Private incentives for voluntary on-farm management of ovine Johne's disease[*]

Stewart Webster[**]

Abstract

Ovine Johne's Disease (OJD) affects the financial performance of individual producers through its biological effect on production and regulatory restrictions in the form of trading and stock movement controls. The latter have attempted to minimise the further spread of the disease while scientific data to support long-term policy decisions is obtained through the National OJD Control and Evaluation Program. An important consideration in the long-term management of OJD is the returns associated with different on-farm management strategies.

This paper examines the financial consequences of three OJD management options – status quo, vaccination and decontamination through destocking - for individual producers located in the Central Tablelands of NSW, Kangaroo Island, SA, and South Gippsland, Victoria. The effect of OJD-related mortality, business equity and risk on outcomes is discussed and the implications for wider policy are identified.

Keywords: disease management, farm profitability, decontamination

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1. Introduction

The present regulation of ovine Johne's disease (OJD) concentrates on restricting high-risk stock movements between regions, and particularly aims to prevent the movement of sheep from high to low prevalence areas without some form of market assurance. A recent report into the epidemiology of OJD in New South Wales (Sergeant, 2001) suggests that proximity to known infected flocks was the major risk factor for presently uninfected flocks, and that the current regulatory program is having little impact on inter-neighbour spread of OJD. It is therefore not surprising that governments and the sheep industry have been interested in on-farm decontamination of OJD. However, there has been little detailed research on the financial implications for individual flock owners attempting to eradicate OJD from their properties, or how such a strategy compares to the vaccination alternative.

This paper reports the results of an examination of three OJD management options in three grazing orientated regions of south east Australia. Its objective is to compare how the private incentives associated with each management option influence the decisions of OJD affected sheep producers, and to use this information to contribute to the present policy debate.

2. The epidemiology of Johne's disease

Johne's disease (JD) is a wasting disease of ruminants caused by *Mycobacterium paratuberculosis*. JD thickens the intestinal wall, reducing the absorption of nutrients. Wasting symptoms do not usually occur for some years after infection, but following its onset, the animal progressively loses condition over a number of months until death occurs. Infected animals do not begin shedding bacteria for some months or even years following infection, but the volume of bacteria shed increases rapidly following the onset of wasting.

The disease is transmitted to uninfected animals through ingestion of bacteria present on pasture or in water. It can be shown that *paratuberculosis* bacteria survive longer on pasture in cooler, wetter areas. Soil type and slope may also influence bacterial survival and spread risk whereas higher stocking density probably accelerates disease spread within a flock. Scientific trials are presently being conducted on the length of time the bacteria can survive in the Australian environment, but it is thought that survival of 12 months or more is possible.

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Distinct ovine and bovine (BJD) strains have been detected in Australia. While OJD has been diagnosed in a small number of cattle, it is not known whether infected cattle can pass the disease on to other cattle or back to sheep. Other potentially susceptible animals include alpaca, llamas and deer (Denholm et al 1997).

In 1999 the National OJD Control and Evaluation Program established a series of on-farm trials and off-farm experiments to increase the stock of scientific knowledge regarding the biology of *M.paratuberculosis* in Australia. One such trial, known as Trial 1.1, was established to investigate the efficacy of the removal of all susceptible animals for a given period of time in eradicating the bacteria from an individual property. The results presented in this paper stem from the economic evaluation component of Trial 1.1.

3. The on-farm financial implications of OJD

OJD presently affects the financial performance of individual producers through both its biological effects on production and regulatory restrictions.

OJD-related mortality, either as the direct consequence of wasting or from the systematic culling of clinically affected animals, is the most obvious biological impact of the disease, with annual losses of up to 20% reported. However, mortality can vary considerably between infected flocks and rates above 10% are uncommon (Eppleston et al 1999). The degree of mortality attributable to OJD varies considerably between different age cohorts within an infected flock, with OJD mortalities usually peaking at around three years of age.

Anecdotal evidence also suggests that OJD adversely affects productivity through reduced lambing percentages, reduced wool production, and possibly decreased fibre quality. However, these affects are yet to be quantitatively substantiated.

Animal disease regulation is a state responsibility under the Australian Constitution. The 1999 National OJD Deed of Agreement obliges the Commonwealth, state and ACT governments and various sheep industry bodies to use standard definitions and rules regarding:

- flock testing;
- determination of flock status;
- establishment of OJD zones;
- decontamination of land; and
- disposal of infected livestock.

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Most regulatory restrictions aim to reduce the spread of the disease by limiting trade in infected, or potentially infected, animals. Properties with "infected" or "suspect" status must only sell susceptible animals for slaughter or, subject to approval, to other infected or suspect properties. There are also geographical zones that aim to restrict the flow of susceptible animals between "residual", "control", "protected" and "free" areas.

