers an economically and technically viable option to manage PRGT. Novel endophyte PRG may also provide a viable alternative perennial pasture providing it persists in the pasture sward and is not invaded by wild-type PRG.

- The animal welfare issues associated with PRGT are a major concern for both the sheep and cattle industry. The welfare issues alone justify the development of better management strategies for PRGT outbreaks.

- Research priorities for PRGT include investigation of production losses, particularly clinical and sub clinical losses, persistence of novel endophyte PRG, PRG seed survival in the digestive tract of livestock and development of predictive models.

- Extension of the benefits of other perennial grasses for PRGT control is required to encourage adoption of alternative perennial grasses, including beneficial endophyte varieties of PRG.

Contents

1 Background

1.1 Background

Perennial Ryegrass (PRG) (Lolium perenne) occupies more than six million hectares of Australia where it provides important forage for grazing livestock. In the cool, temperate, winter-spring rainfall zone, PRG is commonly dominant in pasture, while in the warm, summer rainfall zone, PRG is important but less frequent. Compared with endophyte-free plants, endophyte (Neotyphodium lolii) infected PRG often exhibits greater seedling vigour, tillering frequency, yield, persistence and resistance to insect attack. In a recent random sample of 120 farms in south west Victoria all farms had endophyte infected PRG with a mean frequency of infection of 78%. Concentrations of the alkaloids ergovaline and lolitrem B in grass have a seasonal periodicity, peaking in summer-autumn and often exceeding critical levels for clinical effects in livestock on more than 30% of autumn pastures. Environmental challenges such as moisture stress have been observed to elevate alkaloid concentrations.

Perennial Ryegrass Toxicosis (PRGT) (a term that includes the well know staggers syndrome as well as all other manifestation of intoxication) in sheep is observed nearly every year in some regions. Consumption of endophyte alkaloids has also been associated with heat intolerance, poor fertility and lamb rearing, decreased feed intake, increased faecal contamination of wool and flystrike. In addition there have been several anecdotal reports of abnormal nervous behaviour in cattle grazing PRG in summer-autumn in south west Victoria associated with reduced milk production and meat quality. Adverse effects of endophyte alkaloids have also been reported in cattle offered PRG silage and in feedlot cattle consuming ryegrass roughage.

In most years the majority of clinically affected animals appear to recover. However, severe epidemics with high mortality do occur, with three such events experienced in the last 20 years, the most recent being February to April 2002. It has been reported that during epidemics of PRG toxicosis tens of thousands of sheep and lesser numbers of cattle die. There is no specific antidote or treatment of this endophyte alkaloid toxicosis.

The subclinical effects of exposure to endophyte alkaloids have been investigated in New Zealand where significant increases in liveweight gain of 35% in lambs and hoggets and reductions in dags and signs of heat tolerance were observed in sheep not exposed to endophyte alkaloids. In Australia it is possible that the impact of ergovaline on heat intolerance may be important and it has been suggested that endophyte alkaloidosis contributes to adverse effects on the health and welfare of sheep exported live from Victoria.

Optimal management to reduce the impact of PRGT has not been fully investigated in Australia but measures that have been recommended include:

- Use of PRG strains that are free of alkaloid producing endophytes
- Use of PRG strains that contain beneficial endophytes
- Use of toxin adsorbing or neutralising feed additives
- Changes in the timing of animal husbandry to reduce the consequences of staggers
- Paddock management to reduce exposure to toxic pastures
- Feeding of alternative safer feeds, for example in confined feedlots
- Selection of alkaloid resistant sheep

No formal and systematic investigations of the clinical or subclinical impact of intoxication appear to have been published in Australia although a small number of controlled experiments have been published.

In order to determine the relative importance of clinical and subclinical PRGT as a limit to the production of sheep and cattle an economic assessment is required.

2 Project Objectives

2.1 Project objectives

To assess the economic impact of clinical and subclinical PRGT on livestock enterprises in Australia including:

- The strength, quality and limitations of the information currently available and pertinent to PRGT in livestock Australia.
- Estimates of the number and distribution of animals at risk of PRGT.
- Review and assessment of the causes of economic loss resulting from PRGT.
- Description of the measures that can be implemented to minimise the adverse consequences of PRGT in livestock and an assessment of the impact of these measures on enterprise profitability.
- Overall economic assessment of the impact of PRGT and its control and management, including a description of the degree of uncertainty.
- Recommendations for and justification of priority research needs.

3 Methodology

3.1.1 Review of current information

A review of the literature was undertaken. Much of the literature had been reviewed for the Perennial Ryegrass Toxicosis In Australia seminar held in March 2005 (Reed et al 2005) so a detailed review would only duplicate much of the information presented at that seminar. However, key issues are highlighted.

3.1.2 Number & distribution of animals at risk of PRGT

The number of livestock at risk of PRGT was determined using 2000/2001 Australian Bureau of Statistics census data. More recent survey data were less reliable and not comprehensive so census data have been used for livestock estimates.

Several assumptions and estimates have been made to calculate the final number of livestock at risk. These assumptions and estimates are outlined below:

The above-600mm rainfall zone of temperate southern Australia was determined using Bureau of meteorology rainfall maps (see Appendix 3).

- 2000/2001 Australian Bureau of Statistics census statistical division maps were laid over the bureau maps to generate sheep and cattle numbers in the above-600mm rainfall zone by statistical division.

- Livestock numbers from statistical divisions where rainfall zones varied from above 600mm to below 600mm were calculated by estimating the percentage area of the zone above 600mm and then estimating the percentage of livestock within the statistical division. Specialists from each state were contacted to validate these estimates.
- Not all the livestock in the above 600mm rainfall zone will be grazing improved perennial grasses. A conservative estimate of 70% of the total number of livestock in the above 600mm rainfall zone will be grazing improved perennial grasses. The remainder will be grazing pastures consisting of annual species or natives. This assumption accounts for the fact that improved perennial grass pastures will have a higher stocking rate than non-improved pastures.

3.1.3 Alternative management strategies for PRGT prevention

3.1.3.1 Productivity improvement program

A general recommendation for farms aiming to improve productivity in the short term, without going to the expense of establishing new perennial pastures, is to manipulate existing pastures using increased fertiliser rates, herbicides and grazing management. Increased fertiliser rates on pastures consisting of wild-endophyte infected PRG could lead to increased PRGT risk as the proportion of PRG increases in response to the fertiliser.

Farm businesses that have embarked on a productivity improvement program through increased fertiliser use are potentially at the highest risk of PRGT, though they may also be in the best position to introduce risk reduction measures.

Several scenarios were considered for comparison of different management strategies to manage PRGT risk whilst improving productivity.

3.1.3.2 Low productivity scenario

This scenario assumes that a farm has a low level of pasture productivity and is about to undertake a program to lift productivity. Pasture productivity can be improved cheaply by improving soil fertility but this strategy will increase the risk of PRGT. Alternatively fertiliser can be applied to the majority of the farm area as above. A proportion of the farm area can be sown to alternative perennials to provide a means of reducing the risk of PRGT.

Low prod, fert only: 100% low productivity pasture where productivity is improved with superphosphate application. These pastures, in their unimproved state, are low productivity pastures assumed to have a naturalised PRG base and will sustain a winter stocking rate of 12 DSE per hectare. The application of superphosphate will allow for an increase in stocking rate, over time, to 18 DSE per winter grazed hectare.

Low prod, fert plus perennials: 100% low productivity pasture where productivity is improved by applying superphosphate to 75% of the pasture. The remaining 25% is sown over a period of five years to perennial pasture containing cocksfoot, tall fescue, phalaris or to novel endophyte infected PRG. These pastures, in their unimproved state, are low productivity pastures assumed to have a naturalised PRG base. They sustain a stocking rate of 12 DSE per hectare. The application of superphosphate will allow for an increase in stocking rate to 18 DSE per hectare. The 25% of pasture sown can also be stocked at 18 DSE per hectare.

PRGT risk is eliminated after year five because the whole flock will be moved to the 25% of pasture that does not contain PRG in the event of a PRGT outbreak. The aim of this strategy is to provide a risk free grazing area for short periods of up to one month.

Low prod, fert plus toxic PRG: 100% low productivity pasture where productivity is improved by applying superphosphate to 75% of the pasture. The remaining 25% is sown over a period of five years to a wild type infected perennial ryegrass pasture. These pastures in their unimproved state, are low productivity pastures assumed to have a naturalised PRG base. They sustain a stocking rate of 12 DSE per hectare. The application of superphosphate will allow for an increase in stocking rate to 18 DSE per hectare. The 25% of pasture sown can also be stocked at 18 DSE per hectare.

3.1.3.3 High productivity scenario

This scenario is based on a farm that has already undertaken a program of productivity improvement, primarily by improving soil fertility. In the process the frequency and severity of PRGT outbreaks are increased. One option to reduce the cost of PRGT is to replace a portion of the PRG with alternative perennials. Pasture replacement is a high cost activity due to the combination of lost grazing (prior to and after sowing) and the cost of sowing a new pasture.

High prod, fert only: 100% of pasture consisting of high productivity, PRG based pasture. These pastures have a constant stocking rate of 18 DSE per winter grazed hectare and are fertilised to maintain the stocking rate.

High prod, fert plus perennial: 100% of pasture consisting of high productivity, PRG based pasture. 25% of these pastures are sown to perennial pasture containing cocksfoot, tall fescue, phalaris or to novel endophyte infected PRG. Both of these pastures maintain a constant stocking rate of 18 DSE per hectare and are fertilised to maintain the stocking rate. PRGT risk is eliminated after year five because the whole flock will be moved to the 25% of pasture that does not contain PRG in the event of a PRGT outbreak.

The following assumptions have been made.

1. The gross margin per DSE for a dual purpose flock is $21. This figure is the eight year average of the Holmes Sackett and Associates benchmarking data (Sackett et al 2006a).

2. The gross margin per DSE for a self replacing merino flock is $17. This figure is the eight year average of the Holmes Sackett and associates benchmarking data (Sackett et al 2006a).

3. The average annual cost per DSE of PRGT in a high, medium and low risk situation have been deducted from the average gross margin per DSE to provide three analyses.

4. The net present value is based on a 12 year pasture life with a discount rate of 6%.

Pasture maintenance cost assumptions:

1. Fertiliser rates are based on phosphorus application rates of one kilogram of phosphorus per DSE per hectare.
2. Herbicide and insecticide costs equate to $16 per hectare per year with application costs of $12 per hectare per year except in the year of establishment where costs are accounted for in the establishment cost assumptions below and in the year after establishment where no herbicide costs are incurred.

Pasture establishment assumptions:

1. Total establishment costs are $297 per hectare where PRG alternatives are sown (fertiliser $41, seed $120, sowing $50, herbicide and insecticide $36) and $237 per hectare where toxic PRG is sown (fertiliser $41, seed $60, sowing $50, herbicide and insecticide $36)

2. There are no lime costs associated with pasture sowing in the analysis.

3. Stocking rate decreases to four DSE per hectare in the year of pasture establishment.

4. In the year after pasture establishment stocking rate increases to 18 DSE per hectare.

3.2 Economic Modelling

The cost of PRGT was modelled using the following principles:

- Stochastic spreadsheet models were used to estimate the costs of PRGT. Separate models were used for sheep and beef.

- The impact of PRGT on flock and herd returns was analysed using flock and herd models that are designed to model a steady state enterprise and determine the gross margin for that enterprise. Once a steady state has been established, a 'hit' of PRGT was imposed on the flock or herd and the combined effect of the 'hit' on gross margin determined. Effects taken into account include clinical effects such as increased mortalities, subclinical effects such as any effect on liveweight gain or fleece value and indirect effects such as increased worm burdens as a consequence of suboptimal timing of treatments due to PRGT. Increased costs such as supplementary feed, crutching and drenching were also taken into account. In the year of the 'hit' the flock or herd management strategy was then adjusted to overcome the effects of the PRGT outbreak. The strategy was based on the most likely response that the owner or manager of the herd or flock would implement to restore the enterprise to the same productivity and profitability as was the case prior to the 'hit'. In most cases this involved retention of additional females in the herd or flock, for example by retaining a proportion of five year old ewes until they are 6 years of age. The number retained was based on that required to return the flock to full productivity in the year following the outbreak.

- All effects of diseases were modelled at the margin, that is all possible impacts of the disease were considered and the effects incorporated into the model. All parameters that were not affected by the disease were kept constant. Therefore, the results reflect the marginal cost of the disease to the Australian sheep and beef industries.

- Flock and herd demographic data were based on ABS data for 2001, the most recent available data. The data was available down to statistical divisions. Appendix 1 shows the statistical local areas (SLA) for each state of Australia from which the cattle and sheep numbers were taken.

- The modelling results were consolidated into statistical zones based on the ABS data and best available estimates of disease prevalence and production systems.

- Production effects of PRGT were based on published data and is referenced where used. In some case where data was not available estimates were based on the experience of the authors, often in consultation with experts in the region or the disease.

- All disease costs stop at the farm gate, That is, there was no allowance for off farm costs due to PRGT including extension activities or research.

- The cost of additional labour was $20 per hour. This was based on the average salary for a stationhand of $35,000 per annum (McEachern, 2006), plus a 20% loading to cover superannuation and workers compensation. It did not include other on costs such as accommodation and power because these are primarily fixed, that is they are unrelated to hours worked. This rate underestimates the value of the management input required to manage a disease outbreak but may overestimate the cost of low skilled labour. In cases where existing farm labour is sufficient to manage the disease and no additional cash cost is incurred, the value of the additional labour was still included in the analysis to provide a complete picture of the impact of the disease.

- The cost of PRGT is presented as a cost in the year of the outbreak and as an annual average figure. This was based on modelling outbreaks of varying severity and frequency then combining the results into annual averages.

- All results are expressed in nominal dollars and no discounting has been used.

- Further details are provided in each section on model inputs and assumptions for sheep and beef cattle.

3.2.1 Sheep

- Wool prices used were based on the ten year median price between 1st July 1995 and 30th June 2005. This period included a range of market conditions, from high to low levels, particularly for the finer portion of the clip. It was influenced by the latter period of the reserve price scheme which artificially increased supply, and hence would almost certainly have depressed prices for the medium and broad wool categories that dominated the stock pile. Therefore, the use of price data from this period may result in over or under estimate the economic effects where the disease being analysed influences the quality or quantity of medium or broad wool produced in the flock. Prices used are shown in Appendix 2.

- Sheep and cattle prices for sales and purchases were based on the same period. Data was based on MLA livestock reports and opinion of the authors where there was no data for store sheep. Prices used are shown in Appendix 2.

- Enterprise costs were based on the eight year average from Holmes Sackett & Associates farm benchmarking (Sackett et al 2006a). This is a slightly shorter period than that used for prices but is the longest data series available in detail. These costs are the actual cost incurred in sheep and beef enterprises in a sample of over 100 farms per annum.

