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Animal Health and Welfare

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Assessing the economic cost of endemic disease on the profitability of Australian beef cattle and sheep producers

Abstract

The costs of the major endemic diseases of sheep and beef cattle in Australia were estimated in order to provide current data on the absolute and relative costs of the major diseases. The estimates focused on the effects of the diseases on herd and flock productivity and did not include zoonoses, regulatory costs or food safety costs. Estimates were based on the most recent data of sheep and beef cattle numbers and their distribution, which was the 2001 Agricultural Census by the Australian Bureau of Statistics.

The diseases of major economic importance were identified by a combination of an expert workshop and literature review. The impacts of these diseases on production and financial performance were then modelled at the farm level, taking into account the range of consequences of disease on a farm and the costs to the farm business at the margin, that is, all other factors were held constant and only the marginal impacts and costs of the disease were calculated. Each of the major production systems and zones was modelled separately where appropriate. Results were then aggregated to provide regional and national estimates of cost. The contribution of decreased income versus increased cost was identified for each of the major diseases.

The cost of some potentially high cost diseases, such as pestivirus in beef cattle, could not be adequately modelled because of the lack of data on which to base assumptions such as prevalence and productivity effects.

The diseases that result in the largest economic loss to the sheep and beef industry were as follows:

Table 1 **Highest cost diseases for sheep**

Disease	National cost ($m)
Internal parasites	369
Flystrike	280
Lice	123
Post-weaning mortality	76

Table 2 **Highest cost diseases for beef**

Disease	National cost ($m)
Cattle tick	146
Under-nutrition	117
Bovine ephemeral fever	101
Buffalo fly	78

This analysis provides a basis for prioritising investment in research and development as it is the first time that the major endemic disease have been modelled with a consistent approach, which allows direct comparison between the costs of the diseases.

Executive Summary

Studies over the past thirty years have looked at the cost of endemic sheep and beef cattle diseases in Australia. The studies have two limitations in their current applicability to the Australian industry. Firstly, many of them are now at least 10 years old and do not reflect current disease control practices, livestock numbers and the current economic situation in the industries. Secondly, the studies have often used different methodologies so the results are not directly comparable between diseases and between species. This study was undertaken to address both of these limitations.

The study involved three stages:

- An expert workshop to identify the diseases of major economic importance, work that had been done and factors to be considered in generating new cost estimates — the workshop identified and prioritised diseases for sheep, northern beef herds, southern beef herds and cattle feedlots.
- A review of the literature to identify previous work undertaken and whether or not that work was still applicable or needed to be updated — this was done for each of the major diseases identified at the workshop.
- Modelling the major diseases and their economic impact at the farm level and then aggregating the results to regional and national levels based on the distribution of the disease — livestock numbers and distribution were based on the most recent available data which was the 2001 Agricultural Census of the Australian Bureau of Statistics. Economic impacts were restricted to productivity effects, so did not include the cost of regulation, zoonoses or trade restrictions. Separate models were used for sheep flocks (Merino and prime lamb), beef herds and feedlots. Where appropriate, model assumptions were adjusted to reflect different production zones such as northern and southern beef production systems, and high rainfall, cereal and pastoral zones for sheep. Estimates of cost were undertaken for each of the major production systems where the disease occurred (eg Merino and prime lamb high rainfall flocks). These were based on representative enterprises with average income and costs based on actual farm data. Ten-year average (1995–2005) prices and costs were used for the modelling to minimise the impact of shorter term fluctuations, particularly of price. This may mean that some estimates of disease costs do not reflect the current situation due to recent price changes such as the current above-average beef and sheep prices and below-average fine wool prices. The components (increased cost, decreased income) of the cost of each disease were identified.

Not all the major diseases could be modelled, because of inadequate data on prevalence, incidence or production effects, so the results need to be interpreted accordingly. Estimates for the cost of bovine pestivirus could not be undertaken for these reasons. Annual ryegrass toxicity was not modelled because new estimates would not have provided any additional information to that which currently exists (Allen 2002) and which estimated a cost of $25.8m in WA in 2002.

The results of the modelling of the major endemic diseases of beef cattle are shown in Figure 1 and the cost of the major sheep diseases is shown in Figure 2.

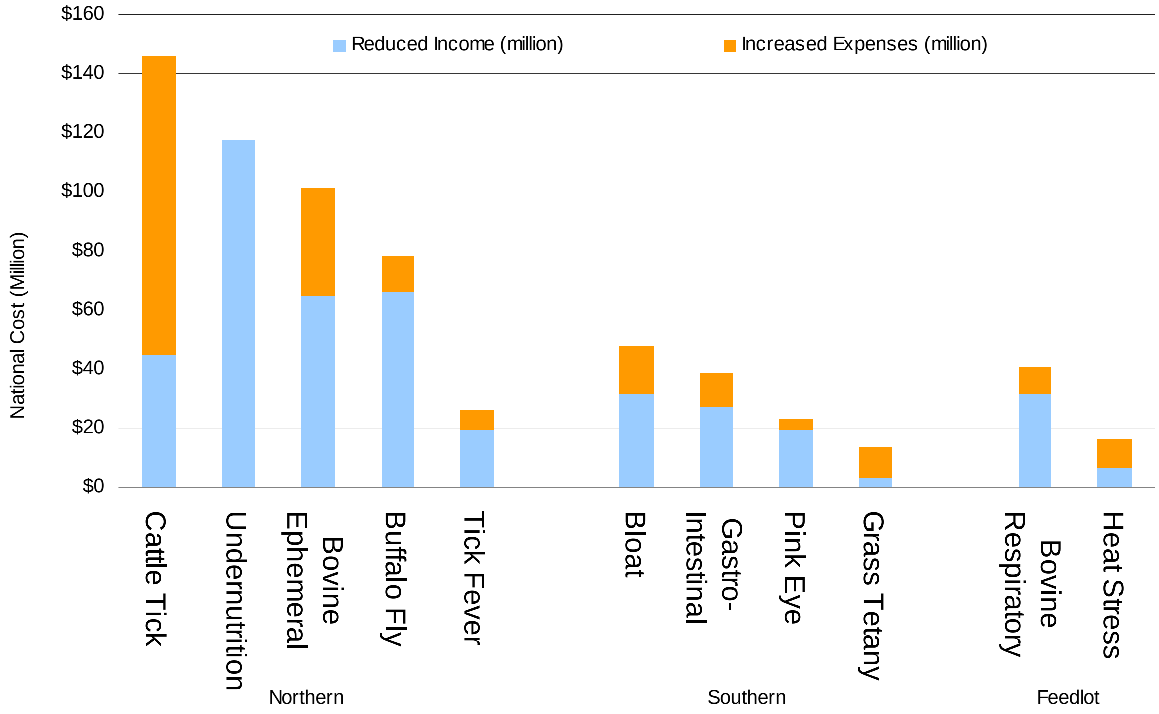

Figure 1 **National cost of diseases to the beef industry**

Note: The cost of peri-natal lamb mortality represents the return to industry for a 10% increase in lamb survival.

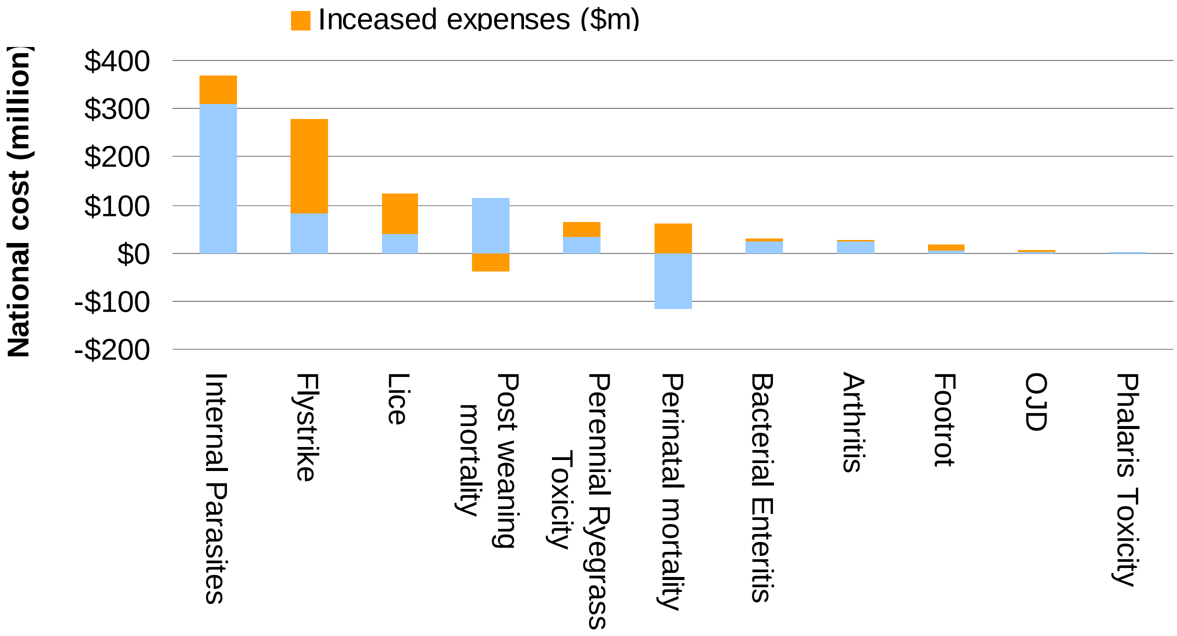

Figure 2 **National cost of diseases to the sheep industry**

There are a number of implications of these results for the industry. This is the first time estimates of the costs of all the major endemic diseases of sheep and beef cattle have been prepared using consistent methodology. This makes the results comparable in terms of industry cost, and provides a basis for identifying where research priorities may lie. However, a disease that has a high cost to the industry is not automatically a priority for research investment. For some diseases, the estimated cost may be substantial but a large component of that cost may be a result of inadequate implementation of currently known technology rather than gaps in knowledge. In such cases, investment in further research may have a low impact on the cost of the disease.

This analysis provides a basis for producers and industry organisations to better prioritise areas for investment in research and extension. However, this process needs to take into account that a number of factors were not included in the cost estimates of the major endemic diseases, specifically:

- known or potential zoonotic effects
- food safety issues
- regulatory issues such as quarantine and its impact
- emerging diseases that may currently have a low cost but whose cost may increase in the future as a result of increased prevalence or severity
- animal welfare considerations that are important for the management and control of many diseases.

When reviewing research priorities, in addition to all of the above, the probability that research investment will develop cost-effective solutions that will be adopted, needs to be taken into account.

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1 Background

Australian livestock producers are fortunate that many animal diseases considered endemic in other parts of the world do not occur within Australia. However, there are still a number of diseases that impact on the productivity of Australian cattle and sheep, and hence the profitability of Australian producers. While animal health is rarely the most important driver of on-farm profitability, it can have a negative impact through its effect on animal productivity, especially during the subclinical phase of disease. Treatment of animals showing clinical signs of disease rarely compensates for these losses because of the added cost of disease treatment and any permanent productivity losses that occur during the clinical and recovery stages.

Various estimates of the annual economic costs of endemic animal diseases to Australian production systems are often quoted, including, for sheep, $220m from worms and scouring, $169m from lice and $161m from flies, and for cattle, $175m from cattle tick, $20–30m from buffalo fly and $20,000 per year for a 3,000-head herd from bovine ephemeral fever. Some of these estimates are more recent, for example those for cattle tick and buffalo fly, whereas others are more dated, especially the cost estimates for the effects of parasites in sheep. For other diseases no economic assessments are currently available.

In order to determine the relative importance of endemic diseases on the profitability of Australian cattle and sheep enterprises, collation, assessment and, where appropriate, revision of the economic assessments of disease are required. This will allow ranking of diseases by relative economic importance and assist Meat & Livestock Australia and Australian Wool Innovation to decide research funding priorities.

It is acknowledged that endemic diseases of Australian livestock can also have an impact through their zoonotic potential, their possible impact on food safety, or because they are notifiable diseases subject to regulation and movement restrictions. These considerations will not be part of this project; rather the focus will be the impact of disease on the productivity of animals on-farm. Notifiable diseases will be included in the analysis but, for the purposes of this project, only their on-farm productivity impacts will be considered.

2 Project Objectives

The objectives of the project are outlined below:

1. Collation of a list of endemic diseases considered to impact on the productivity of beef cattle and sheep (meat and wool) in Australian production systems.

2. Collation of all available contemporary estimates of the economic impact of these diseases on the profitability of Australian beef and sheep producers. This should include costs associated with reduced productivity, mortality, disease control and treatment of clinical cases. Where no previous estimates are available this should be identified. Some of these deficiencies will be for new emerging diseases, for which it is difficult to quantify probable losses, and this should be highlighted.

3. Assessment of these previous estimates to determine which are still valid and which are no longer current and require redoing. The limitations of any estimates considered still valid should also be highlighted. Consideration should also be given to the need to remodel estimates for all diseases using consistent methodology.

4. Development of new economic estimates for a subset of diseases where previous estimates are no longer considered valid, or where previous estimates are not available. Diseases to be remodelled are those where economic impacts are likely to be greatest. These will be selected in consultation with Meat & Livestock Australia and Australian Wool Innovation. If possible, the modelling should indicate where profitability losses are occurring (eg through subclinical production losses, mortalities, treatment costs).

5. A qualitative assessment of how research investment of this subset of diseases might result in largest return, for example through new diagnostic tools, new control options such as vaccines and grazing management, improved extension of current control recommendations, or a combination of these.

3 Methodology

3.1 Expert workshop

An expert workshop was held on 10 August 2005 in Sydney. The objectives of the workshop were:

- to collect the opinion of experts across Australia on diseases of economic significance
- to identify what factors need to be taken into account when modelling the economic impact of diseases
- to help participants develop an understanding of the project and provide some ownership to help with the acceptance and use of the updated analysis.

Workshop participants were divided into groups based on their expertise (Appendix 1) and were initially asked to identify all the diseases for the relevant sector. Once listed, diseases were prioritised into one of the categories based on their economic significance. The prioritisation was based on factors including:

- number of herds/flocks affected or at risk
- cost of the disease at the herd/flock level if uncontrolled
- cost of the disease at the herd/flock level if controlled, and the cost of control.

The second objective (identifying what factors to take into account when undertaking additional modelling) was achieved by:

- identifying key issues that need to be taken into account, such as the effects of the disease on labour, production (clinical and subclinical) and the production system
- identifying key resources (including published and unpublished literature) that should be considered, and people with expertise in a field who could provide additional input
- reviewing the existing information as well as modelling priorities and inputs.

3.2 Review of economic analysis and recommendations

A review of the current state of knowledge on the production loss and/or cost of endemic diseases to sheep and beef production in Australia was undertaken. It was based on an extensive review of the available literature with special reference to Australia. Source material included references that quantify disease prevalence and incidence, and production loss, including mortality rates. The references cited do not include all references to a particular disease in Australia, only those fitting the descriptors above; nor are the references necessarily exhaustive. Whilst every care has been taken to search thoroughly, some references defy most attempts at detection. This is a particular problem in this case, as a significant amount of the work in this area was done 30–40 years ago and can be difficult to locate.

The literature on the economically significant diseases was searched for:

- prevalence and incidence
- mortality rate

- production loss unrelated to mortality including subclinical effects, lowered net reproductive rate, changes to herd/flock structure, delayed turn-off, reduced weight gain and ongoing ill thrift, effects on wool production and quality traits
- economic loss from failed or partially effective treatment and/or control procedures
- considerations specific to a particular disease (for example, with bloat, grass tetany and enterotoxaemia, a conscious decision not to sow pastures that would predispose the herd to those diseases would result in economic loss for the business)
- spill-over effects of control, that is, unintended effects associated with the control of the disease which could be positive or negative (for example, tick control products also provide benefits in fly control at no additional cost)
- recognition of system constraints that occur as a consequence of the disease (for example, weaner ill thrift in Merinos is often managed by changing the production system to an autumn lambing)
- analysis of good management versus average management to identify situations where the cost of the disease may be due to inadequate use of currently available control measures (average management) versus situations where control measures are not available or are too expensive to implement
- whether the analysis adequately reflects current industry structures and trends (eg flock and herd size and composition, prices, enterprise changes such as lamb production, store lamb production, live cattle exports and finer wool clip)
- whether the analysis is representative (eg regional versus national)
- the age of the analysis, including whether technology or the disease incidence has changed.

3.3 Modelling

3.3.1 Principles

All diseases were modelled using the following principles.

Specific spreadsheet models were used to estimate the costs of each disease. A separate model was used for each of the sheep, beef and lotfeeding systems. The models were stochastic.

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.

All prices were discounted to today’s dollars based on the consumer price index.

Flock and herd demographic data were based on Australian Bureau of Statistics data for 2001, the most recent available data. The data was available down to statistical divisions. Appendix 2 shows the statistical local areas for each state of Australia from which the cattle numbers were taken. Where specific regions are described for some diseases, the statistical local areas can be seen on the relevant state map.

The modelling results were consolidated into statistical zones based on the ABS data and best available estimates of disease prevalence and production systems. Assumptions were based on published data, where available, or sourced from organisations such as Animal Health Australia. Assumptions are provided for each disease.

Production effects of the diseases based on published data are referenced. In some cases, where data are not available, estimates were used and these were based on the experience of the authors, often in consultation with disease experts or experts in the region.

All disease costs stop at the farm gate. Regulatory factors such as trading restrictions, disease surveillance and other industry costs have not been estimated or included. Exclusion of these factors can explain some of the variance with other studies, for example, those on cattle tick and ovine Johne’s disease. Therefore estimates presented are for direct costs, usually a combination of reduced income and increased expenses.

Zoonotic costs were also not indicated in cost estimates.

Additional labour cost was valued at $20 per hour. This was based on the average salary for a station hand of $35,000 per year (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.

Some diseases are endemic and affect production annually whilst others are episodic and may appear every few years. The general approach with diseases has been to treat the episodic diseases on an annualised average basis rather than an episode, for two reasons. Firstly, most of the literature reports deaths and losses with episodic diseases, for example bloat and grass tetany, on an annual average basis and these are more reliable than figures quoted for extreme one-off death rates in a particular episode. Secondly, performing the analysis on an episodic basis uses an assumption that potentially increases error. For example, if a particular episodic disease has an average a five-year incidence, the range may well be from nothing in ten years to three episodes in three years. This can occur with footrot and bloat, for example. It is arguably less error prone to take an annual average approach than to try to take into account the effects of herd recovery time from different episode frequencies. Using this methodology, a herd or flock affected with a particular disease is analysed for five years at its long-term annual average rate and this is compared with five years where the disease is absent. The difference is assumed to be the cost.

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.

3.3.2 Cost averaging

In all herds and flocks the general approach has been to average the production loss and costs across all animals in the flock or herd. For example, if a disease caused 50% of the steers to have a 20% lower sale weight, the total production loss was applied to the entire herd. In this example, the sale weight of all steers for the affected years would be reduced by 10%. It was consistently assumed that this loss would be limited to the price by weight calculation and no other discount or penalty would apply. In some instances, the failure to achieve a critical sale weight can incur a penalty because the animal is sold into a lower value class. This varies from region to region and was not accounted for due to the complexity and potential error in the calculations.

Similarly, if some form of treatment or prevention was used (eg 50% of the cows treated at a per-head cost of $10) an average cost per dry sheep equivalent (DSE) across the whole herd was derived. If the base herd had a total of 10,000 DSE, the above example would result in a cost of $0.25 per DSE (assuming a total of 500 cows in the herd).

The principles described above were also applied to feedlots. For example, if 5% of the feedlot animals had to be hospitalised for bovine respiratory disease treatment, the cost of the treatment of the affected cattle, and their production loss, were averaged across the total number of head on feed.

It is important that explanations be understood before considering the results, because at first glance they may appear to understate expectations based on the effect of a disease on individual animal productivity.

3.3.3 Methodology — southern beef herds

The methodology employed to determine the estimated cost of a particular disease was to use a special-purpose spreadsheet designed to simulate a self-replacing beef herd. The herd model is static rather than dynamic due to the limitations of spreadsheet modelling. However, the model has been designed to show how herd structure and total numbers can recover over time from any form of shock resulting in deaths or forced sales. The model is designed to operate over a ten-year timeframe and all the key variables affecting herd structure and numbers can be adjusted on an annual basis or for the full timeframe. The default herd is set up to maintain a constant number of 500 breeders. This herd size was chosen so that relatively small increases in death rates would be reflected in the financial result. The default southern herd had all key variables set to closely match the eight-year average benchmarking result for all commercial herds from the Holmes Sackett & Associates benchmarking process (Sackett et al 2006). Inflation-adjusted ten-year average beef prices have been used in the model (Appendix 3). In this way, the herd is validated to simulate what has happened in real life in a large number of herds across southern Australia. The default herd is therefore the standard against which any change due to disease has been measured. This can come in the form of lost production through deaths or lower sale weights, or from increased expenditure, particularly in animal health, labour and supplementary feeding.

3.3.4 Methodology — northern beef herds

The majority of the general comments made for southern herds also apply to northern herds. The major difference is in the construction of the herd model. Northern herds are assumed to be running two more age groups of cows than southern herds and the turn-off age of steers is one year older. In addition, the net reproductive rate is lower, death rates in all classes of animals are higher and the sale weights of all classes of stock are slightly lower. All of these herd variables have been set from Holmes Sackett & Associates data and other data available in the literature from surveys. The base herd in the model is the yardstick against which any change caused by a disease is measured.

As for southern herds, a brief description is provided of all the key assumptions used. In all cases, production loss assumptions are derived from the literature. Any product or feedstuff used for treatment or prevention has been at current cost and additional labour has been costed at $160 per day. Less important assumptions have not been described.

3.3.5 Methodology — sheep

The model used was a whole flock stochastic representation of a sheep flock. The model can be adapted to a range of sheep enterprises and flock structures. Variables include prices (wool and sheep) and costs:

- Wool prices were based on the ten-year median price between 1 July 1995 and 30 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 wool reserve price scheme (that ended in 1991), 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 overestimate or underestimate 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 4.
- Sheep prices for sales and purchases were based on the same period. Data were based on Meat & Livestock Australia livestock reports, and opinion of the authors where there were no data for store sheep. Prices used are shown in Appendix 4.
- Enterprise costs were based on the eight-year average from Holmes Sackett & Associates farm benchmarking (Sackett et al 2006). This is a slightly shorter period than that used for prices but is the longest, most detailed data series available. These are the actual per-year costs incurred in sheep enterprises in a sample of over 100 farms.

Four flock types were modelled, but not all were used for the analysis of each disease:

- Self-replacing Merino flock (20-micron clip average) run in the high rainfall zone. Wethers were sold at 3.5 years of age.
- Medium wool Merino flock (21-micron average) run in the sheep cereal zone. Wethers were sold at 1.5 years of age.
- Self-replacing Merino flock (23-micron clip average) run in the pastoral zone, selling wether lambs at weaning.
- Prime lamb producing flock based on purchased Border Leicester x Merino cross ewes, selling lambs at weaning.

3.3.6 Variance with past studies

Previous studies have assessed the economic impact of some diseases. Where differences occur between these studies and estimates reported here, the main reasons are discussed, and include:

- different assumptions being used on the production loss and extent of treatment or prevention
- a change in the prevalence and incidence of the disease
- increased cost of prevention or treatment and/or new product availability
- a change in livestock numbers within and between regions
- a change in livestock value, through price and weight
- changes in herd or flock efficiency and profitability.

4 Results and Discussion

4.1 Cattle diseases — southern

The expert workshop ranked beef cattle diseases in southern Australia into high, medium and low economic impact; the results are shown in Table 3.

Rankings in the columns are alphabetical and do not denote a hierarchy of importance. Some diseases may result in severe economic loss, but because they are confined to discrete and small areas nationally, were not considered to be economically significant in the broader sense.

Table 3 **Diseases of beef cattle in southern temperate Australia**

High economic impact	Medium economic impact	Low economic impact
Bloat	Acidosis	Aflatoxin toxicity
Clostridial diseases	Infectious bovine rhinotracheitis	Akabane virus
Gastrointestinal parasites	Ketosis	Anthrax
Grass tetany	Leptospirosis	Beef measles
Liver fluke	Milk fever	Bent leg calf
Pestivirus	Nitrate poisoning	Botulism
Pinkeye	Photosensitivity — primary	Bovine Johne’s disease
Reproductive wastage	Ryegrass staggers	Bovine leucosis
Rotavirus	Salmonella/E.coli	Bracken poisoning
Under-nutrition/starvation	Trace element deficiency	Cancer eye
	Vibriosis	Curly coat
		Cypress poisoning
		Dwarfism
		Ephemeral fever
		Fatty liver
		Foot abscess
		Granular vulvitis/posthitis
		Lice
		Listeria
		Mastitis
		Papilloma virus
		Pasteurellosis
		Phalaris staggers
		Photosensitivity — secondary
		Q fever
		Urea poisoning
		Woody tongue/lumpy jaw

Diseases selected for modelling were those that were of high economic impact. Modelling was not done on those high cost diseases for which there were insufficient data or the form of the disease manifested was arbitrary and would require separate modelling for each case.

4.1.1 Bloat — literature review

A review of the economic impact of bloat on the Australian beef industry was recently prepared for MLA by Sackett (2004). Although the review was comprehensive, it largely related to studies conducted in the New England region of New South Wales. Additional to the references cited by Sackett, a survey was conducted in the Hunter Valley of New South Wales, but the findings were not significantly different from those from New England (Everett 1987). In that survey, the annual losses were estimated at $7.62m, with a long-term prevalence of 3% and losses approaching 5% every fifth year.