For many affected producers, regulatory restrictions impose greater financial costs on their business than do the disease's production effects. For example, the trading restrictions that apply to infected properties can impose significant financial costs on sheep producers that specialise in the production of store lambs and replacement ewes or wethers, as such stock must be sold for slaughter. This may impose a considerable discount on the prices received relative to the price that would be obtained for replacement sheep. Confirmation of OJD effectively ends a stud business, although such producers may be able to switch to wool or lamb production in a relatively short period of time.

4. On-farm management options

There is no known cure for OJD. While the new pooled faecal culture (PFC) test and abattoir surveillance has proven effective in detecting infected flocks, the lack of a quick, inexpensive and accurate single-animal test has rendered the identification of individual infected sheep difficult. Consequently, the "test and cull" method of JD control presently being employed within BJD infected dairy cattle herds in western countries is not financially viable for sheep producers (Brett 1998, Juste et al 1993).

As in-flock prevalence and mortality is thought to be partially related to stocking density and grazing management, state departments of agriculture have produced recommended management strategies for infected flocks. These strategies aim to reduce the exposure of sheep to *M.paratuberculosis* as lambs and to reduce overall pasture contamination. Aside from improved stock management, however, the two primary OJD control options available to Australian sheep producers are vaccination and decontamination.

A single-dose "killed" vaccine is presently being trialed in New South Wales but is not yet registered for widespread use. The vaccine does not prevent infection or the shedding of bacteria, but does delay and considerably reduce the onset of wasting within an infected flock. To be fully effective, the vaccine must be administered to lambs at or before marking (six to eight weeks of age). One side effect of the vaccine is that it often produces lesions at the injection site, which can come and go throughout the vaccinated animal's life, although with decreasing frequency. Such lesions can reduce the value of the carcase by imposing contamination and inspection costs on processors.

The present recommended on-farm decontamination strategy is for an infected property to be destocked of potentially infected animals for a period incorporating two consecutive summers[1]. For the purposes of decontamination, cattle are not considered susceptible to OJD and are therefore able to be grazed during the destocked period. Some sheep trading enterprises are also permitted to be run during the destocked period, provided that they are sourced from a "clean" flock and are not held on the property long enough for them to contract OJD and start shedding bacteria. The property is then restocked with sheep from either a low OJD-risk area or a market assured flock.

5. Past and present decontamination schemes

Section 3 of the National OJD Deed of Agreement states the first objective of the National OJD Program's as being "to evaluate existing and potential methods for detecting, controlling and eliminating ovine strains of *Mycobacterium paratuberculosis* from infected sheep and properties and regions of Australia" (Chudleigh et al, 2001). Despite this apparent emphasis on evaluation rather than decontamination, numerous attempts to eradicate OJD from parts of Australia have been implemented or are presently being contemplated.

While the Deed prescribes many definitions and procedures relating to the regulation of OJD until the completion of the National Program in 2003, state governments have been free to pursue pre-emptive decontamination strategies. The varying approaches taken by the three most seriously affected states, New South Wales, Victoria and South Australia reflect, to some extent, their differing OJD prevalence.

New South Wales has placed infected flocks in quarantine since 1996, although prior to this, infected flock owners were asked to give written assurances that they would not trade their stock other than for slaughter. Aside from National Program incentive payments to around 30 producers associated with Trial 1.1, destocking compensation has not been paid in New South Wales. Consequently, most producers that have attempted to decontaminate their properties have done so voluntarily. By the end of 2001, 116 property disease eradication plans had been completed and there remained 698 known infected flocks in New South Wales (NSW Agriculture, 2002).

From late 1996, the Victorian OJD Control Program offered compensation payments to the owners of infected flocks for decontaminating their properties through destocking. A Victorian Parliamentary committee later found that this scheme was effectively compulsory (ENR Committee, 2000). The scheme, which was jointly funded by Industry and the Victorian Government, was suspended in late 1999 due to concerns over its increasing cost. Around 200 properties were destocked prior to suspension of the scheme.

[1] The eradication guidelines are very complex, and a full explanation is not possible here.

South Australia introduced an industry-funded destocking compensation scheme for infected flock owners in 2000. Around 30 South Australian properties had been destocked by mid 2001 (SRRATR Committee, 2001).

The national sheep industry, through its peak bodies, is presently contemplating a voluntary scheme to encourage the owners of infected flocks within control zones to decontaminate their properties. The aim of such a scheme would be to complement the present stock movement restrictions by reducing the spread of OJD via neighbour to neighbour contact within low prevalence areas. The scheme would provide destocking incentive payments of up to $60,000 per property to the owners of infected flocks, and would be funded through an increase in existing national transaction levies on sheep and wool sales.