- The following flock types were modelled:
  1. Self replacing merino flock (20 Micron clip average) run in the High Rainfall zone. Wethers were sold at 3.5 years of age.
  2. Prime lamb producing flock based on purchased Border Leicester X Merino cross ewes, selling lambs at weaning.
  3. The beef herd was assumed to be a self replacing herd, calving in spring with steer progeny sold at 15-18 months of age to the feedlot market.

4 Results and Discussion

4.1 Strength, Quality and limitations of the information currently available and pertinent to PRGT in livestock in Australia

The effect of PRGT on livestock in Australia can be considered under a number of categories.

1. Endophyte – Plant Interaction. There is a considerable quantity of literature that relates to this area of PRGT. This includes quality data on pathogenesis in the plant, method of infection, seasonality of endophyte production. Also the relationship between presence of endophyte and ryegrass persistence and productivity, tolerance to Argentinean Stem Weevil also appears to be adequately documented in a combination of the Australian and New Zealand literature. One area that does appear to be deficient in information is that of the success of establishing the low risk endophyte strains of PRG. There is limited information available form New Zealand that indicates that PRG pastures sown with the low risk endophyte may eventually become contaminated by resident PRG from the seedbank/dung. As this contains the wild type endophyte it subsequently presents an increased risk of PRGT. Without some knowledge of the risk and time for this to occur, the often recommended strategy of establishing new PRG pasture with the low risk or safe endophyte may not provide an economic or successful method of minimising or preventing PRGT (see below).

2. Endophyte and Toxicity. Many of the major issues related to the toxicity of the endophyte are reasonably well explained. This includes seasonality of toxicity, threshold levels for clinical signs, and the effect of grazing management on the likely intake of endophyte. One area that is not well defined is the level of endophyte and the effect of the range of toxins that could result in subclinical losses in sheep and cattle. There are many reports of ill thrift, reduced weight gain and reduced reproductive performance as a consequence of PRGT The vast body of the experimental evidence is from NZ; information from Australia is mainly anecdotal and case studies. However, data from other countries, particularly NZ, has shown quite variable results of trials conducted to detect subclinical disease (see below). The interaction with ambient temperature/external heat load (NZ/USA research) makes the conduct of studies in Australia important

3. Effect of endophyte on Animal Productivity and Welfare. There is a large amount of information which attempts to define the effects of PRGT on animal production. Much of the data is based on overseas work, particularly studies of PRG and sheep in NZ and fescues and beef cattle in North America. The work that has been done in Australia is based primarily on observation and

surveys. Only a limited amount of controlled experimental work that attempts to define the areas of production loss from PRGT have been done under Australian conditions. The main areas of possible and/or demonstrated economic loss associated with PRGT can be divided into clinical, subclinical and indirect losses. These are discussed further below in Section 4.3.

4.2 Number and distribution of animals at risk of PRGT

PRG is suited to the temperate zone of southern Australia where average annual rainfall exceeds 600mm. This area takes in the coastal areas and tablelands of NSW, most of southern Victoria, Tasmania and the Bass Strait islands, the lower south east of SA, the Adelaide Hills and the eastern part of Kangaroo Island, The Yorke Peninsula in South Australia and the coastal fringe areas of the south west of Western Australia.

Table 1: Total number of sheep by state and PRGT risk

State and Zone	PRGT Risk	Total Sheep Number in Zone	Total Number Sheep Potential to Graze PRG	Total Number Sheep Estimated to Currently Graze PRG
New South Wales	High	0	0	0
	Moderate	0	0	0
	Low	38,775,593	18,048,732	11,369,030
	Nil	2,111,748	0	0
Australian Capital Territory	High	0	0	0
	Moderate	0	0	0
	Low	110,114	104,608	72,037
	Nil	0	0	0
Victoria	High	12,395,783	12,139,225	8,237,072
	Moderate	5,142,194	2,440,599	1,616,922
	Low	0	0	0
	Nil	4,733,900	0	0
Queensland	High	0	0	0
	Moderate	0	0	0
	Low	0	0	0
	Nil	8,660,053	0	0
South Australia	High	5,261,485	2,893,817	1,905,800
	Moderate	0	0	0
	Low	0	0	0
	Nil	7,323,203	0	0
Western Australia	High	0	0	0
	Moderate	0	0	0
	Low	6,329,165	1,578,558	1,079,808
	Nil	16,800,234	0	0
Tasmania	High	3,284,248	3,284,248	2,238,502
	Moderate	0	0	0
	Low	0	0	0
	Nil	0	0	0

State and Zone	PRGT Risk	Total Sheep Number in Zone	Total Number Sheep Potential to Graze PRG	Total Number Sheep Estimated to Currently Graze PRG
Northern Territory	High	0	0	0
	Moderate	0	0	0
	Low	0	0	0
	Nil	0	0	0
TOTAL ALL ZONES		**110,927,720**	**40,489,787**	**26,519,171**

Table 2: Number of sheep at risk of PRGT in Australia

	PRGT Risk	Total Sheep Number in Zone	Total Number Sheep Potential to Graze PRG	%	Total Number Sheep Estimated to Currently Graze PRG	%
NATIONAL TOTAL	**High**	**20,941,516**	**18,317,291**	**87%**	**12,381,374**	**59%**
	Moderate	**5,142,194**	**2,440,599**	**47%**	**1,616,922**	**31%**
	Low	**53,874,925**	**19,731,897**	**37%**	**12,520,875**	**23%**
	Nil	**30,969,085**	**-**	**-**	**-**	**-**
TOTAL		**110,927,720**	**40,489,787**	**37%**	**26,519,171**	**24%**

Of the 111 million sheep in Australia based on 2001 data, 26.5 million (25% of the national flock) are at some risk of PRGT. Of these 26.5 million, 12.4 million are considered to have a high risk of PRGT, 1.6 million have a moderate risk and 12.5 million have a low risk. Approximately two thirds of the high risk sheep are in Victoria with the balance being shared between SA and Tasmania while the majority of the low risk sheep are in NSW. Of the sheep that have no risk of PRGT (83 million or 75% of the national flock), the majority are in Western Australia and NSW.

Numbers of merino and non merino sheep by each zone are shown in Appendix 5.

Table 3: Total number of cattle by state and PRGT risk

State and Zone	PRGT Risk	Total Cattle Number in Zone	Total Number Cattle Potential to Graze PRG	Total Number Cattle Estimated to Currently Graze PRG
New South Wales	High	0	0	0
	Moderate	0	0	0
	Low	5,703,012	2,672,965	1,665,703
	Nil	83,082	0	0
Australian Capital Territory	High	0	0	0
	Moderate	0	0	0
	Low	11,013	10,462	7,323
	Nil	0	0	0
Victoria	High	1,503,591	1,316,552	921,587
	Moderate	792,598	473,269	319,465
	Low	0	0	0

State and Zone	PRGT Risk	Total Cattle Number in Zone	Total Number Cattle Potential to Graze PRG	Total Number Cattle Estimated to Currently Graze PRG
	Nil	138,508	0	0
Queensland	High	0	0	0
	Moderate	0	0	0
	Low	0	0	0
	Nil	11,087,566	0	0
South Australia	High	657,248	339,576	237,703
	Moderate	0	0	0
	Low	0	0	0
	Nil	393,011	0	0
Western Australia	High	0	0	0
	Moderate	0	0	0
	Low	579,245	579,245	405,471
	Nil	1,422,119	0	0
Tasmania	High	426,460	426,460	298,522
	Moderate	0	0	0
	Low	0	0	0
	Nil	0	0	0
Northern Territory	High	0	0	0
	Moderate	0	0	0
	Low	0	0	0
	Nil	1,706,919	2,082,589	0
TOTAL ALL ZONES		**24,504,371**	**7,901,119**	**3,855,774**

Table 4: Number of cattle at risk of PRGT in Australia

		Total Cattle Number in Zone	Total Number Cattle Potential to Graze PRG	%	Total Number Cattle Estimated to Currently Graze PRG	%
NATIONAL TOTAL	**High**	**2,587,298**	**2,082,589**	**80%**	**1,457,812**	**56%**
	Moderate	**792,598**	**473,269**	**60%**	**319,465**	**40%**
	Low	**6,293,269**	**3,262,672**	**52%**	**2,078,498**	**33%**
	Nil	**14,831,205**	**0**	**-**	**0**	**-**
TOTAL		**24,504,371**	**5,818,530**	**24%**	**3,855,774**	**16%**

Of the national beef herd of 24 million head (2001 ABS data) only 1.5 million (6%) are at risk of PRGT. These cattle are run in what is classified as high risk areas. Victoria accounts for nearly one million of the cattle at high risk, with the balance distributed nearly equally between South Australia and Tasmania. The majority of the Australian beef herd (94%) is not at risk of PRGT given the current distribution of PRGT and location of outbreaks over the last twenty years. The cattle in moderate and low risk zones are not considered to be at risk of PRGT due to their lower susceptibility of PRGT compared with sheep.

4.3 Review and Assessment of the Causes of Economic Loss Resulting from PRGT

4.3.1 Clinical

- Increased deaths. Surveys of recent outbreaks in Victoria, SA, Tasmania and SW Western Australia have attempted to quantify losses associated with PRGT outbreaks in 2002 and 2005. These found that the death rate was higher in sheep (0.67%) than in cattle (0.2%) (Knee 2005) but the estimates of death rates were based on voluntary farmer responses so could not take into account any bias introduced by farmer responses being influenced by the extent to which PRGT affects the business. Therefore extrapolation to determine mortality rates across the sheep or beef industry is difficult to do with certainty. The lack of this data makes quantification of economic loss difficult and highly dependant on estimates. The Victorian Grasslands society is also undertaking a survey of the effects of the 2005 outbreak but it is likely to have similar limitations as previous surveys. Lean (2005) proposed that the risk of PRGT is increasing as soil fertility is improved and stocking rates are increased. This is not consistent with the findings of Foot et al (1988) which found that lower stocking rates tended to be associated with more severe effects of PRGT. If the risk of PRGT increases with increasing stocking rate, previous estimates of the incidence of outbreaks and the mortality rates associated with these outbreaks, may underestimate the severity and frequency of PRGT in the future. Deaths were due to a combination of hyperthermia and misadventure secondary to staggers. No data are available on the relative importance of these two causes of losses.

- Reduced reproduction. Cummins (2005) reviewed the currently available information on the effect of PRGT and fescue toxicosis on ewe and cow fertility and reported a number of observations where there may have been a large effect. Foot at al (1988) showed a significant decrease in ewe fertility associated with grazing of high endophyte pasture. The trial ran for two years with a new group of ewes each year. One year showed a 9% reduction in lambs born and a 26% increase in lamb mortality on the high endophyte pasture. The next year there was no effect of PRGT on ewe fertility although lamb mortality was increased on a cultivar infected with endophyte. No staggers were reported at the time of joining in the second year despite assays of endophyte showing high levels in January though this was prior to joining in April. Cummins raises the question whether the effect of PRGT was due to an effect of PRGT staggers during joining or whether exposure as weaner sheep had depressed prolactin with subsequent poor fertility. Also a 16% reduction in ewe fertility was associated with crossbred ewes grazing pastures with a higher level of endophyte. Assuming no effect of PRGT on lamb survival rate and an 85% lamb survival, this would result in a 14% reduction of lambs marked. Cummins (2005) concludes “there is very little good experimental evidence linking infertility in grazing sheep and cattle with ryegrass staggers”. However data from American cattle show clearly that the tall fescue endophyte is associated with infertility and demonstrate a range of possible mechanisms that could be involved. Ergovaline has been the toxin that is presumed to be the major cause of this infertility in USA. Australian PRG pastures often contain similar concentrations of ergovaline to those of endophyte infected fescue in USA. Endophyte infected tall fescue has caused infertility in small experiments with young ewes in USA and New Zealand. For PRG however, the role of lolitrem B, which is present in addition to the ergot alkaloids, in reproductive failure is not clear.

In summary the five possible areas of the effect of wild endophyte alkaloids on reproductive rate are:
- Impaired uterine development due to exposure of pubescent females to alkaloids
- Reduced conception rate due the direct effect of PRGT during joining

- Reduced conception rate due to the lower liveweight of ewes affected with PRGT just prior to or during joining
- Reduced lamb survival.
- Physical disruption to joining if outbreaks occur during joining. As autumn joining of ewes is the most profitable production system in many of the areas at risk of PRGT this may be a major cost. This is in contrast to cattle where joining during autumn is a less productive and profitable system than joining for a spring calving in southern temperate Australia.

The extent to which these factors affect herd and flock fertility during both clinical occurrences and during periods of high alkaloid exposure but without clinical signs has not been studied.

- Increased dag (faecal staining). There is good experimental evidence from New Zealand that sheep that develop PRGT have increased dag (Fletcher et al 1999). Dag scores of sheep gazing wild endophyte infected PRG pasture were significantly higher in all five trials with hoggets or lambs. The extent of the increase in dag score ranged from 0.4 to 2.0 and averaged 1.1 across the five experiments. These trial results are supported by anecdotal evidence in Australia. This increase in dags appears to be associated with higher faecal moisture (Fletcher 1999) though the exact mechanism is not clear. In addition PRGT has resulted in increased dag secondary to reduced efficacy of worm control programs due to outbreaks of PRGT. The increase dag may have a number of effects including:
  - Increased flystrike of the breech
  - Increased requirement for crutching
  - Decreased value of wool associated with additional crutching and or dag.

  If no satisfactory alternative to mulesing is available by 2010 and the industry ceases mulesing the cost of the above three factors is likely to increase substantially if no equally effective alternative is available. Therefore, current estimates of losses due to PRGT will be an underestimate.

- Fleece value. The only study on the effect of PRGT on fleece value was that done by Foot et al (1988) which showed that the greasy fleece weight of ewes grazing high endophyte PRG was not affected compared to ewes grazing low endophyte PRG. This is despite the effect of liveweight (see below) which would be expected to affect fleece weight and fibre diameter. No data are available on the effect on wool quality, the most important components of which are fibre diameter and staple strength. Anecdotal reports from 2002 PRGT outbreaks indicate staple strength was reduced by an estimated 5 N/ktex and fleece weight by 15% (Lean 2005). These effects could be due to either direct effects of PRGT on wool quality or secondary to disruption of grazing caused by staggers. Also the difficulty of adequately supplementary feeding sheep and introducing them rapidly to cereal rations whilst they have severe staggers may indirectly contribute to reduced wool quantity and quality.