The available data on bloat are therefore confined largely to two neighbouring (albeit significant) regions and it will be problematic to extend these findings nationally without using broad assumptions. However, this approach is likely to give a reasonable estimate nationally.

4.1.2 Bloat — modelling results

Although bloat can occur anywhere, at any time, it is generally confined to high-rainfall regions where white clover is an important part of the pasture base or to regions in which lucerne dominates the pasture. The incidence of this disease and the number of deaths are highly variable, leading to a relatively broad range of cost results. An important point to bear in mind about this disease is that one of the preferred treatments, the antibloat capsule, has growth promoting activity. This explains why treated herds have a negative cost (the steers are sold heavier). However, the trade-off is that the economics is also heavily influenced by the proportion of the herd treated with antibloat capsules. All these factors have been taken into account in arriving at the cost range.

Key assumptions for high risk, no prevention, are that:

- the death rates are increased by 1.5% in all classes of stock except bulls which are increased by 0.5%
- steers grow 0.3kg per day slower for the 90 days of the peak bloat season.

Key assumptions for high risk, prevention, are that:

- antibloat capsules are the prevention treatment of choice and these result in an additional liveweight gain of 8kg in sale steers
- capsules are administered to 75% of the total herd
- an additional 0.2% of deaths across the herd still occur
- the high-risk scenario resulting in the above occurs once every three years.

The incidence of bloat is dictated by the presence of legume-dominant pasture and in particular white clover. The regions identified as being at high risk were the statistical divisions of Northern and Hunter in New South Wales; Ovens–Murray in Victoria; and Perth, South West and Lower Great Southern in Western Australia. All other areas are considered to be at low risk.

Within this high-risk zone, 40% of the cattle present were estimated to have been given prevention measures, with 60% receiving no prevention measures.

The key assumption for low risk, no prevention is that:

- background death rates are increased by 0.5% per year, with no penalty on growth rates.

See Appendix 5 for further details of assumptions. The economic effects of bloat in beef cattle in the southern zone is shown in Tables 4–6.

Table 4 Cost of bloat in beef cattle — southern

Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
High risk, no prevention	1,820,591	17.69	32,206,985
High risk, prevention	1,213,727	11.72	14,222,458
Low risk, no prevention	7,263,846	0.15	1,098,294
Total	10,298,164		47,527,736

Table 5 Per-head sources of loss due to bloat in beef cattle — southern

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health*	Labour	Feed	
High risk, no prevention	17.69	–	–	–	17.69
High risk, prevention	–1.51	8.62	4.61	–	11.72
Low risk, no prevention	0.15	–	–	–	0.15

* Animal health includes all additional costs associated with the treatment of the disease including vaccine, anthelmintic, parasiticide and capsules. The products used are provided in the text or the appendixes.

Table 6 National sources of loss due to bloat in beef cattle — southern

Category	Reduced income ($)	Increased expenses ($)	Total ($)
High risk, no prevention	32,206,985	–	32,206,985
High risk, prevention	–1,835,156	16,057,614	14,222,458
Low risk, no prevention	1,098,294	–	1,098,294
Total	31,470,123	16,057,614	47,527,737

Key references used for loss and cost assumptions are Everett (1987) and Sackett (2004). The results of this analysis are the first to quantify the national cost of bloat. The costs per head are higher than those of Sackett (2004) for both control and no control strategies. The main reason for the difference is the higher death rate due to bloat in this analysis.

4.1.3 Gastrointestinal parasites — literature review

Gastrointestinal parasites of cattle are, or have the potential to be, a cause of significant economic loss in southern Australian beef herds. There is only one report on this matter evident in the literature. Smeal (1981) reported on studies in New South Wales between 1964 and 1978 on 42 commercial properties and 4 departmental research stations ranging from Lismore to Bega and as far west as Orange. He found the most common parasites to be *Ostertagia ostertagi, Trichostrongylus axei* and *Cooperia* spp*. O. ostertagi* was predominant and most pathogenic.

Smeal et al (1981) conducted studies on the tablelands and north coast regions of New South Wales that compared liveweight gains of suppressively and strategically treated cattle grazing the same pasture as untreated controls. The suppressively treated cattle were treated every four weeks with a benzimidazole-based compound to suppress gastrointestinal worms, as well as three additional strategic treatments per year. The suppressively treated cattle showed a consistent and significant liveweight response compared to the untreated control cattle, despite the obvious design flaw (concurrent grazing) in the study which would result in the real differences being understated. This difference disappeared by 16–20 months of age. Overall, the conclusions were that gastrointestinal worms caused significant production losses in growing cattle, relatively strong immunity developed by 16–20 months of age and that, at least in the higher rainfall tablelands and slopes environments, regular treatment of cattle to control gastrointestinal parasites was cost effective.

The problem with these data is that they were using, by today's standards, inefficient products. Today it is recognised that the macrocyclic lactone (ML) group has superior efficacy to all pre-existing active compounds. Products based on an ML active have excellent activity against *Ostertagia* spp. and some of the products have persistent activity against these species. The general effect of the widespread use of these products could arguably be to change the dynamics of the cattle–worm populations on some higher-rainfall beef farms. This can be brought about by the superior and prolonged activity of the ML group against *Ostertagia* spp*.* As *Cooperia* spp*.* are the dose-limiting parasite for the market leaders of the ML group, these species could build up to dominate the worm populations in many beef herds.

There is anecdotal evidence from both New Zealand and the eastern tablelands and slopes country of New South Wales that this fundamental shift has happened on at least some properties. Because *Cooperia* spp. are less pathogenic than *Ostertagia*, the weight gain responses to treatment and fundamental economics of gastrointestinal parasite control in cattle may have shifted considerably.

Anthelmintic resistance is rare or unknown in beef cattle around the world and is unlikely to be playing a significant role in production loss in Australian beef herds, as it does in sheep. The problem lies at the other end of the spectrum where the default position is to undertreat cattle, at least in terms of frequency of treatment.

In terms of quantifying the cost of gastrointestinal worm parasites in southern beef herds, the existing data would form a sound enough base for the economic significance to be recalculated. It is highly likely that, across southern Australia, location would not materially alter production loss from worm parasites, given equal rainfall. However, much of the original work of Smeal would need to be redone to get a truly accurate assessment of the changes that may have taken place in worm population dynamics over the last 40 years.

4.1.4 Gastrointestinal parasites — modelling

The prevalence of worms is mainly a function of rainfall and, to a lesser extent, stocking rate. The herd structure may also play some part in determining the cost of the disease. As a general principle, the cost of the disease has a wider variation when untreated than when treated. There were no special considerations needed in the calculations for this disease given that the main form of economic loss is lower sale weights. High-risk regions were judged to be those above 600mm of annual rainfall.

There is one key assumption for high risk, no prevention:

- The weights of all sale stock are reduced by 25kg, with no increase in death rates or fertility penalty. No fertility penalty is included because most herds exceed minimum liveweight/condition score targets required for minimum acceptable fertility.

Key assumptions for high risk, prevention are:

- the weights of all sale stock are reduced by 5kg, with no increase in death rates or fertility penalty (assuming that any control program will never be 100% effective)
- three strategic drenches are given to all stock less than three years of age and no cattle older than this are treated.

The key assumption for low-risk, no prevention is that:

- the sale weights of all mature stock are reduced by 10kg, with no increase in death rates or fertility penalty.

Worms were considered only a risk in southern herds, with those at high risk within this region in areas with average annual rainfall of greater than 600mm. Bureau of Meteorology data were used to determine the boundaries and although these were as precise as possible, some provision had to be made as to the exact allocation of these areas. The statistical divisions not included within the analysis are North Western, Far West, 30% of Central West, 50% of Murrumbidgee and 70% of Murray in New South Wales; Wimmera, Mallee, Loddon and Goulbourn in Victoria; Yorke and Lower North, Murray Lands, South East and Eyre in South Australia; and Upper Great Southern and 40% of Midlands in Western Australia.

Of those cattle at risk, 90% were assumed to receive prevention and 10% no prevention. See Appendix 5 for further details on assumptions. The economic effect of gastrointestinal worms in beef cattle in the southern zone is shown in Tables 7–9.

Table 7 Cost of gastrointestinal worms in beef cattle — southern

Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
High risk, no prevention	710,580	10.13	7,198,462
High risk, prevention	6,395,222	3.40	21,756,546
Low risk, no prevention*	3,192,362	3.02	9,653,702
Total	10,298,164		38,608,711

* The cost associated with low risk and no prevention represents the aggregate low level of production loss in all regions outside the high-risk zones, excluding those regions where gastrointestinal worms would pose no risk at all.

Table 8 **Sources of economic loss due to gastrointestinal worms in beef cattle — southern**

Category	Reduced income (per head) ($)	Increased expenses (per head) ($)			Total ($)
		Animal health	Labour	Feed	
High risk, no prevention	10.13	–	–	–	10.13
High risk, prevention	1.66	1.51	0.23	–	3.40
Low risk, no prevention	3.02	–	–	–	3.02

Table 9 **National sources of economic loss due to gastrointestinal worms in beef cattle — southern**

Category	Reduced income ($)	Increased expenses ($)	Total($)
High risk, no prevention	7,198,462	–	7,198,462
High risk, prevention	10,636,534	11,120,013	21,756,547
Low risk, no prevention	9,653,702	–	9,653,702
Total	27,488,698	11,120,013	38,608,711

This is the first estimate of the cost of gastrointestinal worms to the Australian beef industry. The primary reference for production effects was that of Smeal (1981) and the assumptions were changed slightly to account for the fact that in his trials, treated and untreated cattle were grazed concurrently. Also, these data were based on the use, by today's standards, of inefficient products.

4.1.5 Infectious kerato-conjunctivitis (pinkeye) — literature review

A comprehensive national survey of 4,880 beef herds for pinkeye was conducted in the early 1980s (Slatter et al 1982a). The disease is widespread, and herd owners regarded it as a major cause of economic loss, with 74.7% of affected cattle showing unilateral lesions and the course of the disease running for around three weeks. Affected cattle can be set back for months after the acute phase, and delayed sale and treatment costs are the major forms of loss.

The authors estimated the cost of the disease to be $22m annually with a further cost of $1.5m for treatment. Much of the treatment is ineffective because it is given too late and yarding of the cattle can further spread the infection to other animals. An effective vaccine has been developed experimentally (Billson et al 1994) but has not been produced commercially; however, numerous pinkeye vaccines are available for use in cattle overseas.

4.1.6 Pinkeye — modelling

The survey on this disease conducted by Slatter (1982ab) was comprehensive and most of the findings have been incorporated into the model. The major deficiency with Slatter's work was that he relied on producer estimates of the economic value of the loss. When these estimates are examined in detail and adjusted to 2006 values, they are difficult to understand and justify, appearing to grossly overestimate potential loss. Accordingly, we have used our own estimates of the losses from other data included in the Slatter survey that have a much higher level of agreement with what we would expect to see in an affected herd. Most experts agree that most of the treatment for this disease is wasted expense and effort because it is often given too late and the process of mustering and yarding the cattle can complicate existing infections and create new ones. This explains why the total cost of disease is higher in treated herds than in untreated herds. Also, there is no distinction between high- and low-risk regions because this disease is genuinely ubiquitous and can occur in any region, generally in the warmer months.

Key assumptions are:

- sale weights are reduced by 3–5% on affected stock two years of age and less, with no penalty on sale stock older than this
- death rates of weaners are increased by 1%
- 10% of cattle less than one year of age are affected

Prevalence assumptions were based on the survey findings of Slatter (1982a) and treatment costs were adjusted for the percentage of non-treated herds described by Slatter.

All cattle in all districts across Australia were considered to be in the prevalence area for pinkeye, and the risk for infection was based on the findings of Slatter (1982b) (see Appendix 5). The risk rates were applied on a state-wide basis to all statistical divisions. Of those at risk it was assumed that 50% received treatment and 50% did not receive treatment. See Appendix 5 for further details on assumptions. The economic effect of pinkeye in beef cattle in Australia is shown in Tables 10–12.

Table 10 Cost of pinkeye in beef cattle in Australia

Zone	Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
Southern	**No treatment**	4,434,254	1.11	4,927,875
	Treatment	4,434,254	1.29	5,732,426
Northern*	**No treatment**	5,217,359	1.11	5,798,155
	Treatment	5,217,359	1.29	6,744,793
Total				23,203,249

* QLD, NT and northern WA

Table 11 Per-head sources of economic loss due to pinkeye in Australia

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal Health	Labour	Feed	
No treatment	1.11	–	–	–	1.11
Treatment	0.91	0.07	0.32	–	1.29

Table 12 National sources of loss due to pinkeye in Australia

	Reduced income ($)	Increased expenses ($)	Total ($)
Southern			
No treatment	4,927,875	–	4,927,875
Treatment	4,022,755	1,709,671	5,732,426
Northern*			
No treatment	5,798,155	–	5,798,155
Treatment	4,733,188	2,011,605	6,744,793
Total			23,203,249

* QLD, NT and northern WA

The primary reference for the assumptions used for pinkeye was the work of Slatter et al (1982ab). The economic analysis conducted by Slatter was based on producer estimates rather than modelling and the total cost of $23.5m was similar to the estimate in this report in nominal terms. In real terms (inflation adjusted) the estimated cost is lower than the estimate of Slatter (1982a), with the major explanation being that Slatter's estimate was based on producer estimates in a survey, whereas this study was based on modelling using Slatter's findings of prevalence within herds. The two studies are in close agreement, with the source of economic loss being primarily reduced production, with only a minority of the total cost being associated with preventative treatment.

4.1.7 Hypomagnesaemia (grass tetany) — literature review

Grass tetany is almost exclusively confined to medium and high-rainfall regions where improved pastures have been established. It has been reported in commercial beef herds in all southern states. It is a disease associated with high-production beef farming and is endemic in discrete areas. It is regarded as economically significant because, when it strikes, mortality rates can be high and it can be the biggest cause of deaths in any given herd in any given year. Most of the survey work has been done in Victoria where, in bad years, up to 42% of herds can be affected, with overall mortality rates of around 1% (Herd et al 1965, Campbell 1972, Forbes 1972, Spath and Anderson 1982).

This disease has economic effects that go beyond simple mortality rates. There are additional labour and cash costs for annual prevention, and labour and treatment costs in the face of a disease outbreak. In addition, the highest risk animals are cows at the peak of their productivity, and overall herd productivity can suffer, through changes in herd structure, if large numbers of these cows are lost. An additional problem in some regions is that there is a relationship between the use of potassium and nitrogen fertiliser and the incidence of grass tetany (Caple 1989). This means that some producers may have to compromise on potassium and nitrogen fertiliser application, which can constrain herd and overall farm profitability.

4.1.8 Grass tetany — modelling

Grass tetany is regionally specific, requiring special circumstances to create epidemics in certain years. In high-risk areas, some degree of background loss is occurring all the time. As a general principle, the cost of running a prevention program in an at-risk herd is usually greater than the average result for not doing so. The problem is that there is high variability around the mean for the cost of the disease with a nil-prevention strategy, and the highest cost is much greater than prevention costs. The problem with prevention is that it is very labour intensive and the addition of magnesium oxide inflates the supplementary feed cost. In this instance, the cost of prevention is more like an insurance premium that is paid out each year in anticipation of offsetting the cost of the once-a-decade disaster.

Key assumptions for high risk, no prevention are:

- death rates in four- to eight-year-old cows are increased by 2%, in three-year-old cows by 1%, otherwise all other death rates remain unchanged
- there is no decrease in sale weights or fertility penalty.

Key assumptions for high risk, prevention are:

- hay treated with magnesium oxide is the treatment of choice, and all four-to eight-year-old cows are fed 2.5kg per day for 50 days
- death rates in four- to eight-year-old cows are increased by 0.5%
- there is no decrease in sale weights or fertility penalty.

The key assumption for low-risk, no prevention is:

- death rates of four- to eight-year-old cows are increased by 0.2%.

The statistical divisions included for grass tetany were East Gippsland, Gippsland, Ovens–Murray, Melbourne, Barwon, Central Highlands and the Western District of Victoria; 40% of Murray in New South Wales; and the South East of South Australia.

Of those cattle at risk, 70% were assumed to receive prevention and 30% received no prevention. See Appendix 5 for further details on assumptions. The economic effect of grass tetany in beef cattle in the southern zone is shown in Tables 13–15.

Table 13 Cost of grass tetany in beef cattle — southern

Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
High risk, no prevention	759,876	2.34	1,780,845
High risk, prevention	1,773,043	6.12	10,857,407
Low risk, no prevention	7,765,246	0.08	587,053
Total	10,298,164		13,225,304

Table 14 Per-head sources of economic loss due to grass tetany in beef cattle — southern

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
High risk, no prevention	2.34	–	–	–	2.34
High risk, prevention	0.30	0.53	2.12	3.18	6.12
Low risk, no prevention	0.08	–	–	–	0.08

Table 15 National sources of loss due to grass tetany in beef cattle — southern

Category	Reduced income ($)	Increased expenses ($)	Total ($)
High risk, no prevention	1,780,845	–	1,780,845
High risk, prevention	536,168	10,321,239	10,857,407
Low risk, no prevention	587,053	–	587,053
Total	2,904,066	10,321,239	13,225,305

The primary references used for the assumptions were Campbell (1972) and Spath and Anderson (1982). These two studies were conducted in the highest risk region and it was assumed that most other high-rainfall cattle regions, especially along the southern coast, had lower prevalence and incidence. No national estimates of the cost of grass tetany were available for comparison.

4.1.9 Pestivirus — literature review

Attempting to quantify the extent of economic loss caused by pestivirus in southern Australian herds is difficult. Firstly, there are no data on prevalence or incidence of this disease and hence no way of quantifying the number of affected cattle. In addition, Littlejohns (1989), in a review of pestivirus, shows that this disease can manifest itself in a range of forms. It can have reproductive, respiratory and gastrointestinal forms that each results in a different type of economic loss. The economic outcome for a herd that may suffer over time from reduced net reproductive rate, diarrhoea or pneumonia, would be quite different.

A vaccine for this disease is available, but it is expensive and it is very difficult to determine whether it is cost-effective in any particular herd. Most producers with known pestivirus-infected herds choose to run known carrier animals with young, immunologically naive animals in order to boost their immunity before the effects of the disease take hold. Surveys of the prevalence and incidence of this disease in overseas countries are of no help for Australia because of the different climatic and geographic circumstances that prevail.

All that is known about this disease in southern Australia is that infected herds are widespread, it manifests itself in different forms, and in each form it has potentially serious adverse economic consequences. In order to properly quantify the extent of these adverse economic consequences in southern Australia, large-scale serological surveys would need to be undertaken. Current serology data appear to be sporadic and clinically based rather than epidemiologically or demographically based.

4.1.10 Pestivirus — modelling

Despite the request to attempt an analysis on pestivirus, it was felt that to do this on the basis of serology evidence alone would not result in a meaningful outcome. One of the more important considerations in arriving at this decision was attempting to determine just which form of the disease would present most commonly in any given region. This was too difficult to determine and likely to be of low accuracy and therefore of low value.

4.2 Cattle diseases — northern

The expert workshop ranked beef cattle diseases in northern Australia into high, medium and low economic impact; the results are shown in Table 16. Listings in the columns are alphabetical and do not denote a hierarchy of importance. Some diseases may result in severe economic loss but, because they are confined to discrete and small areas nationally, were not considered to be economically significant in the broader sense.

Table 16 Diseases of beef cattle in northern Australia

High economic impact	Medium economic impact	Low economic impact	Unknown impact
Botulism*	Clostridial diseases	Akabane	Emerging diseases
Bovine ephemeral fever	Internal parasites	Blue tongue	Genetic diseases
Buffalo fly	Pestivirus	Cancer eye	Myositis/stearitis
Nutritional deficiency	Pinkeye	Genetic diseases	Neospora
Reproductive wastage		Leptospirosis	Neurological disease
Tick and tick fever		Lice	Plant toxins
		Transit tetany	Sporadic bovine encephalitis
		Weaner stress syndrome (low–medium)	

*Botulism lacks sufficient data to model. The cost of prevention through vaccine is straightforward but the numbers of producers providing phosphorus through various means is unknown. There are also no reliable data on deaths and production loss with or without prevention.

4.2.1 Cattle tick — literature review

The economic impact of ticks and tick fever has been extensively reviewed and analysed in MLA project AHW.054a MLA (Playford 2005). The conclusion from this project was that ticks cost the cattle industry (including dairy) between $170–200m per year, with the lowest costs for *Bos indicus* cattle and the highest for *Bos taurus* cattle. There are approximately 8 million cattle in tick endemic areas (Playford 2005). According to L Turner (Department of Primary Industries and Fisheries, Queensland, pers comm, 2005), 1995 figures estimated tick costs at >$21 per head per year. Each engorging female tick costs the northern beef industry 0.6 grams per head per day.

Direct costs include reduced productivity, veterinary costs, chemical treatment and regulatory costs. The government-controlled ‘tick line’ inspection points from New South Wales to Queensland cost between $2m and $7m, and the maintenance of the tick line within Queensland costs $3.3m, which has been reduced by $1.5m with privatisation. In 2003, $16.8m was spent on tickicides. Over the last decade, the method of administration of tickicides has changed considerably, with a producer preference for the convenience of ‘pour-ons’. However, these come at a cost, being ten times the cost of dipping cattle (Playford 2005).

Indirect costs include labour costs during mustering and treatment, capital cost of facilities for treatment (the cost of installing a dip is approximately $20,000) and costs of research and policy (Playford 2005).

Ticks have a direct effect on cattle production through increasing mortality and morbidity rates, weight loss, decreased immunity and fertility decline (Jonsson 2005). Indirect production effects include reduced markets (discrimination against Brahman cattle and difficulties producing organic beef), animal welfare, hides (reduced value by 25–30%), residues (withholding period, export slaughter interval), and occupational health and safety issues (Playford 2005).

According to Sutherland (2004), weight gain in certain periods is affected but final weight is not affected by treatment for ticks. Sutherland (2004) and Jonsson (2005) concluded that Brahman cattle should be treated for ticks according to feed supply, not tick burdens. Economic response to treatment for ticks will vary depending on geography, breed and management (Sing et al 1983, Jonsson 2005). There is also weight loss from keeping cattle in yards or holding paddocks during periods of tickicide treatment for production or regulatory purposes (clearing the line).

4.2.2 Cattle tick — modelling

Recent surveys on the cost of tick infestation to the cattle industry have included dairy cattle and costs beyond the farm gate, including regulatory costs and additional research. This analysis does not include dairy cattle and all calculations on losses end at the farm gate. A big-picture approach has been used for this disease because the number of possible scenarios to model is too large. For example, there has been no distinction made between different effects of tick infestation on *Bos taurus* and *Bos indicus* cattle because it is too difficult to get accurate information on the exact numbers of these two genotypes in northern Australia. In any event, the number of pure *Bos taurus* cattle inside the tick line is likely to be a small proportion of the total. It has also been assumed that despite any inherent resistance to ticks in the cattle, some form of control is also being conducted. The broad approach taken is to assume that all cattle inside the tick line are at risk, the effects on production are slightly bigger than those reported for pure *Bos indicus* (to allow for the effect of *Bos taurus* crosses), and that the majority of control on stations is being conducted with the use of pour-on products rather than dipping. The cost of the pour-on products has been discounted to allow for some dipping to be done.

Key assumptions are:

- the death rates are increased by 0.5–1.0% in most classes of stock
- sale weights in all mature stock are reduced by 5kg
- a total of three treatments for control purposes are given during the year
- additional labour is costed at $160 per day and cattle are assumed to be treated when being yarded for some other procedure.

See Appendix 6 for further details on assumptions. The economic effect of cattle tick on beef cattle in northern Australia is shown in Tables 17–19.

For cattle ticks, the area of prevalence was those areas that are within the tick line (Figure 3). The areas taken in by the tick line were not exactly matched by the borders of statistical divisions; however, the line was matched to these borders as closely as possible. Therefore the statistical divisions included inside the tick line are half of Mid North Coast and all of Richmond–Tweed in New South Wales; Brisbane, Moreton, Wide Bay–Burnett, Fitzroy, Mackay, Northern, Far North and North West in Queensland; Darwin and half of the remainder of the Northern Territory; and the Kimberly of Western Australia. Of those cattle at risk, it was assumed that all received treatment (treatment frequency and product varies from region to region and is based on anecdotal evidence as hard data are not available, so an averaging approach to treatment frequency has been used).