6. The approach taken

6.1. Previous work

There has been considerable recent work into the "economic" effects of OJD. Some of this work has involved estimating the overall "cost" of OJD to the sheep industry or the nation (see ABARE 1997, Topp et al 2001) by extrapolating simplified per property OJD costs up to represent the entire industry. Most other work in the area consists of discussion papers, based on small numbers of property case studies, that seek to estimate the on-farm consequences of the disease (see Hassall & Associates 2000, Holmes and Sackett P/L 1996, Australian Animal Health Council 1997, NSW Farmers' Association 1997, and Patterson 1998).

A shortcoming with many of these studies is the treatment of the on-farm production and regulatory consequences of OJD. Most rely on simplified, steady state, enterprise budgets and do not adequately track enterprise mix changes over time, particularly in the case of disease decontamination scenarios. Many of these studies also use simplistic assumptions in regard to the epidemiology of the disease which, in most cases, are not incorporated into their financial models.

Finally, the estimated financial position of an OJD affected producer is invariably compared with that of an uninfected producer. As McInerney et al (1992) points out, it is not the total cost of a particular disease that is useful, but the avoidable component of that cost. In the case of OJD, it is therefore more appropriate to compare the infected status quo with realistic alternative scenarios, such as a vaccination program or an attempt to decontaminate the property.

6.2. The model

The approach taken here is to develop a spreadsheet based, representative farm model for each of three high OJD prevalence regions: the Central Tablelands of NSW; Kangaroo Island, SA; and South Gippsland, Victoria. All three areas are dominated by grazing enterprises, particularly sheep, have relatively high carrying capacities and few cropping opportunities.

For each location, the model calculates a stream of monthly net farm income over a 20 year period for each of three OJD management options: the status quo, vaccination and decontamination. The first two options do not involve any change to the enterprise mix, but decontamination requires the disbandment of all existing sheep enterprises and their replacement with various interim enterprises until the expiry of the destocked period, when the previous sheep enterprises are reinstated.

The model is deterministic in that all future prices and costs are exogenously determined and annual carrying capacity of each representative farm remains static over time. The likely implications of reinfection and the inherent risks associated with price and season are discussed later in the paper.

The model incorporates the two major effects of OJD on farm businesses - additional flock mortality and price discounts on surplus sheep sales. Hence, each option influences the number of OJD-related mortalities suffered by the sheep enterprises run on the property, the number of surplus sheep sold, and the prices received for surplus sheep.

The model produces a number of outputs to assist in evaluating the outcomes of each management option. The effect of each management option on individual enterprise gross margins is reported, as is the net present value (NPV) of monthly net income over five, ten, fifteen and twenty years. The level of equity held in the business over time is also estimated.

6.3. Assumptions

Farm area, enterprise mix, overhead costs, land value and level of debt for each location were determined using data from:

- infected properties participating in Trial 1.1;
- the NSW Agriculture OJD database;
- real estate agents;
- rural financial counsellors; and
- a special data extraction from ABARE's farm survey database.

Further information, particularly with regard to the calender of operations, was obtained through detailed interviews with four or five producers in each location.

The primary physical and financial characteristics of each representative farm are detailed in Table 1. While these characteristics were derived to represent the farming system in each location, the area and carrying capacities of all three representative farm models were found to be similar.

Table 1: Representative farm physical characteristics by location

Characteristic	Central Tablelands	Kangaroo Island	South Gippsland
Property size (ha)	700	650	635
Carrying capacity (DSE per ha)[2]	7.5	10	8.5

Information about the assumed initial enterprise mix and proportion of carrying capacity attributed to each enterprise in each location is contained in Table 2. The initial enterprise mix of all three representative farms is dominated by Merino wool enterprises, although the type and quantity of wool varies considerably, with the Central Tablelands, Kangaroo Island and South Gippsland farms assumed to be running 18.5, 23 and 19.5 micron ewes and wethers, respectively. First cross ewes producing export weight second cross lambs and a significant beef cattle breeding herd are also assumed to be run in the Central Tablelands, whereas trade weight first cross lambs are produced on Kangaroo Island by joining sound cast-for-age Merino ewes to terminal sires.

Table 2: Initial enterprise mix and proportion of carrying capacity by location

	Central Tablelands		Kangaroo Island		South Gippsland	
Enterprise	**# head**	**% DSEs**	**# head**	**% DSEs**	**# head**	**% DSEs**
Merino ewes	929	46.0%	1250	60.0%	1267	70.0%
Merino wethers	776	20.0%	1233	30.0%	1098	30.0%
1st cross lambs	n/a	n/a	246	10.0%	n/a	n/a
2nd cross lambs	227	10.0%	n/a	n/a	n/a	n/a
Beef cows	52	14.0%	n/a	n/a	n/a	n/a
Beef yearlings	66	10.0%	n/a	n/a	n/a	n/a

The assumed interim enterprises for each location are described in Table 3. After consultation with producers in each location, it has been assumed within the Central Tablelands representative farm that a beef breeding herd is maintained, a yearling steer operation is expanded and a Merino wether lamb trading enterprise is introduced during the destocked period. Seasonal factors enable two intakes of Merino wether lambs to occur while the representative farm is destocked.