4.3.2 Subclinical

- Reduced growth rates/liveweight. There are many anecdotal observations of reduced growth rate as a consequence of PRGT including 2002 when many affected sheep were reported to have performed poorly for the rest of the year despite good nutrition. However there are very few studies that have investigated this area of production loss. Foot et al (1988) demonstrated a two kilogram reduction in liveweight of weaner merino ewes that had a high prevalence of staggers in autumn. However the affected sheep regained the liveweight after the autumn break and within several weeks of the break there was no difference in liveweight. The following year sheep grazing high endophyte PRG were two kilograms lighter on the cultivar Ellet. There was no difference between sheep grazing the high and the low endophyte Victorian PRG cultivar despite the presence of high levels of endophyte over summer and low levels over autumn (Foot et al 1988). Based on the available work there is no good evidence to quantify either the extent or the risk of liveweight losses, though it is apparent that losses occur under some conditions.

There are a number of reasons that the above information has limited application directly to the Australian sheep and beef industries, specifically:

- Many of the effects are based on information from overseas where for example the summer autumn period is often not as dry or hot as in many PRGT prone areas of Australia. Therefore the effects seen under New Zealand and North America in conditions may be quite different to those seen in Australia. In North America PRG is reasonably uncommon compared to fescue. In New Zealand the longer grazing season and greater contribution of white clover compared to sub clover in Australia means less PRG dominant pastures over summer and autumn.

- Much of the Australian work is based on anecdotes or surveys of affected producers so it is extremely difficult to quantify the production losses due to the bias associated with survey respondent's observations, where those that show the most interest are more likely to be the ones most affected. Conversely those that do not see PRGT as a problem are less likely to participate. Also some owners of severely affected herds and flocks may choose not to report the extent of their losses.

- The reports of the effects on some production factors such as fertility, liveweight and fleece value (fibre diameter, staple strength and fleece weight) are often contradictory or not significant. However the extent of the production effects are substantial in some cases and would have a major effect on flock/herd productivity and profitability but there is no robust information to quantify the effects at the flock, herd or national level. Hence, the economic estimates presented below are based on 'best estimates' rather than solid evidence.

4.3.3 Indirect effects

These are effects on the farm business that do not relate directly to PRGT but are due to PRGT disrupting normal flock and herd management programs that subsequently result in adverse production effects. Lean (2005) estimated that approximately one third of losses in sheep flocks were attributable to indirect losses. These include:

- Interference with routine husbandry procedures such as joining, supplementary feeding, shearing, crutching and lambing. The effects of these disruptions will vary from nothing more than an inconvenience to major costs if for example shearing is delayed and flystrike develops.

- Interference with general farm management activities such as fertiliser spreading. The effects of this will vary between farms and between years but they are unlikely to have major economic impacts longer term because these strategies could be adapted if PRGT outbreaks occur regularly.

- Suboptimal timing of internal parasite control programs. Delays in the timing of the strategic summer drenches can result in increased worm larval contamination of pastures and higher worm burdens over the subsequent winter – spring period. The worm burdens may then result in reduced liveweight gain, fleece value, and increased mortalities.

- Interference with disease management programs such as footrot. Footrot control and eradication programs are often based on multiple inspections of feet during the summer/autumn period. PRGT outbreaks can make inspections difficult or impossible to achieve. Vasoconstrictor alkaloids are well known to induce disorders of the feet, most notably as ‘fescue foot’.

- The extent of these indirect effects will vary widely between farm businesses depending on their management program and their ability to adapt the program to PRGT outbreaks. Some management procedures can be easily adapted, for example fertiliser spreading, without serious ramifications for the productivity or profitability of the farm business. Others, such as timing of strategic drenches provide much less scope to be altered without affecting subsequent production.

4.3.4 Social Effects

Apart form the effect on the animals and their productivity, there is a considerable social cost associated with PRGT. Farmers describe the management of a severe outbreak as being extremely stressful as there are a limited number of actions that can be undertaken to prevent the problem and any intervention to attempt to ameliorate the situation often exacerbate it because it involves some interaction with the sheep or cattle. The combination of powerlessness and the stress of seeing animals suffering often results in severe anxiety for producers.

While this cannot be valued in pure economic terms, it should not be underestimated as a major impact of PRGT.

4.3.5 Welfare

One of the major effects of PRGT outbreaks is on the welfare of affected livestock. In a severe outbreak the welfare impacts are considerable and of such a magnitude that they represent a major risk to the grazing industries if better management strategies are not available or implemented.

The welfare implications are described by Caple (2005) and include:

- Direct effects associated with staggering, including inability to graze effectively and difficulty drinking. This includes misadventure such as entanglement in fences and falling into troughs and dams. This is a major occupational health and safety issue with PRGT outbreaks in cattle herds where the size of the animals makes management difficult and at times dangerous.

- Secondary effects on welfare are due to the difficulty of carrying out routine husbandry procedures such as strategic blowfly and worm control (the second summer drench is often scheduled for late summer or autumn, a time of high PRGT risk).

Even if the direct and indirect economic impact of PRGT was negligible, the welfare implications of PRGT are such that a better understanding of risk factors as well as viable and effective management strategies need to be developed. If strategies are not in place at the time of the next serious PRGT outbreak, the industry will risk being seen in a poor light if there is not a substantial effort to develop prevention and management strategies.

4.4 Measures that can be implemented to minimise the adverse consequences of Perennial Ryegrass Toxicosis in livestock and an assessment of the impact of these measures on enterprise profitability

The impact of Perennial Ryegrass Toxicosis (PRGT) can be minimised by removing 'wild endophyte' infected perennial ryegrass (PRG), sowing endophyte-free or novel-endophyte PRG based pasture or changing livestock management. None of these measures is without risk or financial consequence. Potential management strategies and an assessment of the impact of these strategies on enterprise profitability are outlined below.

4.4.1 Grow alternative perennial grass species

Rainfall requirements of perennial grasses such as phalaris, cocksfoot and fescue are similar to those of PRG. These species can be as productive and persistent as PRG but they are far slower to establish and soil constraints, such as high aluminium levels, can limit their productivity and persistence. Phalaris, cocksfoot and fescue have a deeper root system than PRG [Nie et al 2004] and are more tolerant of soil moisture deficit. Phalaris, cocksfoot and fescue can be more difficult to establish than PRG. Phalaris does have the potential to induce phalaris staggers and sudden death in livestock but the risk is substantially less than PRGT.

Nie et al. (2004), in a trial conducted in south-west Victoria, demonstrated that the slower establishment of a mix of phalaris, cocksfoot and fescue resulted in an annual dry matter accumulation of 3.2 tonnes dry matter per hectare (t DM/ha) compared to an annual dry matter accumulation of 6.0 t DM/ha for a mix of PRG sown at the same time.

The same trial demonstrated the improved productivity of phalaris, cocksfoot and fescue over PRG in dry seasons. The phalaris, cocksfoot and fescue mix accumulated 2t DM/ha more than the PRG during the dry season of 2000.

The trial also demonstrated that much of the production from the phalaris, cocksfoot and fescue mix occurred outside of the spring period depending on the season. For example, in 1999 approximately 60% of the herbage accumulation in the phalaris, cocksfoot and fescue mix occurred outside the spring months compared with 40-45% in the ryegrass based treatments. This equated to 1.5t DM/ha per year additional pasture outside the spring period from the phalaris, cocksfoot and fescue mix. The PRG did however, produce 1t DM/ha per year more pasture than the phalaris, cocksfoot and fescue mix in spring.

Lean (pers comm 2005) has reported success with spring (September) sowing winter active phalaris cultivars such as Landmaster, Holdfast and Mediterranean type tall fescue cultivars such as Fraydo and Resolute in south western Victoria. Lean considered the traditional autumn sowing allowed too much weed competition in the establishment phase. Spring sowing mixed sward pastures is a controversial practice because it is considered that the sub-clover (annual) component of the sward does not have time to set adequate viable seed for the following year.

In high-risk PRGT areas the substitution of wild endophyte infected PRG with perennial pasture species such as phalaris, cocksfoot and fescue is a suitable strategy to minimise the consequences of PRGT. A crop phase for two successive years is desirable but not essential to allow for the use of selective herbicides to control wild type endophyte infected PRG and to reduce the seed bank.

Successful removal of existing ‘wild endophyte’ PRG and prevention of seedling recruitment is necessary to prevent reversion to ‘wild endophyte’ dominant pastures.

A cropping period of two years in arable paddocks will allow for reduction of the PRG seed bank through the use of non-selective herbicides in the fallow phase and selective herbicides in the cropping phase. In non-arable areas a strategic herbicide program, including application of glyphosate prior to seed set in spring and application of glyphosate prior to sowing of the new pasture, will be necessary to minimise incursion of PRG into the sward.

Strict livestock quarantine is necessary to minimise seed dispersal in dung, recruitment and reversion back to ‘wild endophyte’ dominant pasture. New Zealand experience suggests that 24-48 hours is an adequate interval to quarantine cattle to significantly reduce the number of viable seeds in their dung. Lean (pers comm 2005) suggests that the quarantine period in Australia will need to be far greater due to the different climatic conditions that lead to prolonged seed viability in Australian PRG. Research supporting this assumption was conducted by Blackshaw and Rode (1991) on weed seeds in America. They concluded that seed germination and viability were affected by the hardness of the seed coat, the length of time in the rumen and the basal diet. Studies into annual ryegrass, Lolium rigidum, digestibility and germination (Stanton et al 2002) demonstrated that, while a significant proportion of the total seed ingested by sheep and cattle was unviable, a small proportion of viable seed was excreted 14 days after ingestion. If these results hold true for PRG then the time taken for passage of seed through the digestive system of sheep and cattle would provide logistic difficulties for quarantine measures. Therefore establishment of alternative pastures is only likely to be effective if the alternative perennial pastures are sufficiently competitive to prevent reestablishment of PRG. As PRG can establish in alternative perennial pastures, the logistics of long quarantine periods (up to 14 days) will limit the efficiency of alternative pastures for PRGT prevention.

Where pastures are kept dense and productive, contamination from a low endophyte infected PRG base will be minimal.

4.4.2 Substitute wild endophyte infected perennial ryegrass with endophyte-free (E-) perennial ryegrass

Some cultivars or endophyte-free PRG have been shown to lack persistence when compared to endophyte-infected PRG in Australia. New cultivars which are yet to be released commercially are expected to have greater persistence.

Quigley (2000) undertook research at Hamilton, Victoria to clarify the importance of PRG endophyte in temperate pasture systems. The study found that the use of endophyte infected (E+) PRG seed is desirable in order to maintain long-term density of PRG in sheep-production systems. Both establishment density and persistence of PRG were substantially enhanced by the presence of endophyte, with no harmful effects on companion subterranean clover. Some studies have shown that endophyte can impair the growth and regeneration of clover.

Kemp’s trial data, presented by Wheatley (2005), demonstrated significant dry matter differences between endophyte-infected and nil endophyte PRG.

Table 5: Comparisons of dry matter production of E+ and E- perennial ryegrass in Bega (NSW) district
Dry Matter (t/ha)

	Yatsyn			**Vedette**			**LSD (0.05)**
	High endo	**Nil endo**	**Difference**	**High endo**	**Low endo**	**Difference**	
Autumn '96 2 harvests	5.59	2.16	-3.43	5.18	1.74	-3.44	1.29
Winter '96 2 harvests	5.21	2.53	-2.68	4.90	2.02	-2.88	1.05
Spring '96 4 harvests	11.57	8.74	-2.83	10.89	5.65	-5.24	2.07
Summer 96-97 2 harvests	5.80	3.22	-2.58	4.19	1.09	-3.1	0.88

Source: H. Kemp, Department of Primary Industries, Bega Site 1 - 1996 (Year 3 of trial) (mean of 3 reps) (Wheatley 2005)

Substitution of wild endophyte-infected PRG with endophyte free PRG into long term pastures for the prevention of PRGT is not recommended. The production losses from the lower establishment density, reduced biomass and lack of persistence when compared with endophyte-infected PRG will outweigh livestock losses from PRGT. It should be emphasised that this data has been generated in an environment that differs climatically to the high risk PRGT region.

4.4.3 Substitute wild endophyte infected perennial ryegrass with novel endophyte infected perennial ryegrass

Strains of endophyte that produce beneficial alkaloids but not livestock-toxic alkaloids have been successfully inoculated into PRG. The novel endophyte strain AR1 produces peramine, the Argentine stem weevil deterrent, but not ergovaline and lolitrem B both of which are responsible for toxic livestock effects. AR1 does not deter African black beetle to the same extent as the wild-endophyte infected PRG.

Early indications suggest that production and persistence of AR1 ryegrass is equivalent to wild-endophyte infected PRG in the early years after establishment (Table 6) but is less persistent in subsequent years (Wheatley 2005).

Table 6: Effect of novel endophyte on PRG yield (Year 2 of trial)

		Yield (7 harvests)	
	Wild Type	**AR1**	**Difference**
Bronsyn	90	89	-1%
Impact	100	91	-9%
Meridian	88	99	+10%

Impact WT ('wild type' endophyte) = 100
Source: H. Kemp, Department of Primary Industries, Bega (Wheatley 2005)

The results of a two year trial conducted by Bluett et al (2005) in Hamilton, New Zealand found no difference in DM production, tiller density and botanical composition between wild endophyte infected PRG, nil endophyte PRG and novel-endophyte infected PRG. The trials were grazed in a short rotation by dairy cows. If novel-endophyte PRG does not persist for close to or the same time as wild type PRG, the use of novel endophyte strains will not provide satisfactory alternatives for management of PRGT for many farms. It may provide an alternative where persistence is not critical for example in a short crop pasture rotation or where environmental conditions are very favourable for PRG persistence.

Substitution of wild endophyte-infected PRG with novel endophyte infected PRG into long term pastures is a suitable strategy for the prevention of PRGT provided long term persistence is not compromised. A crop phase for two successive years is necessary to allow for the use of selective herbicides to control wild type endophyte infected PRG and to reduce the seed bank.

The impact of the different pasture based options for management of PRGT depends on the PRGT risk and the enterprise. Tables 7-10 show the net present value for a self replacing merino enterprise and a dual purpose sheep enterprise with varying degrees of PRGT risk.