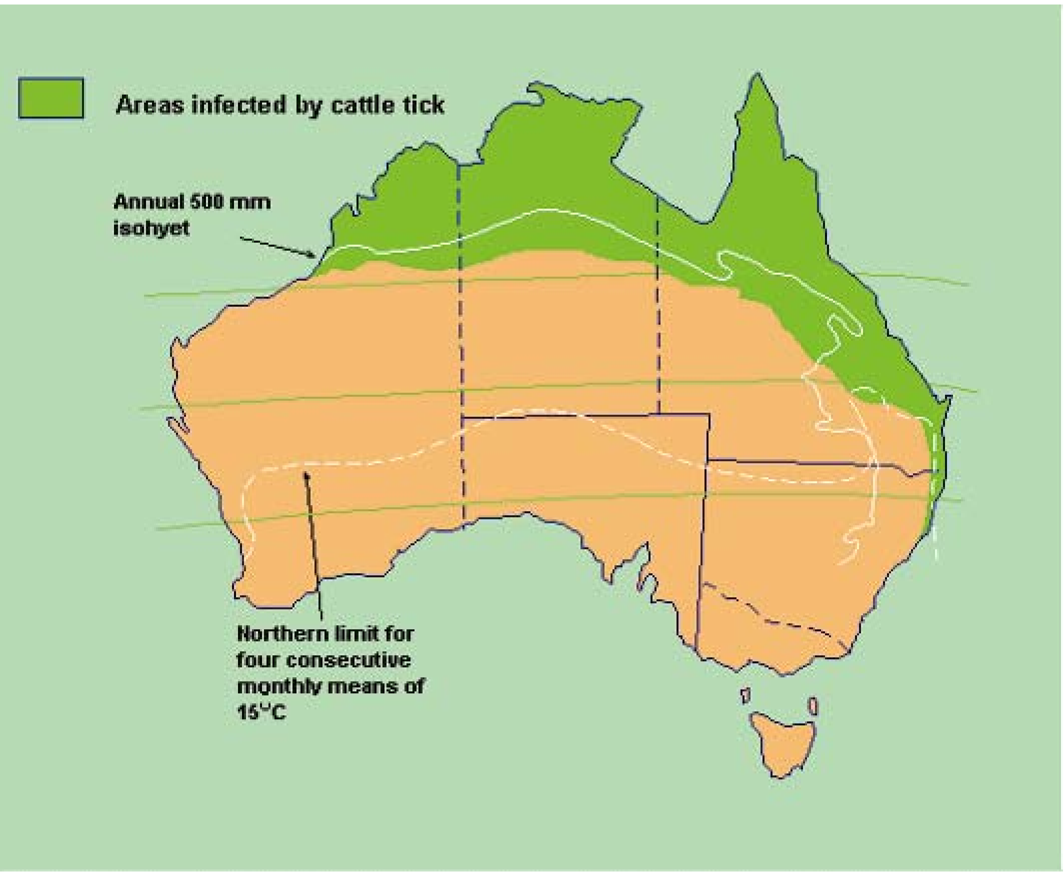

Figure 3 Map showing the tick line in Australia

Table 17 Cost of cattle tick in Australia — treated

Zone	Number of cattle at risk	Cost per head ($)	Total cost ($)
Northern	8,968,822	15.62	140,103,759
Southern	380,250	15.62	5,939,966
Total	9,349,072		146,043,725

Table 18 Per-head sources of economic loss due to cattle tick in Australia — treated

	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
Northern and southern	4.78	8.85	1.99	–	15.62

Table 19 National sources of loss due to cattle tick in Australia — treated

	Reduced income ($)	Increased expenses ($)	Total ($)
Northern	42,888,906	97,214,853	140,103,759
Southern	1,818,357	4,121,609	5,939,966
Total			146,043,726

The key references used were MLA (1999), Jonsson (2005), Sing (1983) and Playford (2005). This study reports a lower estimate of the cost than previous studies, which can be explained largely by changes in the value of cattle, the fact that previous studies included regulatory and other costs outside the farm gate, and in some cases included dairy cattle. The economic estimate for this disease does not differ substantially from previous studies as shown in Table 20.

Table 20 Estimated cost of cattle ticks from various studies

Original estimate of cost, $m)	Author	Year of the original cost estimate	2004 values ($m)*
33	Cattle Tick Commission (1975)	1973	239
132	McLeod (1995)	1995	172
>100	Willadsen (1997)	1997	>122
87	Davis (1998)	1973	217.5
134	Canyon (2002)	1995	175

*Assuming annual inflation rate of 3%
Source: AHW.054a (Playford 2005)

4.2.3 Under-nutrition — literature review

The expert panel held the strong and unanimous view that there is a direct link between under-nutrition or starvation and many of the diseases, including the less economically important diseases. For example, a poorly managed herd, nutritionally, would be unlikely to reach its full economic potential but would also be more susceptible to the effects of other diseases.

Therefore, although under-nutrition/starvation is not a disease in itself, it is an important and widespread predisposing cause of many of the more commonly seen diseases of beef cattle in northern Australia. It is also a significant cause of suboptimal reproductive performance in a self-replacing herd.

The expert panel recommends that this condition be regarded as a disease of management and be given the economically significant status attributed to some of the more important diseases of the herd. This condition is not discussed specifically in the scientific literature and the only things that can be said with confidence are that it is widespread and its impact is season dependent.

4.2.4 Under-nutrition — modelling

Under-nutrition is a management problem rather than an actual disease of cattle. Despite this, it is one of the most serious causes of economic loss in northern herds. The approach taken with this analysis was to construct a worst-case scenario in which death rates in breeding females, combined with the net reproductive rate, resulted in a herd with almost no female sales. This may sound extreme, but it is very easy to find such herds. More commonly, in drought years, female numbers will run down, only to build up again with a run of good seasons. The net effect is still minimal female sales. In addition, the turn-off weight of the steers was significantly reduced (40kg). Sale prices were reduced by approximately 10%. It is well recognised that under-nutrition increases the the impact of other diseases and therefore has a compounding effect. Obviously, this worst-case scenario will not be happening across all of northern Australia and to get an approximation of the actual cost will require a judgment call on the number of affected herds. It is suggested that a realistic estimate would be around 30%, in which case the calculated industry figure should be multiplied by 0.3. If a different estimate is made, the multiplier would be adjusted accordingly.

All northern cattle were considered at risk from under-nutrition. However, only 30% of the total number of herds were considered to be actually suffering the effects of under-nutrition. The economic effects are shown in Tables 21–23.

Table 21 Cost of under-nutrition in all northern cattle herds

Number of cattle at risk	Cost per head ($)	Total cost ($)
4,261,862	27.58	117,525,962

Table 22 Per-head sources of economic loss due to under-nutrition in all northern cattle herds

Reduced income ($)	Increased expenses ($)			Total ($)
	Animal health	Labour	Feed	
27.58	–	–	–	27.58

Table 23 National sources of loss due to under-nutrition in all northern cattle herds

Reduced income ($)	Increased expenses ($)	Total ($)
117,525,962	–	117,525,962

The estimate for this ‘disease’ is based entirely on the stated assumptions and these are, in turn, underpinned by the experience of the authors working in northern Australia. The cost is a worst-case scenario for the individual herd and the 30% prevalence can be debated. No previous estimates are available for comparison.

4.2.5 Bovine ephemeral fever — literature review

In an internal report for Stanbroke Pastoral Company (S Jephcott, pers comm, 2005), it was estimated that bovine ephemeral fever (BEF) cost the beef and dairy industries $100m in lost production annually. This report was the instigation for a current collaborative project being managed by Dr Penelope McGown, with contributions from MLA, North Australian Pastoral Company, Australian Agricultural Company and Fort Dodge. This project is assessing the economic impact of BEF in northern Australia with the objective of developing a more ‘user friendly’ and effective vaccine.

There have been six major epidemics of BEF over the past 50 years. Since 1976, sweeping epidemics have not been seen, but the disease now appears to have become endemic over a wide area of eastern Australia, emerging as localised outbreaks, mainly in the summer and autumn. In the 1983, 1984 and 1985 outbreaks, there was an antibody prevalence of 15%, 18% and 21% respectively in 2–3-year-old cattle. Uren (1989) has reported successive years of high and low incidence of BEF, however successive years of low disease prevalence followed by a summer of high rainfall could interrupt the pattern of endemic foci and provide the conditions necessary to sustain an epidemic (Walker and Cybinski 1989).

In the tropics, BEF outbreaks are controlled by rainfall; further south, temperature is the controlling factor. Frost terminates any outbreaks. General weather pattern (local heavy rain) and prevailing wind direction appear to influence the direction of movement of epidemics. Winter rain can cause outbreaks of BEF in areas where frost is less prevalent. Outbreaks usually occur four weeks after rain but the time lag can be shorter. Flood rain can terminate outbreaks due to its detrimental effect on the insect population (St George 1986).

The production effects of BEF include 20% weight loss, temporary sterility in bulls, milk loss, abortion, deaths of valuable animals such as bulls and heavy steers (mortality rarely exceeds 1%), depressed calf growth, calf mortality (from milk loss) and secondary mastitis. Additional costs include insurance of stud animals, veterinary costs, disruption to management procedures; effects on international trade and cost of laboratory testing for export animals and dislocation of marketing (S Jephcott, pers comm, 2005; St George 1986; Uren 1989). The disease mostly affects naïve cattle between 0.5 and 2 years of age (Uren 1989). Young cattle do not suffer as severely as mature cattle; non-lactating cows less than lactating cows; cattle under favourable climatic conditions less than those exposed to severe conditions; heavy stud bulls, heavy bullocks and heavy lactating cows are worst affected. Complete recovery occurs in 95–97% of uncomplicated cases.

The scale of economic loss is determined largely by climatic conditions and the availability of susceptible cattle (Walker and Cybinski 1989). Morbidity rates in outbreaks are usually about 35%, but if the population is highly susceptible may reach 100%. In enzootic areas, only 5–10% of the herd is affected. Outbreaks (epizootics) can occur in enzootic areas due to changes in virulence or in the vector population. Symptoms and immunity vary depending on the virulence of the strain. Cross immunity is limited, so there will always be some susceptible animals (S Jephcott, pers comm, 2005*)*.

4.2.6 Bovine ephemeral fever — modelling

Some historical changes are evident with BEF. Firstly, it appears to have shifted from being largely episodic to now being mainly endemic with occasional large episodes. Secondly, a commercial vaccine seems to be gaining favour with producers and is now widely used. This is the main reason a non-vaccinated scenario has not been constructed. The main assumptions used are that vaccination is an annual event and that female death rates remain largely unchanged from the base model. All age groups of bulls have the death rate increased by 1–2% and steers sale weights are reduced by 5kg. These numbers include a built-in assumption that a severe episode every five years will increase the average annual background rates. An annual vaccination program has increased animal health expenses by $2.40 per head across the whole herd. See Appendix 6 for further details on assumptions. The economic effects of BEF are shown in Tables 24–26.

The prevalence area for ephemeral fever follows the tropic of Capricorn from Western Australia across to Queensland and then runs down the coast into New South Wales. Those statistical divisions included for the analysis were the Pilbara and Kimberley of Western Australia; all of the Northern Territory; all of Queensland except the South West; and

Northern, Richmond–Tweed, Mid North Coast and Hunter in New South Wales. All of the cattle in these regions were included in the analysis.

Table 24 Cost of BEF for at-risk cattle herds in Australia

Zone	Number of cattle at risk	Cost per head ($)	Total cost ($)
Northern	12,416,329	6.69	17,936,579
Southern	2,679,181	6.69	83,124,838
Total			101,061,417

Table 25 Per-head sources of economic loss due to BEF in cattle herds in Australia

Zone	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
Northern & southern	4.30	2.39	–	–	6.69
Total					6.69

Table 26 National sources of loss due to BEF for at-risk cattle herds in Australia

	Reduced income ($)	Increased expenses ($)	Total ($)
Northern	53,437,396	29,687,442	83,124,838
Southern	11,530,658	6,405,921	17,936,579
Total	64,968,054	36,093,363	101,061,417

The key references used for this disease are St George (1986), Uren (1989) and Walker and Cybinski (1989). The only other estimate of the cost of BEF (S Jephcott, pers comm, 1999–2000) also put the figure at around $100m but did not have the vaccination assumptions used in this report and included dairy cattle.

4.2.7 Buffalo fly — literature review

In September 2003, MLA published a book titled '*Recommendations for integrated buffalo fly control*' (MLA 2003). The conclusion from this publication was that the estimated costs of buffalo fly to the Australian cattle industry included up to $30 per head per year in lost production; producers spend $4–6m annually on chemical control; and the total cost to the industry was $20–30m per year. Buffalo fly affects 50% of the Australian states. Of these, Queensland and the Northern Territory are most affected. A 1997 Queensland Department of Primary Industries survey reported that 98% of beef herds were affected by buffalo fly and two-thirds of producers used buffalo fly treatment (Bean et al 1987). Acaricides can be applied in various ways — sprays, pour-ons, back rubbers or ear tags.

Buffalo flies affect production through reduced weight gain during critical periods, hide damage, and transmission of *Stephanofilaria* which causes sores in the corner of eyes and some hide damage (MLA 2003). Various studies quoted in MLA (2003) have shown 14% increase in weight gain over a 13 month period in cattle treated for buffalo fly.

4.2.8 Buffalo fly — modelling

The same cattle genotype tolerance and susceptibility issues apply to buffalo fly and ticks and have been handled as described for ticks. The economic cost of this disease is almost exclusively confined to lower sale weights, and background death rates have been left unchanged. Sale weights of all mature stock have been reduced by 5–20kg. In addition, the final sale price has been discounted slightly to reflect hide damage. In the control scenario, three annual treatments are assumed, with the product of choice being a pour-on. A marginal increase in the cost of labour was used on the assumption that the cattle were most likely to be already yarded and being treated for ticks.

Buffalo fly prevalence included those cattle inside the tick line (Figure 3). The statistical divisions covered are identical to those for cattle tick. Of the cattle at risk it was assumed that 30% received preventive measures and 70% received no prevention. See Appendix 6 for further detail on assumptions. The economic effect of buffalo fly is shown in Tables 27–29.

Table 27 Cost of buffalo fly on cattle in Australia

Zone	Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
Northern	**Control**	2,690,647	6.14	16,512,229
	No control	6,278,175	9.32	58,543,357
Southern	**Control**	114,075	6.14	700,067
	No control	266,175	9.32	2,482,057
Total		9,349,072		78,237,710

Table 28 Per-head sources of economic loss due to buffalo fly on cattle in Australia — Northern

	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
Control	1.83	2.55	1.75	–	6.14
No control	9.32	–	–	–	9.32

Table 29 National sources of loss due to buffalo fly on cattle in Australia

Zone	Category	Reduced income ($)	Increased expenses ($)	Total ($)
Northern	**Control**	4,932,224	11,580,005	16,512,229
	No control	58,543,357	–	58,543,357
Southern	**Control**	209,111	490,956	700,067
	No control	2,482,057	–	2,482,057
Total				78,237,710

The primary references for buffalo fly were Bean et al (1987) and MLA (2005). This report estimates a higher cost to the industry than previous studies which is most likely related to the increased value of cattle and that three annual treatments are used (higher cost pour-on products). If the treatment cost assumptions are reduced, the cost to the industry is more in line with previous estimates.

4.2.9 Tick fever — literature review

In 1999, MLA and Queensland Department of Primary Industries funded a project, *Tick Fever in the Northern Beef Industry* (MLA 1999). This project estimated that tick fever cost the beef industry $27m, with vaccine costs estimated at $2.4m. In 1999, only 33% of producers in endemic areas used the tick fever vaccine (870,000 doses). According to R Bock (Department of Primary Industries and Fisheries, Tick Fever Research Centre, pers comm, 2005), based on the average weighted cost of losing a beast, the cost of tick fever to cattle industries in Queensland is estimated to be as much as $57.2m. The benefit of vaccination ranged from $13.4m to $26.8m.

The direct effects of tick fever on beef cattle production include increased mortality and morbidity (acute and chronic). *Bos indicus* cattle are very resistant to both *Babesia* parasites but they and crossbreds are very susceptible to *Anaplasma marginale.* Crossbred cattle are resistant to *B. bigemina*, but *B. bovis* causes significant mortality (MLA 1999).

Indirect effects include market access and timing of vaccination relative to shipment and handling. Live export market access can be denied for 6–12 months after a tick fever outbreak on individual properties. The tick fever vaccine is a live vaccine so cattle exhibit symptoms of a mild form of disease. Cattle should, therefore, be exposed to minimum stress for four weeks post-vaccination.

Current methods of control are strongly correlated with tick control and include genetics (crossbreeeding, within breed selection) and annual weaner tick fever vaccination at 6–9 months of age (MLA 1999). Poor seasons and *Bos indicus* cattle have a dramatic negative effect on tick resistance. In this scenario, there is low natural transmission and therefore poor naturally acquired immunity (MLA 1999).

4.2.10 Tick fever — modelling

As for cattle ticks, the at-risk area has been assumed to be inside the tick line (Figure 3). Of those cattle at risk it was assumed that 40% were vaccinated and 60% did not receive vaccination. The production loss with this disease is almost exclusively confined to increased death rates and reduced weight gain in cattle from weaning up to three years of age. Accordingly, death rates in these classes of cattle have been increased by between 1–2% and sale weights reduced by between 5 and10kg. The majority of the adult cattle variables have been left unchanged. In vaccinated herds, the production loss is assumed to be almost completely negated, with only a slight increase in death rates. Vaccination has been confined to weaner steers and weaner heifers each year and the labour for this task has been considered to be an additional cost. See Appendix 6 for further detail on assumptions. The economic effect of tick fever is shown in Tables 30–32. The key references used for tick fever are the same as used for cattle tick.

Table 30 Cost of tick fever per unit in cattle in Australia

Zone	Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
Northern	**Vaccinated**	3,587,529	1.83	6,576,299
	Unvaccinated	5,381,293	3.43	18,442,230
Southern	**Vaccinated**	152,100	1.83	278,815
	Unvaccinated	228,150	3.43	781,894
Total		9,349,072		26,079,238

Table 31 Per-head sources of economic loss due to tick fever in cattle — northern

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	**Labour**	**Feed**	
Vaccinated	3.43	–	–	–	3.43
Unvaccinated	–	1.28	0.56	–	1.83

Table 32 National sources of loss due to tick fever in cattle in Australia

	Category	Reduced income ($)	Increased expenses ($)	Total ($)
Northern	**Vaccinated**	–	6,576,299	6,576,299
	Unvaccinated	18,442,230	–	18,442,230
Southern	**Vaccinated**	–	278,815	278,815
	Unvaccinated	781,894	–	781,894
Total		19,224,124	6,855,114	26,079,238

4.3 Feedlots

The expert workshop ranked diseases of beef cattle in feedlot conditions into high, medium and low economic impact; the results are shown in Table 33. Listings in the columns are alphabetical and do not denote a hierarchy of importance. Some diseases may result in severe economic loss, but because they are confined to discrete and small areas, were not considered to be economically significant in the broader sense.

Table 33 Diseases of beef cattle in feedlot conditions in Australia

High economic impact	Medium economic impact	Low economic impact
Bovine respiratory disease complex	Acidosis syndrome	Bloat
Heat stress	Buller syndrome	Botulism
	Caste	Bovine ephemeral fever
	Footrot	Clostridial
	Non-doers (inanition)	Coccidiosis
	Pregnancy (prolapse)	Flies
	Prolapsed prepuce	Infectious/indifferent and diarrhoea
	Tick and tick fever	Injury (structured and genetic)
	Water belly	Lice
		Polioencephalomalacia
		Ringworm/mange
		Transit tetany

4.3.1 Feedlots — literature review

Diseases in Australian beef feedlots are simple and straightforward. Bovine respiratory disease (BRD) accounts for between 60 and 70% of all illness and mortality. The balance is composed of a wide range of one-off or region-specific conditions. The literature review was evaluated on a general feedlot basis.

4.3.2 Feedlots — modelling

A special-purpose model for analysis of the cost of disease in feedlot cattle has been constructed for this project. The base assumption is that the cattle are being fed for 90 days for a turn-off weight of 500kg, with a background death rate of 0.5%. All losses are measured against this. Lower average daily gain performance can be expressed as either reduced feed intake and more days to finish or a lower final weight; in this case the lower final weight is the preferred method. It is important to note that, while this method is simpler to calculate, it will produce a slightly bigger economic loss than the ‘more days on feed’ approach. Additional labour has been costed at $160 per day and all products used in prevention or treatment are at current cost.

The number of animals on feed was based on Australian Lot Feeders Association data for 2001.[1] However, the number of animals at risk in any 12-month period is substantially greater due to the fact that the majority of cattle are on feed for less than 12 months. Data for stock turn-off[1] indicates that the number of animals lot fed in 2001 is three times the average number on feed for the year. Therefore the number of animals considered at risk is based on average number on feed multiplied by three.

It is important to read the explanations provided in the methodology section (Chapter 3) on the method used to account for production loss and costs, which have been spread over all cattle in the lot rather than just the affected cattle.

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[1] http//:feedlots.com.au

4.3.2.1 Bovine respiratory disease — modelling

For BRD, death rates have been increased by 0.2% in unvaccinated animals and the turn-off weight reduced by 5kg. Approximately 7% of animals are assumed to succumb and are moved to hospital pens for treatment. The extra labour involved in this is costed. Where vaccination is used, it is assumed that all three commercially available products are used in conjunction (from discussions with feedlot managers) and the cost has been discounted slightly for the fact that some animals are vaccinated during backgrounding and before feedlot entry. This cost is sometimes wholly or partly borne by the backgrounder. The economic effects of BRD are shown in Tables 34–36.

Table 34 Cost of bovine respiratory disease in feedlots

Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
Vaccinated	204,373	12.24	2,501,521
Unvaccinated	1,839,353	20.77	38,203,370
Total	2,043,726		40,704,891

Table 35 Per head sources of economic loss due to bovine respiratory disease in feedlots — northern

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
Vaccinated	–	11.76	0.48	–	12.24
Unvaccinated	17.04	0.49	3.24	–	20.77

Table 36 National sources of economic loss due to bovine respiratory disease in feedlots

Category	Reduced income ($)	Increased expenses ($)	Total
Vaccinated	–	2,501,521	2,501,521
Unvaccinated	31,342,582	6,860,788	38,203,370
Total	31,342,582	9,362,309	40,704,891

4.3.2.2 Comparisons to previous estimates

The most relevant historical studies on cattle feedlot diseases in Australia show that up to 64% of mortalities result from the BRD complex (Dunn et al 1993). The economic impact of this, estimated by Dunn et al (1993), was $4,194,445 on a national basis. These calculations were based on 1991 prices and at that time it was estimated that 275,000 cattle were on feed. This puts a cost of the disease complex at $15.25 per head. This study estimates the potential economic loss at $20.77 per head in feedlots where vaccination is not practised and $12.24 per head where vaccination is practised (Table 34). The most important comparison is between $15.25 and $20.77 because the Dunn studies were essentially measuring production loss in the absence of preventive measures. If this is the case, the annual compound difference is 1.2% which is below the inflation rate for that period. If this is the basis for comparison, either the studies conducted by Dunn are an overestimate or this current study is an underestimate.

4.3.2.3 Heat stress — modelling

The base assumption used in the model is that around 30% of the animals in the feedlot will be suffering from heat stress every summer and that this will slightly depress the turn-off weights in these animals through loss of appetite. The economic effects are shown in Tables 37–39.

Table 37 Cost of heat stress of cattle in feedlots — northern

Category	Number of cattle at risk	Cost per head ($)	Total cost ($)
Shade	1,021,863	9.78	9,993,820
No shade	1,021,863	6.46	6,601,235
Total	2,043,726		16,595,055

Table 38 Per-head sources of economic loss due to heat stress of cattle in feedlots — northern

Category	Reduced income ($)	Increased expenses ($)			Total ($)
		Animal health	Labour	Feed	
Shade	–	–	–	–	9.78
No shade	6.46	–	–	–	6.46

Table 39 National sources of economic loss due to heat stress of cattle in feedlots — northern

Category	Reduced income ($)	Increased expenses ($)	Total ($)
Shade	–	9,993,820	9,993,820
No shade	6,601,235	–	6,601,235
Total	6,601,235	9,993,820	16,595,055

The analysis on the effects of heat stress needs to be interpreted with caution. Firstly, the incidence and prevalence are highly variable, depending on location and weather events. The cost of controlling this ’disease‘ is expressed almost exclusively as a capital outlay in the construction of shade. A number of feedlots were contacted in order to estimate this cost and an assumption was made that the cost should be amortised over a 20-year period. This resulted in an annual cost per animal of just under $10, but this would vary with the amortisation period and the quality of the infrastructure. At least some of this capital expenditure has to be regarded as an animal welfare expense rather than a disease control expense.

4.3.2.4 Comparison to previous estimates

As far as can be determined from the literature, all previous studies on heat stress in feedlots have been production focused, and economic analysis has been either rudimentary or entirely lacking.

4.4 Diseases — sheep

The expert workshop ranked sheep diseases into high, medium and low economic impact; the results are shown in Table 40. Listings in the columns are alphabetical and do not denote a hierarchy of importance. Some diseases may result in severe economic loss, but because they are confined to discrete and small areas, were not considered to be economically significant in the broader sense.

Table 40 Diseases of sheep in Australia

High economic impact	Medium economic impact	Low economic impact
Abortion and stillbirth	Caseous lymphadenitis	Clostridia
Arthritis	Fluke	Dermatophilosis
Blowfly	Foot abscess	Grain poisoning
Lice	Redgut	Hypocalcaemia/pregnancy toxaemia
Ovine Johne’s disease	Scabby mouth	Mycoplasma ovis
Peri-natal mortality	Trace element deficiency	Nitrate poisoning
Plant poisons	Yersinia	Ovine brucellosis, actinobacillosis
Post-weaning mortality		Pneumonia
Scouring		
Worms		

Most of the diseases of high economic impact were modelled. Exceptions were abortion and stillbirth which can be caused by a number of diseases, each of which the expert panel considered to be of relatively minor importance. Also, some of the impacts were modelled on peri-natal mortality. A number of diseases have at some time caused abortion or stillbirths in sheep flocks, with some of the more common ones being *Campylobacter, Chlamydia, Listeria*, brucellosis, border disease and akabane.