In the Kangaroo Island representative farm it is assumed that both a yearling steer enterprise and a Merino wether lamb enterprise is introduced. Only one intake of Merino wether lambs is included due to the seasonal pattern of Kangaroo Island.

The proximity of South Gippsland to the Victorian dairy industry has enabled many OJD affected producers in that location to undertake a range of dairy related enterprises, including a permanent switch to dairying where irrigation is available. Within the South Gippsland representative farm, two consecutive September 100-head intakes of pedigreed dairy heifer calves are therefore included. These are sold, in calf, at around 15 months. Pregnant dairy cows are also assumed to be agisted during the destocked winter in order to maintain pasture condition and provide cash flow.

[2] Nutrition requirements for the various categories of livestock modelled were estimated in dry sheep equivalents (DSEs). Due to interstate variations in the definition of a DSE, all nutrition requirements in

Table 3: Interim (destocked) enterprise mix and proportion of carrying capacity by location

	Central Tablelands		Kangaroo Island		South Gippsland	
Enterprise	**# head**	**% DSEs**	**# head**	**% DSEs**	**# head**	**% DSEs**
Merino wether lambs	1,881	43%	2,462	50%	n/a	n/a
Beef cows	52	14%	n/a	n/a	n/a	n/a
Beef yearlings	282	43%	406	50%	n/a	n/a
Dairy heifers	n/a	n/a	n/a	n/a	200	3.4%
Dairy agistment	n/a	n/a	n/a	n/a	200	24.6%

While both the Central Tablelands and Kangaroo Island representative farms are assumed to be fully stocked during the destocked period, the South Gippsland farm is not. This is because the dairy heifer raising enterprise assumed to be run in the latter location is highly labour intensive, particularly in the early stages, and it was deemed unrealistic for any further calves or other enterprises to be run during the destocked period. Similarly, it has been assumed that all representative farms have access to adequate cattle handling facilities, although this may mean sharing a neighbour's cattle yards, and that the South Gippsland farm has suitable shed space for the initial stages of the dairy heifer raising enterprise. As the above assumptions applied to most case study properties interviewed, no capital expenditure has been allowed in any location for the switch to cattle enterprises during the decontamination option.

Table 4 contains information about the flock mortality assumptions incorporated in the base run simulations. Of the three locations considered, the Central Tablelands has the highest average and absolute reported OJD mortality, with a few properties reporting annual losses of 20 per cent. Both Kangaroo Island and South Gippsland producers are reporting far fewer deaths, although this may be due to the shorter history of OJD in those locations.

Table 4: Base run annual flock mortality assumptions by location

Sheep Age Cohort or Enterprise	Infected Mortality	Vaccinated Mortality	Background Mortality	Comment
0.25-1.5	0.5%	0.00%	2.5%	Weaning to joining age
1.5-2.5	5.9%	0.00%	2.5%	Applied to all ewe enterprises in
2.5-3.5	9.8%	0.48%	2.5%	all locations. Wether enterprises
3.5-4.5	5.0%	1.00%	2.5%	assumed to have adult average
4.5-5.5	2.6%	0.78%	2.5%	uninfected mortality of 1.5%
5.5-6.5	1.3%	0.27%	2.5%	due to no lambing risk
Adult average	**5.0%**	**0.50%**	**2.5%**	**1.5 to 6.5 years old**
>6.5	1.3%	0.27%	3.0%	Older KI ewes for 1st X lambs

The "background" mortality regime represents deaths unrelated to OJD, such as lambing complications, flystrike etc, and applies to all management options including post-decontamination enterprises. The model adds the relevant mortality regimes to derive the total flock mortality for each management option. For instance, total mortality under the status quo scenario is represented by the sum of the background and infected mortality regimes. The mortality rates for beef cows, yearlings steers and dairy

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the model have been standardised to DSEs defined as the average energy requirements of a 50kg heifers are assumed to be two per cent, one per cent and one per cent (post weaning), respectively, in all locations.

The chosen OJD-related flock mortality base level of 5 per cent per annum represents a significant level of infection for Kangaroo Island and South Gippsland, though it is well within the reported mortality range of the Central Tablelands (Eppleston et al 1999). This discrepancy between the three regions may be explained by the much longer history of the disease in the Central Tablelands.

OJD vaccines are widely reported as being at least 90 per cent effective in reducing mortalities and bacterial shedding (Denholm 1999, Brett 1998). OJD-related mortalities were therefore assumed to be 0.5 per cent under the vaccination management option.