Table 7: Net present value for a self replacing merino enterprise, low productivity

	Low prod, fert only	**Low prod, fert + perennials**	
Risk	**100% Poor PRG to 100% Good PRG with Phos**	**100% Poor PRG to 25% Imp Alt, 75% Phos**	**Advantage of increasing alternative perennials**
	NPV/ha*	**NPV/ha***	
High	$962	$1,145	+$184
Moderate	$1,305	$1293	-$11
Low	$1,495	$1375	-$120
None	$1,503	$1379	-$124

*6% discount rate, 12 year pasture life

Table 8: Net present value for a self replacing merino enterprise, high productivity

	High prod, fert only	**High prod, fert + perennials**	
Risk	**Good pasture 100% Impr PRG NPV/ha**	**100% Imp PRG to 25% Imp Alt 75% PRG NPV/ha**	**Advantage of increasing alternative perennials**
High	$1,294	$1463	+$169
Moderate	$1,664	$1638	-$26
Low	$1,869	$1734	-$134
None	$1,878	$1739	-$139

Table 7 and Table 8 demonstrate that the net present value of Low prod, fert + perennial exceeds that of Low prod, fert only in a high PRGT risk wool enterprise run in a low productivity scenario. In a moderate PRGT risk situation there is little difference in the NPV between Low prod, fert only and Low prod, fert + perennial and in a low risk situation the NPV of Low prod, fert only exceeds that of Low prod, fert + perennial. This suggests that only in a high risk situation does the cost of lost livestock production exceed the cost of managing the change in pasture composition. However, as a strategy to improve productivity the use of alternative perennials and fertiliser provides an economically feasible strategy for management of both high and moderate PRGT risk. This analysis is very sensitive to the life of the pasture – if the alternative pasture persists for less than the 12 years, the benefits of investment in that new pasture will be rapidly eroded.

Table 9 and 10 show the results of similar analyses for a dual purpose enterprise. The results show that there is a benefit of using alternative perennials for both high and low productivity scenarios to manage PRGT in high risk situations. For flocks that have a moderate risk the NPV is slightly lower as a consequence of incorporating perennials into the system but the loss is not large and in many cases producers may consider that it is worth incurring to reduce the risk of PRGT.

Dual purpose flocks that have low or nil risk of PRGT will be worse off from investing in alternative perennials. Note that this does not take into account other potential benefits of those perennials such as soil and water use.

Table 9: Net present value of a dual purpose enterprise, low productivity

	Low prod, fert only	Low prod, fert + perennials	
Risk	**100% poor PRG to 100% good PRG w/ phos NPV/ha**	**100% poor PRG to 25% imp alt 75% phos NPV/ha**	**Advantage of increasing alternative perennials**
High	$1,522	$1686	+$164
Moderate	$1,865	$1834	-$31
Low	$2,055	$1916	-$139
Nil	$2,063	$1919	-$144

Table 10: Net present value of a dual purpose enterprise, high productivity

	High prod, fert only	High prod, fert + perennials	
Risk	**Good pasture 100% Impr PRG NPV/ha**	**100% Imp PRG to 25% Imp Alt 75% PRG NPV/ha**	**Advantage of increasing alternative perennials**
High	$1,898	$2047	+$149
Moderate	$2,267	$2221	-$46
Low	$2,473	$2318	-$154
None	$2,482	$2323	-$159

Table 11: Net present value for a self replacing merino enterprise, low productivity

Risk	100% poor PRG to 25% Toxic PRG Alt 75% Phos NPV/ha
High	$869
Moderate	$1,200
Low	$1,384
None	$1,392

Table 12: Net present value for a dual purpose enterprise, low productivity

Risk	100% poor PRG to 25% Toxic PRG Alt 75% Phos NPV/ha
High	$1,409
Moderate	$1,740
Low	$1,924
None	$1,932

Table 11 and Table 12 show that the net present value of Low prod, fert plus toxic PRG in high and moderate risk wool enterprises are $276 and $93 respectively, lower than sowing alternative perennials (Low prod, fert plus perennials Table 7). Table 11 and 12 show that the net present value of Low prod, fert plus toxic PRG in high and moderate risk dual purpose sheep enterprise are $277 and $94 respectively, lower than sowing alternative perennials (Low prod, fert plus perennials Table 9). There is little difference between low risk and no risk scenarios.

Given the low average annual cost of PRGT to beef herds, the NPV from investing in alternative pasture is likely to make it uneconomic to prevent PRGT.

4.4.4 Feedlotting/Confinement

It is possible to reduce the incidence of PRGT by moving stock from wild type endophyte infected PRG pastures into exclusion feedlots for the period of PRGT risk. Feedlots can be purpose built or existing paddocks can be modified to confine stock. Feeding livestock in a confinement area reduces intake of PRG and increases intake of alternative feeds thereby diluting their toxin consumption. Anecdotal reports suggest that toxicosis is still possible in confinement areas, particularly where green pick of PRG is available though the risk is substantially reduced. However, feedlotting can be a labour intensive and costly process.

Training sheep, particularly weaners, to grain feed prior to the onset of a risk period can increase the effectiveness of supplementary feeding during an epidemic. Reed et al (2003), in a review of the 2002 PRGT outbreak, reported that many producers had not trained sheep to eat grain in the previous spring due to the good seasonal conditions and this reduced the effectiveness of supplementary feeding during the PRGT outbreak. Without training, confinement and feeding of weaner sheep is unlikely to be successful. Also confinement feeding can be difficult once a PRGT outbreak has commenced because it requires regular disturbance of stock which can exacerbate the signs of PRGT unless the confinement area is safe and sheep have been introduced in time, well in advance of the outbreak. The other potential complication is the time required to introduce a maintenance ration of a cereal based diet to sheep that have not recently been fed cereals. The three to four weeks required to do this may not always be compatible with confining and maintenance feeding stock at the commencement of an outbreak, particularly in situations where they have not been provided with cereals immediately prior to the outbreak.

The cost of feed requirements of a 1000 ewe sheep flock and 120 cow beef cattle herd for a 28 day period were calculated to assess the economic impact of feedlotting on enterprise profitability. Sheep were fed a maintenance wheat ration at a price of $200 per tonne and cattle were fed a maintenance hay ration at a price of $100 per tonne. Wheat grain was assumed to contain 13 megajoules of metabolisable energy per kilogram of dry matter (MJ ME/kg DM) while hay was assumed to contain 8.3 MJ ME/kg DM. No account for increased labour was made.

Feedlotting a self replacing merino flock for a period of 28 days results in an increase in supplementary feed costs of $2.49 per DSE. The result of this increase in costs to an average wool producer is a decrease in gross margin from $17.00 per DSE to $14.51 per DSE and a decrease in net profit per DSE from $3.41 to $0.92 per DSE. This represents an 11% decrease in gross margin and a 55% decrease in profit per annum. Figures are based on the eight year average of the Holmes Sackett and Associates benchmarking data (Sackett et al 2006a).

The cost of $2.49 per DSE (approx $2.74 per head) to feed merino sheep in a feedlot for a 28 day period were exceeded by the estimated cost in a severe and moderate outbreak. This suggests that only in high risk situations is it economically viable to feedlot sheep annually. The cost of feedlotting at high risk periods will outweigh the losses from PRGT in low risk situations ($0.64 per head). The difficulty for livestock managers is to know the level of risk they are facing, and hence the most cost effective strategy prior to or at the commencement of a PRGT outbreak. In flocks that face high risk of PRGT and are more likely to suffer severe losses, the cost of lotfeeding for 28 days each year is less than the estimated annual average cost of an outbreak for both merino and prime lamb flocks. Therefore producers should be encouraged to prepare for lotfeeding as a routine procedure in high risk areas, if low risk pastures are not available. Preparation should include designated areas, access to water and training of weaner sheep and others not trained to grain.

Feedlotting cattle for a period of 28 days results in an increase in supplementary feed costs of approximately $17.70 per head. The result of this increase in costs to an average beef producer is a decrease in gross margin from $18.47 per DSE to $16.11 per DSE and a decrease in net profit per DSE from $5.85 to $3.49 per DSE. These represent a 13% decrease in gross margin and a 40% decrease in profit per annum. Figures are based on the eight year average of the Holmes Sackett and Associates benchmarking data (Sackett et al 2006a). Given that the average cost of an outbreak is $4.98 per head, the cost of confining and feeding a cattle herd is less than the cost of an average PRGT outbreak. Therefore confining and lotfeeding is only likely to be economical for a beef herd in an extremely severe outbreak or to better manage the welfare and OH&S risks associated with PRGT in cattle.

4.4.5 Other Strategies

Reed et al (2003) reported that sheep suffering from toxicosis could be kept upright, cool, close to other sheep and away from toxic pasture when dropped into trenches dug into the ground. Trenches were dug to a sufficient depth so that sheep could not stand and escape using a small specialist mechanical trench digger. Feed and water need to be provided if sheep are confined for more than one day which would make management difficult.

There are reports of heat stressed animals, induced by PRGT, drowning in dams and waterways. Livestock crowd into dams apparently seeking respite from hyperthermia. Fencing dams and waterways and providing alternative watering points as troughs will help to prevent death by misadventure. Death by drowning in troughs is possible but monitoring and prevention of drowning is easier with troughs. Both of these strategies only provide a means of managing affected animals during an outbreak and tend to be labour intensive.

4.5 Economic Analysis

An economic analysis was undertaken to provide an estimate of the cost of PRGT to the Australian sheep and beef industries. Lean (2005) calculated the economic cost of PRGT to the sheep industry in Victoria to be $73M or $6.39 per head for the 2002 outbreak. When the losses from the three serious outbreaks are amortised over 20 years this equated to $1 per head per annum, assuming no subclinical losses. However there have been no estimates for the national sheep industry, nor have there been any estimates for the beef industry, either at the national or regional level. The lack of estimates limits the ability for decisions to be made regarding the priority which should be placed on investment in PRGT research as well as the effort that producers should invest in planning for and managing PRGT outbreaks. However the economic analysis should only be one factor taken into account – the welfare of the animals and the effect of PRGT outbreaks on those who tend the animals should also be taken into consideration when decisions are made on these issues.

The production effects of a PRGT outbreak on a flock and herd were based on three scenarios according to the severity of the effects – a severe, a moderate, and a mild outbreak. The effects were determined using a combination of reports in the literature and estimates of veterinary consultants who have observed a number of PRGT outbreaks (Graham Lean, John Webb-Ware pers comm). Assumptions on production effects for merino and prime lamb flocks are shown in Table 13 and Table 14 and the assumptions for cattle herds are shown in Table 15.

Table 13: Effects of PRGT outbreaks on productivity of Merino flocks

	High risk	Moderate Risk	Low Risk
Increased Deaths			
- **weaners**	12%	3%	1%
- **adults**	7%	2%	0%
Staple strength N/Ktex	-5	0	0
Fertility	-12%	-6%	-2%
Extra drenches			
- **weaners**	+2	+1	-
- **adults**	+1	-	-
Additional supplement (kg/grain)	+10kg	+5kg	-
Clean Fleece Weight	-	-	-
Fibre Diameter	-	-	-
Extra crutching			
- **weaners**	0.5	-	-
- **adults**	0.25	-	-
Liveweight (Lwt)			
- **weaners**	-2kg (=16kg grain)	1kg (=8kg grain)	0
- **adults**	-2kg (=16kg grain)	8kg	0
Frequency	1 year in 5 severe 2 years in 5 moderate*	1 year in 3 -	1 year in 10 -
Decrease in wool production due to poorer worm control (weaners only)	0.9 clean kg 0.3µm	- -	- -
Additional labour (days)	14	7	7
Additional labour unit	$2240	$1120	$1120

* Assumes that sheep in high risk areas suffer a severe outbreak every five years and a moderate outbreak two years in five. Therefore PRGT losses occur three years in five.

Table 14: Effects of PRGT outbreaks on productivity of Prime Lamb flocks

	High Risk	Moderate Risk	Low Risk
Increased Deaths			
- **weaners**	4%	1%	0%
- **adults**	7%	2%	0%
Staple strength N/ktex	0	0	0
Fertility	-18%	-9%	-3%
Extra drenches			
- **weaners**	+1	-	-
- **adults**	+1	-	-
Additional supplement (kg grain)	+10kg	+5kg	-
Clean Fleece Weight	-	-	-
Fibre Diameter	-	-	-
Extra crutching			
- **weaners**	0.5	-	-
- **adults**	0.25	-	-
Liveweight (Lwt)			
- **weaners**	1kg (=8kg grain)	0 kg	0
- **adults**	2 kg (=16kg grain)	1kg (=8kg grain)	0
Frequency	1 year in 5 severe 2 years in 5 moderate	1 year in 3	1 year in 10
Additional labour (days)	14	7	7
Additional labour cost	$2240	$1120	$1120

Table 15: Effects of PRGT outbreaks on productivity of Beef herds

	High	Moderate	Mild
Deaths	+1%	Nil	Nil
Liveweight (Lwt)			
- **Adult**	Nil	Nil	Nil
- **Weaner/Yearling**	Nil		
Additional supplement Kg/hd 50% of maintenance ration, 28 days		-	-
- **weaner**	56kg		
- **cows**	84kg		
Frequency	1 year in 5	Nil	Nil
Additional labour (days)	7 days	-	-
Additional labour cost	$1120	-	-

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4.5.1 Economic Loss

The results of the modelling are shown in Table 16 to Table 19 for merino sheep.