Surveys have shown that infection from all diseases combined accounts for approximately 2% of lamb losses (Haughey 1981) when measured over a large number of flocks and therefore is of relatively minor economic significance. However, outbreaks on farms, although uncommon, can be dramatic and result in considerable economic loss, which at times leads to the perception that infectious agents can cause up to 70% lamb losses. Dennis (1974) diagnosed infectious abortion on 14.5% of farms over the two years 1963–65 with neonatal and congenital infections accounting for only 2.2% of all lambs born. There is anecdotal evidence from the expert committee that there is an increasing incidence of late-term abortions, particularly due to *Campylobacter* infection but there are no data to support this. One possible reason for an increase is the trend to increase overall farm stocking rates and to increase stock density by some form of rotational grazing.

The only plant poison modelled was *Phalaris* toxicity. Perennial ryegrass toxicity was modelled in a separate report with the same methodology, while annual ryegrass toxicity could not be satisfactorily modelled due to lack of information compared to the most recent estimates.

Scouring was not specifically modelled but its effects were accounted for in a number of other diseases such as breech strike and worms.

Yersinia, which the expert panel considered to be of medium importance, was modelled because it was considered to be an emerging disease.

4.4.1 Internal parasites — literature review

The most frequently cited estimate of the cost of intestinal parasitism is that of McLeod (1995) of $222m. The cost was derived from control costs ($81m), losses of wool and meat production ($100m) and mortalities ($41m). He considered nematodiasis the greatest constraint on the Australian grazing industry.

The source of data on the effects of intestinal parasitism used by McLeod (1995) was a number of publications published in the 1970s and 1980s. The results of those studies, in biological terms, are likely to be still applicable today. There have been, however, substantial changes in the demography of sheep in Australia since the early 1990s and the relative values of sheep meat and wool have changed, as have the costs of treatments and other procedures. The expert panel considered that there was a need to re-examine the cost of parasitism in the light of current prices for chemicals and services, including labour, the availability of new treatment options (eg capsules), new strategies (eg integrated parasite management of sheep) and the continuing problem of anthelmintic resistance. Alternative methods of evaluating economic assessments should also be addressed (Perry and Randolph 1999).

Anthelmintic resistance in particular presents serious constraints to sheep production in high-rainfall areas, affecting the optimum flock structure, stocking rate and level of parasite control that can be justified. The most effective long-term strategies may seek to minimise the impact of parasites on sheep, while accepting that a degree of production loss is preferable to the excessive exposure of worm populations to anthelmintics (Besier and Love 2003).

There are sufficient data available to estimate the costs of intestinal nematodiasis in sheep but the analysis should be performed using current prices, reviewing current production strategies and with methods that reflect the value of achievable and sustainable parasite control. The modelling studies should be performed for high-, medium- and low-rainfall areas.

4.4.2 Internal parasites — modelling

The effects of internal parasites were modelled for the following flocks:

- high-rainfall fine wool flock in the summer rainfall zone where the major internal parasites are *Haemonchus* and *Trichostrongylus*
- high-rainfall fine wool flock in the winter-dominant and year-round rainfall zones where the major parasites are *Trichostrongylus* and *Teladorsagia*
- medium wool flock in the sheep cereal zone with predominantly *Trichostrongylus* and *Teladorsagia*
- prime lamb producing flocks which are spread across all of the above production zones.

Internal parasites were assumed not to have any effect on pastoral zone production systems.

Factors taken into account in the analysis included:

- reduction in fleece weight and fibre diameter
- reduction in wool staple strength
- reduced liveweight of ewes and subsequent reduction in fertility
- reduced weaner liveweight and increased mortality rate
- increased costs associated with monitoring and treatment.

Details of the assumptions for each of these factors for each scenario are given in Appendix 8 and the national cost is shown in Table 41–43. Detailed economic costs are given in Appendix 7.

Table 41 **Cost of internal parasites of sheep**

Zone	Control	Number of sheep	Cost per head ($)	Total cost ($)
High rainfall, summer	Good	1,547,785	4.13	6,398,518
	Poor	2,321,678	7.13	16,555,977
High rainfall, winter	Good	11,171,390	3.14	35,061,409
	Poor	26,066,576	5.24	136,637,327
Sheep cereal	Good	20,991,893	2.25	47,231,760
	Poor	13,994,596	2.62	36,665,841
Pastoral	Good	0	0.00	–
	Poor	0	0.00	–
Prime lamb	Good	5,323,775	4.93	26,246,208
	Poor	5,323,775	12.08	64,311,196
National				369,108,236

Table 42 **National economic effect of internal parasites of sheep**

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall, summer	19,980,954	2,973,541	22,954,495
High rainfall, winter	153,324,968	18,373,768	171,698,736
Sheep cereal	54,438,977	29,458,624	83,897,601
Pastoral	–	–	–
Prime lamb	82,465,267	8,092,137	90,557,404
Total	310,210,166	58,898,070	369,108,236

Table 43 Per-head economic effects of internal parasites of sheep

Zone	Reduced income ($)	Increased expenses ($)				Total ($)
		Crutching	Drenching	Shearing	Other	
High rainfall, summer	5.16	0.55	0.77	–0.33	–0.22	5.93
High rainfall, winter	4.61	0.17	0.73	–0.23	–0.17	4.61
Sheep cereal	1.56	0.08	0.89	–0.08	–0.05	2.40
Pastoral	–	–	–	–	–	–
Prime lamb	7.75	0.12	0.71	–0.06	–0.01	8.51

In real terms, the estimate from this study is probably not substantially different from that of McLeod (1995). Like McLeod, this study found the majority of the losses (87%) were due to a production loss rather than the costs associated with treatment and prevention.

The sector suffering the greatest loss is Merino flocks in the winter-dominant high rainfall zone, followed by prime lamb sector, then Merino flocks in the sheep cereal zone. The result was due to a combination of the degree of economic loss per head and the number of sheep in each of these sectors.

4.4.3 Flystrike — literature review

Flystrike is taken to include body, breech and pizzle strike. Poll and wound strike are not considered sufficiently important diseases to warrant specific attention.

There have been three economic analyses in the last 35 years of the cost of flystrike to the Australian sheep industry. The first was that of Brideoake (1979) which was based on comprehensive surveys of practices including crutching, mulesing and jetting conducted as part of the Grazing Industry Surveys during the 1970s. The cost of blowfly control was estimated to be $55m in 1977–78. However, this study is of limited value for today’s industry due to four factors:

- The changes in cost structure (labour was costed at $2.29 per hour and crutching cost 15¢ per head), even after adjusting for inflation, are likely to be inaccurate because they may have changed at a greater or lesser rate than the consumer price index. The value of wool and surplus sheep have also changed substantially, with a real decline in price (average saleyard wether price was $6.50 per head).
- New products are available for treatment and prevention of flystrike, and resistance has developed to some of the cheaper products that were available for control and prevention. Some of the new products have a lower labour requirement than earlier products.
- Mulesing is currently carried out on a higher proportion of the flock than in the 1970s.
- The sheep population has reduced from 150m to approximately 100m.

The second major study was that of Beck et al (1985) which estimated the cost of flystrike was $2,300 per farm in an average season and ranging from $1,100 in a low-risk year to $3,500 in a high-risk year. These results are of limited value for many of the same reasons that the Brideoake (1979) study is outdated.

The third study was that of McLeod (1995) in which the total sheep blowfly cost was $161m, made up of $31m due to production loss and $130m due to the cost of prevention (chemicals and labour). Details for the methodology are limited, but the study appeared to provide comprehensive assessment of the cost of blowfly strike. However, it needs to be brought up to date to reflect the issues discussed above.

One of the limitations of each of the three studies reviewed above is that there is no distinction between the three main forms of flystrike. Although there are interactions between the three forms (eg treatment for breech strike will reduce the fly population and hence the potential risk or severity of body strike), each of the three forms of blowfly strike need to be considered separately and an economic estimate prepared for each. These could then be consolidated into one cost for all forms of blowfly strike. Bryant and Watts (1983) estimated that breech strike control and prevention cost $944 for a flock of 1000 ewes in a severe challenge.

4.4.4 Flystrike — modelling

The economic impact of flystrike was modelled for the three main types of flystrike — body, breech and pizzle.

4.4.4.1 Body strike

Sheep production systems were modelled in each zone with ‘typical flocks’ as discussed in the methodology section (Chapter 3). Within each zone it was assumed that there is a range of management strategies to prevent and control flystrike and where information was available, these were based on the published literature. Where information was not available, an estimate was used based on the experience of the authors.

The effects on struck sheep that were incorporated into the model include:

- reduced clean fleece weight
- reduced fibre diameter of fleece
- reduced staple strength of fleece
- increased mortality rate
- reduced fertility
- increased labour cost associated with monitoring for flystrike, treatment of struck sheep and chemical application for prevention of strike
- increased cost of chemicals to treat or prevent strike.

Detailed assumptions for each flock are shown in Appendix 9.

The economic effect of body strike is shown in Table 44–46.

Table 44 Cost of body strike in sheep

Zone	Category	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	**High risk**	2,055,371	1.28	2,630,875
	Medium risk	4,110,743	0.79	3,247,487
	Low risk	10,276,857	0.49	5,035,660
	Prevention	24,664,458	1.28	31,570,506
	Total	41,107,430	1.03	42,484,528
Sheep cereal	**High risk**	699,730	1.19	830,163
	Medium risk	4,548,244	0.92	4,180,989
	Low risk	8,746,622	0.50	4,364,787
	Prevention	20,991,893	1.44	30,170,749
	Total	34,986,489	1.13	39,546,688
Pastoral	**High risk**	1,119,746	1.26	1,406,743
	Medium risk	2,239,493	0.51	1,141,007
	Low risk	13,436,957	–0.13	–1,684,474
	Prevention	5,598,732	1.13	6,335,284
	Total	22,394,928	0.32	7,198,560
Prime lamb	**No Prevention**	4,975,549	1.25	6,222,138
	Prevention	7,463,324	1.06	7,911,294
	Total	12,438,873	1.14	14,133,432
Total		110,927,720		103,363,208

Table 45 National sources of economic loss due to body strike in sheep

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall	9,249,172	33,235,357	42,484,528
Sheep cereal	9,301,957	30,244,731	39,546,688
Pastoral	4,352,543	2,846,017	7,198,560
Prime lamb	6,800,478	7,332,954	14,133,432
Total	29,704,150	73,659,059	103,363,208

Table 46 Per-head sources of economic loss due to body strike in sheep

Zone	Reduced income ($)	Increased expenses ($)				Total ($)
		Jetting	**Labour**	**Dipping**	**Other**	
High rainfall	0.23	0.69	0.10	0.05	–0.03	1.03
Sheep cereal	0.27	0.75	0.11	0.06	–0.05	1.13
Pastoral	0.19	0.34	–	0.03	–0.24	0.32
Prime lamb	0.55	0.43	0.15	0.04	–0.03	1.14

4.4.4.2 Breech strike

The same sheep production systems were modelled as for body strike. Effects included those as described above as well as:

- the cost of mulesing at the contract marginal rate of 33¢ per head (excludes the cost of the lamb marking component)
- half the cost of crutching, assuming that crutching would still be required for clip preparation purposes.

Detailed assumptions are shown in Appendix 9. The economic effect of breech strike is shown in Table 47–49.

Table 47 Cost of breech strike in sheep

Zone	Category	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	**High risk**	2,055,371	1.60	3,288,594
	Medium risk	6,166,114	1.11	6,844,387
	Low risk	8,221,486	0.98	8,057,056
	Prevention	24,664,458	1.56	38,476,554
	Total	41,107,430	1.38	56,666,592
Sheep cereal	**Medium risk**	5,247,973	1.29	6,751,798
	Low risk	8,746,622	1.12	9,796,217
	Prevention	20,991,893	1.69	35,539,179
	Total	34,986,489	1.49	52,087,194
Pastoral	**Medium risk**	4,478,986	0.94	4,198,279
	Low risk	13,436,957	0.76	10,148,160
	Prevention	4,478,986	1.50	6,724,317
	Total	22,394,928	0.94	21,070,757
Prime lamb	**No prevention**	6,219,437	1.61	10,030,157
	Prevention	6,219,437	1.13	7,042,195
	Total	12,438,873	1.37	17,072,352
Total		110,927,720		146,896,895

Table 48 National sources of loss due to breech strike in sheep

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall	8,015,949	48,650,643	56,666,592
Sheep cereal	5,630,870	46,456,324	52,087,194
Pastoral	3,912,671	17,158,086	21,070,757
Prime lamb	7,897,287	9,175,066	17,072,352
Total	25,456,776	121,440,119	146,896,895

Table 49 Per head sources of loss due to breech strike in sheep

Zone	Reduced income ($)	Increased expenses ($)				Total ($)
		Crutching	Jetting	Mark/mules	Other	
High rainfall	0.20	0.58	0.41	0.10	0.10	1.38
Sheep cereal	0.16	0.63	0.44	0.14	0.12	1.49
Pastoral	0.17	0.68	0.16	0.17	–0.25	0.94
Prime lamb	0.63	0.36	0.21	–	0.17	1.37

4.4.4.3 Pizzle strike

Modelling was done using the same sheep production systems as above with detailed assumptions shown in Appendix 9. The same factors as for body strike were included but with the addition of half the cost of ringing (full marginal cost 20¢ per head), assuming that ringing confers benefits to clip preparation.

The economic effect of pizzle strike is shown in Tables 50–52.

Table 50 Cost of pizzle strike in sheep

Zone	Category	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	**High risk**	16,442,972	0.68	11,221,239
	Medium risk	16,442,972	0.41	6,757,933
	Low risk	8,221,486	0.21	1,696,722
	Total	41,107,430	0.48	19,675,894
Sheep cereal	**High risk**	13,994,596	0.41	5,767,985
	Medium risk	13,994,596	0.26	3,708,167
	Low risk	6,997,298	0.11	735,840
	Total	34,986,489	0.29	10,211,992
Total		76,093,919		29,887,886

Table 51 National sources of loss due to pizzle strike in sheep

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall	17,980,911	1,694,983	19,675,894
Sheep cereal	9,567,834	644,158	10,211,992
Pastoral	–	–	–
Prime lamb	–	–	–
Total	27,548,745	2,339,141	29,887,886

Table 52 Per-head sources of economic loss due to pizzle strike in sheep

Zone	Reduced income ($)	Increased expenses ($)				Total ($)
		Shearing	Dipping	Crutching	Other	
High rainfall	0.44	–0.04	0.06	0.05	–0.02	0.48
Sheep cereal	0.27	–0.03	0.04	0.04	–0.03	0.29
Pastoral	–	–	–	–	–	–
Prime lamb	–	–	–	–	–	–

4.4.4.4 Total cost of flystrike

The national cost of all forms of flystrike in sheep (excluding poll strike and wound strikes both of which are considered to be of minor significance) is shown in Table 53.

Table 53 National cost of all forms of flystrike in sheep

	High rainfall ($)	Sheep cereal ($)	Pastoral ($)	Prime lamb ($)	Total ($)
Income	35,246,031	24,500,661	8,265,213	14,697,765	82,709,670
Expenses	83,580,983	77,345,214	20,004,103	16,508,020	197,438,319
Total	118,827,014	101,845,874	28,269,316	31,205,785	280,147,990

This study found that all forms of flystrike result in a loss of $280m to the Australian sheep industry. This loss consisted of $83m decrease in income and $197m increase in expenses. Of all these forms of flystrike, breech strike represented the greatest loss ($147m) followed by body strike ($103m) and then pizzle strike ($30m).

Even after adjusting for inflation, this study estimated larger losses than that of McLeod (1995). This is in spite of the reduced flock size in this study. Therefore, this study found a substantially higher per-head cost for flystrike, possibly due to more detailed modelling of the impact of production losses and expenses associated with the management of flystrike.

4.4.5 Post-weaning mortality — literature review

Causes of post-weaning mortality include intestinal nematodiasis, flystrike and yersiniosis, which are discussed separately. Another major cause or contributing factor that the expert panel considered sufficiently important to examine was under-nutrition. While not strictly a ‘disease’, it is a major cause of loss of young sheep, particularly Merinos, and is readily preventable in many cases.

Campbell (2004) reported the results of a study conducted in western Victoria. Mortality rates from weaning to 12 months of age ranged from 8% to 27%. The probability of death before 12 months was significantly related to bodyweight at weaning.

We are not aware of any previously published economic analysis of the cost of weaner mortalities.

4.4.6 Post-weaning mortality — modelling

Post-weaning mortality is a syndrome rather than a disease. However, it does result in substantial losses in many flocks. In many situations it is likely to be a combination of nutritional and disease factors, particularly gastrointestinal parasitism, flystrike and yersiniosis. Therefore, it should not be considered in addition to other diseases that cause mortality in weaner sheep. Modelling assumptions included:

- 10% mortality in high rainfall zone
- 8% mortality in both sheep cereal and pastoral zones.

Prime lambs are not included, as it is assumed that the majority of lambs are turned off at weaning or soon after and also because post-weaning mortality is of much lesser importance in prime lamb flocks than Merino flocks. The economic effect of post-weaning mortality is shown in Tables 54–56.

Table 54 Cost of post-weaning mortality in sheep

Zone	**Total Number at Risk**	**Cost per head ($)**	**Total Cost ($)**
High Rainfall	41,107,430	0.81	33,457,165
Sheep cereal	34,986,489	0.52	18,169,208
Pastoral	22,394,928	1.08	24,186,522
Total	98,488,847		75,812,895

Table 55 Economic effect of post-weaning mortality in sheep

Zone	**Reduced Income ($)**	**Increased expenses ($)**	**Total Cost ($)**
High Rainfall	49,119,724	-15,662,558	33,457,165
Sheep cereal	32,516,305	-14,347,097	18,169,208
Pastoral	31,128,950	-6,942,428	24,186,522
Total	112,764,979	-36,952,083	75,812,895

Table 56 Per-head sources of economic loss due to post-weaning mortality in sheep

Zone	**Reduced Income ($)**	**Increased Expenses ($)**				**Total ($)**
		Shearing	**Crutching**	**Dipping**	**Other**	
High Rainfall	1.19	-0.14	-0.03	-0.01	-0.19	0.81
Sheep cereal	0.93	-0.15	-0.03	-0.01	-0.21	0.52
Pastoral	1.39	-0.18	-0.04	-0.01	-0.07	1.08

The reasons for the differences between zones relate primarily to flock structure; the high rainfall zone has a smaller proportion of ewes (and therefore weaners) in the flock. The sheep cereal and pastoral flocks are ewe dominant, and sell wethers and weaners, respectively. Post-weaning mortality in pastoral flocks is restricted to the ewe portion of the flock because the wether portion is sold at weaning.

This is the first estimate of the cost of post-weaning mortality in the Australian sheep industry. The cost is substantial and greater than many other common diseases in the industry. It is important when considering these results that the cost estimate is for all post-weaning mortality. It does not automatically follow that 100% of this loss can be prevented. The most likely scenario is that there will be diminishing returns from investment in reducing post-weaning mortality. A portion of the losses could be presented with relatively low investment, but prevention of subsequent losses will require greater investment and at some point prevention of further losses will reduce flock profitability.

4.4.7 Lice — literature review

The last comprehensive estimate of the cost of lice was by McLeod in 1995. This study found that the cost of sheep lice totalled $169m, of which $114m was due to the cost of control and prevention and $55m was due to production loss. Adjusted to 2005 dollars these equate to $144m and $69m, respectively, for a total cost of $213m, based on changes in treatment strategies, prevalence of lice infestations or changes in national flock demographics. There are several areas that may limit the value of this study to the current sheep industry:

- There is no indication of how production losses were estimated and whether they were based on surveys of infestations. Additional information has since become available on the prevalence of lice infestations (James and Riley 2004).
- Treatment strategies have been changing as resistance to synthetic pyrethroids has increased, resulting in greater emphasis on insect growth regulator products.
- The national flock has shrunk since 1995 and the structure of the flock has changed, with fewer wethers, more ewes and a greater emphasis on the production of meat. The distribution of the flock has also changed, most notably in Queensland, where sheep numbers have declined rapidly.
- Prices for outputs of wool and meat have changed in both nominal and real terms.

Before the study of McLeod (1995), Beck et al (1985) estimated the total cost of lice to be an average of $457and $490 per farm in 1985 dollars, all of which was associated with treatment and prevention cost because it was assumed that there was no production loss due to lice. This assumption would have resulted in the cost of lice being underestimated. This study was based on 1985 prices for inputs (labour, chemicals for control and prevention, etc) and outputs (meat and wool) as well as 1980–81 livestock numbers.

4.4.8 Lice — modelling

The estimates for the cost of lice were based on the following key assumptions.

- Production losses were assumed to be for fleece weight and fleece value only. It was assumed that there was no effect of lice on either liveweight or fibre diameter.
- Current national flock prevalence data is not available. The most recent data are from South Australia and much of the other data are from surveys conducted 10–15 years ago. Given the widespread use of backline insect growth regulator-based products in the last 10 years, some of the assumptions may not accurately reflect the situation in 2006.
- The cost of treatment was calculated as the cost of the chemical plus an allowance for application at the contract rate.
- An allowance was made for labour to monitor sheep as part of management of a lice infestation and in the case of lice not being present. An allowance was also made for

monitoring fences and at-risk mobs. The full cost of maintaining fences was not included because such maintenance is required to manage a range of diseases and livestock species, as well as pest control.

Further detail is provided in Appendix 10.

Flocks were classified into one of six categories for each of the production zones and for prime lamb flocks. The categories were:

- severe lice infestation
- moderate lice infestation
- mild lice infestation
- controlled infestation; that is, lice are present but at low levels that result in minimal production loss
- lice not present but the flock undergoes a regular treatment program because of the risk of lice (eg from neighbouring flocks) or because of uncertainty about the success of a previous eradication program
- lice not present and no regular treatment undertaken other than biosecurity measures.

The proportion of flocks in each category and the effect on production are detailed in Appendix 10. The economic effect of lice infestation is shown in Tables 57–59.

Table 57 Estimated cost of lice in sheep by production zone

Zone	Category	No. sheep	Cost per head ($)	Total cost ($)
High rainfall	**Severe**	411,074	7.14	2,936,547
	Moderate	2,055,371	4.55	9,358,413
	Light	2,877,520	2.32	6,685,395
	Controlled	2,877,520	1.54	4,426,761
	Nil plus annual control	16,442,972	1.02	16,839,645
	Nil, no control	16,442,972	0.14	2,332,085
Total cost, high rainfall				**42,578,845**
Sheep cereal	**Severe**	349,865	5.40	1,888,732
	Moderate	1,749,324	3.97	6,947,476
	Light	2,449,054	2.10	5,154,630
	Controlled	2,449,054	1.39	3,404,864
	Nil plus annual control	20,642,029	0.88	18,250,123
	Nil, no control	7,347,163	0.14	1,032,243
Total cost, sheep cereal				**36,678,068**
Pastoral	**Severe**	671,848	5.46	3,670,263
	Moderate	1,791,594	4.03	7,217,106
	Light	2,239,493	2.15	4,822,283
	Controlled	2,015,543	1.44	2,892,522
	Nil plus annual control	14,780,652	0.92	13,614,809
	Nil, no control	895,797	0.14	123,778
Total cost, pastoral				**32,340,761**
Prime lamb	**Severe**	124,389	2.45	281,002
	Moderate	621,944	1.90	1,057,645
	Light	1,741,442	1.52	2,278,854
	Controlled	–	–	–
	Nil plus annual control	6,219,437	1.30	6,754,808
	Nil, no control	3,731,662	0.22	691,683
Total cost, prime lamb				**11,063,992**
Total national cost				**122,661,667**

Table 58 **National effect of lice in sheep on income and expenses**

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall	15,098,237	27,480,608	42,578,845
Sheep cereal	10,891,875	25,786,194	36,678,069
Pastoral	12,062,468	20,278,293	32,340,761
Prime lamb	912,381	10,151,612	11,063,993
Total	38,964,961	83,696,706	122,661,667

Table 59 **Per-head effect of lice in sheep on income and expenses**

Zone	Income ($)	Expenses ($)			Total ($)
		Dipping	Labour	Other	
High rainfall	0.37	0.41	0.26	–	1.04
Sheep cereal	0.31	0.59	0.15	–	1.05
Pastoral	0.54	0.75	0.16	–	1.44
Prime lamb	0.07	0.29	0.52	–	0.89

These estimates are lower than those made previously for two main reasons:

- the size of the national flock is lower
- the introduction of insect growth regulator-based products may have reduced the prevalence of lice as well as the severity of infestations and associated fleece damage.

Of the $123m estimated cost, $84m (68%) is associated with increased costs due to lice infestations. The costs are predominantly associated with chemicals and labour for treatment, as well as for labour for general management associated with lice such as monitoring and fence maintenance. The remaining $39m (32%) of the cost is due to reduced income as a result of a combination of reduced wool quality and quantity.

4.4.9 Perennial ryegrass toxicity

The cost of perennial ryegrass toxicity has been modelled as part of a separate MLA project (AHW 089) (Sackett and Francis 2006). This project used the same principles and methodology, including models and input assumptions, as were used for other diseases analysed in this report. The project estimated that perennial ryegrass toxicity cost the Australian sheep industry an average of $63.3m per year.

4.4.10 Peri-natal mortality — literature review

Peri-natal lamb mortality is defined as death occurring in the first week after birth, and accounts for 15–33% of all the lambs born in Australia (Dennis 1974, Kleeman et al 1991, Kilgour 1992). No economic analysis of the value of these losses has been undertaken. The survey of Kimbal and Curtis (2005) found that ewes made up 67% of the national flock. Assuming a total national flock of 105 million, and an average conception rate of 120%, total annual lamb losses range from 13 to 28 million. This represents a major loss to the industry and also could be perceived as an animal welfare issue. However, it is unrealistic to assume that intervention at any level will prevent all the losses, and any economic analysis needs to consider what proportion of the losses are preventable with varying degrees of intervention.