The infected mortalities detailed in Table 4 represent the initial mortality regime for all three management options. Epidemiological studies have shown that middle-aged cohorts are most likely to suffer the highest mortalities, and that the overall rate of OJD mortality for an unvaccinated flock generally rises over time, although climate and soil types may also have a role (Eppleston et al 1999, Denholm et al 1994, Sigurdsson 1960). The proportion of OJD-related mortalities for each age cohort are therefore made to conform to an assumed distribution for any given level of OJD mortality, where OJD-related mortality peaks at 40 per cent of all OJD-related mortalities within the 2.5 to 3.5 year old age cohort. OJD-related flock mortality for the status quo management option is also assumed to increase by 10 per cent each year.

A similar approach was taken to modelling the effect on mortality of using the killed vaccine presently being trialed in New South Wales. As each vaccinated cohort moves through the various age categories, the OJD-related mortality applied to that age group switches from the infected to the vaccinated mortality regimes in Table 4. It therefore takes six simulated years before OJD-related mortalities are minimised under the vaccination management option. OJD-related mortality is thought to be delayed by vaccination. Consequently, the proportion of OJD-related mortalities for each age cohort is assumed to peak within the 3.5 to 4.5 year old age cohort under the vaccination management option.

Wool quantity and quality is an important factor influencing the profitability of Merino enterprises. Both production characteristics depend to a large extent on animal age. In tracking each age cohort separately, the model is able to apply different wool cuts and prices to hoggets, 1.5 to 6.5 year old adults and ewes older than 6.5 years. This provides a more accurate estimation of the effect of age-related OJD mortalities under the three management options examined than has been attempted in past studies.

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wether, equalling 9.7 megajoules per day.

The main wool and livestock prices assumed to be received by the enterprises run in each location are detailed in Table 5. Clip prices were derived from Australian Wool Exchange Northern and Southern region micron indicators for the 2000-2001 season. All livestock prices were derived from National Livestock Reporting Service data for 1999-2001.

Table 5: Main assumed wool and livestock prices by location

Enterprise	Central Tablelands		Kangaroo Island		South Gippsland	
	price (c/kg or c/head)	description	price (c/kg or c/head)	description	price (c/kg or c/head)	description
Merino adult wool	1108	18.5 micron	382	23 micron	781	19.5 micron
Merino lambs wool[3]	846	19 micron	518	20 micron	n/a	n/a
Crossbred wool	291	28 micron	n/a	n/a	n/a	n/a
Prime lambs	195	22-25kg	207	18-22kg	n/a	n/a
Beef weaners	148	steers	n/a	n/a	n/a	n/a
Beef yearlings	147	steers	152	steers	n/a	n/a
Dairy heifers	n/a	n/a	n/a	n/a	$900/h	in calf
Dairy agistment	n/a	n/a	n/a	n/a	$5/h	per week

While the wool and livestock prices used in the model are significantly lower than present levels, they are intended to provide long-term enterprise income streams. Sensitivity analysis of wool and livestock prices within the model did not alter management option rankings for any location.

Surplus sheep prices will, at any given time, be determined by the market based on the potential productivity of the animals in question, their slaughter value and the prevailing regulatory environment. These factors have been incorporated into the model where possible, except that it has been assumed that the OJD vaccine presently being trialed has been registered, and producers are free to buy and sell vaccinated sheep for restocking purposes.

The difference in price between vaccinated and infected surplus sheep sold as replacements is perhaps the least reliable variable in the analysis. Little objective data is available at this time regarding the attractiveness to potential buyers of vaccinated stock as the only vaccinated sheep in Australia at present must be sold for slaughter under the conditions of the vaccine trial. In the absence of empirical Australian estimates, the assumed prices for vaccinated surplus sheep have been based on the estimates of experienced industry participants and New Zealand evidence regarding additional processing costs associated with vaccinated sheep.

It has been assumed that cast-for-age sheep and prime lambs are routinely sold for slaughter regardless of OJD status, and so no discount has been applied to sales of infected cast-for-age sheep. However, New Zealand experience (Brett 1998) suggests that vaccinated animals sold for slaughter are subject to discounts as a result of increased processing costs associated with lesions at the injection site. Consequently, a flat $5 per head discount has been applied to all vaccinated animals sold for slaughter.

The largest discount has been applied to the sale of surplus Merino wether weaners and ewe hoggets. The base run price discounts applied within the model to these classes of sheep are detailed in Table 6. The assumed sale price for the vaccinated and infected sheep listed in Table 6 are based on the expected sale price of their uninfected (or more precisely "unassessed") counterparts.