Table 16: Cost of PRGT in year of outbreak in Merino sheep

	Reduced Income	Increased Expenses			Total
		Shearing	Supplement	Other	
High risk	$6.98	-$0.62	$4.63	$1.16	$12.15
Moderate	$2.06	-$0.22	$2.43	$0.43	$4.70
Low risk	$0.20	-$0.03	-$0.02	$0.49	$0.64
Total	$9.24	-$0.87	$7.04	$2.08	$17.49

Table 17: National cost of PRGT – Merino sheep

Category	Number of sheep affected	Average annual cost per head	Total Cost
High	10,883,440	$4.31	$46,928,669
Moderate	1,383,833	$1.57	$2,169,211
Low	11,502,442	$0.06	$735,668
Total	23,769,716	$2.10	$49,833,549

Table 18: Average annual per head effect of PRGT on income and expenses- Merino sheep

Category	Reduced Income	Increased Expenses			Total
		Shearing	Supplement	Other	
High	$2.23	-$0.21	$1.90	$0.41	$4.31
Moderate	$0.69	-$0.07	$0.81	$0.14	$1.57
Low	$0.02	-	-	$0.04	$0.06
Total	$2.94	-$0.28	$2.71	$0.59	$2.09

Table 19: Average annual national sources of economic loss due to PRGT – Merino sheep

	Reduced Income	Increased Expenses	Total
High	$24,175,947	$22,752,722	$46,928,669
Moderate	$951,769	$1,217,443	$2,169,211
Low	$232,956	$502,713	$735,668
Total	$25,360,672	$24,472,877	$49,833,549

Table 20: Cost of PRGT in year of outbreak in Non Merino sheep

	Reduced Income	Increased Expenses			Total
		Shearing	Supplement	Other	
High risk	$11.99	-$0.25	$3.24	$5.88	$20.86
Moderate	$6.36	-$0.07	$1.61	$2.17	$10.07
Low risk	$2.97	-	-	$0.91	$3.88
Total	$21.32	-$0.32	$4.85	$8.96	$34.81

Table 21: National cost of PRGT – Non Merino sheep

Category	Number of sheep affected	Average annual cost per head	Total Cost
High	1,497,933	$8.20	$12,282,859
Moderate	233,089	$3.36	$782,236
Low	1,018,433	$0.39	$395,827
Total	2,749,456	$4.90	$13,460,921

Table 22: Average annual effect per head of PRGT on income and expenses – Non merino sheep

Category	Reduced Income	Increased Expenses				Total
		Shearing	Supplement	Labour	Other	
High	$4.94	-$0.08	$1.29	$0.75	$1.28	$8.20
Moderate	$2.12	-$0.02	$0.54	$0.32	$0.39	$3.36
Low	$0.30	-	-	$0.10	$0.01	$0.39
Total	$7.36	-$0.10	$1.83	$1.17	$1.68	$4.90

Table 23: Average annual national sources of economic loss due to PRGT – Non Merino sheep

Category	Reduced Income	Increased Expenses	Total
High	$7,403,720	$4,879,139	$12,282,859
Moderate	$494,372	$287,863	$782,236
Low	$302,746	$93,081	$395,827
Total	$8,200,838	$5,260,083	$13,460,921

Table 24: National cost of PRGT to Australian sheep industry

Category	Reduced Income	Increased Expenses	Total
High	$31,579,667	$27,631,861	$59,211,528
Moderate	$1,446,141	$1,505,306	$2,951,447
Low	$535,702	$595,794	$1,131,495
Total	$33,561,510	$29,732,960	$63,294,470

Table 25: Cost of PRGT in year of outbreak in beef herds

Category	Reduced Income	Increased Expenses			Total
		Animal health	Labour	Supp Feed	
High Risk	$3.20	-	$0.64	$1.15	$4.98

Table 26: Average annual per head effect of PRGT on income and expenses – beef herds

Category	Reduced Income	Increased Expenses			Total
		Animal health	Labour	Supp Feed	
High Risk	$0.64	-	$0.13	$0.23	$1.00

Table 27: Average annual national sources of economic loss due to PRGT – beef herds

Category	Reduced Income	Increased Expenses	Total
High	$932,252	$520,194	$1,452,446

Table 28: National cost to sheep and beef cattle industries in year of outbreak

Category	Severe	Moderate	Mild
Self replacing merino	$12.15	$4.70	$0.64
Prime lamb	$20.86	$10.07	$3.88
Self replacing beef	$4.98	-	-

Table 29: Average annual cost of PRGT in sheep and beef industries

Category	Severe	Moderate	Mild
Self replacing merino	$4.31	$1.57	$0.06
Prime lamb	$8.20	$3.36	$0.39
Self replacing beef	$1.00	-	-

Table 30: Average annual cost of PRGT

Category	Severe	Moderate	Mild	Source
Self replacing merino	$46,928,669	$2,169,211	$735,668	Tables 15 & 17
Prime lamb	$12,282,859	$782,236	$395,827	Tables 19 & 21
Self replacing beef	$1,452,446	-	-	Table 25
National Total	$60,663,974	$2,951,447	$1,131,495	

4.6 Recommendations for and justification for priority research needs

This section includes extension and research priorities in order to minimise the economic and welfare impacts of PRGT. The extension activities provide an opportunity to assist producers to develop alternative strategies that can be implemented now or in the face of the next PRGT outbreak, whilst the research questions will aim to address critical knowledge gaps.

4.6.1 Extension

It is clear from the economic analysis in this report that the provision of alternative pastures in high and moderate risk PRGT areas provide a viable option for the management of PRGT. As the analysis was based on sowing 25% of the grazed area to alternative perennial pastures this strategy will not prevent outbreaks of PRGT but rather will provide a simpler and more practical means of managing PRGT just prior to or in the early stages of an outbreak. One of the major advantages of the use of alternative perennials is that, once the sheep or cattle are moved into those areas, no additional management or animal handling will be required, thus minimising the risk of exacerbating the signs of PRGT. If required to be confined for long periods, supplementary feeding in small sacrifice areas may be required because the stocking rate will be up to four times that of normal and would adversely affect the new pasture. Depending on age of pasture, dominance of PRG, cultivars used and old strains extant, some wild endophyte pastures will be less toxic than others. Tests of pasture are available to help producers recognise the degree of risk they represent.

There is a need for extension of this information to producers in high and moderate risk areas as soon as possible because establishment of a sufficient area of alternative pastures will take at least several years.

Encouraging the adoption of alternative pasture is a low risk strategy because most producers have the knowledge and experience of perennial pasture establishment and if they do not have the expertise it is widely and readily available.

4.6.2 Research

The following subjects of research are not presented in order of priority.

1. Knowledge of the length of time that PRG seeds remain viable in the digestive tract of sheep and cattle. This is important to know for producers who wish to establish novel endophyte pastures and not have pastures rapidly reinfested with wild type endophyte strains of PRG. The viability of the endophyte, not the seed, is what is important in the seed bank and dung.

2. Knowledge of how well novel endophyte PRG/alternative pastures will withstand the invasion of wild type strains, so that in combination with the above point, producers can develop strategies that ensure lower risk pastures remain as low risk.

   Develop a method of predicting the risk of PRGT in order to provide an early warning of the extent and timing of PRGT risks. The model may be quite simple, for example based on temperature and rainfall or it may need to be quite complex. Using tests on a sample of the flock might be an option for an individual farm. The model would need to have a reasonably high level of skill in order to accurately predict outbreaks and to avoid predicting outbreaks which do not eventuate. Plant studies are needed on the effects of soil moisture and temperature on toxin production, distribution and accumulation. It is not known whether it would be possible to develop sufficient skill but this should be considered prior to any substantial investment in model development. This would enable producers to commence implementation of preventative and management strategies before an outbreak becomes too severe with substantial production and welfare impacts. Further investigate the impact of PRGT on production losses. The existing data are often confusing and contradictory and the economic modelling for this report is based on some assumptions that are, at best, informed guesses. The dilemma with research into this area is the unpredictable timing of PRGT outbreaks, their severity and the variation between outbreaks. This may mean that studies need to be conducted over long periods to provide valid results. One option could investigate potential long term effects such as fertility and growth rate, of PRGT exposure, particularly on young animals. This could be done on animals that had PRGT and would be simpler than the larger scale long term trials that would be needed to substantially improve our knowledge of the range of production effects in the face of an outbreak.

3. Intensive survey work of a random sample of properties to more accurately quantify the impact of PRGT on the number of animals affected and mortality rates. Current data are based on estimates and samples that are likely to be biased. This could be a combination of close monitoring of affected farms when we have a major PRGT outbreak as well as random surveys across the affected areas. This is not a high priority given that even if current estimates for example double the number of stock at risk the problem is still substantial and warrants management of both the industry and the individual farm level.

4. The focus of the work should be on PRGT effects on sheep, both wool and meat because they account for the majority of the economic loss, though the welfare issues with cattle can be considerable. It is likely that many of the findings from sheep could be applied to cattle.

5. Assessment of the impact of PRGT on sheep being shipped from southern parts for the live export trade. Sheep with clinical or substantial signs, or possibly previous exposure to PRGT, may result in higher levels of ill thrift or death during shipping. Ergot alkaloids cause heat stress and lower immunity and may be stored in fatty tissues from which they can be released and

cause adverse effects when fat is mobilised. This would be particularly important in autumn and winter embarkations from Portland.

5 Success in Achieving Objectives

The main objective of assessing the impact of clinical and subclinical effects of PRGT on the sheep and beef industries in Australia has been completed. The estimates of the number of animals at risk and the degree of risk were based on a combination of rainfall and expert opinion and provide a reasonably accurate guide to the total animals at risk. This is the first time there has been an estimate for the national cost of PRGT to the sheep and beef industries.

The economic estimates of the cost of PRGT are developed and these provide a reasonable indication of the total cost of PRGT to the Australian sheep and beef industries. The major constraint in developing these estimates was accurate and comprehensive data on the production losses due to PRGT in both sheep and beef cattle. While the estimates of production losses may vary form those used, they are unlikely to substantially change the total cost to the industry which shows that PRGT has a moderate economic cost to industry.

Analysis of alternative management strategies to manage PRGT outbreaks show that the replacement of high and moderate risk PRGT pasture with lower risk alternative perennial pastures or with novel endophyte pastures are viable options to reduce the economic impact at the farm level. There is a need to extend this message to producers as it provides a short term and profitable method of PRGT prevention.

A number of research priorities were identified, most of which focused on applied research which will better enable producers to manage and prevent PRGT.

6 Impact on Meat and Livestock Industry – now & in five years time

The impact of this work on the meat and livestock industries will potentially be:

- The industry is in a better position to make rational investment decisions now that the cost to each of the sheep and beef sectors has been quantified
- The analysis of the cost effectiveness of management strategies that can be implemented to prevent PRGT show that there are economically attractive options available to producers without the requirement of further research work. If implemented now the impact of PRGT would be substantially reduced in the areas of high and moderate risk in five years time. Such options are less attractive for producers in the low PRGT risk areas but there is less of an imperative for them to implement such strategies. Extension of the results to the high and moderate risk areas will be required to encourage producers to implement the strategies.
- Implementation of these findings will provide an opportunity for the industry to avoid the serious welfare implications associated with PRGT.
- A number of areas of research are required to better predict and manage the PRGT risk. The results of these may be available in three to five years time so the industry will be in a better position to manage the risk of PRGT.

7 Conclusions and Recommendations

There are approximately 26.5 million sheep and 1.5 million beef cattle that are at risk of PRGT in Australia. These are predominantly in the south eastern corner of Australia where annual average rainfall exceeds 600mm. Of the total sheep numbers 12.4 million are considered to be at risk of severe outbreaks, 1.6 million at risk of moderate outbreaks and 12.5 million at risk of mild outbreaks. Cattle are less susceptible than sheep to PRGT and of the cattle at risk, they are predominantly in the same area of the sheep population that is considered to be at risk of severe outbreaks.

The cost of an outbreak of PRGT is shown below for a range of flocks/herds and for a range of PRGT severities.

Table 31: Cost of PRGT outbreak for a range of severities in the year of the outbreak

Category	Severe	Moderate	Mild
Self replacing merino	$12.15	$4.70	$0.64
Prime lamb	$20.86	$10.07	$3.88
Self replacing beef	$4.98	-	-

If these costs are adjusted for the frequency and severity of outbreaks the annual average cost of PRGT is shown in Table 32.

Table 32: Average annual cost of PRGT per head for the range of severities and enterprises

Category	Severe	Moderate	Mild
Self replacing merino	$4.31	$1.57	$0.06
Prime lamb	$8.20	$3.36	$0.39
Self replacing beef	$1.00	-	-

When the figures in Table 32 are combined with the number of stock at risk, the average annual cost of PRGT is shown in Table 33.

Table 33: Average annual national cost of PRGT

Category	Severe	Moderate	Mild	Total
Self replacing merino	$46,928,669	$2,169,211	$735,668	$49,833,549
Prime lamb	$12,282,859	$782,236	$395,827	$13,460,921
Self replacing beef	$1,452,446	-	-	$1,452,446
National Total	$60,663,974	$2,951,447	$1,131,495	$64,746,916

The total cost of PRGT to the Australian sheep industry is less than that for Internal Parasites and Flystrike ($369M and $280M per annum) but considerably greater then the cost of other diseases that attract considerable resources, both in terms of research, and in producer concern and attitude such as Footrot ($18.4M) and Ovine Johnes Disease ($4.4M) (Sackett et al 2006b). Welfare considerations aside, the relative cost of the disease justifies the allocation of additional resources to PRGT management and prevention.

Management options for PRGT include:

- Use of novel endophyte PRG strains. Based on currently available trial data these strains have similar pasture production to wild type strains. There is however lack of data on persistence of these strains in the most affected regions.

- Replacement of PRG with alternative perennial grass/legume/herb based pastures such as phalaris, cocksfoot or fescue. This is a cost effective option for flocks in high and moderate risk PRGT areas. It is not an economic option for beef herds or for flocks in the low risk areas because the cost of the disease is less than the cost of establishing alternative pastures.