4.4.11 Peri-natal mortality — modelling

Peri-natal mortality is commonly in the range of 20 to 40% in Merino flocks and 10 to 20% in prime lamb flocks. The causes of the deaths include dystocia, starvation, mismothering, exposure and, less commonly, infectious diseases.

As it is difficult to attribute mortalities to each of the specific causes, an approach was taken whereby the cost of several mortality rates was determined. This then provides a basis for determining how much can be spent to prevent peri-natal mortality.

The modelling included:

- the effect of lamb survival on ewe selection and subsequent productivity
- the effect of pregnancy on wool production
- the effect on sales strategy for the flock.

The results from the modelling of a 10% and a 20% increase in lamb survival are shown in Table 60–66.

Table 60 Economic impact of increase in lamb survival by 10% and 20%

Category	Increased income ($)	Increased expenses ($)	Total ($)
Increase lamb survival by 10%	117,353,014	60,730,356	56,622,657
Increase lamb survival by 20%	223,511,432	105,424,331	118,087,102

Table 61 Cost of peri-natal mortality (lamb survival increased by 10%)

Zone	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	47,234,031	0.28	13,034,692
Sheep cereal	39,507,436	0.42	16,606,491
Pastoral	24,186,253	1.12	26,981,475
Total	110,927,720		56,622,658

Table 62 Cost of peri-natal mortality (lamb survival increased by 20%)

Zone	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	47,234,031	0.78	36,675,732
Sheep cereal	39,507,436	0.92	36,223,558
Pastoral	24,186,253	1.87	45,187,812
Total	110,927,720		118,087,102

Table 63 **National sources of economic loss due to peri-natal mortality (lamb survival increased by 10%)**

Zone	Increased income ($)	Increased expenses ($)	Total ($)
High rainfall	38,315,985	25,281,294	13,034,692
Sheep cereal	42,929,109	26,322,617	16,606,492
Pastoral	36,107,920	9,126,445	26,981,475
Total	117,353,014	60,730,356	56,622,658

Table 64 **National sources of economic loss due to peri-natal mortality (lamb survival by increased 20%)**

Zone	Increased income ($)	Increased expenses ($)	Total ($)
High rainfall	78,714,799	42,039,067	36,675,732
Sheep cereal	81,685,126	45,461,567	36,223,558
Pastoral	63,111,508	17,923,697	45,187,812
Total	223,511,433	105,424,331	118,087,102

Table 65 **Per-head sources of economic loss due to peri-natal mortality (lamb survival increased by 10%)**

Zone	Increased income ($)	Increased expenses ($)				Total ($)
		Shearing	Supplement	Labour	Other	
High rainfall	0.81	0.14	0.09	0.18	0.13	0.28
Sheep cereal	1.09	0.19	0.13	0.18	0.17	0.42
Pastoral	1.49	0.22	–	–	0.16	1.12

Table 66 **Per-head sources of economic loss due to peri-natal mortality (lamb survival increased by 20%)**

Zone	Increased income ($)	Increased expenses ($)				Total ($)
		Shearing	Supplement	Labour	Other	
High rainfall	1.67	0.27	0.18	0.18	0.26	0.78
Sheep cereal	2.07	0.37	0.25	0.18	0.35	0.92
Pastoral	2.61	0.44	–	–	0.30	1.87

The results of this modelling show there are substantial returns from reducing peri-natal lamb mortality. However, this modelling is simplistic in that it allowed for the additional costs associated with the management of the additional lambs, but does not include the cost of implementing strategies to achieve the survival of the additional lambs. Some of these strategies may be low cost and provide substantial returns, while others may well cost more to implement than the value of the increased production. This needs to be kept in mind when interpreting these findings.

4.4.12 Bacterial enteritis — modelling

This is considered a syndrome rather than a specific disease. It occurs in weaner Merino sheep, possibly associated with *Yersinia* in winter, but also occurs in summer with the aetiology not determined. Another commonly used description for the syndrome is ‘sulfa responsive scours’.

The major assumptions for bacterial enteritis were as follows:

- Only weaner sheep are affected in an outbreak, with 50% of weaners affected. In affected mobs, 10% of weaners are severely affected and 40% mildly affected (B Allworth Allworth Sheep and Cattle Production Services, pers comm, 2006).
- 50% of flocks in the high rainfall zone are affected.
- Affected sheep are treated once only with sulfadimidine and severely affected sheep suffer substantial production loss, increased mortalities and require additional management and supplementary feed to recover.

Detailed assumptions are provided in Appendix 11.

The estimated cost of bacterial enteritis is shown in Table 67–70. This cost is at best an estimate because of the lack of information on prevalence and production effects. However, it does provide an indication of the cost of the syndrome to the sheep industry, though the estimate may include a number of different diseases.

Table 67 Cost of bacterial enteritis — all sheep flocks

Number of sheep at risk	Cost per head ($)	Total cost ($)
36,857,058	0.80	29,479,256

Table 68 National sources of economic loss due to bacterial enteritis — all sheep flocks

Reduced income ($)	Increased expenses ($)				Total ($)
	Crutching	Supplement	Drenching	Other	
23,248,783	2,005,046	2,832,173	1,671,599	–278,345	29,479,256

Table 69 Per-head sources of economic loss due to bacterial enteritis — all sheep flocks

Reduced income ($)	Increased expenses ($)				Total ($)
	Crutching	Supplement	Drenching	Other	
0.63	0.05	0.08	0.05	–0.01	0.80

Table 70 National sources of economic loss due to bacterial enteritis — all sheep flocks

Reduced income ($)	Increased expenses ($)	Total ($)
23,248,783	6,230,473	29,479,256

4.4.13 Arthritis — literature review

There have been no estimates of the economic impact of arthritis on the Australian sheep industry. Farquarhson (1990) calculated an economic loss of $8,500 in one severely affected flock but the calculations are limited in that there are no indications of the effect on flock gross margins or profitability. New South Wales Agriculture Regional Veterinary Laboratory records showed a morbidity rate of 3.1% and a mortality rate of 1.3% in flocks where arthritis was investigated during 1998 and 1999 (Farquarhson 1990). Paton et al (2003) estimated the cost of arthritis to the meat processing sector to be $5 per head in 1997 with an estimated prevalence of 1% of lambs slaughtered diagnosed with arthritis (Paton 1994). In addition 1.4% of lambs were culled on-farm due to arthritis. The combined cost of these to the Western Australian lamb industry was estimated to be over $1m in 1997.

4.4.14 Arthritis — modelling

The cost of arthritis (see Tables 71–72) was based on two key assumptions:

- 1% of lambs slaughtered have arthritis detected and this cost an average of $5 in 1997 due to reduced carcase value. This is based on Western Australian data (Paton et al 2003) but is all that is available so is used as a basis for national assumptions. The loss is adjusted to a percentage reduction in carcase value then applied to the 10-year average prices used in all the modelling.
- An additional 1% of lambs are culled on-farm due to arthritis and these are assumed to have no commercial value (Farquharson 1990, Paton et al 2003).

Table 71 Cost of arthritis in sheep

Category	Number of sheep at risk	Cost per head ($)	Total cost ($)
Merino	98,484,350	0.18	17,209,926
Prime lamb	12,438,873	0.57	7,100,335
Total	110,923,223		24,310,261

The majority of the losses are incurred on-farm because these animals have no commercial value, whereas those that are detected at slaughter have on average a 13% reduction in carcase value.

Table 72 Estimated national cost of arthritis in sheep

Category	Cost ($)
Reduced income (on-farm)	24,310,261
Slaughter losses	1,643,502
Farm expenses	–
Total	25,953,763

Extending the findings of Paton et al (2003) findings to the national flock gives an estimated cost of arthritis of $30m, the majority of which occurs on-farm rather than in the processing sector. Affected animals on-farm are assumed to have no value, primarily because they die or are euthanased. Affected lambs that have any residual value are accounted for in the slaughter numbers and in most cases the cost is only partial carcase loss, not loss of the whole animal as for on-farm arthritis cases.

The incidence of arthritis may change if there are changes to the number of sheep mulesed or if the method of mulesing is changed, and as a consequence the risk of arthritis is reduced. The alternative methods of mulesing that are currently being researched, are likely to reduce the incidence of arthritis due to an expected reduction in infection, if an open wound does not result from the alternative procedures.

4.4.15 Footrot — literature review

The fact that virulent footrot (VFR) causes severe lameness and that lameness in grazing sheep will inevitably reduce feed intake and therefore productivity, has been recognised since the earliest reports (Mohler and Washburn 1904, Gregory 1939, Beveridge 1941). Beveridge (1941) also noted the effect of footrot on bodyweight, wool quality and fleece weight, and reproduction, without estimating the degree of losses.

There are no published studies of the effect of natural outbreaks of VFR on the productivity of Merino sheep. The limited studies that have been performed have been done in pens and small plots with single isolates introduced artificially. The one published report on a large field trial (Marshall et al 1991) was also based on the introduction of one isolate of a virulent strain of *Dichelobacter nodosa*. The effect of footrot was estimated by comparing bodyweights and wool weights of untreated sheep with those of sheep treated by footbathing at frequent intervals during transmission periods.

VFR reduces the rate of bodyweight gain, increases the loss of bodyweight or leads to the maintenance of lower bodyweights in affected sheep compared to uninfected sheep. (Hunt 1958 Littlejohn 1964; Symons 1978; Stewart et al 1984, 1986; Marshall et al 1991).

Attempts have been made to measure the effects on production of benign footrot (Glynn 1993) and intermediate footrot (Cummins et al 1991, Glynn 1993, Abbott 2000) in natural outbreaks. Stewart et al (1986) reported two pen experiments demonstrating the different effects on production of infection with benign, intermediate and virulent strains.

Foot lesions caused by infection with VFR reduce the wool production of sheep (Symons 1978, Stewart et al 1984, Marshall et al 1991). Infection with less virulent strains of *D. nodosa* causes less severe effects on wool weight and bodyweight than virulent strains (Stewart et al 1984, 1986; Cummins et al 1991; Glynn 1993; Abbott 2000).

Roycroft (1986) records the occurrence of pregnancy toxaemia in ewes as a consequence of benign footrot infection.

Carmody (1981) carried out an economic evaluation of footrot control in the New England Protected Area and estimated benefit:cost ratios for the previous and future programs. There are no current estimates of the costs of footrot on a national basis. Allworth (1990, 1994) has estimated the cost per head of footrot infection in a Merino flock. Dobson (1986), without providing specific estimates of the effects of intermediate footrot, records that the economic motivation to eradicate it is almost non-existent.

The information necessary to evaluate the impact of footrot in an infected flock is largely available. The published information on the effect of footrot on liveweight, wool production and the indirect costs of footrot in a flock remain applicable. It is probably reasonable to infer the effect of footrot on reproductive rate by considering its effect on the liveweight of ewes.

There is, however, a lack of accurate information about the prevalence of infected flocks. There are no recent surveys of flock prevalence and, even if there were, it is likely that the true prevalence would be under-estimated due to the effects of the widespread drought in eastern Australia in 2001–2004. Estimates are available from authorities in each of the mainland states on the prevalence of VFR, but the estimates are often indicative only, not based on surveillance.

4.4.16 Footrot — modelling

The modelling was done using prevalence data provided by New South Wales Department of Primary Industries, South Australian Research and Development Institute, Department of Agriculture Western Australia, Paul Nilon (private vet, Tasmania) and John Larsen, the Mackinnon Project, University of Melbourne. The varying quality, and in some cases absence of data on footrot prevalence is a major limitation to the modelling.

Scenario 1: Footrot introduced into an uninfected flock and eradication undertaken

In this scenario, the disease has a severe impact when introduced, infecting 80% of the flock and causing marked reduction in fleece production, increased mortality rate in all age groups of sheep and reduced average liveweight in all age groups. In the following year, this leads to increased rates of supplementation of weaners and reduced reproductive rates in ewes.

In the first year post-infection, control strategies including vaccination and foot-bathing are put into effect. A proportion of infected sheep are culled, requiring adjustments to the flock structure to maintain numbers.

In the second year post-infection, a successful eradication program is put in place. Again, a proportion of sheep are culled due to footrot, and adjustments to flock structure are necessary.

In the third, fourth and fifth years post-infection, continuing adjustments gradually return the flock to its most profitable structure.

Flocks that are in quarantine for footrot are considered to be in one of four categories with respect to years since footrot was introduced — either in the first year of infection or the first, second or third year post-infection. It is assumed that 25% of quarantined flocks are in each category. The cost of footrot to a producer in any one year is the cost in the current year plus the discounted cost of footrot over the subsequent two, three, four or five years before the flock structure, income and expenditure return to normal. The average cost of footrot for producers in quarantine, therefore, is the average cost of footrot for producers in all categories.

Scenario 2: Footrot endemic and an annual control program undertaken

In this scenario, the owners of flocks in which footrot is endemic are assumed to take measures to limit the effect of the disease. These measures include vaccination and footbathing on six occasions (high rainfall Merinos) or three occasions (sheep cereal and prime lamb flocks). Some labour is expended on treatment of individual sheep with footrot or the consequences of footrot, such as flystrike. The control measures are assumed to be moderately effective, reducing the prevalence of infection from 80% to 10% in uncontrolled flocks in the high rainfall zones, and in the sheep cereal zones from 60% (uncontrolled) to 5%.

We have further assumed that a small proportion of the quarantined flocks are 'living with footrot' and we have applied our estimates of the cost of endemic footrot to these flocks.

The full assumptions on flock productivity are shown in Appendix 12.

The economic effect of footrot in sheep is shown in Tables 73–76.

Table 73 **Economic effect of footrot in sheep — introduced**

Zone	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	1,359,606	9.11	12,388,646
Sheep cereal	156,703	9.07	1,421,203
Pastoral	–	–	–
Prime lamb	220,807	8.30	1,832,438
Total	1,737,116		15,642,287

Table 74 **Economic effect of footrot in sheep — endemic**

Zone	Number of sheep at risk	Cost per head ($)	Total cost ($)
High rainfall	640,579	3.54	2,226,501
Sheep cereal	74,809	3.01	225,214
Pastoral	–	–	
Prime lamb	103,562	2.96	306,071
Total	818,950		2,797,786

Table 75 **National effect of footrot in sheep — introduced and endemic**

	Reduced income ($)	Increased expenses ($)	Total ($)
Introduced	4,659,626	10,982,661	15,642,287
Endemic	414,917	2,382,870	2,797,786
Total	5,074,543	13,365,531	18,440,073

Table 76 Per-head sources of economic loss due to footrot in sheep

Category	Reduced income ($)	Increased expenses ($)				Total ($)
		Vaccination	Labour	Supplement	Other	
Introduced						
High rainfall	2.58	3.83	3.36	1.58	–2.24	9.11
Sheep cereal	1.78	4.28	3.78	2.42	–3.19	9.07
Pastoral	–	–	–	–	–	–
Prime lamb	3.96	2.94	2.40	–	–1.01	8.30
Endemic						
High rainfall	0.50	2.20	0.82	0.02	0.01	3.54
Sheep cereal	0.37	2.12	0.55	–	–0.03	3.01
Pastoral	–	–	–	–	–	–
Prime lamb	0.65	1.43	0.37	0.04	0.46	2.96

Comparison with other published estimates

Allworth (1990) estimated the cost of footrot in an infected Merino flock, exercising control over the infection and vaccinating all sheep twice, to be $9.90 per head. This estimate is comparable to the estimate from our model of $7.64 per head in Year 1 post-infection in a high rainfall Merino flock with endemic infection. Allworth (1990) included some indirect costs that we did not include, such as delayed weaning, loss of interest in flock improvement and decrease in stocking rate, as well as the direct cost of two vaccinations, compared with one in our model.

Egerton (1991) estimated the cost of footrot nationally to be between $60m and $100m. Walker (1996) estimated the direct costs of footrot in NSW in 1990 to be $39m but to have declined to be between $9.3m and $13.3m by 1996. Our estimate of $18,440,000 nationally could be considered consistent with these estimates given that the implementation of control measures plus widespread drought during the early 2000s has almost certainly reduced the prevalence of infected flocks (or, at least, the prevalence of known infected flocks) and the incidence of new flock infections or detections. On the other hand, our estimate could be relatively low compared to those other recent estimates, given that our method has included the discounted future cost of footrot in those flocks that are in the first three years of quarantine and will incur additional costs in subsequent years. It is not clear that the other authors have included future costs in their estimates.

Our considered opinion is that our estimate of the cost of footrot is conservative and the true cost is more likely to be higher, rather than lower.

4.4.17 Ovine Johne’s disease — literature review

Losses of productivity associated with ovine Johne’s disease (OJD) infection include an increase in the number of sheep that die or are euthanased because they are not saleable, a reduction in sales income from adult sheep with advanced subclinical infection or early clinical infection, a reduction in wool weight and wool quality in affected animals surviving to shearing and, probably but not yet proven, a reduction in reproductive rates due to increased mortality of lambs born to affected ewes. Bush (2005) estimated the cost of OJD infection due to effects on productivity to be a 6% to 9% decrease in gross margin.

Losses have also been incurred by restrictions on trade, although these have been eased following the introduction of the National Approach to the Management of Ovine Johne's Disease in Australia in July 2004. Hassall and Associates (2003) estimated the total annual cost of OJD to the sheep industry to be $52.7m prior to the easing of regulatory controls in 2004. They assigned 85% of the total to ‘market’ losses and 15% to productivity losses. In exploring options, they estimated the net costs over a 10-year period of a risk-based trading environment, which is now in place, at $177.1m.

While the Hassall and Associates report remains the most recent analysis of the cost of OJD, much new information is now available. In particular, the regulatory environment has changed, new information on effects on productivity have been published (Abbott et al 2004, Bush 2005), the use of vaccine has become more widespread and unrestricted and its effects better understood, and the flock prevalence has increased and is now better known — chiefly through abattoir surveillance.

4.4.18 Ovine Johne’s disease — modelling

The losses from OJD were modelled based on six assumptions:

- OJD-infected flocks are categorised as being either vaccinated or not vaccinated and, if vaccinated, for how many years. The number of years that vaccine has been used affects the death rate and production loss in the flock (see Appendix 13). The cost of vaccine is included in the model in vaccinated flocks.
- A proportion of the OJD infected flocks have not been identified by the owner as infected.
- Infected flocks do not incur any penalty in the value of clinically normal sale sheep. This is not currently the case for many flocks with OJD but the flocks were modelled with this approach to calculate the effects of the disease on production. Therefore, the actual cost of the disease will be greater for some infected flocks and for the industry than predicted by our modelling of production costs alone.
- Vaccination reduces the rate of clinically affected sheep by 90%.
- Sheep in the last six months of clinical OJD (before dying) can be identified by the owner.

OJD prevalence figures were based on data supplied by Animal Health Australia. These figures are of varying quality because of the differences between states in the extent of activities directed toward identifying the presence of OJD in flocks. This will most likely result in an underestimate of the prevalence of OJD in Australia.

In the modelled flocks, shearing occurs in December and all adult sheep that are likely to die in the next six months from OJD are culled. Hence the annual mortality rate from OJD is one half of the annual rate of clinical OJD. Lambing occurs in August and it is expected, therefore, that the ewes that will die between the off-shears sale and the following shearing will fail to rear their lambs — either because they die before the lamb is old enough to survive alone or they are in such poor condition during lactation that they fail to rear a lamb. The impact of ewe deaths on weaning rates is calculated by multiplying the OJD-free weaning rate by the mortality rate per 100 adults.

The ewes that are clinical cases by December (ie those that are about to be culled) rear lambs but some of these lambs have low weaning weights due to the poor lactation of the ewes. The weaners born to those ewes are estimated to have twice the risk of dying before their next shearing compared to weaners from unaffected ewes.

The allocation of flocks to one of six categories is discussed in Appendix 13. In short, infected flocks are in one of the following categories: (1) vaccinated for five years or more, (2) vaccinated for four years, (3) vaccinated for three years, (4) vaccinated for two years, (5) vaccinated for one year, (6) not vaccinated and not diagnosed.

The weighted (by proportion in each category) average loss for sheep across all six categories is calculated for each flock type and zone. The cost of infection for each zone (Tables 77–78) is the product of the number of sheep in each flock type and zone, the estimated prevalence of infected flocks in that zone and the weighted average cost per head.

Table 77 Economic impact of OJD on sheep

Zone	Category	No. sheep	Cost per head ($)	Total cost ($)
High rainfall	**Known infected**	1,650,902	1.36	2,248,506
	Undiagnosed	272,169	0.58	158,854
Total cost, high rainfall		1,923,072		2,407,360
Sheep cereal	**Known infected**	749,081	1.68	1,257,720
	Undiagnosed	131,915	0.62	82,039
Total cost, sheep cereal		880,995		1,339,759
Pastoral	**Known infected**	66,004	1.42	93,773
	Undiagnosed	12,928	0.58	7,466
Total cost, pastoral		78,932		101,239
Prime lamb	**Known infected**	349,895	1.50	524,042
	Undiagnosed	59,774	0.65	39,049
Total cost, prime lamb		409,669		563,091
Total national cost				4,411,450

Table 78 National cost of OJD on sheep — all areas

Zone	Reduced income ($)	Increased expenses ($)	Total ($)
High rainfall	1,509,760	897,600	2,407,360
Sheep cereal	786,580	553,180	1,339,759
Pastoral	40,314	60,925	101,239
Prime lamb	229,656	333,435	563,091
Total	2,566,310	1,845,140	4,411,450

Most other estimates of the economic impact of OJD in flocks have been based on infected flocks that are not vaccinated. One recent estimate is $7.68 per dry sheep equivalent, based on a study of 12 OJD-infected flocks (Bush 2005). This estimate is similar to estimates we made in the course of modelling (results not shown) for unvaccinated flocks. We found the cost of OJD in a vaccinated fine-wool Merino flock in the high rainfall zone to be $1.16 per head or $2,700 in a 1,000-ewe flock.

An Australian Bureau of Agricultural and Resource Economics report to Agriculture Fisheries and Forestry Australia (Topp and Bailey 2001) estimated the cost to New South Wales wool-producing farms of OJD causing 10% mortalities would be $5,540 per year. The cost if mortalities were 1% would be $540 and the cost of vaccination on each farm to be $1,290 per year. From this, one could infer the cost each year of 1% mortalities plus vaccination to be $1,830 per farm.

Our total estimated national annual cost of OJD through lost productivity and additional on-farm costs is $4.4m. We believe this to be the first estimate of the cost of OJD for the national flock now that vaccination is widely available and practised. This cost does not take into account the costs associated with regulation which the Hassall and Associates report (2003) estimated to be $45m, while the production loss was estimated to result in losses of $8m per year.

4.4.19 *Phalaris* toxicity — literature review

Three plant poisons were considered of sufficient economic significance by the working group to be further investigated: *Phalaris*, perennial ryegrass toxicity and annual ryegrass toxicity. *Phalaris* is discussed in this section. Perennial ryegrass toxicity has been reviewed and economic assessment provided in a separate report (Sackett and Francis 2006). Annual ryegrass toxicity was not modelled because new estimates would not have provided any additional information to that which currently exists (Allen 2002).

Most reports of *Phalaris* toxicity (both sudden death and nervous forms) are case reports of severe or unusual outbreaks (eg Moore et al 1961, Bourke et al 1987). No economic analysis of the diseases could be found and a major limitation of any economic analysis would be the lack of data on prevalence in both the sheep and cattle populations. Data are lacking at the flock level over time (what proportion of and classes of stock are affected, and variation in prevalence from year to year) and at the regional or district level (proportion of flocks affected and between-year prevalence).

These limitations will make any economic analysis speculative rather than rigorous but ‘best guesses’ based on the experience of the authors and others working in the field could be used to generate a range of estimates.

4.4.20 *Phalaris* toxicity — modelling

There is a lack of data on incidence of outbreaks of *Phalaris* toxicity which limits the value of estimates of the economic loss. Likewise, reliable estimates of the proportion of sheep affected in outbreaks are not available.

Given these limitations, modelling was used to estimate the cost of *Phalaris* toxicity (see Tables 79–81). Increased deaths associated with the two forms (acute and nervous) were not considered separately, but rather as one disease that results in increased mortalities.

Assumptions for modelling include that:

- dead sheep are replaced by additional sheep of the same class (ewe or wether) to maintain flock numbers at the steady state level

- no cost is incurred in prevention or treatment of *Phalaris* toxicity outbreaks; this may underestimate the cost because of the potential cost of grazing management strategies and use of cobalt bullets (no data were available on either of these).

Table 79 Estimated cost of *Phalaris* toxicity with varying severity and classes of sheep at risk

Class of sheep at risk	Mortality rate in hit year (%)	Average cost per head in flock ($)
Weaners	2	0.13
Weaners	5	0.36
Whole flock	1	0.55
Whole flock	2	1.00
Whole flock	5	1.51

Table 80 Total number of sheep at risk from *Phalaris* toxicity

Class of sheep at risk	Number of sheep
Weaners	2,551,484
Adults	8,005,249
Total	10,556,733

Table 81 Estimated national cost of *Phalaris* toxicity at a frequency of 1 year in 20*

Class and mortality rate	Total cost ($)
Weaners 2%	16,585
Weaners 5%	45,927
Whole flock 1%	290,310
Whole flock 2%	527,837
Whole flock 5%	797,033
Total	1,677,691

*Some *Phalaris* toxicity occurs 1 year in 4, but classes of stock and severity vary

Compared to many other endemic diseases, *Phalaris* toxicity is estimated to have a low cost of $1.7m. It is likely that a greater cost of this disease, which was not modelled, is the cost for farmers of deciding not to sow *Phalaris* pastures because of their concern about *Phalaris* toxicity.