Table 6: Assumed base-run sale prices for surplus Merino weaners and hoggets by location

Sheep type	Central Tablelands	Kangaroo Island	South Gippsland
Uninfected wether weaner	$30.00	$30.00	$30.00
Vaccinated wether weaner	$20.00	$20.00	$20.00
Infected wether weaner	$15.00	$15.00	$15.00
Uninfected ewe hogget	$40.00	$35.00	$35.00
Vaccinated ewe hogget	$30.00	$25.00	$25.00
Infected ewe hogget	$20.00	$25.00	$25.00

All uninfected Merino wether weaners are assumed to be sold as replacements for $30 per head, although the net slaughter value for these animals if grown out to slaughter weight also provides a floor to this price. Vaccinated wether weaners are assumed to be sold to other infected properties as replacements (which is presently subject to official approval). The net prices received for vaccinated weaners are $10 below the uninfected price for similar stock. While it is difficult to empirically justify this discount, the market for vaccinated replacements is not as robust as that for uninfected sheep, and $10 was considered a conservative estimate of this effect. Infected wether weaners are assumed to sell for $15 per head, the net price after being fed supplements to bring them up to slaughter weight, which is the only marketing opportunity for such stock.

Uninfected Merino ewe hoggets are assumed to be sold as replacements for $35 per head on Kangaroo Island and in South Gippsland. Central Tablelands uninfected ewe hoggets are assumed to sell for $40 per head, reflecting their higher value as replacements under the wool prices used. Vaccinated ewe hoggets are assumed to sell for $10 per head less than their uninfected counterparts, again reflecting the less robust restocker market for such animals. Infected ewe hoggets are assumed to be sold direct for slaughter and hence bring a lower price than ewe hoggets sold as replacements. The fine wool ewe hoggets of the Central Tablelands are smaller framed sheep than those of the other locations, and consequently fetch a lower slaughter price

The assumed financial parameters used in the base run simulations for all three locations Table 7. Initial equity was set at 80 per cent of land value in all three locations. While this is somewhat arbitrary, the implications of other levels of debt are discussed later in the paper. The uninfected total gross margin of the initial enterprise mix indicates that the level of returns in each location are similar, as are annual fixed costs.

[3] Specifically, the wool produced by interim Merino wether lambs.

Table 7: Base-run financial parameters by location

Parameter	Central Tablelands	Kangaroo Island	South Gippsland
Initial equity[4]	80%	80%	80%
Land value per hectare	$2,000	$855	$2,200
Uninfected total gross margin	$108,929	$56,532	$111,478
Fixed costs per annum	$61,500	$56,700	$54,000

One point of difference, however, is the land value associated with Kangaroo Island, which is less than half that of the other two locations. Given that Kangaroo Island has the highest assessed carrying capacity of all three locations, this aspect of the data is surprising. Presumably, Kangaroo Island land values are influenced by factors such as additional transport costs and foregone marketing opportunities.

7. Results

7.1. Base runs

The difference in monthly income between the vaccinated and status quo options and the decontamination and status quo options were calculated over twenty years. The net present values (NPV) of these differences, which are detailed in Table 5, were then calculated using a real discount rate of 4 per cent per annum to allow comparison of the three management options in each location.

Decontamination requires a much larger initial investment than a vaccination program, but results in higher annual net farm income once the initial enterprise mix is reinstated. Consequently, the NPV of decontamination overtakes that of vaccination over longer investment horizons. The year at which decontamination overtook vaccination is shaded in Table 5 for each location.

From these results it can be seen that positive returns to an investment in a vaccination program are earned almost immediately. Vaccination is the most profitable short-term option in the Central Tablelands and South Gippsland, although decontamination overtakes vaccination as the most profitable management option on Kangaroo Island within two years. However, the decontamination NPVs ignore the risk of reinfection – a significant problem in high prevalence areas.

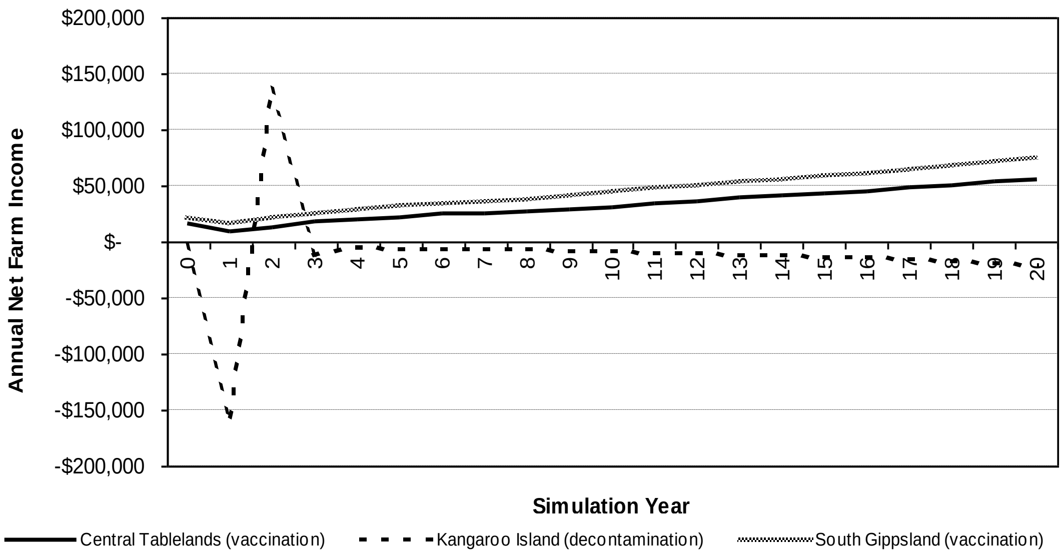
[4] Equity has been calculated using the method recognised by financial institutions: (total land value – total debt)/total land value. This differs from the accounting approach, which uses total assets rather than land value, and thereby affects a producer’s ability finance decontamination.