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9 Appendices

9.1 Appendix 1: Statistical Local areas (SLA)

Figure 1: Australian Capital Territory Statistical divisions 2004

Figure 2: New South Wales Statistical divisions 2004

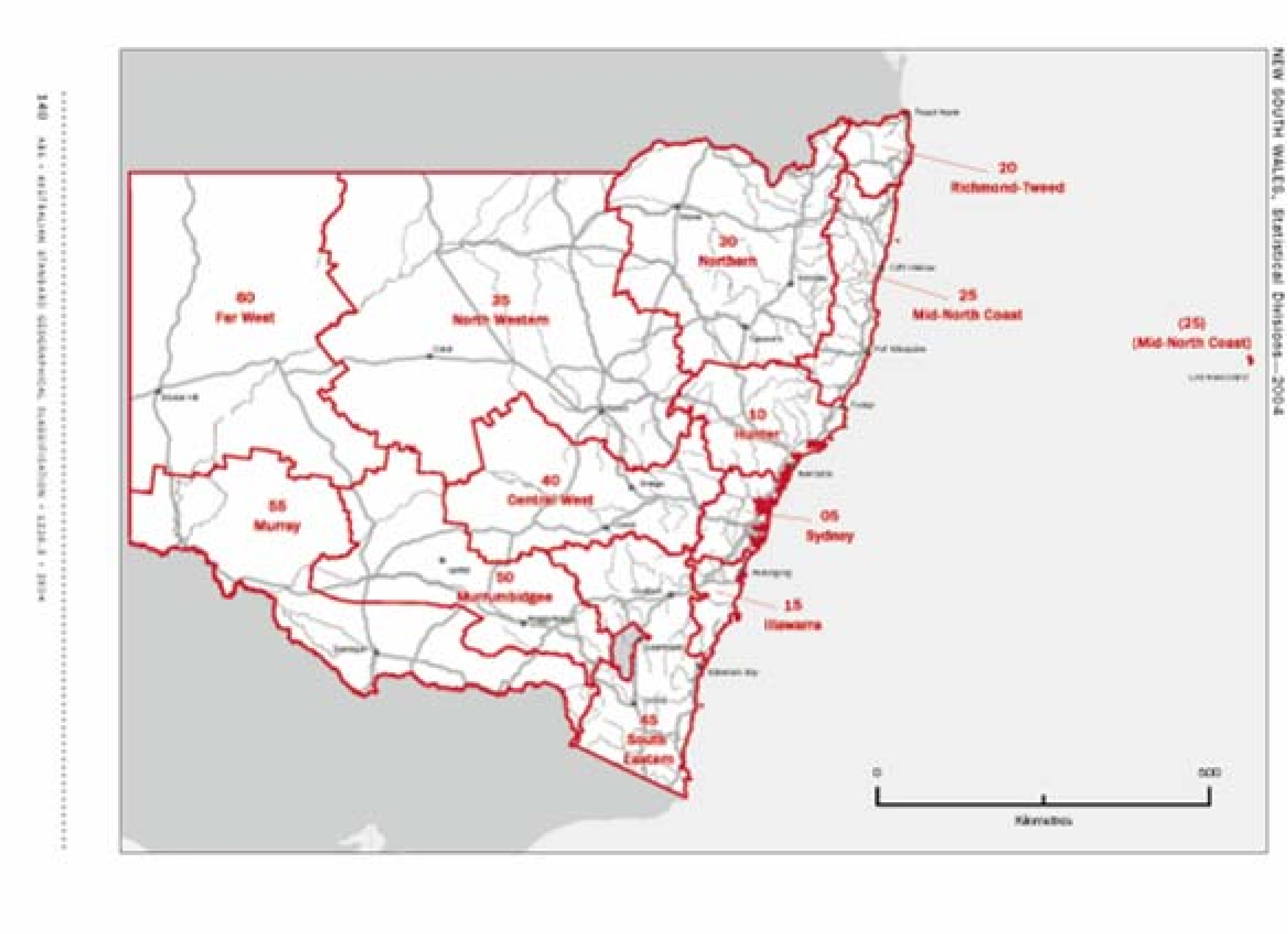


Figure 3: Northern Territory Statistical divisions 2004

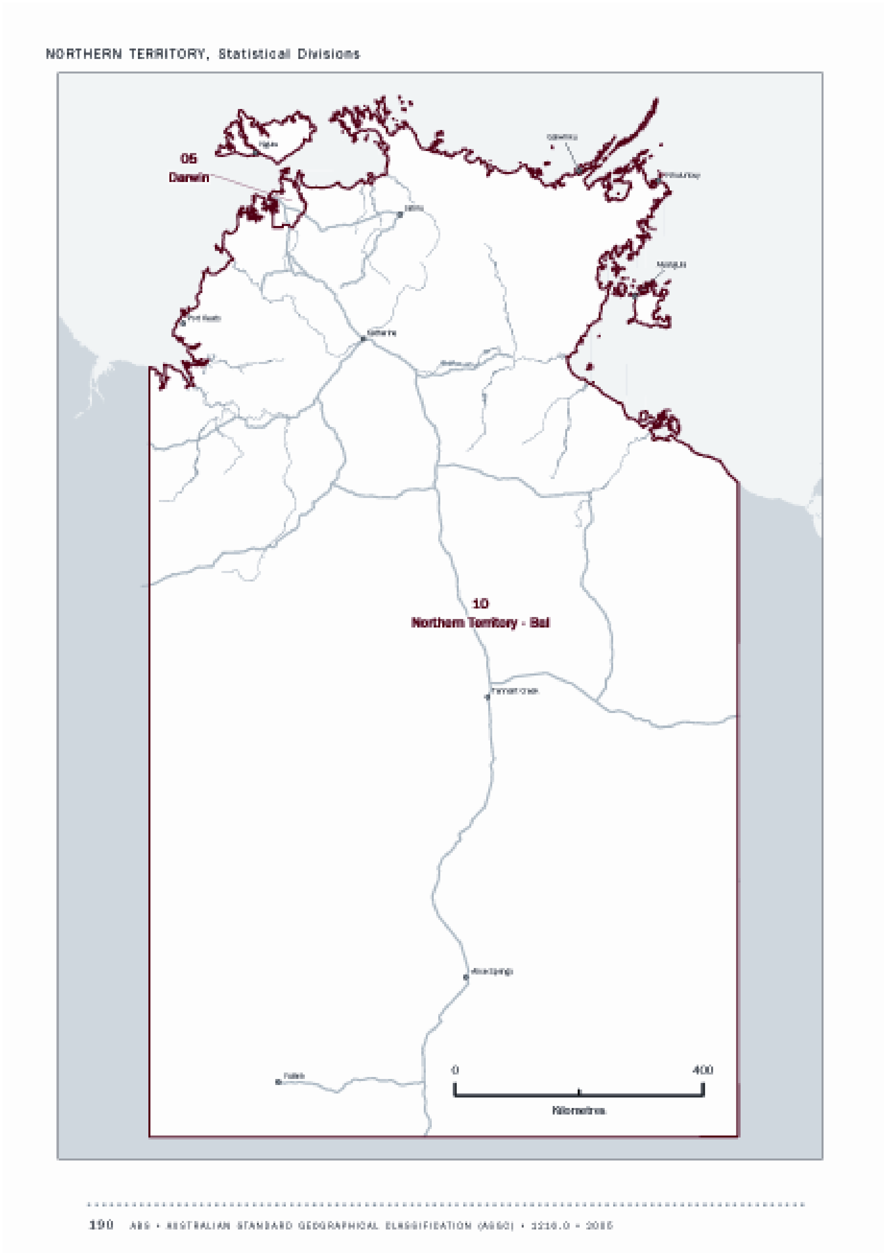


Figure 4: Queensland Statistical divisions 2004

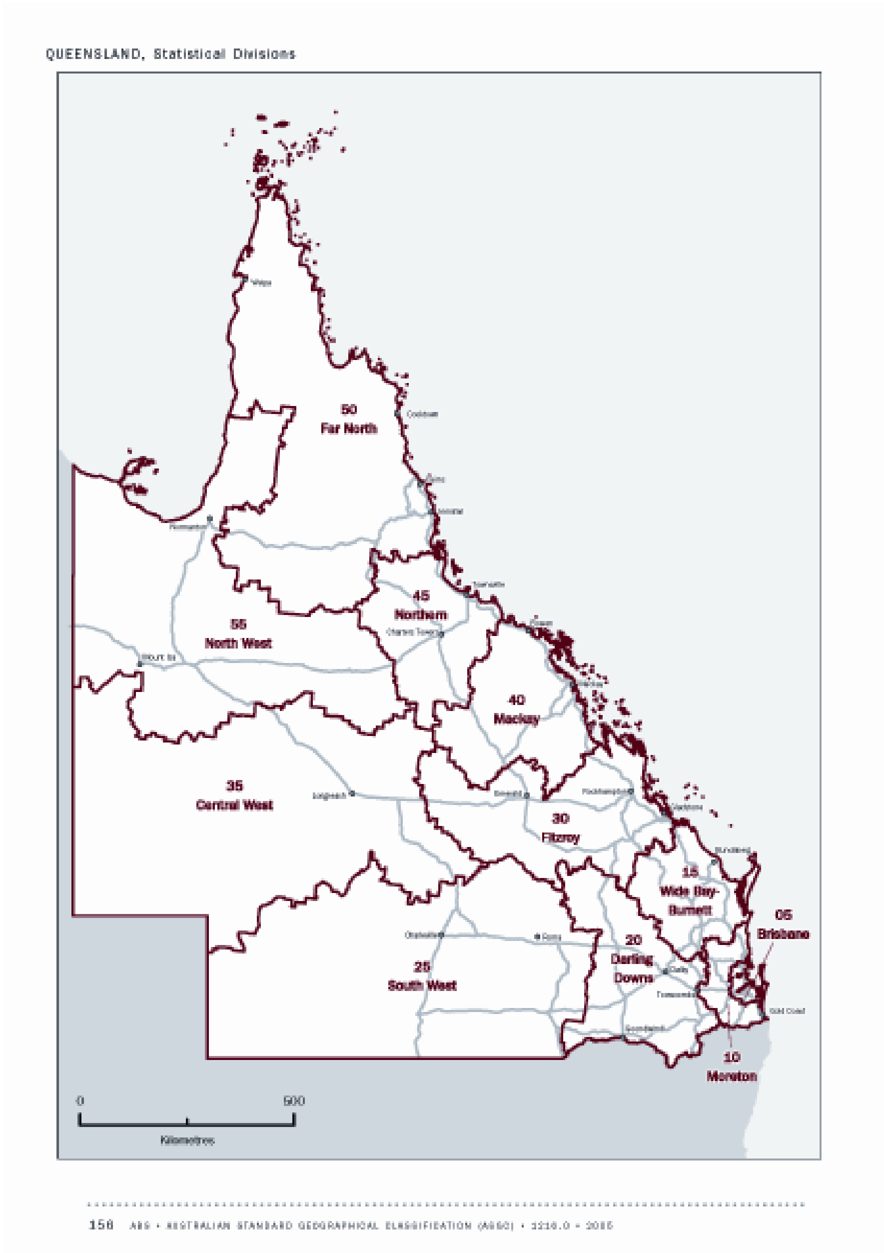


Figure 5: South Australia Statistical divisions 2004

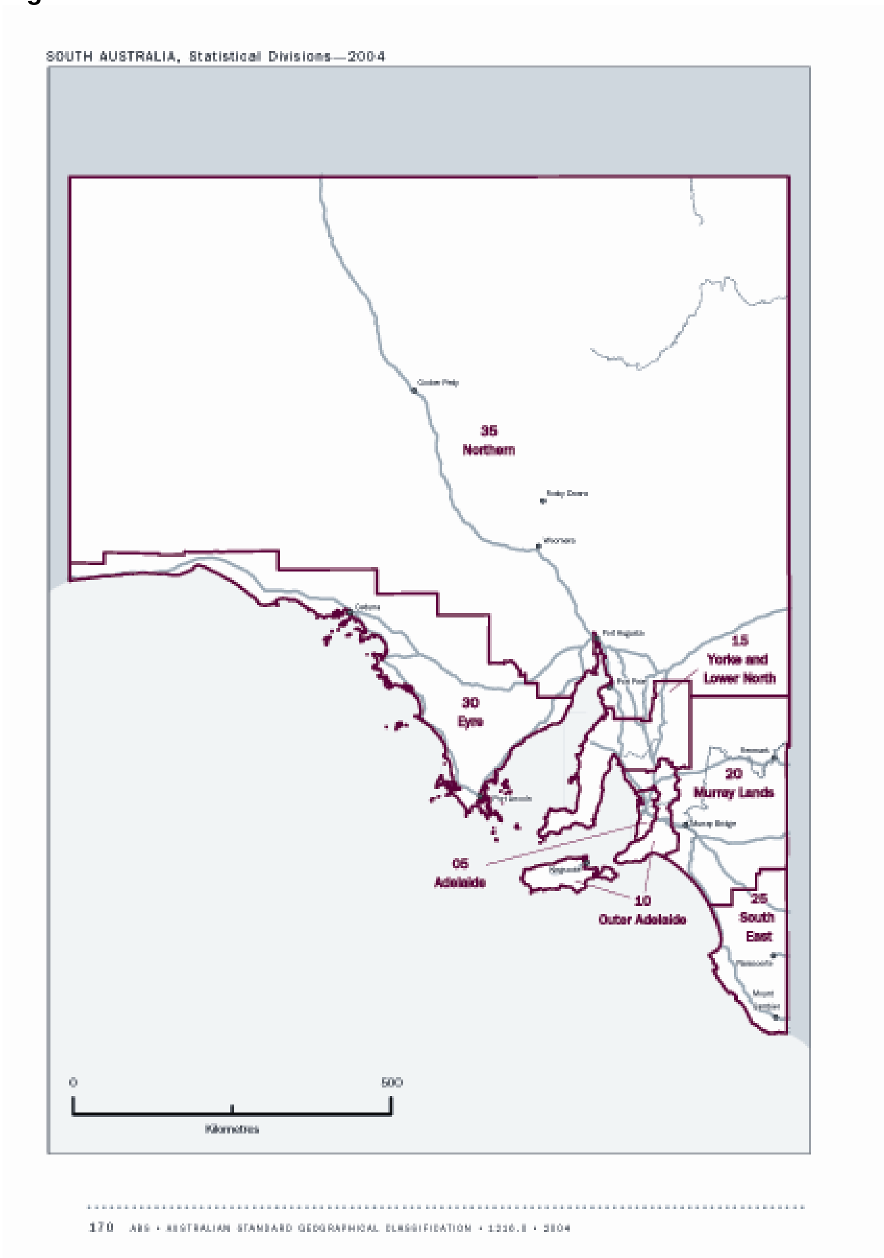


Figure 6: Tasmania Statistical divisions 2004

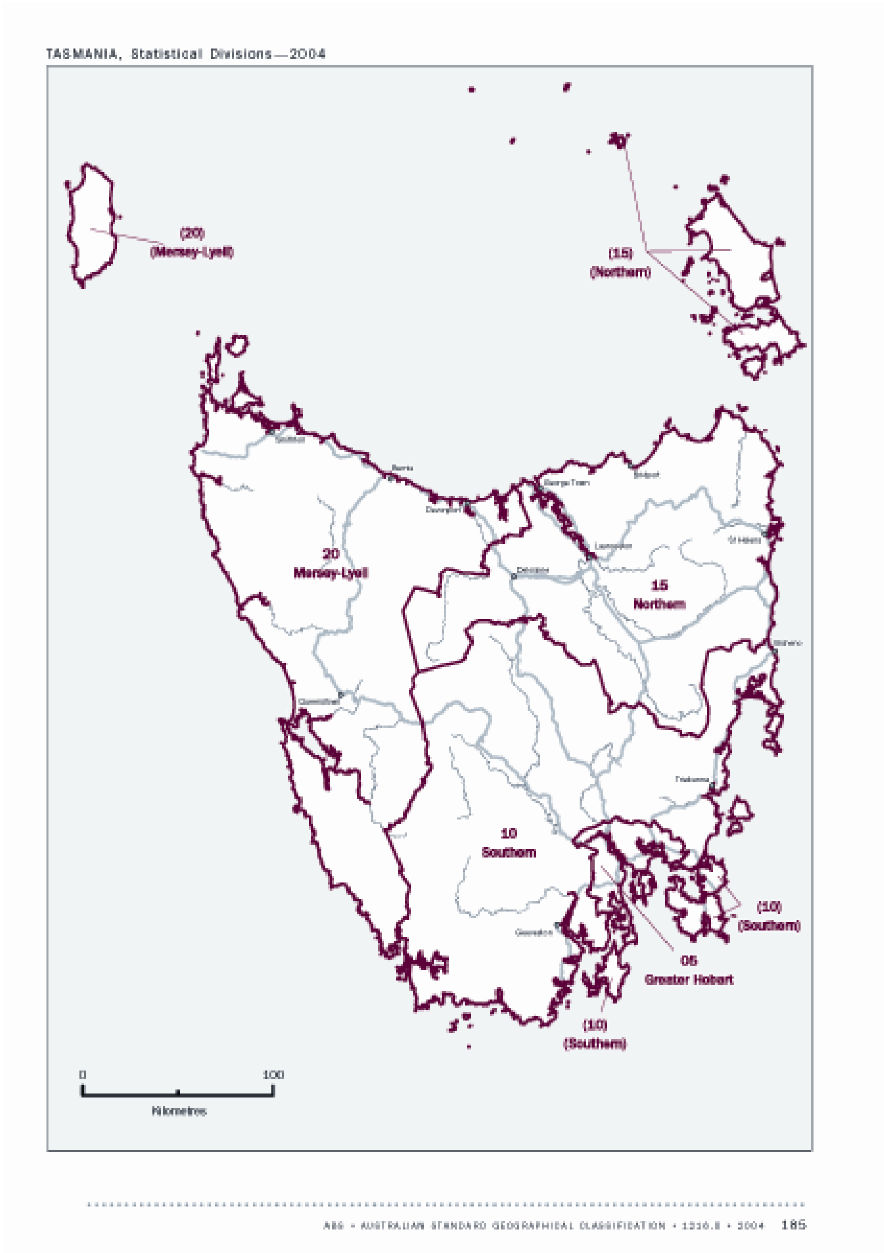


Figure 7: Victoria Statistical divisions 2004

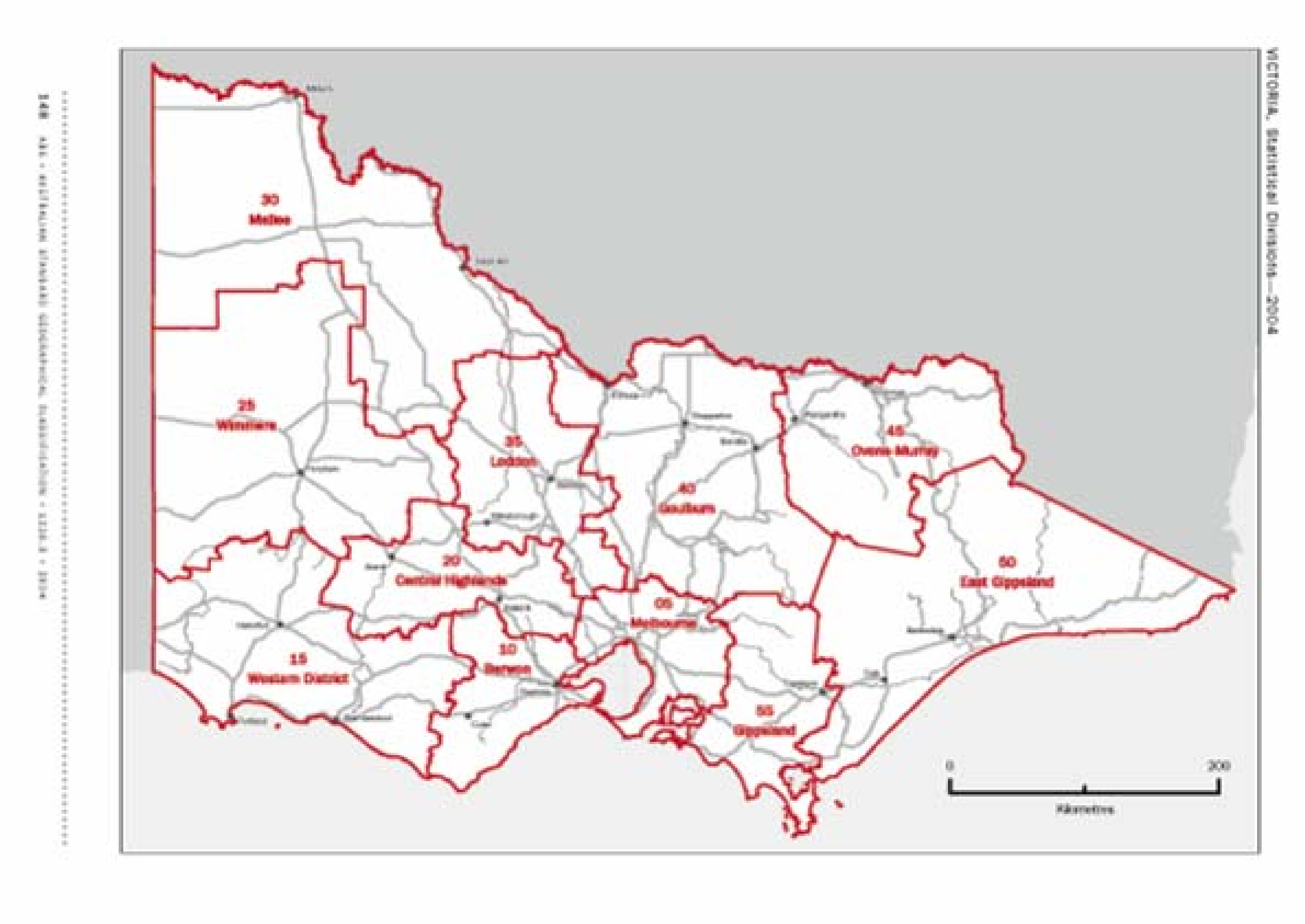
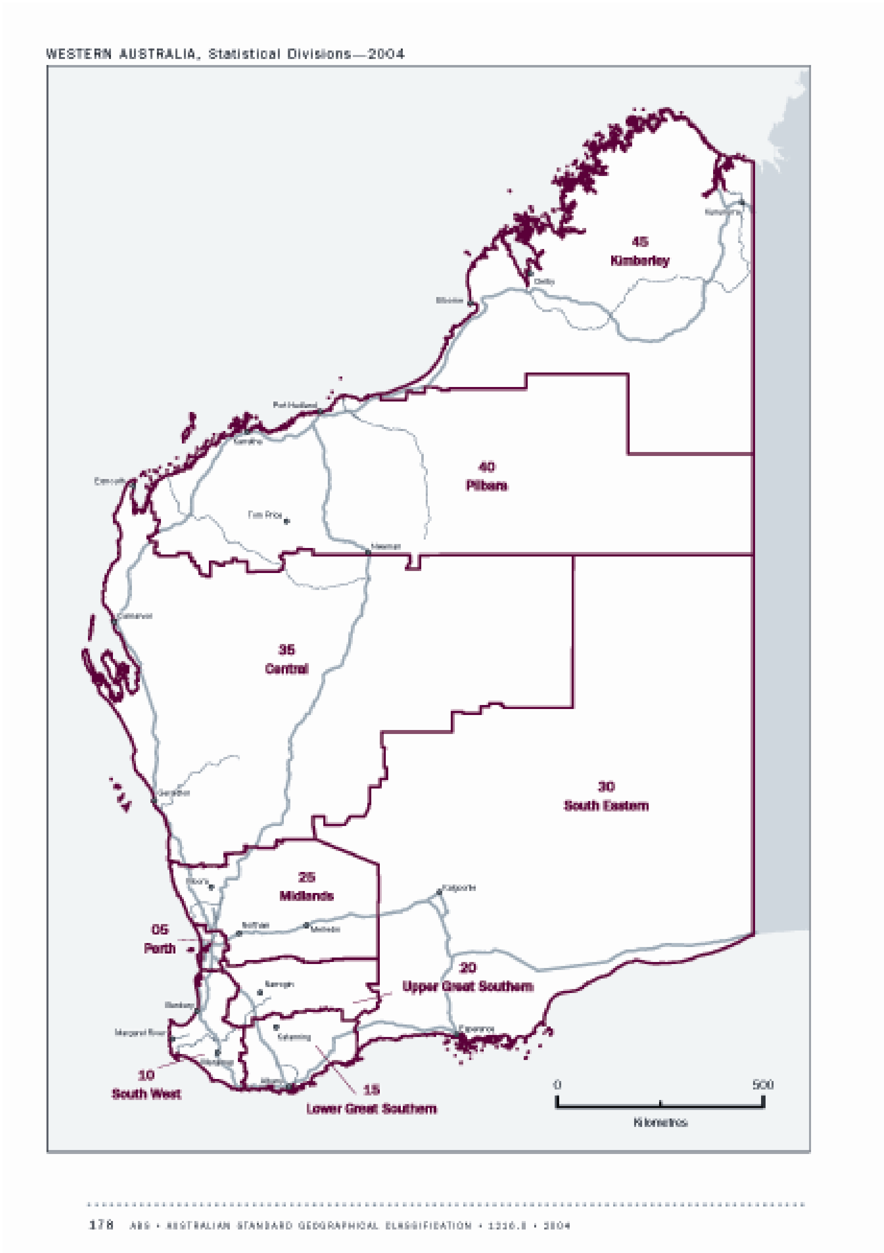


Figure 8: Western Australia Statistical divisions 2004



9.2 Appendix 2: Sheep, cattle and wool price assumptions

Table 1: Ten year median wool prices 1996-2005 (2005 dollars)

Fibre Diameter (µ)	35 Nktex (c/kg clean)	45 Nktex (c/kg clean)
16	2146	2447
17	1531	1877
18	1196	1343
19	986	986
20	807	807
21	710	710
22	673	673
23	627	627
24	603	603
25	575	575
26	546	546
27	525	525
28	504	504
29	485	485
30	465	465

Source: Independent Commodity Services