5 Success in Achieving Objectives

The first objective of holding an expert workshop was to identify the major economic diseases, identify key information that may not have been in the public domain, and identify key issues that should be addressed if the modelling work was successful. The workshop provided valuable national and regional expertise on disease prevalence, productivity effects and management implications, as well as expertise in specific diseases.

The second objective, the literature review, was successfully completed. The quantity and quality of literature available for the economic impact of each disease varied widely. Some diseases such as internal parasitism (sheep and cattle) had a reasonable body of previous work that primarily needed updating to reflect current demographics, enterprises, control and prevention strategies, commodity prices and input expenses. Other diseases had little or no previous work done to estimate the cost of the disease to the national industry.

The third objective, to model the diseases of major economic importance, was completed for most of the important diseases. This provided an estimate based on the same methodology for each disease, including prices and current demographics, which enabled the results to be directly comparable in terms of financial impact on the industry. In some cases, the modelling required substantial assumptions, for example disease prevalence and management practices, because no current information was available. In these cases, assumptions were based on a combination of author experience, most recent data and opinion of experts. These assumptions are reported to provide transparency for readers and, if required, some can be varied relatively easily and the cost of the disease adjusted. In some cases, the modelling could not be undertaken because there was simply inadequate data on key inputs such as prevalence or production effects. In these cases modelling was deemed to be of very limited value because the lack of certainty about the inputs. Examples of such diseases included annual ryegrass toxicity in sheep and pestivirus in beef cattle. If additional information becomes available on these diseases it would be possible to model their economic impacts using the same principles as were used for the diseases analysed in this project.

6 Impact on Meat and Livestock Industry — now and in five years

There are a number of implications of these results for the industry. This is the first time estimates of the costs of all the major endemic diseases of the sheep and beef cattle industries have been prepared with a consistent methodology. These make the results comparable in terms of industry cost, and provide a basis for identifying where research priorities may lie. However, a disease with a high cost to the industry should not automatically be a priority for research investment. For some diseases, the estimated cost may be substantial, but a large component of that cost may result from inadequate implementation of currently known technology rather than gaps in knowledge. In such cases investment in further research may have a low impact on the cost of the disease.

The cost estimates in this study do not take into account a number of potentially important factors:

- Known or potential zoonotic effects.
- Food safety issues.
- Regulatory issues such as quarantine and its impact on farm businesses, trade between farms and between regions, as well as the direct costs associated with implementing a regulatory policy (eg staff and their support).
- Emerging diseases that may currently have a low cost but whose cost may increase in the future due to increased prevalence or severity. This may be due to a change in the epidemiology of the disease, for example the introduction of a new, more effective vector. Alternatively, a change in the structure of the sheep or beef industries may result in a low-cost disease becoming more important. For example, the development of feedlots for finishing lambs is an emerging trend, and, if it becomes a permanent and substantial feature of the sheep industry as it has for beef, new diseases of economic importance may emerge.
- Animal welfare considerations are a major issue associated with many diseases. In fact, it could be argued that any disease is a welfare issue, but this is especially so when managers of livestock fail to implement known management or prevention strategies that would reduce the adverse welfare consequences of some diseases.
- Some diseases may be perceived to have greater welfare consequences than others, even if the perception is not based on fact. Diseases (or syndromes) that may come into this category include peri-natal lamb mortality and post-weaning mortality, heat stress in cattle feedlots and perennial ryegrass toxicity in both sheep and beef cattle.

Some or all of the above need to be taken into account when determining future research and extension priorities for both the sheep and beef industries.

In a number of cases the economic modelling showed that a disease has a lower cost when strategies are implemented to manage the disease. In other cases, the cost of the control measure exceeds the economic loss of the disease so implementation of a control or management program increases the cost of the disease.

In cases where implementation of control strategies improves returns, a component of the national cost of the disease is due to lack of implementation of available technology, that is adoption failure rather than a lack of knowledge on disease strategies. That portion of the cost of the disease that can be overcome with implementation of current knowledge is shown in Table 82 for cattle and Table 83 for sheep. Diseases where control strategies increased the cost of the disease are shown in Table 84. In these cases the management strategies are a net cost to the industry — in some cases due to inadequate management strategies for the disease and in other cases due to the high cost of implementing the strategy.

Table 82 **Cattle diseases where implementation of available technology would reduce the national cost of the disease**

Disease	Total cost ($)	Estimated cost due to failure to implement known management strategies		Estimated cost due to not being able to control disease using current technology	
		$	%	$	%
Bloat	47,527,736	10,873,298	23	36,654,438	77
Buffalo fly	78,237,710	20,863,389	27	57,374,321	73
Tick fever	26,079,237	8,941,453	34	17,137,784	66
Internal parasites	36,608,711	4,791,068	12	33,827,643	88
Feedlot — BRD	40,704,891	15,689,685	39	25,015,206	61

BRD = bovine respiratory disease

For example, the cost of bloat in a high-risk beef herd that does not implement any control measures is $17.69 per head. By comparison, the cost in the same high-risk herd that implements a prevention strategy, in this case antibloat capsules, is $11.72 per head per year. If producers in high-risk areas adopted the prevention strategy used in the modelling, the national cost of bloat would be reduced by $10.8m per year, a reduction of 23%. Therefore there is a potentially large industry benefit in encouraging producers to implement known technology in the case of bloat.

By comparison, pinkeye in beef cattle (see Table 84) does not have an effective prevention or control option, so a greater proportion of the total industry cost could be reduced by research that identified cost-effective management or prevention strategies. This is not a recommendation for research in this area because the decision of whether to invest in research needs to take into account not only the cost of the disease, but the probability of the research developing effective solutions that will be adopted.

Table 83 **Sheep diseases where implementation of available technology would reduce the national cost of the disease**

Disease	Total cost ($)	Estimated cost due to failure to implement known management strategies		Estimated cost due to not being able to control disease using current technology	
		$	%	$	%
Internal parasites					
High rainfall, summer	22,954,495	6,958,200	30	15,996,295	70
High rainfall, winter	171,698,736	54,827,374	32	116,871,362	68
Sheep cereal	83,897,601	5,178,000	6	78,719,600	94
Prime lamb	90,557,404	38,064,988	42	52,492,417	58
Lice	122,661,667	122,661,667	100	–	–

Table 84 **Diseases where implementation of available technology will increase the national cost of the disease**

Disease	Total cost ($)	Estimated cost due to failure to implement known management strategies		Estimated cost due to not being able to control disease using current technology	
		$	%	$	%
Grass tetany	13,225,304	–2,872,330	–22	16,097,634	122
Pinkeye	23,203,250	–1,751,189	–8	24,954,439	108
Feedlot — heat stress	16,595,055	–3,392,585	–20	19,987,640	120

Similarly, the cost of sheep lice (see Table 83) in a severely affected flock in the high rainfall zone was $7.14 per head per year. However the cost of a controlled infestation in the same flock is only $1.54 per head per year. In most severely infested flocks, the constraints in controlling a lice infestation are not related to lack of industry knowledge on how to control the lice, but more to the attitude and ability of the manager to implement an effective control program. Alarge component of the cost of lice is the routine treatment of uninfected flocks. The cost of lice when there is no infestation and no treatment is undertaken is 14¢ per head per year. However, when treatment is undertaken in the same lice-free flock, the cost is $1.02 per head per year, an additional expense of 88¢ cents per head. In some instances such a treatment may be justified by an event that may have increased the risk of lice so that treatment is undertaken as a means of managing a possible outbreak. However, many sheep that are free of lice and not at high risk of infestation are treated without any need, imposing a major cost on the industry.

7 Conclusions and Recommendations

As a result of the expert workshop, literature review and economic modelling, the current cost of the major endemic diseases in sheep and beef cattle have been determined. The results are summarised in Figures 4 and 5.

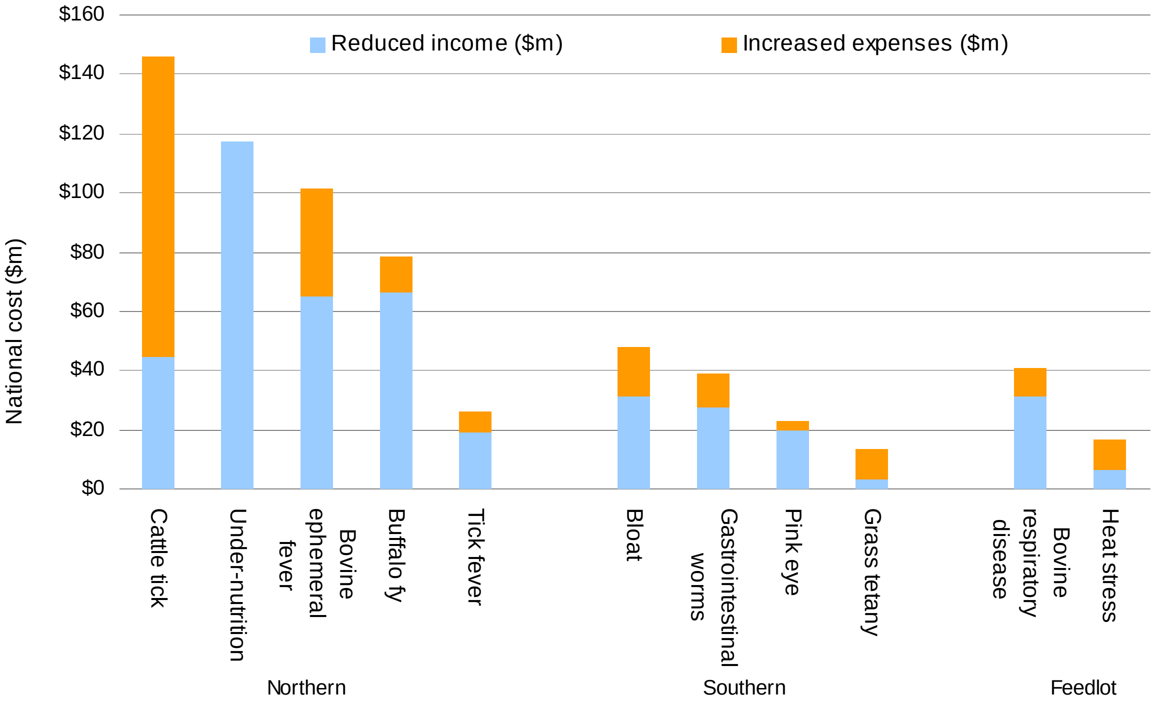

Figure 4 **National cost of diseases to the beef industry**

Note: The cost of peri-natal lamb mortality represents the return to industry for a 10% increase in lamb survival.

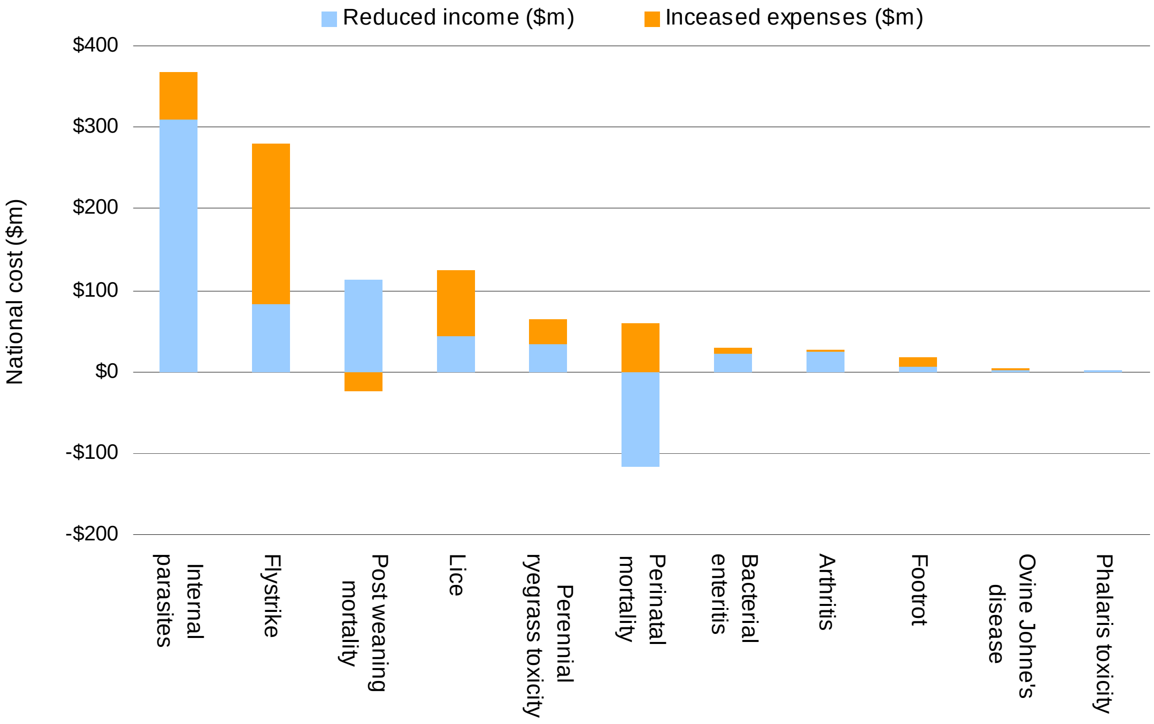

Figure 5 National cost of diseases to the sheep industry

The cost of several potentially important endemic diseases could not be estimated due to a lack of epidemiological and production data or to other new estimates that would not have been substantially different from existing estimates. The former included bovine pestivirus and the latter annual ryegrass toxicity, which was estimated to cost $25.8m in WA in 2002 (Allen 2002).

The cost of a disease was attributed to either failure to implement known technology or absence of cost-effective technology that could manage or prevent the disease. The contribution of each of these varied widely between diseases and provides a basis for determining whether there is a need for extension or research for each of the diseases.

This analysis provides a basis for producers and industry organisations to better prioritise areas for investment in research and extension. However, this process needs to take into account a number of factors that were not included in the cost estimates of the major endemic diseases, specifically:

- known or potential zoonotic effects
- food safety issues
- regulatory issues such as quarantine and its impact
- emerging diseases that may currently have a low cost but whose cost may increase in the future due to increased prevalence or severity
- animal welfare considerations that are a major factor in the management and control of many diseases.

When reviewing research priorities, in addition to all of the above, the probability that research investment will develop cost-effective solutions that will be adopted, needs to be taken into account.

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9 Appendixes

Appendix 1 Workshop participants

Table A1.1 List of workshop participants

Name	Organisation	State	Workshop group
Mark Barber	ACIL Tasman	ACT	Southern beef
David Sackett	Holmes Sackett & Associates	NSW	Sheep
Phil Holmes	Holmes Sackett & Associates	NSW	Southern beef
Kym Abbott	Charles Sturt University	NSW	Sheep
Joan Lloyd	Meat & Livestock Australia	NSW	Northern beef/feedlot
Bob Freer	Antek Pty Ltd Livestock Industry Consultants	NSW	Southern beef
John Plant	Veterinary specialist (sheep medicine)	NSW	Sheep
Bruce Allworth	Allworth Sheep and Cattle Production Services	NSW	Sheep
Sandi Jephcott	Nutrition Service Associates Pty Ltd	QLD	Northern beef/feedlot
Geoff Niethe	Meat & Livestock Australia	QLD	Northern beef/feedlot
Mark Perkins	Colonial Agriculture	QLD	Northern beef/feedlot
Des Rinehart	Project Manager Feedlots, Meat & Livestock Australia	QLD	Northern beef/feedlot
Lee Taylor	Department of Primary Industries and Fisheries	QLD	Northern beef/feedlot
Simon Ellis	Ellis Farm Consultancy	SA	Sheep
Greg Johnsson	Agvet Services Pty Ltd	SA	Sheep
David Counsell	Tasmanian Institute of Agricultural Research	TAS	Sheep
Scott Williams	Australian Wool Innovation	VIC	Sheep
John Webb-Ware	Mackinnon Project	VIC	Southern beef
Leo Cummins	Dr J L Cummins	VIC	Southern beef
Rod Manning	Mansfield Veterinary Clinic	VIC	Southern beef
Kevin Bell	Sheep management and production consultants	WA	Sheep

Table A1.2 Invited but unable to attend workshop

Name	Organisation	State
Phillip Harpham		NSW
Steve Petty	Heytesbury Beef	NT
Janet Berry	Dept of Primary Industries, Longreach	QLD
John Keaveny	Meat Holdings Australia	QLD
Peter Smith	Western Australia Dept of Agriculture	WA
Bob Nickels		WA