Table 8: NPV of vaccination and decontamination options over the status quo by location

	Period	Vaccination	Decontamination
Central Tablelands	5 years	$24,336	$17,604
	7 years	$44,348	$50,432
	10 years	$81,033	$110,623
	15 years	$172,404	$241,718
	20 years	$304,791	$414,089
Kangaroo Island	2 years	-$2,813	$16,085
	5 years	$666	$66,162
	10 years	$18,413	$192,879
	15 years	$65,547	$376,035
	20 years	$165,926	$642,564
South Gippsland	5 years	$27,422	$22,330
	10 years	$96,721	$80,023
	13 years	$155,229	$161,718
	15 years	$201,027	$223,343
	20 years	$353,682	$416,910

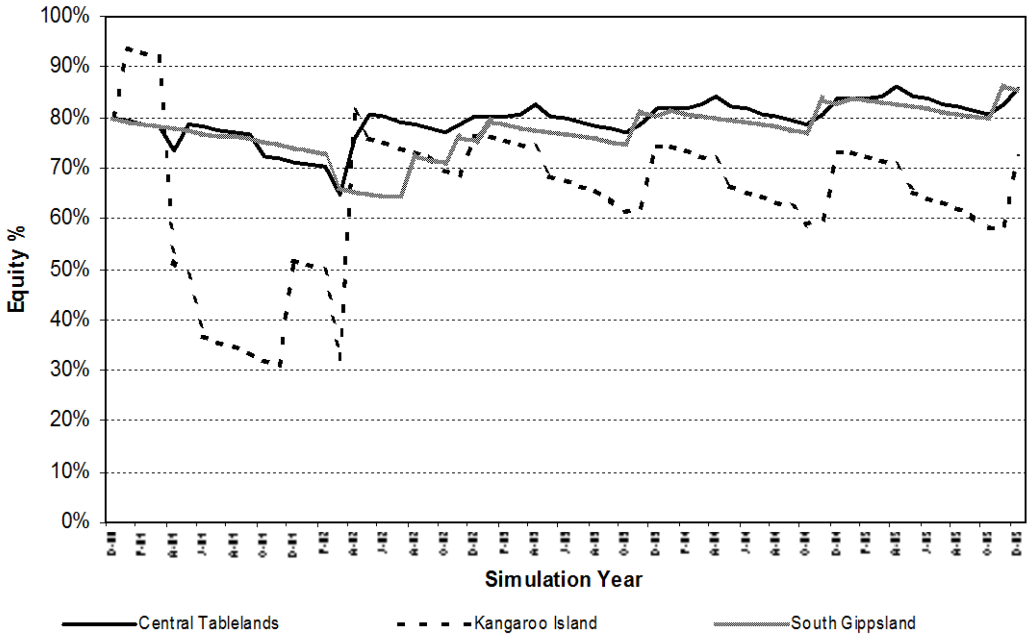
Of the three base run simulations, only Kangaroo Island consistently returns negative annual net farm income for all three management options. This is illustrated in Chart 1 by the comparison of annual net farm income flowing from the most profitable short-term option in each location. While the low profitability of the Kangaroo Island representative farm model is primarily a function of the assumed wool and livestock price levels, the order of profitability between the three locations tends to reflect the land values used in the model.

Chart 1: Most profitable base run option annual net farm incomes



An OJD affected producer that is contemplating decontamination as a management option would need to consider the financial constraints that may thwart such a decision. Financial institutions lend on the basis of business equity expressed as a proportion of the property's land value, with few willing to lend beyond 50 per cent equity. It is therefore possible that a switch to a finance-intensive interim enterprise, such as yearling steers, could not be funded through short-term debt. For example, Chart 2 tracks the equity level for each location under the decontamination management option.

Chart 2: Base run decontaminated equity to year 5



The short-term fall in equity shortly after commencing decontamination may mean that a producer may not be able to fully stock their property, and hence maximise their income, during the destocked period, thereby further increasing the relative cost of the option. While the base runs ignore these financial constraints, it is worth noting that, at an initial equity of 80 per cent, the financial constraint is likely to be binding only for Kangaroo Island producers, who have relatively low land values. At initial equity levels lower than 70 per cent, however, such finance constraints also affect the Central Tablelands and South Gippsland.