Table 2: Real Sheep prices 1996-2005 (2005 dollars)

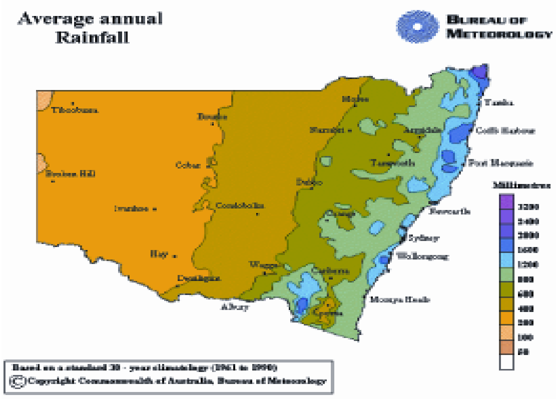
Category	Price	Source
Lamb 20-22kg F.S. 3	290c/kg Dwt	MLA Market reports
Mutton 18-24kg F.S.3	115c/kg Dwt	MLA
First cross ewe purchase price	$70/head	HSA Estimate
Store merino ewe price		
1&2 year old	$35/head	HSA Estimate
3 year old	$33/head	HSA Estimate
4 year old	$31/head	HSA Estimate
5 year old	$29/head	HSA Estimate
6 year old	$27/head	HSA Estimate

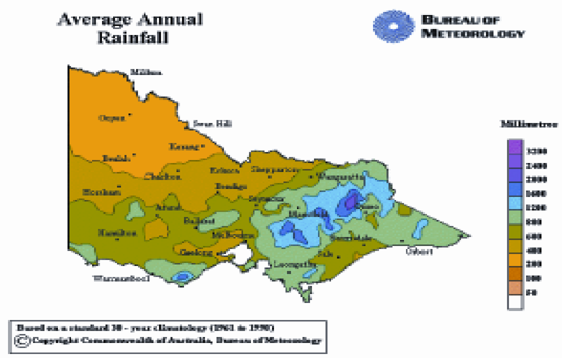
Table 3: Australian Beef Liveweight Price Deciles 1996-05

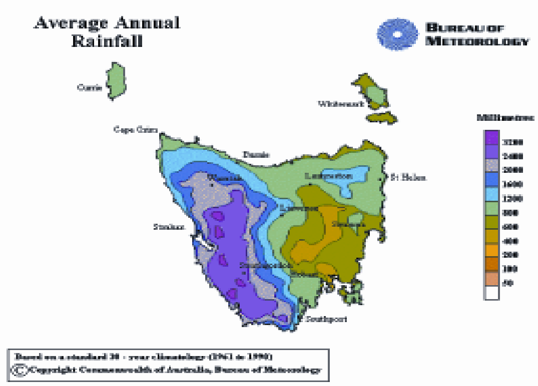
Decile	All	Cows	Bulls	Steers
0%	82	65	82	100
10%	103	80	103	124
20%	115	90	115	139
30%	120	94	120	145
40%	127	99	127	153
50%	**132**	**104**	**132**	**160**
60%	148	116	148	179
70%	155	121	155	187
80%	161	126	161	195
90%	171	134	171	207
100%	197	154	197	239

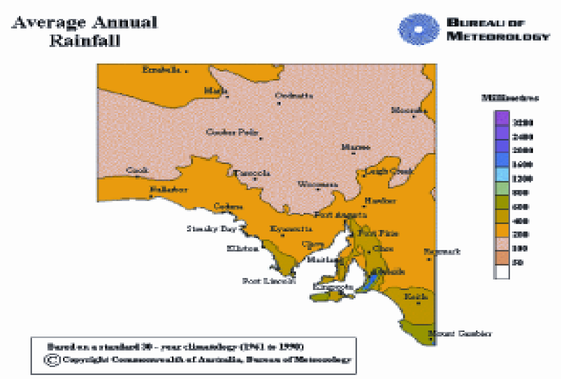
Source: MLA Market reports

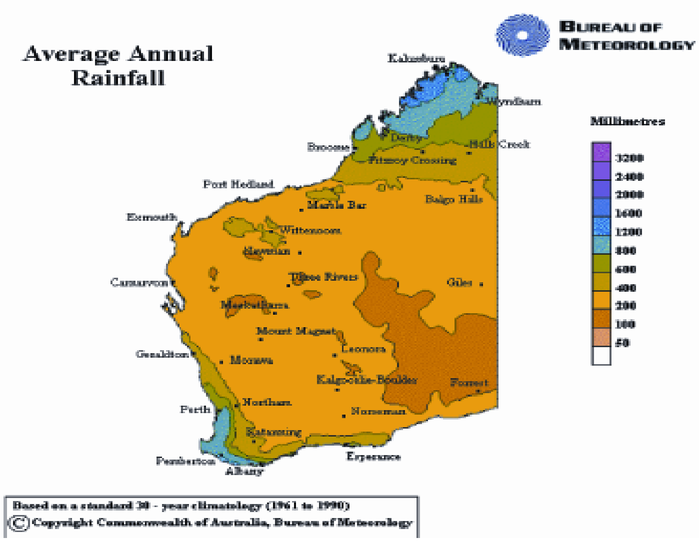
9.3 Appendix 3: 600mm rainfall zone of temperate southern Australia











9.4 Appendix 4: Number and distribution of animal at risk of PRGT

Table 1: National Sheep numbers by statistical division and proportion of sheep at risk of PRGT