Appendix 2 Statistical local areas

Figure A2.1 Australian Capital Territory statistical divisions, 2004

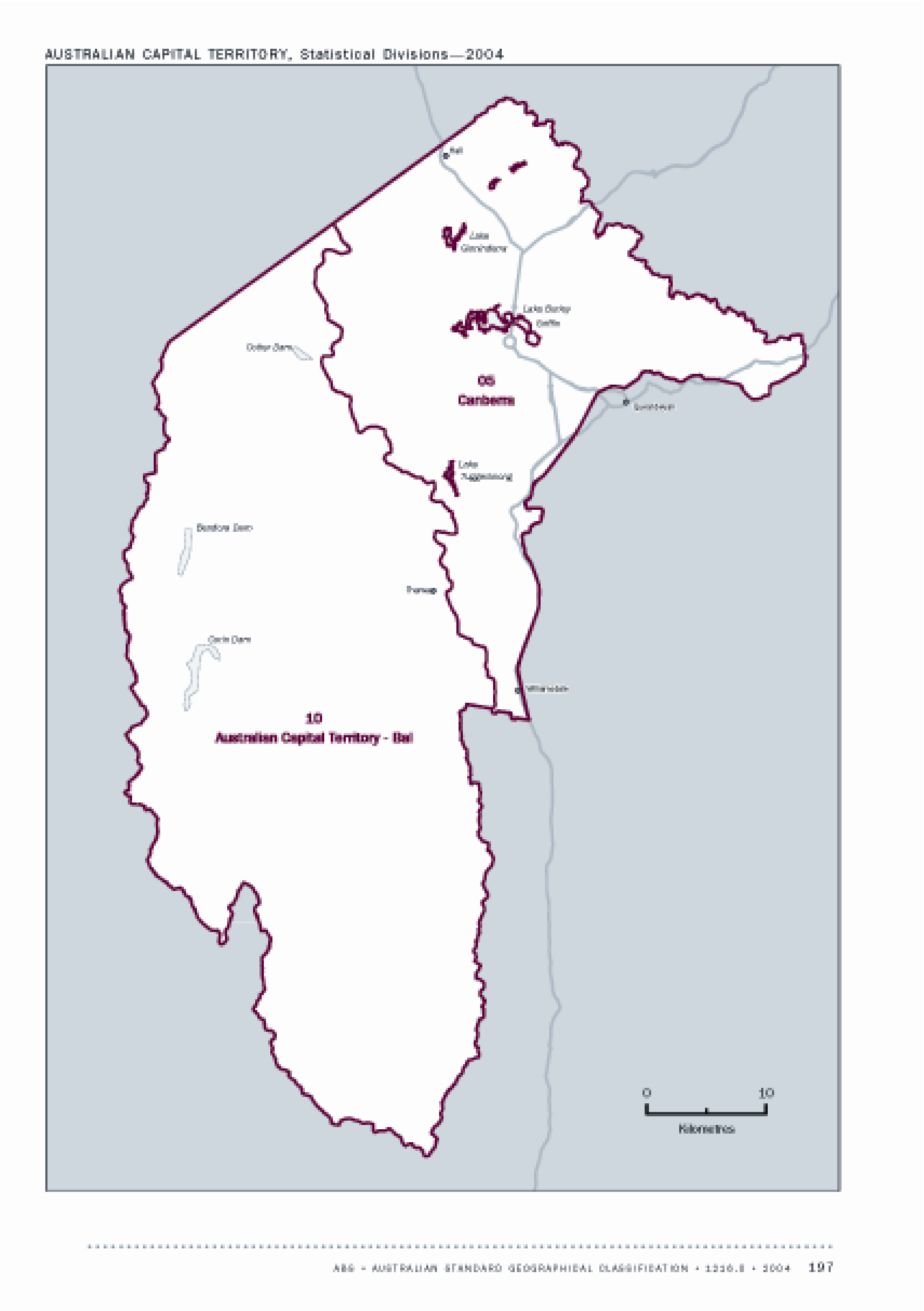


Figure A2.2 New South Wales statistical divisions, 2004

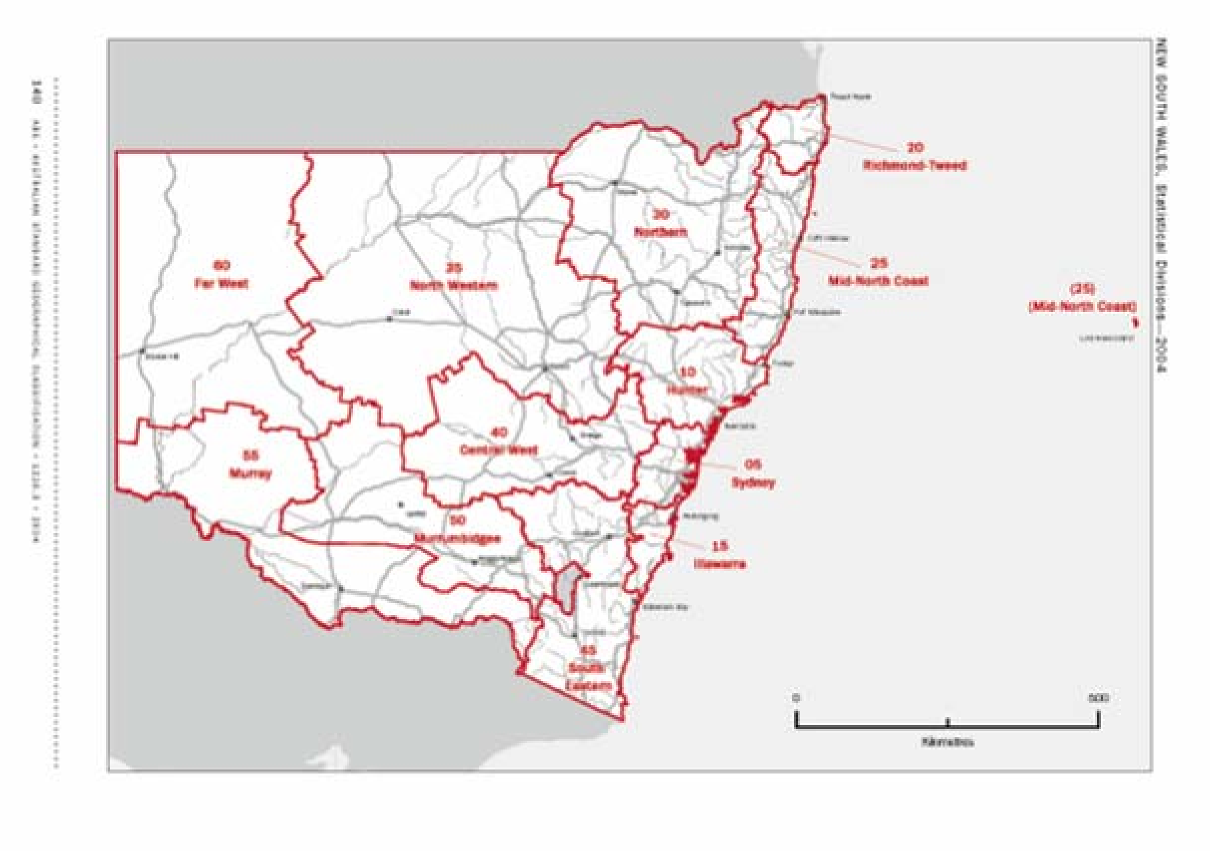


Figure A2.3 Northern Territory statistical divisions, 2004

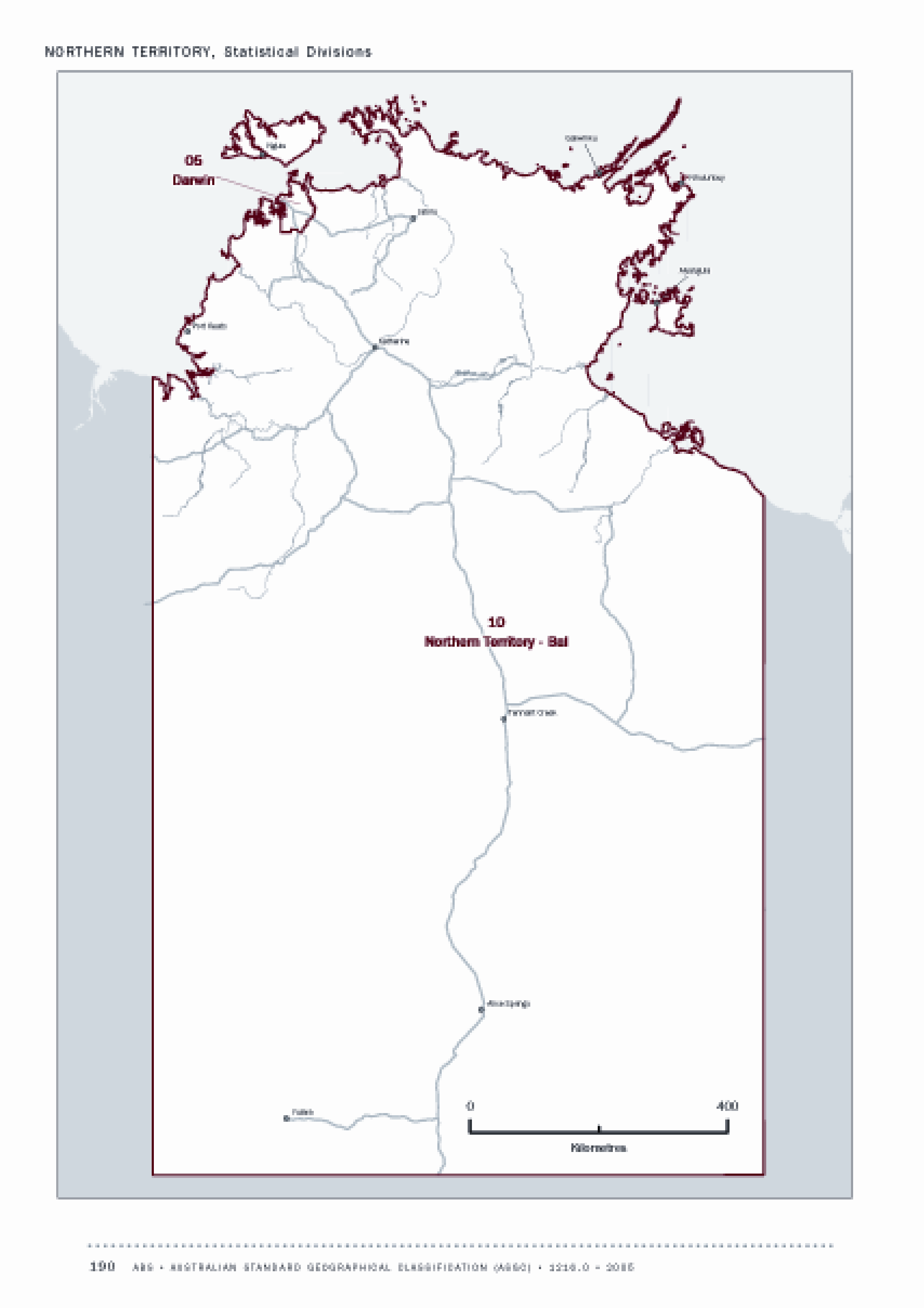


**Figure A2.4	Queensland statistical divisions, 2004**

Figure A2.4 South Australian statistical divisions, 2004

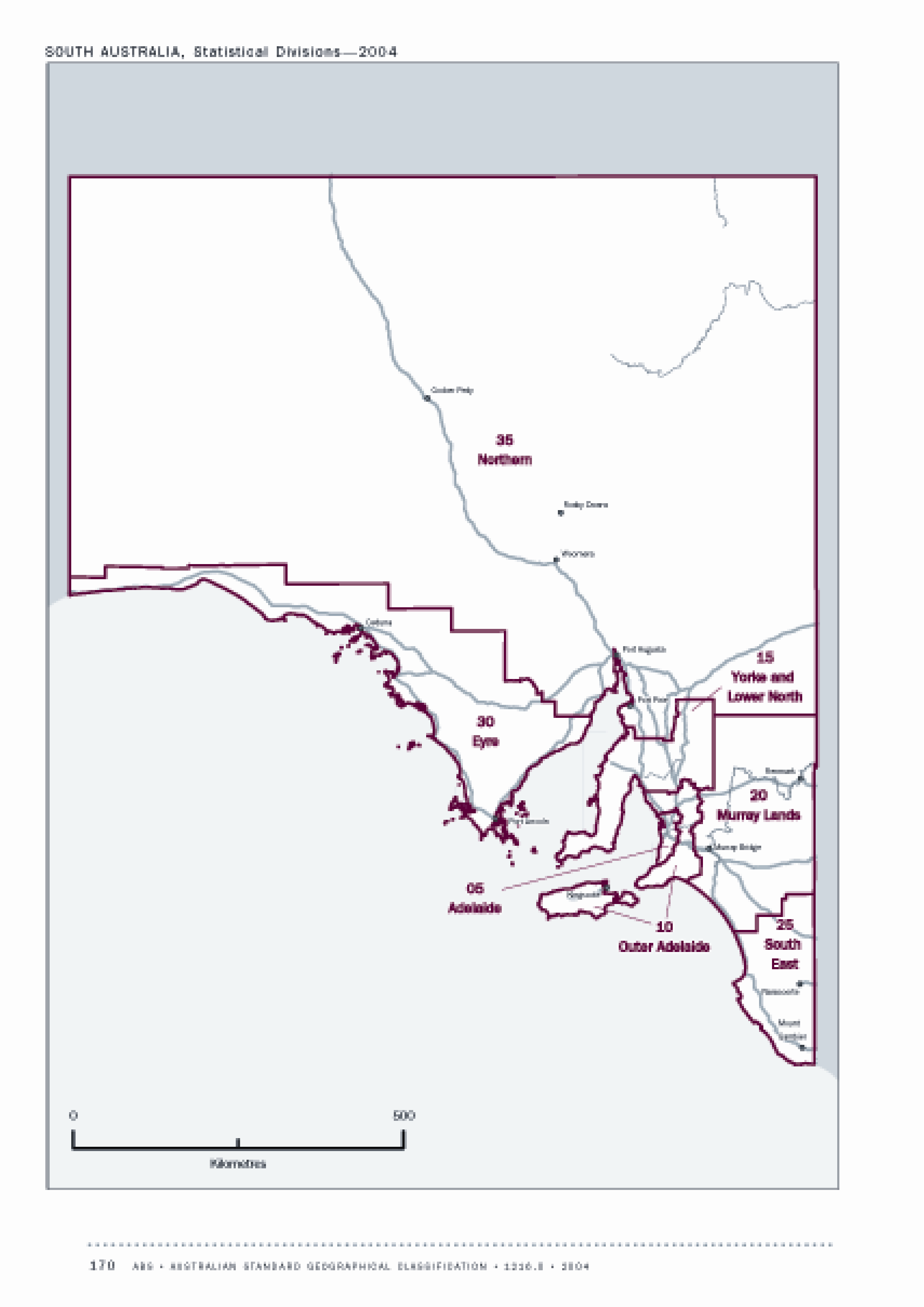


Figure A2.5 Tasmanian statistical divisions, 2004

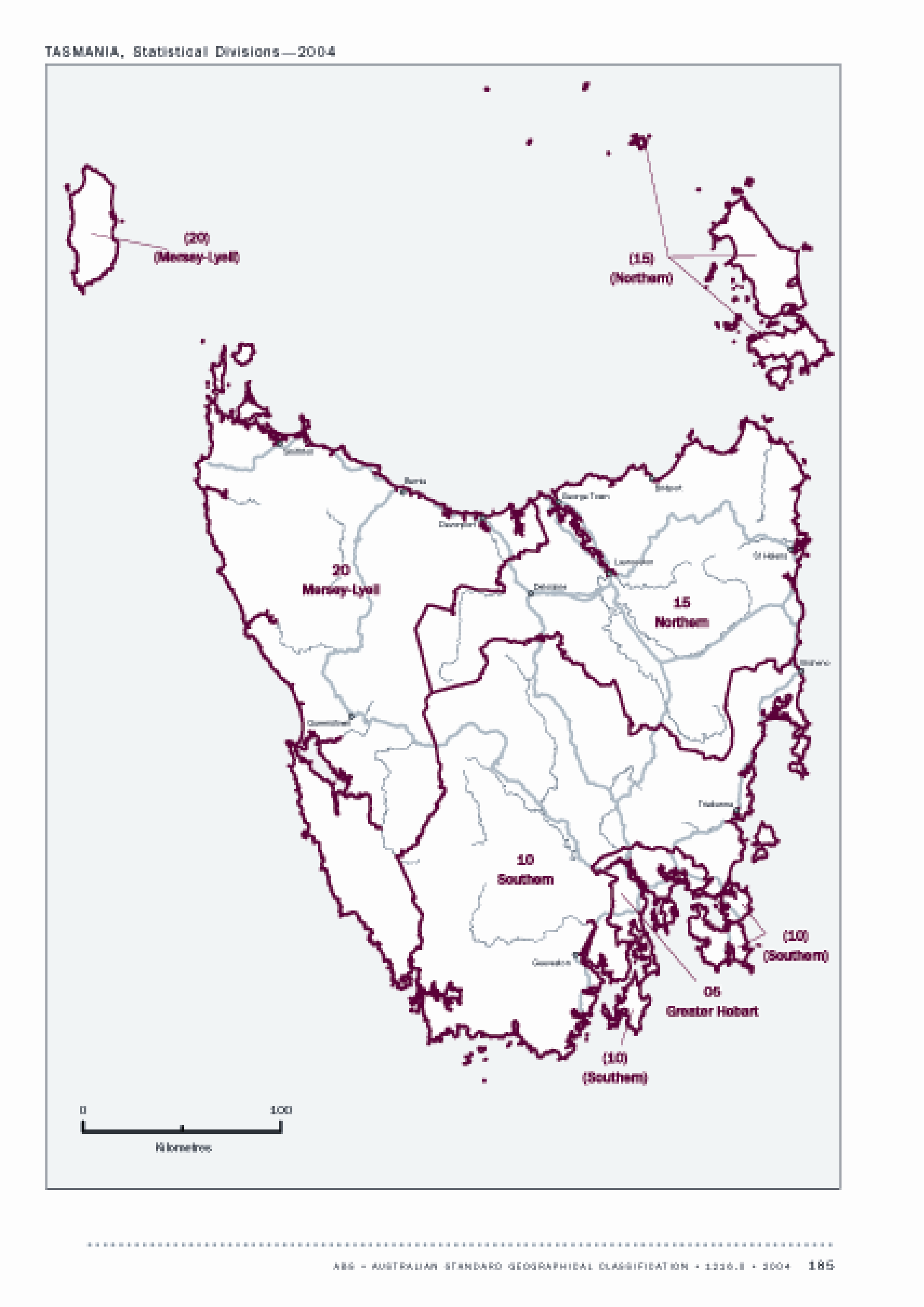


Figure A2.6 Victorian statistical divisions, 2004

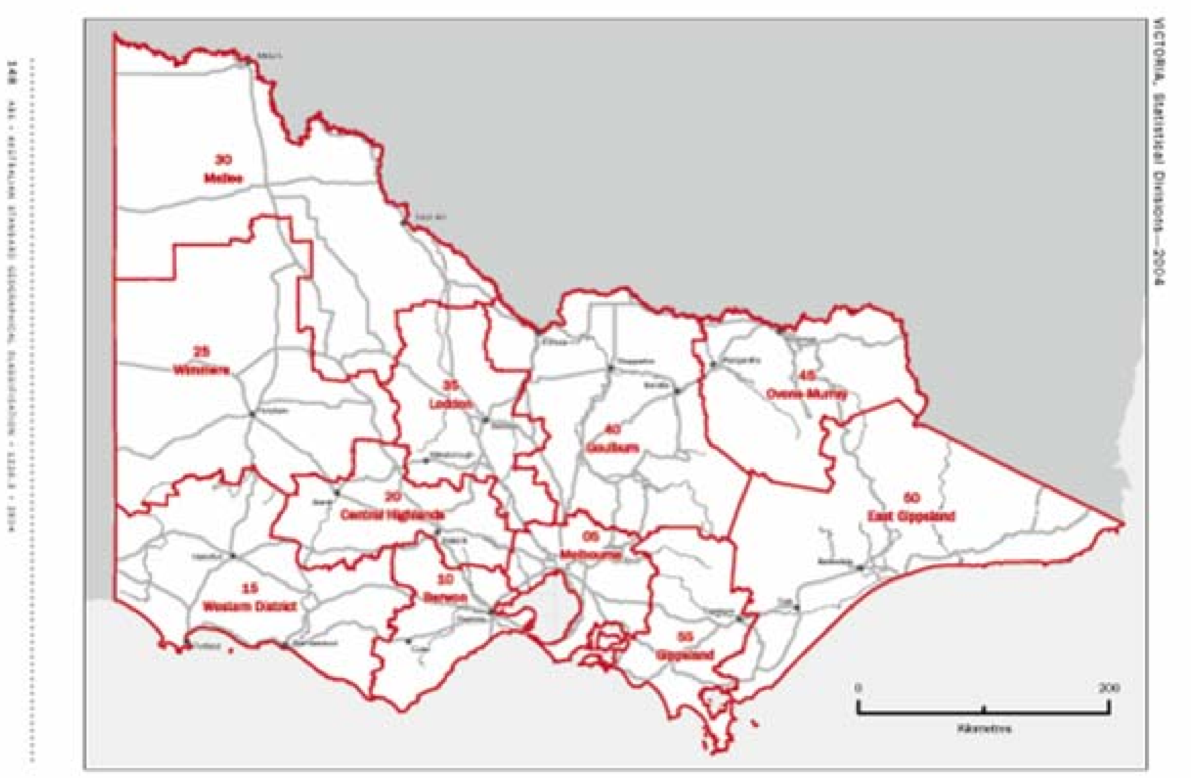
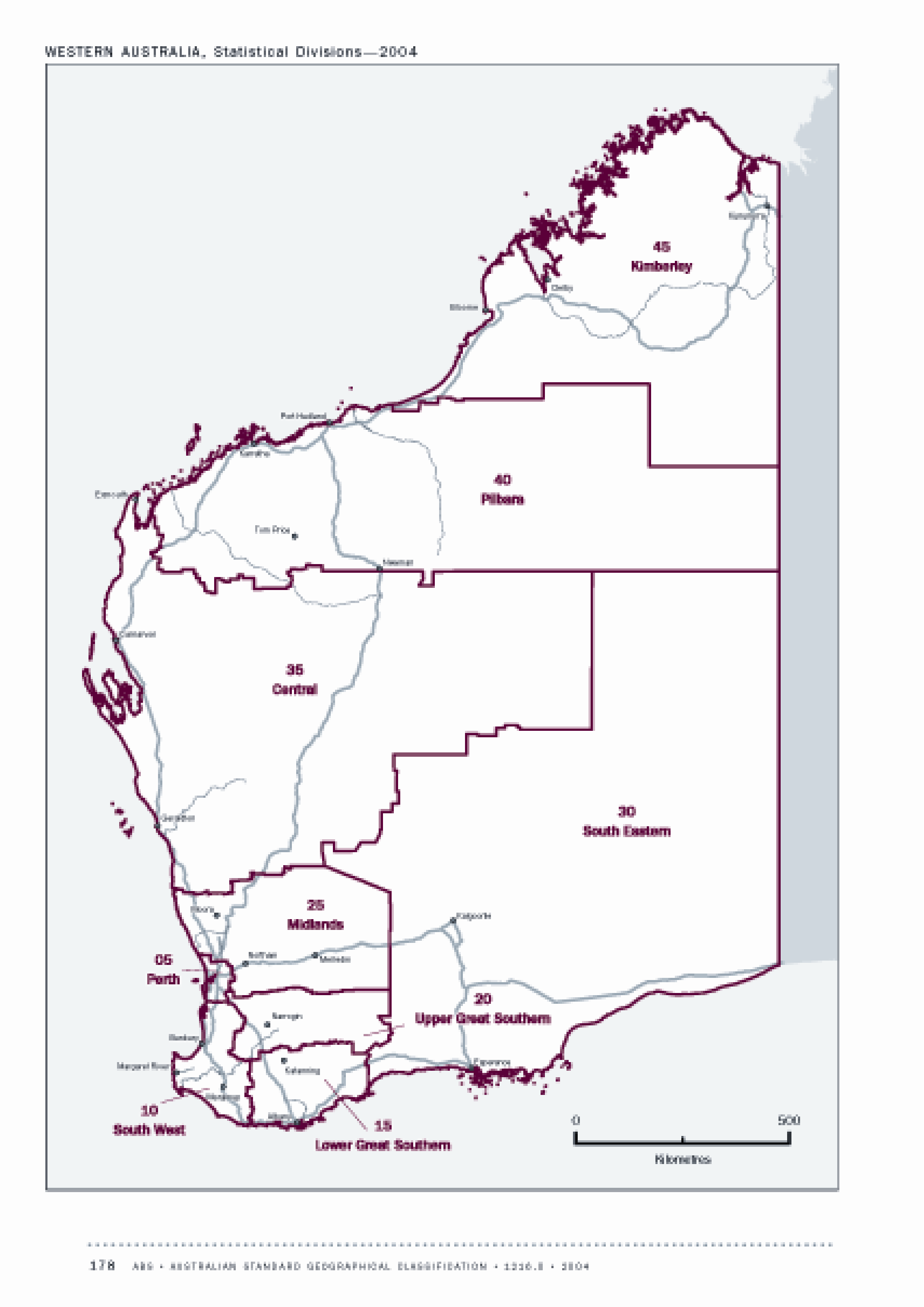


Figure A2.7 Western Australian statistical divisions, 2004



Appendix 3 Beef prices

Table A3.1 Australian beef liveweight price deciles, 1996–2005

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: National Livestock Reporting Service, Meat & Livestock Australia, 1996–2005

Appendix 4 Sheep prices

Table A4.1 Ten year median wool prices, 1996–2005 (2005 dollars)

Fibre diameter (micron)	35 Nktex (¢/kg clean)	45 Nktex (¢/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: Wood A (2006) Independent Commodity Services, Wagga Wagga

Table A4.2 Real sheep prices, 1996–2005 (2005 dollars)

Category	Price	Source
Lamb 20–22kg FS 3	290¢/kg Dwt	MLA market reports
Mutton 18–24kg FS 3	115¢/kg Dwt	MLA market reports
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

Dwt = dressed weight; FS = fat score

Appendix 5 Assumptions for southern beef herds

Table A5.1 Effect of bloat on herd mortality rates

	Base herd	High risk, no prevention	High risk, prevention	Low risk, no prevention
% herds		18%	12%	71%
Death rates				
Heifer weaners	2%	+1.5%	+0.2%	+1%
1-year-old heifers	2%	+2%	+0.2%	+1%
2-year-old heifers	2%	+0.5%	+0.2%	+1%
3–8-year-old	2%	+0.5%	+0.2%	+0.5%
Heifer bull	1%	+0.5%	+0.1%	+0.5%
Cow bull	1%	+0.5%	+0.1%	+0.5%
Weaner steers	2%	+2%	+0.2%	–
Steers 1-year-old	2%	+2%	+0.2%	+0.2%

Table A5.2 Effect of bloat on herd sale weights

	Base herd weight	High risk, no prevention	High risk, prevention	Low risk, no prevention
Female				
1-year-old	350kg	–30kg	–	–
2-year-old	425kg	–25kg	–	–
3-year-old	425kg	–10kg	–	–
4–10-year old	475kg	–	–	–
Steers				
Weaners	250kg	–	–	–
1-year-old	450kg	–28kg	+10kg	–

Table A5.3 Effect of gastrointestinal worms on mortality rates

	Base herd	High risk, no prevention	High risk, prevention	Low risk, no prevention
% herds		7%	62%	31%
Death rates				
2-year-old heifer cull rate	28%	+2%	–	–
2-year-old weaning rate	80%	–2%	–	–

Table A5.4 Effect of gastrointestinal worms on herd sale weights

	Base herd	High risk, no prevention	High risk, prevention	Low risk, no prevention
Female				
1-year-old	350kg	–25kg	–5kg	–10kg
2-year-old	425kg	–25kg	–5kg	–
Steers				
1-year-old	450kg	–25kg	–5kg	–10kg

Table A5.5 Effect of grass tetany on mortality rates

	Base herd	High risk, no prevention	High risk, prevention	Low risk, no prevention
% herds		7%	17%	75%
Death rates				
2-year-old	2%	+1%	–	–
3–8-year-old	2%	+2%	+0.5%	+0.2%

Table A5.6 Effect of grass tetany on herd sale weights

	Base herd	High risk, no prevention	High risk, prevention	Low risk, no prevention
Female				
2-year-old	425kg	–	–	–
3–8-year-old	425–475kg	–	–	–

Table A5.7 Risk of pinkeye infection

State	% Cattle affected by pinkeye
NSW	96
ACT	96
VIC	91
QLD	77
WA	67
SA	57
NT	57
TAS	17

Source: Slatter et al (1982a)

Table A5.8 Effect of pinkeye on mortality rates (all herds)

	Base herd	All herds
% herds		100% (50% treatment, 50% no treatment)
Death rates		
1-year-old	2%	+0.5%
2-year-old weaning rate	80%	–2.0%

Table A5.9 Effect of pinkeye on herd sale weights

	Base herd	All herds
Female sales		
1-year-old	350kg	–5kg
2-year-old	425kg	–8kg
3-year-old	425kg	–5kg
Steer sales		
1-year-old	450kg	–8kg (south)
2-year-old	450kg	–5kg (north)

Appendix 6 Assumptions for northern beef herds

Table A6.1 Effect of bovine ephemeral fever on mortality rates (all cattle herds)

	Base herd	All herds
% herds		
Death rates		
4–8-year-old	15%	+1%
4–8-year-old weaning rate	80%	–2%
> 8-year-old death rate	15%	+1%
> 8-year-old cull rate	25%	+2%
> 8-year-old weaning rate	78%	–2%
2-year-old steer	4%	+0.5%
Cow bull death rate	4%	+1%

Table A6.2 Effect of bovine ephemeral fever on cattle herd sale weights

	Base herd	All herds
Female sales		
4–8-year-old	475kg	–
> 8-year-old	450kg	–
Steer sales		
2-year-old	420kg	+5kg

Table A6.3 Effect of buffalo fly on mortality rates

	Base herd	No control	Control
% herds			
Death rates			
2-year-old	10%	–	–

Table A6.4 Effect of buffalo fly on herd sale weights

	Base herd	No control	Control
Female sales			
2-year-old	400kg	–	–
Steers			
2-year-old	420kg	–20kg	–8kg

Table A6.5 Effect of tick fever on mortality rates

	Base herd	Unvaccinated	Vaccinated	All treatment and prevention
% herds				
Death rates				
Females				
1-year-old deaths	6%	+2%	–	–
1-year-old culls	17%	–2%	–	+0.2%
2-year-old deaths	10%	–	–	+1%
2-year-old culls	16%	–	–	+1%
4–8-year-old weaning rate	80%	–	–	–2%
> 8-year-old weaning rate	78%	–	–	–2%
Steers				
2-year-old deaths	4%	+1%	–	–

Table A6.6 Effect of tick fever on cattle herd sale weights

	Base herd	Unvaccinated	Vaccinated	All treatment and prevention
% herds				
Death rates				
Females				
1-year-old deaths	6%	–	–	–
1-year-old culls	17%	–	–	–
2-year-old deaths	10%	–	–	+1%
2-year-old culls	16%	–	–	+1.0%
4–8-year-old weaning rate	80%	–	–	–2%
> 8-year-old weaning rate	78%	–	–	–2%
Steers				
2-year-old	4.0%	–10.0kg	–	–

Table A6.7 Effect of under-nutrition on cattle mortality rates

	Base herds	All herds
% herds		30%
Death rates		
1-year-old	6%	+2%
1-year-old culls	17%	+1%
2-year-old culls	16%	–11%*
2-year-old weaning rate	69%	–14%*
3-year-old culls	15%	–9%*
3-year-old weaning rate	55%	–10%*
3–8-year-old	9%	+6%
3–8-year-old culls	14%	–8%*
3–8-year-old weaning rate	80%	–10%*
>8-year-old cull rate	25%	–20%*
> 8-year-old weaning rate	78%	–13%*

*Animals unfit to mate in first year are culled from the system. After this occurs culling rates need to be reduced to maintain herd structure and numbers.