7.2. The effect of OJD mortality levels and surplus sheep prices

The effect that the level of OJD mortality and surplus sheep prices have on the profitability of OJD management options are interrelated. As income received for surplus sheep constitutes a substantial proportion of total income for some sheep enterprises, particularly on Kangaroo Island, both the prices received and the number of head sold influence profitability under any management strategy.

The level of OJD mortality applied to the status quo option has a bearing on the results in that the status quo is the benchmark that both vaccination and decontamination are measured against. The level of total mortality applied in each option affects the number of surplus sheep to be sold and so both the "background" and vaccinated mortality assumptions also influence the results.

Sensitivity analysis showed that the profitability of both the vaccination and decontamination options in all locations is primarily due to the assumed price differences between infected and uninfected surplus Merino sheep. This is not surprising, as the sale of surplus Merino weaners and hoggets constitutes 20, 32 and 24 per cent of uninfected Merino ewe enterprise income in the Central Tablelands, Kangaroo Island and South Gippsland, respectively.

Vaccination was found to be relatively insensitive to the initial rate of OJD mortality. However, in the absence of price premiums for vaccinated surplus sheep, initial OJD mortality must exceed 2.8 per cent in the Central Tablelands, 4.8 per cent on Kangaroo Island and 3.5 per cent in South Gippsland for vaccination to be profitable within 5 years.

Decontamination was found to remain profitable over 20 years in all locations, even when initial OJD mortality was set to zero. However, the length of time required before the NPV of decontamination became positive varied considerably between locations, with eight years required for the Central Tablelands and 18 years for South Gippsland. Decontamination on Kangaroo Island became profitable within two years under the same assumptions, due to that location's greater reliance on surplus sheep sales and the relatively high profitability of the assumed interim enterprises relative to the initial enterprise mix.

8. The implications of risk

The analysis above ignores risk. However, OJD affected producers who are deciding on their management strategy face significant price and production risks, additional to the usual price and seasonal risk faced by all sheep producers. These risks particularly affect the relative attractiveness of decontamination.

The decontamination option incorporated into the regional models assumes that decontamination is, and remains, successful. However, producers attempting such a strategy face three major risks:

1. decontamination is unsuccessful, in that paratuberculosis persists on the pasture or in watercourses, thereby infecting restocked sheep;
2. decontamination was successful, but paratuberculosis was reintroduced to the property from an infected neighbour via either straying sheep or other vectors; and
3. decontamination was successful but infected sheep were unwittingly purchased to restock the property, hence recontaminating the property.

The realisation of any of these risks may place the producer in question in a worse financial position than when they started the process, as they have spent thousands of dollars on destocking without receiving the benefit of lower mortality and higher prices for surplus sheep. The likelihood of such risks being realised is difficult to estimate, but infected neighbours have been shown to present a major infection risk to uninfected properties, and all three locations are high prevalence areas. Additionally, some Trial 1.1 properties that have restocked following decontamination have again proven to be infected, although it is not yet possible to attribute which of the three factors above was responsible in each case. The risk of reinfection would, therefore, appear to be not inconsiderable.

The major price risk is that associated with stock prices. Should a producer attempt to decontaminate their property, they will need to sell all of their sheep, buy into or expand an existing interim enterprise, and then purchase replacement sheep at the end of the destocked period. Where a producer buys store cattle, as is assumed in all three representative farm models, it is assumed that the price of cattle remains steady over the destocked period. With most available capital tied up in the interim enterprise, the producer therefore faces the risk of major losses should cattle prices decline during the destocked period. Price risk similarly applies to interim cropping enterprises. Of course, interim enterprises may also rise during the destocked period, resulting in a windfall gain to the producer.

Fluctuations in wool or prime lamb prices can also represent a risk over and above the consequent affect on replacement sheep prices. The opportunity cost of not having sheep, albeit infected sheep, during the destocked period would increase if wool or prime lamb prices increased. Decontamination is therefore less likely to be attempted if producers feel that wool or prime lamb prices are going to rise, and vice versa.

A further opportunity cost which may affect the willingness of producers to digress from the status quo is regulatory risk. At any given time, there is always the possibility that government policy affecting the profitability of OJD infected sheep enterprises might change. The apparent switch in national emphasis from decontamination to vaccination over the last four years is a case in point. An OJD affected producer four years ago effectively had two options – the status quo or decontamination. The vaccine trial has provided many New South Wales producers with a third, less risky, option and expectations of the vaccine’s national registration is probably reducing the number of producers presently attempting decontamination.

8. Conclusions

The analysis has shown that under a wide range of mortality assumptions, vaccination is a substantially more profitable short-run OJD management strategy than either the status quo or decontamination in the Central Tablelands and South Gippsland. Vaccination also has the advantage of being far less costly to implement than decontamination and is a much less risky management strategy.

While decontamination shows promise on Kangaroo Island, the reinfection risks associated with decontamination appear to reduce that management strategies usefulness in high prevalence areas.

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