State and Zone	Risk of PRGT	Total Sheep Number in zone	% of Area Where PRG can be grown	Total Number Sheep potential to graze PRG	% of Stock Estimated to currently graze PRG	Total Number Sheep Estimated to currently graze PRG
NEW SOUTH WALES						
Sydney	Low	**10,084**	100	10,084	70	7,059
Northern	Low	**6,024,542**	70	4,217,179	60	2,530,308
Illawarra	Low	**17,060**	100	17,060	60	10,236
Richmond-Tweed	Low	**5,192**	100	5,192	60	3,115
Mid-North Coast	Low	**1,130**	100	1,130	60	678
Central West	Low	**7,408,816**	60	4,445,290	60	2,667,174
Hunter	Low	**487,649**	100	487,649	60	292,589
Murrumbidgee	Low	**5,721,448**	20	1,144,290	70	801,003
South Eastern	Low	**7,009,242**	95	6,658,780	70	4,661,146
North Western	Low	**7,514,873**	5	375,744	60	225,446
Murray	Low	**4,575,556**	15	686,333	70	480,433
Far West	Nil	**2,111,748**	0	0	0	0
AUSTRALIAN CAPITAL TERRITORY						
Australian Capital Territory	Low	**110,114**	95	104,608	70	73,226
VICTORIA						
East Gippsland	High	**855,191**	70	598,633	70	419,043
Gippsland	High	**236,650**	100	236,650	70	165,655
Melbourne	High	**135,192**	100	135,192	70	94,635
Barwon	High	**1,439,971**	100	1,439,971	70	1,007,980
Western District	High	**6,422,496**	100	6,422,496	70	4,495,747
Central Highlands	High	**3,306,283**	100	3,306,283	70	2,314,398
Ovens-Murray	Moderate	**412,770**	95	392,131	70	274,492
Loddon	Moderate	**2,210,864**	30	663,259	70	464,282
Goulburn	Moderate	**2,518,560**	55	1,385,208	70	969,646
Wimmera	Nil	**3,436,014**	0	0	0	0
Mallee	Nil	**1,297,887**	0	0	0	0
QUEENSLAND						
Brisbane	Nil	**447**	0	0	0	0
Moreton	Nil	**15,266**	0	0	0	0
Wide Bay-Burnett	Nil	**3,636**	0	0	0	0
Darling Downs	Nil	**1,011,411**	0	0	0	0
South West	Nil	**3,237,740**	0	0	0	0
Fitzroy	Nil	**45,645**	0	0	0	0
Central West	Nil	**3,728,947**	0	0	0	0
Mackay	Nil	**4**	0	0	0	0
Northern	Nil	**12,064**	0	0	0	0
Far North	Nil	**4,492**	0	0	0	0
North West	Nil	**600,400**	0	0	0	0
SOUTH AUSTRALIA						
Outer Adelaide	High	**1,511,278**	55	831,203	70	581,842
South East	High	**3,750,208**	55	2,062,614	70	1,443,830

State and Zone	Risk of PRGT	Total Sheep Number in zone	% of Area Where PRG can be grown	Total Number Sheep potential to graze PRG	% of Stock Estimated to currently graze PRG	Total Number Sheep Estimated to currently graze PRG
Murray Lands	Nil	**1853862**	0	0	0	0
Adelaide	Nil	**32,398**	0	0	0	0
Eyre	Nil	**1,781,586**	0	0	0	0
Yorke and Lower North	Nil	**1,430,394**	0	0	0	0
Northern	Nil	**2,224,963**	0	0	0	0
WESTERN AUSTRALIA						
Perth	Low	**56,331**	100	56,331	70	39,431
South West	Low	**1,193,259**	85	1,014,270	70	709,989
Lower Great Southern	Low	**5,079,576**	10	507,958	70	355,570
Midlands	Nil	**5,950,603**	0	0	0	0
Upper Great Southern	Nil	**5,457,630**	0	0	0	0
South Eastern	Nil	**2,137,052**	0	0	0	0
Central	Nil	**3,206,052**	0	0	0	0
Pilbara	Nil	**48,896**	0	0	0	0
Kimberley	Nil	**0**	0	0	0	0
TASMANIA						
Greater Hobart	High	**91,134**	100	91,134	70	63,794
Southern	High	**1,272,561**	100	1,272,561	70	890,793
Northern	High	**1,731,700**	100	1,731,700	70	1,212,190
Mersey-Lyell	High	**188,853**	100	188,853	70	132,197
NORTHERN TERRITORY						
Darwin	Nil	**0**	0	0	0	0
Northern Territory - Bal	Nil	**0**	0	0	0	0
TOTAL ALL ZONES		**110,927,720**		**40,489,787**		**27,387,926**

Table 2: National beef cattle numbers by statistical division and proportion of cattle at risk of PRGT

State and Zone	Risk	Total Cattle Number in Zone	% of Area Where PRG Can be Grown	Total Number Cattle Potential to Graze PRG	% of Stock Estimated to Currently Graze PRG	Total Number Cattle Estimated to Currently Graze PRG
NEW SOUTH WALES						
Sydney	Low	25,007	70	17,505	70	12,253
Hunter	Low	524,879	70	367,415	60	220,449
Illawarra	Low	51,279	30	15,384	60	9,230
Richmond-Tweed	Low	234,455	30	70,337	60	42,202
Mid-North Coast	Low	291,590	20	58,318	60	34,991
Northern	Low	1,628,257	70	1,139,780	60	683,868
North Western	Low	835,607	5	41,780	60	25,068
Central West	Low	601,194	60	360,716	60	216,430
South Eastern	Low	432,432	95	410,811	70	287,567
Murrumbidgee	Low	583,469	20	116,694	70	81,686
Murray	Low	494,843	15	74,227	70	51,959
Far West	Nil	83,082	0	0	0	0
AUSTRALIAN CAPITAL TERRITORY						
Australian Capital Territory	Low	11,013	95	10,462	70	7,323
VICTORIA						
Melbourne	High	122,338	100	122,338	70	85,636
Barwon	High	108,305	100	108,305	70	75,813
East Gippsland	High	277,167	95	263,309	70	184,316
Gippsland	High	318,132	100	318,132	70	222,693
Central Highlands	High	100,382	100	100,382	70	70,267
Western District	High	577,267	70	404,087	70	282,861
Goulburn	Moderate	394,128	30	118238	60	70,943
Loddon	Moderate	96,533	55	53093	70	37,165
Ovens-Murray	Moderate	301,938	100	301938	70	211,357
Wimmera	Nil	57,832	0	0	0	0
Mallee	Nil	80,677	0	0	0	0
QUEENSLAND						
Brisbane	Nil	20,580	0	0	0	0
Moreton	Nil	293,354	0	0	0	0
Wide Bay-Burnett	Nil	753,941	0	0	0	0
Darling Downs	Nil	1,193,907	0	0	0	0
South West	Nil	1,159,616	0	0	0	0
Fitzroy	Nil	1,998,853	0	0	0	0
Central West	Nil	1,149,646	0	0	0	0
Mackay	Nil	875,778	0	0	0	0
Northern	Nil	1,080,414	0	0	0	0
Far North	Nil	688,994	0	0	0	0
North West	Nil	1,872,482	0	0	0	0
SOUTH AUSTRALIA						
South East	High	529,452	40	211,781	70	148,247
Adelaide	High	7,441	100	7,441	70	5,209
Outer Adelaide	High	120,354	100	120,354	70	84,248
Yorke and Lower North	Nil	36,280	0	0	0	0
Murray Lands	Nil	115,501	0	0	0	0
Eyre	Nil	26,175	0	0	0	0
Northern	Nil	215,055	0	0	0	0

State and Zone	Risk	Total Cattle Number in Zone	% of Area Where PRG Can be Grown	Total Number Cattle Potential to Graze PRG	% of Stock Estimated to Currently Graze PRG	Total Number Cattle Estimated to Currently Graze PRG
WESTERN AUSTRALIA						
Perth	Low	23,276	100	23,276	70	16,293
South West	Low	350,634	100	350,634	70	245,444
Lower Great Southern	Low	205,335	100	205,335	70	143,735
Upper Great Southern	Nil	47,388	0	0	0	0
Midlands	Nil	178,064	0	0	0	0
South Eastern	Nil	153,763	0	0	0	0
Central	Nil	261,444	0	0	0	0
Pilbara	Nil	250,558	0	0	0	0
Kimberley	Nil	530,903	0	0	0	0
TASMANIA						
Greater Hobart	High	4,988	100	4,988	70	3,492
Southern	High	51,831	100	51,831	70	36,281
Northern	High	169,986	100	169,986	70	118,990
Mersey-Lyell	High	199,655	100	199,655	70	139,759
NORTHERN TERRITORY						
Darwin	Nil	126	0	0	0	0
Northern Territory - Bal	Nil	1,706,793	0	0	0	0
TOTAL ALL ZONES		**24,504,371**	**2,270**	**5,818,530**	**2,090**	**3,855,774**

Table 3: Estimated number of sheep at risk of PRGT by zone

State and Zone	Risk	Merino Grazing PRG		Non Merino-Total Grazing PRG		Non Merino-Ewes Grazing PRG		Total Number Sheep Estimated to Currently Graze PRG
		Number	% Total Sheep	Number	%Total Sheep	Number	% Total Sheep	
NEW SOUTH WALES								
Sydney	Low	6,356	90	703	10	553	8	**7,059**
Northern	Low	2,321,678	92	208,630	8	164,312	6	**2,530,308**
Illawarra	Low	7,995	78	2,241	22	1,588	16	**10,236**
Richmond-Tweed	Low	2,482	80	634	20	591	19	**3,115**
Mid-North Coast	Low	377	56	301	44	224	33	**678**
Hunter	Low	268,944	92	23,646	8	18,556	6	**292,589**
Central West	Low	2,298,696	86	368,477	14	264,574	10	**2,667,174**
South Eastern	Low	4,246,828	91	414,318	9	323,719	7	**4,661,146**
Murrumbidgee	Low	667,555	83	133,447	17	93,663	12	**801,003**
Murray	Low	415,387	86	65,046	14	45,574	9	**480,433**
North Western	Low	203,534	90	21,912	10	15,842	7	**225,446**
Far West	Nil	0	0	0	0	0	0	**0**
AUSTRALIAN CAPITAL TERRITORY								
Australian Capital Territory	Low	67,537	92	5,689	8	4,501	6	**73,226**
VICTORIA								
East Gippsland	High	365,313	87	53,731	13	42,925	10	**419,043**
Gippsland	High	128,470	78	37,185	22	30,774	19	**165,655**
Melbourne	High	72,290	76	22,344	24	16,738	18	**94,635**
Barwon	High	880,147	87	127,833	13	99,529	10	**1,007,980**
Western District	High	3,723,434	83	772,314	17	613,814	14	**4,495,747**
Central Highlands	High	2,074,698	90	239,700	10	188,940	8	**2,314,398**
Ovens-Murray	Moderate	221,090	81	53,401	19	37,353	14	**274,492**
Loddon	Moderate	392,291	84	71,991	16	51,319	11	**464,282**
Goulburn	Moderate	770,452	79	199,194	21	144,418	15	**969,646**
Wimmera	Nil	0	0	0	0	0	0	**0**
Mallee	Nil	0	0	0	0	0	0	**0**
QUEENSLAND								
Brisbane	Nil	0	0	0	0	0	0	**0**
Moreton	Nil	0	0	0	0	0	0	**0**
Wide Bay-Burnett	Nil	0	0	0	0	0	0	**0**
Darling Downs	Nil	0	0	0	0	0	0	**0**
South West	Nil	0	0	0	0	0	0	**0**
Fitzroy	Nil	0	0	0	0	0	0	**0**
Central West	Nil	0	0	0	0	0	0	**0**
Mackay	Nil	0	0	0	0	0	0	**0**
Northern	Nil	0	0	0	0	0	0	**0**
Far North	Nil	0	0	0	0	0	0	**0**
North West	Nil	0	0	0	0	0	0	**0**
SOUTH AUSTRALIA								
Outer Adelaide	High	469,309	81	112,533	19	82,832	14	**581,842**
South East	High	1,156,438	80	287,393	20	197,221	14	**1,443,830**
Murray Lands	Nil	0	0	0	0	0	0	**0**
Adelaide	Nil	0	0	0	0	0	0	**0**
Eyre	Nil	0	0	0	0	0	0	**0**
Yorke and Lower North	Nil	0	0	0	0	0	0	**0**

State and Zone	**Risk**	**Merino Grazing PRG**		**Non Merino-Total Grazing PRG**		**Non Merino-Ewes Grazing PRG**		**Total Number Sheep Estimated to Currently Graze PRG**
		Number	% Total Sheep	Number	%Total Sheep	Number	% Total Sheep	
Northern	Nil	0	0	0	0	0	0	**0**
WESTERN AUSTRALIA								
Perth	Low	31,390	80	8,041	20	6,902	18	**39,431**
South West	Low	638,599	90	71,389	10	54,816	8	**709,989**
Lower Great Southern	Low	325,083	91	30,487	9	23,016	6	**355,570**
Midlands	Nil	0	0	0	0	0	0	**0**
Upper Great Southern	Nil	0	0	0	0	0	0	**0**
South Eastern	Nil	0	0	0	0	0	0	**0**
Central	Nil	0	0	0	0	0	0	**0**
Pilbara	Nil	0	0	0	0	0	0	**0**
Kimberley	Nil	0	0	0	0	0	0	**0**
TASMANIA								
Greater Hobart	High	57,027	89	6,767	11	5,454	9	**63,794**
Southern	High	794,418	89	96,375	11	79,252	9	**890,793**
Northern	High	1,058,704	87	153,486	13	121,147	10	**1,212,190**
Mersey-Lyell	High	103,194	78	29,003	22	19,306	15	**132,197**
NORTHERN TERRITORY								
Darwin	Nil	0	0	0	0	0	0	**0**
Northern Territory - Bal	Nil	0	0	0	0	0	0	**0**
TOTAL ALL ZONES		**23,769,716**		**3,618,211**		**2,749,456**		**27,387,926**

9.5 Appendix 5: Animals affected by PRGT by zone

Table 1: Number of animals affected by PRGT

Category	Severe	Moderate	Mild
Self replacing merino	10,883,440	1,383,833	11,502,442
Prime lamb	1,497,933	233,089	1,018,433
Self replacing beef	1,457,812	-	-

Table 2: National cost of PRGT – Non Merino

Zone	Category	Reduced Income	Increased Expenses	Total
Non-Merino	High risk	$7,403,720	$4,879,139	$12,282,859
	Moderate	$494,372	$287,863	$782,236
	Low risk	$302,746	$93,081	$395,827
	Total	$8,200,838	$5,260,083	$13,460,921

Table 3: Per head sources of economic loss due to PRGT – Non-Merino

Category	Reduced Income	Increased Expenses				Total
		Shearing	**Supplement**	**Labour**	**Other**	
High	$4.94	-$0.08	$1.29	$0.75	$1.28	$8.20
Moderate	$2.12	-$0.02	$0.54	$0.32	$0.39	$3.36
Low	$0.30	-	-	$0.10	$0.01	$0.39
Total	$7.36	-$0.10	$1.83	$1.17	$1.68	-$4.90