Table A6.8 Effect of under-nutrition on cattle sale weights

	Base herd	All herds
% herds		30%
Female		
1-year-old	300kg	–30kg
2-year-old	400kg	–30kg
3-year-old	400kg	–30kg
4-year-old	475kg	–30kg
5-year-old	475kg	–30kg
6-year-old	475kg	–30kg
7-year-old	475kg	–30kg
8-year-old	475kg	–30kg
9-year-old	475kg	–30kg
10-year-old	475kg	–30kg
Male		
2-year-old	420kg	–40kg

Table A6.9 Effect of feedlots on cattle mortality rates

	Base herd	BRD vaccinated	BRD unvaccinated	Heat stress
% herds				
Death rates				
Females				
1-year-old deaths	6%		–	+0.1%
Steers				
1-year-old deaths	5%	–	+0.7%	–

BRD = bovine respiratory disease

Appendix 7 Economic effects of internal parasites of sheep

Table A7.1 Economic effect of internal parasites — high rainfall, summer dominant

Total number of sheep			3,869,463
Control	Good	Poor	Total
Sheep at risk (%)	40%	60%	100
Sheep at risk (no.)	1,547,785	2,321,678	3,869,463
Income			
Wool	–$3,172,774	–$8,994,304	–$12,167,078
Sales	–$1,927,181	–$5,886,695	–$7,813,875
Total income	–$5,099,955	–$14,880,999	–$19,980,954
Wool freight	$19,460	$60,505	$79,965
Shearing	$324,128	$963,086	$1,287,214
Dipping	$22,000	$65,368	$87,367
Crutching	–$436,258	–$1,697,708	–$2,133,967
Drenching	–$1,399,338	–$1,570,951	–$2,970,288
Vaccination	$15,020	$44,475	$59,494
Jetting	$17,230	$51,139	$68,368
Ear tags	$10,185	$29,935	$40,120
Supplement	$101,850	$299,348	$401,198
Mark/mules	$27,160	$79,826	$106,986
Labour	–	–	–
Stock purchases	–	–	–
Total expenses	–$1,298,563	–$1,674,978	–$2,973,541
Total cost	**–$6,398,518**	**–$16,555,977**	**–$22,954,495**

Table A7.2 Economic effect of internal parasites — high rainfall, winter

Number of sheep in zone			37,237,966
Control	Good	Poor	Total
Sheep at risk (%)	30%	70%	100%
Sheep at risk (no.)	11,171,390	26,066,576	37,237,966
Income			
Wool	–$19,581,321	–$82,892,687	–$102,474,008
Sales	–$8,188,531	–$42,662,429	–$50,850,960
Total income	–$27,769,852	–$125,555,116	–$153,324,968
Total expenses	–$7,291,557	–$11,082,211	–$18,373,768
Wool freight	$110,277	$512,633	$622,910
Shearing	$1,429,507	$7,178,617	$8,608,123
Dipping	$97,025	$487,236	$584,262
Crutching	–$1,182,777	–$5,299,432	–$6,482,209
Drenching	–$8,620,312	–$18,385,565	–$27,005,877
Vaccination	$69,976	$352,274	$422,250
Jetting	$81,467	$414,323	$495,789
Ear tags	$52,923	$267,637	$320,560
Supplement	$529,229	$2,676,369	$3,205,598
Mark/mules	$141,128	$713,698	$854,826
Labour	–	–	–
Stock purchases	–	–	–
Total expenses	–$7,291,557	–$11,082,211	–$18,373,768
Total cost	**–$35,061,409**	**–$136,637,327**	**–$171,698,736**

Table A7.3 Economic effect of internal parasites — sheep cereal

Number of sheep in zone			34,986,489
Control	Good	Poor	Total
Sheep at risk (%)	60%	40%	100%
Sheep at risk (no.)	20,991,893	13,994,596	34,986,489
Income			
Wool	–$21,576,315	–$17,679,649	–$39,255,964
Sales	–$7,407,287	–$7,871,421	–$15,278,708
Total income	–$28,983,602	–$25,551,070	–$54,534,672
Total expenses	–$17,627,927	–$11,390,388	–$29,018,315
Wool freight	$92,734	$141,640	$234,374
Shearing	$1,334,288	$1,373,343	$2,707,631
Dipping	$90,563	$93,213	$183,776
Crutching	–$1,212,446	–$1,746,795	–$2,959,241
Drenching	–$19,027,740	–$11,868,718	–$30,896,458
Vaccination	$73,959	$59,959	$133,918
Jetting	$92,449	$74,949	$167,398
Ear tags	$67,922	$35,270	$103,192
Supplement	$679,219	$352,699	$1,031,918
Mark/mules	$181,125	$94,053	$275,178
Labour	–	–	–
Stock purchases	–	–	–
Total expenses	–$17,627,927	–$11,390,388	–$29,018,315
Total cost	**–$46,611,529**	**–$36,941,457**	**–$83,552,987**

Table A7.4 Economic effect of internal parasites — prime lamb

Number of sheep in zone			10,647,549
Flock risk	All flocks	All flocks	Total
	No prevention	Prevention	Body strike
Sheep at risk (%)	50	50	100
Sheep at risk (no.)	5,323,775	5,323,775	10,647,549
Income			
Wool	–$1,519,156	–$3,124,327	–$4,643,484
Sales	–$21,514,385	–$56,277,450	–$77,791,835
Total income	–$23,033,541	–$59,401,777	–$82,435,318
Total expenses	–$3,808,845	–$5,848,547	–$9,657,392
Wool freight	$24,590	$44,967	$69,557
Shearing	$193,671	$390,557	$584,229
Dipping	$8,763	$17,672	$26,436
Crutching	–$407,654	–$817,657	–$1,225,311
Drenching	–$3,006,096	–$4,512,766	–$7,518,861
Vaccination	$12,269	$24,741	$37,010
Jetting	$6,573	$13,254	$19,827
Ear tags	–	–	–
Supplement	–	–	–
Mark/mules	–	–	–
Labour	–	–	–
Stock purchases	–	–	–
Total expenses	–$3,167,884	–$4,839,230	–$8,007,114
Total cost	**–$26,201,425**	**–$64,241,007**	**–$90,442,433**

Appendix 8 Assumptions for internal parasites of sheep

Table A8.1 Assumptions for internal parasites — high rainfall, winter

Control	Poor		Good	
	Weaners	**Adults**	**Weaners**	**Adults**
Wool loss (g)	90	175	45	90
Fibre diameter reduction (micron)	0.3	0.315	0.15	0.162
Bodyweight reduction (kg)	1	4	0	2
Fertility (%)	0	6	0	3
Increased deaths (%)	5	2	2	1
Staple strength redution (Nktex)	10	10	5	0
Dags (%)	46	46	20	20
Cost of dags (¢)	7.5	7.5	0.7	0.7
Cost of crutching (¢)	20	20	10	10
Drenches (No.)	4	3	4	2
Cost of drench ($)	1.04	1.08	1.04	0.72
Monitoring (frequency)	0	0	4	3
Cost of monitoring (¢)	0	0	28	21

Table A8.2 Assumptions for internal parasites — high rainfall, summer

Control	Poor		Good	
	Weaners	**Adults**	**Weaners**	**Adults**
Wool loss (g)	90	175	45	90
Fibre diameter (micron)	0.3	0.315	0.15	0.162
Bodyweight reduction (kg)	1	4	0	2
Fertility (%)	0	6	0	3
Increased deaths (%)	8	4	4	2
Staple strength reduction (Nktex)	10	10	5	0
Dags (%)	15	10	5	2
Cost of dags (¢/kg)	2.5	1.5	0	0
Cost of crutching (¢)	6.5	5	2.5	1
Drenches (No.)	4	3	4	3
Cost of drench ($)	1.04	1.08	1.04	1.08
Monitoring (frequency)	0	0	4	3
Cost of monitoring (¢)	0	0	28	21

Table A8.3 Assumptions for internal parasites — sheep cereal

Control	Poor		Good	
	Weaners	Adults	Weaners	Adults
Wool loss (g)	45	90	20	45
Fibre diameter redution (micron)	15	0.162	0.036	0.081
Bodyweight reduction (kg)	0	2	0	1
Fertility (%)	0	3	0	1.5
Increased deaths (%)	2	1	1	0
Staple strength reduction (Nktex)	5	0	2.5	0
Dags (%)	20	20	10	10
Cost of dags (¢)	0.7	0.7	0	0
Cost of crutching (¢)	10	10	5	5
Drenches (No.)	4	2	3	2
Cost drench ($)	1.04	0.72	0.78	0.72
Monitoring (frequency)	0	0	3	2
Cost of monitoring (¢)	0	0	21	14

Table A8.4 Assumptions for internal parasites — prime lambs

Control	Poor		Good	
	Weaners	Adults	Weaners	Adults
Wool loss (g)	0	87.5	0	45
Fibre diameter reduction (micron)	0	0	0	0
Bodyweight reduction (kg)	5	3	2	1
Fertility (%)	0	4.5	0	1.5
Increased deaths (%)	3	2	2	1
Staple strength reduction (Nktex)	0	0	0	0
Dags (%)	46	46	20	20
Cost of dags (¢)	3	3	0	0
Cost of crutching (¢)	20	20	10	10
Drenches (No.)	3	3	2	2
Cost of drench ($)	0.78	1.08	0.52	0.72
Monitoring (frequency)	0	0	2	2
Cost of monitoring (¢)	0	0	14	14

Table A8.5 Assumptions for internal parasites — unit for wool price required

Fibre diameter (micron)	10 Nktex	5Nktex	Wool price received — normal
17	29	11	1531
18	21	6	1196
19	8	3	986
20	6	3	807
21	6	3	710
22	6	3	673

Table A8.6 Assumptions for internal parasites — cents per kilogram reduction in wool price based on staple strength

Fibre diameter (micron)	10 Nktex	5 Nktex
17	443.99	168.41
18	251.16	71.76
19	78.88	29.58
20	48.42	24.21
21	42.60	21.30
22	40.38	20.19

Appendix 9 Assumptions for flystrike in sheep

Table A9.1 High rainfall, assumptions for body strike

Risk of strike	High, no prevention	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	5	10	25	60	Plant and Dawson (1999)
Flock prevalence (%)	10	5	3	1	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFWt
Staple strength reduction					
% fleeces at risk	44	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	15	
Bodyweight (kg reduction)	9	6	3	2	
Fertility (% reduction)	12	9	5	3	1.5% lost per kg BW, Moule (1948)
Death rate of struck sheep					
Young sheep (%)	20	20	20	20	
Mature sheep (%)	10	10	10	10	

Table A9.2 High rainfall, assumptions for mulesed flock — breech

Risk of strike	High, no prevention	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	5	15	20	60	Plant and Dawson (1999)
Flock prevalence (%)	6	3	2	1	Watt, Murray and Graham (1979) Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFWt
Staple strength reduction					
% fleeces affected	44	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	15	
Bodyweight (kg reduction)	9	6	3	2	
Fertility (% reduction)	12	9	5	3	1.5% lost per kg BW Moule (1948)
Death rate of struck sheep					
Young sheep (%)	20	20	20	20	
Mature sheep (%)	10	10	10	10	

Table A9.3 High rainfall, assumptions for flystrike — pizzle

Risk of strike	High, no control	Medium, no control	Low, no control	Reference
% flocks	40	40	20	
Flock prevalence (%)	8	5	2	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	White and McConchie (1976) — estimates using clean fleece weight
Staple strength reduction				
% fleeces affected	44	30	15	Moule (1948)
Nktex for affected fleeces	15	15	15	
Bodyweight (% reduction)	15	10	5	
Death rate of struck sheep				
All wethers (%)	30	30	30	

Table A9.4 Sheep cereal, assumptions for flystrike — pizzle

Risk of strike	High, no prevention	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	2	13	25	60	
Flock prevalence	7	5	3	1	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFW
Staple strength reduction					
% fleeces affected	44	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	15	
Bodyweight (kg) reduction	9	6	3	2	
Fertility (% reduction)	12	9	5	3	1.5% lost per kg BW Moule (1948)
Death rate of struck sheep					
Young sheep (%)	20	20	20	20	
Mature sheep (%)	10	10	10	10	

Table A9.5 Sheep cereal, assumptions for flystrike — breech

Risk of strike	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	15	25	60	
Flock prevalence (%)	3	2	1	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFW
Staple strength				
% fleeces affected	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	
Bodyweight (kg reduction)	6	3	2	
Fertility (% reduction)	9	5	3	1.5% lost per kg BW Moule (1948)
Death rate of struck sheep				
Young sheep (%)	20	20	20	
Mature sheep (%)	10	10	10	

Table A9.6 Sheep cereal, assumptions for flystrike — pizzle

Risk of strike	High, no control	Medium, no control	Low, no control	Reference
% flocks	40	40	20	
Flock prevalence	8	5	2	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	White and McConchie (1976) — estimates using CFW
Staple strength reduction				
% fleeces affected	44	30	15	Moule (1948)
Nktex for affected fleeces	15	15	15	
Bodyweight (% reduction)	15	10	5	
Death rate of struck sheep				
All wethers (%)	30	30	30	

Table A9.7 Pastoral, assumptions for flystrike — pizzle

Risk of strike	High, no prevention	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	5	10	60	25	
Flock prevalence (%)	3	2	1	1	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.4	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.72	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFW
Staple strength reduction					
% fleeces affected	44	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	15	
Bodyweight (kg) reduction	9	6	3	2	
Fertility (% reduction)	12	9	5	3	1.5% lost per kg BW Moule (1948)
Death rate of struck sheep					
Young sheep (%)	20	20	20	20	
Mature sheep (%)	10	10	10	10	

Table A9.8 Pastoral, assumptions for flystrike — breech

Risk of strike	Medium, no prevention	Low, no prevention	All flocks, prevention	Reference
% flocks	20	60	20	
Flock prevalence (%)	3	1	1	Brobeck and Hill (1983)
Clean fleece weight reduction (kg)	0.3	0.2	0.1	Raadsma and Baker (1983) Gill and Graham (1939a) Gill and Graham (1939b)
Fibre diameter reduction (micron)	0.54	0.36	0.18	White and McConchie (1976) — estimates using CFW
Staple strength reduction				
% Fleeces affected	30	30	30	Moule (1948)
Nktex for affected fleeces	15	15	15	
Bodyweight (kg reduction)	6	3	2	
Fertility (% reduction)	9	5	3	1.5% lost per kg BW Moule (1948)
Death rate of struck sheep				
Young sheep (%)	20	20	20	
Mature sheep (%)	10	10	10	

Appendix 10 Assumptions for lice modelling

Table A10.1 Assumptions for lice modelling, clean fleece weight reduction

Severity	Severe	Moderate	Mild	Controlled	Nil plus annual control	Nil, no control
CFWt reduction	–18%	–12%	–5%	–2%	0	0
Fibre diameter	Nil	Nil	Nil	Nil	Nil	Nil
Bodyweight	Nil	Nil	Nil	Nil	Nil	Nil

CFWt = clean fleece weight
Source: Wilkinson et al (1981), Wilkinson (1988)

Table A10.2 Assumptions for lice modelling, flock prevalence

Severity	Severe	Moderate	Low	Controlled	Nil plus annual control	Nil, no control
High rainfall	1%	5%	7%	7%	40%	40%
Sheep cereal	1%	5%	7%	7%	59%	21%
Pastoral	3%	8%	10%	9%	66%	4%
Prime lamb	1%	5%	14%	–	50%	30%

Source: Morcombe et al (1994), Plant and Dawson (1999), James and Riley (2004)

Table A10.3 Assumptions for lice modelling, treatment method

Severity	Severe	Moderate	Low	Controlled	Nil plus annual control	Nil, no control
Treatment method	Pastoral	Sheep cereal	High rainfall	–	–	–
Dip plunge	17	17	17	–	–	0
Dip shower	4	15	28	–	–	0
Backline	77	72	59	–	–	0
Other	4	2	0	–	–	0

Table A10.4 Assumptions for lice modelling, cost of treatment

Treatment	Cost ($)
Insect growth regulator	0.48
Shower	0.02
Contract plunge	0.50
DIY plunge	0.04

Table A10.5 Effect of lice infestation on net average fleece prices

Fibre diameter (micron)	Severe	Moderate	Mild	Controlled	Nil plus annual control	Nil, no control
16	29.8%	10.5%	0.3%	–	–	–
17	21.5%	7.0%	0.3%	–	–	–
18	19.3%	6.5%	0.3%	–	–	–
19	15.5%	7.0%	0.5%	–	–	–
20	14.8%	6.0%	0.4%	–	–	–
21	14.5%	5.3%	0.3%	–	–	–
22	13.0%	5.0%	0.3%	–	–	–
23	11.8%	4.8%	0.3%	–	–	–
28–32	4.0%	0.8%	–	–	–	–

Appendix 11 Assumptions for bacterial enteritis in sheep

Table A11.1 Effects of bacterial enteritis on sheep productivity

Level of infection	**Mild**	**Severe**	**Not at risk**	**Weighted cost per head**	
Proportion affected (%)	5	20	75		
Clean fleece weight reduction (g)	45	90	0	13.5	
Fibre diamater reduction (micron)	0.081	0.162	0	0.02	1.8 micron
Staple strength reduction (Nktex)	10	20	0	3	
Body weight reduction (kg)	0	5	0	0.25	%kg reduction in BW — 7kg of feed @ 150 per tonne
Additional supp feed ($)	0	5.25	0	0.26	
Mortality rate (%)	0	10	0	0.5	
Dags (¢/head)	35	80	0	11	
Additional crutching (¢/head)	22	45	0	7	
Labour (¢/head)	16	32	0	5	
Treatment (¢/head)	60	60	0	15	

Table A11.2 Assumptions for bacterial enteritis in sheep — effect of staple strength on wool value compared with 35 Nktex

Fibre diameter (micron)	**10 Nktex**	**20Nktex**	**Wool price received (35Nktex)**
17	–29	–43	1531
18	–21	–30	1196
19	–8	–18	986
20	–6	–15	807
21	–6	–15	710
22	–6	–15	673

Table A11.3 bacterial enteritis in sheep — cents per kilogram reduction in wool price based on staple strength

Fibre diameter (micron)	10 Nktex	20 Nktex	Weighted across flock
17	443.99	658.33	122
18	251.16	358.80	68
19	78.88	177.48	25
20	48.42	121.05	16
21	42.60	106.50	14
22	40.38	100.95	13

Appendix 12 Footrot assumptions in sheep

Table A12.1 Footrot assumptions in sheep — fine wool 20-micron Merino flocks

	Outbreak			
	Hit year	**Year 1**	**Year 2**	**Endemic**
Effect	Footrot introduced	Control strategy in place	Eradication performed	Control strategy in place
Prevalence of footrot	80%	10%	5%	10%
Productivity				
Wool	–120g all adults	–15g all adults	Normal	–15g all adults
Reproduction	Normal	5% below normal	1% below normal	1% below normal
Weaner supplementation	+ 3kg per wnr	Normal	Normal	Normal
Mortality rates	+2%	+1%	+0.5%	+0.5%
Culling	Normal	5% all adults	5% all adults	2% all adults
Sale price, culls	50% of normal	50% of normal	50% of normal	50% of normal
Costs				
Vaccine ($1.50) (including labour)	None	Two to all sheep	One to all sheep but weaners twice	One to all sheep
Footbaths (including labour)	All sheep x 6 at 13.5 cents	All sheep x 6	All sheep x 6	All sheep x 6
Additional labour for treatment of individual sheep (flystrike, lameness, etc)	1 man day per 1,000 sheep at $150	0.5 man day per 1,000 sheep	0.5 man day per 1,000 sheep	0.5 man day per 1,000 sheep
Eradication labour	None	None	Two inspections at $1 per head per inspection	None

Table A12.2 Footrot assumptions in sheep — sheep cereal zone 21-micron Merino flocks

	Outbreak			
	Hit year	**Year 1**	**Year 2**	**Endemic**
Effect	Footrot introduced	Control strategy in place	Eradication performed	Control strategy in place
Prevalence of footrot	60%	7.5%	3.75%	5%
Productivity				
Wool	–105g all adults	–12g all adults	Normal	–7.5g all adults
Reproduction	Normal	3.75% below normal	0.75% below normal	0.5% below normal
Weaner supplementation	+ 2kg per wnr	Normal	Normal	Normal
Mortality rates	+1.5%	+0.75%	+0.375%	+0.25%
Culling	Normal	3.75% all adults	3.75% all adults	1% all adults
Sale price, culls	50% of normal	50% of normal	50% of normal	50% of normal
Costs				
Vaccine ($1.50) (including labour)	None	Two to all sheep	One to all sheep but weaners twice	One to all sheep
Footbaths (including labour)	All sheep x 6 at 13.5 cents	All sheep x 6	All sheep x 6	All sheep x 3
Additional labour for treatment of individual sheep (flystrike, lameness, etc)	1 man day per 1,000 sheep at $150	0.5 man day per 1,000 sheep	0.5 man day per 1,000 sheep	0.25 man day per 1,000 sheep
Eradication labour	None	None	Two inspections at $1 per head per inspection	None

Pastoral zone: Endemic footrot is not considered a significant problem in pastoral zone Merinos.

Table A12.3 Footrot assumptions in sheep — prime lamb flocks

	Outbreak			
	Hit year	**Year 1**	**Year 2**	**Endemic**
Effect	Footrot introduced	Control strategy in place	Eradication performed	Control strategy in place
Prevalence of footrot	80%	10%	5%	10%
Productivity				
Wool	–120g all adults	–15g all adults	Normal	–7.5g all adults
Reproduction	Normal	5% below normal	1% below normal	0.5% below normal
Weaner supplementation	Normal	Normal	Normal	Normal
Lamb growth rate	20% of lambs are 3kg lighter	10% of lambs are 2kg lighter		10% of lambs are 2kg lighter
Mortality rates	+2.0%	+1%	+0.5%	+0.25%
Culling	Normal	3.75% all adults	3.75% all adults	1% all adults
Sale price, culls	50% of normal	50% of normal	50% of normal	50% of normal
Costs				
Vaccine ($1.50) (including labour)	None	Two to all sheep	One to all sheep but 2 yo twice	One to all sheep
Footbaths (including labour)	All sheep x 6 at 13.5 cents	All sheep x 6	All sheep x 6	All sheep x 3
Additional labour for treatment of individual sheep (flystrike, lameness etc)	1 man day per 1000 sheep at $150	0.5 man day per 1000 sheep	0.5 man day per 1000 sheep	0.25 man day per 1000 sheep
Eradication labour	None	None	Two inspections at $1 per head per inspection	None

Appendix 13 Ovine Johne's disease assumptions

- 10% of the adult flock (>18 months of age) develop clinical OJD each year. All clinical cases will die if not sold first.
- Half of the annual clinical cases are identified off-shears because they are 5–15kg lighter than expected. Half of these are in the 5–10kg range and are sold at reduced value while half are in the 10–15kg range and are sold at no value, or destroyed on-farm. T
- The other half of the clinical cases (total 5%) die in the second half of the year.
- If the annual clinical OJD rate is 10%, it is expected that 20% of the sheep are, at any one time, affected by OJD with lesions of type 3a or 3b. Sheep with these types of lesions produce 0.291kg less wool (greasy) than unaffected sheep or sheep with less severe lesions. Assuming 70% yield of clean wool, it is predicted that there is on average, across the adult flock, 0.7 x 0.291 x 0.2 = 0.0408kg of clean wool lost to OJD in the sheep which are shorn.
- Off-shears, there will be some sheep that are in poor condition due to OJD infection which will be sold or destroyed, but have no value. The MLA study (Abbott et al 2004) demonstrated that sheep in the last 6 months of their lives will be 10–30% lighter than expected. For a 50kg sheep, this means a 5–15kg lower bodyweight than expected. If 10% of the adult sheep are at risk of dying from OJD each year, it is therefore expected that at any one time, 5% are in the last 6 months of their lives and weigh 5–15kg less than expected. Half of these are culled off-shears at no value, the other half are culled at half their normal value.
- Shearing occurs in December and all ewes that are likely to die in the next six months from OJD are culled. Lambing is in the following August and it is therefore expected that the 5% of ewes that will die between the off-shears sale and the following shearing will fail to rear their lamb — either because they die before the lamb is old enough to survive or they are in such poor condition during lactation that they fail to rear a lamb. The impact of ewe deaths on weaning rates is (100-adult mortality rate) of what it would be in the absence of OJD.
- The ewes which are clinical cases by December (ie those which are about to be culled) rear lambs but some lambs have low weaning weights due to the poor lactation of the ewes. These weaners have twice the risk of dying before their next shearing as weaners from unaffected ewes.

Table A13.1 Effect of years of vaccination on clinical ovine Johne's disease

Infected for	>= 5 yrs	4 yrs	3 yrs	2 yrs	1 yr
Clinical OJD	1%	1.5%	2.0%	2.5%	3%
Proportion of flocks	40%	15%	15%	15%	15%
Per head	$1.16	$1.33	$1.44	$1.59	$1.76

OJD = ovine Johne's disease

The weighted average loss across these flocks is $2,893.40 or $1.18 per DSE ($1.38 per head).

Table A13.2 Effect of years of vaccination — pastoral zone flocks (23-micron Merino)

Infected for	>= 5 yrs	4 yrs	3 yrs	2 yrs	1 yr
Clinical OJD	1%	1.5%	2.0%	2.5%	3%
Proportion of flocks	40%	15%	15%	15%	15%
Per head	$1.21	$1.36	$1.48	$1.71	$1.91

OJD = ovine Johne’s disease

The weighted average loss across these flocks is $1.45 per head.

The undiagnosed, non-vaccinating flocks have a rate of clinical OJD of 1% and are losing $0.28 per head.

Table A13.3 Effect of years of vaccination — sheep cereal zone flocks (21-micron Merino)

Infected for	>= 5 yrs	4 yrs	3 yrs	2 yrs	1 yr
Clinical OJD	1%	1.5%	2.0%	2.5%	3%
Proportion of flocks	40%	15%	15%	15%	15%
Per DSE	$1.26	$1.42	$1.61	$1.78	$1.97
Per head	$1.41	$1.59	$1.80	$1.99	$2.21

DSE = dry sheep equivalent; OJD = ovine Johne’s disease

The weighted average loss across these flocks is $1.70 per head

The undiagnosed, non-vaccinating flocks have a rate of clinical OJD of 1% and are losing $0.63 per head.

Table A14.4 Effect of years of vaccination — prime lamb flocks

Infected for	>= 5 yrs	4 yrs	3 yrs	2 yrs	1 yr
Clinical OJD	1%	1.5%	2.0%	2.5%	3%
Proportion of flocks	40%	15%	15%	15%	15%
Per head	$2.27	$2.62	$2.96	$3.24	$3.60

OJD = ovine Johne’s disease

The weighted average loss across these flocks is $2712.85 or $1.21 per DSE ($2.77 per head).

The undiagnosed, non-vaccinating flocks have a rate of clinical OJD of 1% and are losing $617 or $0.27 per DSE or $0.63 per head.

Abbreviations and Acronyms

BEF	bovine ephemeral fever
BRD	bovine respiratory disease
BW	bodyweight
CFWt	clean fleece weight
DSE	dry sheep equivalent
Dwt	dressed weight
ML	macrocyclic lactone
MLA	Meat & Livestock Australia
Nktex	newtons per kilotex
OJD	ovine Johne’s disease
SS	staple strength
VFR	virulent footrot