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Lamb Alive

A long term approach to the changing climate risk

October 2009

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Lamb Alive – a long term approach to the changing climate risk

MAF SFF Climate Change 08/028: 'Lamb Alive'

October 2009

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1. Executive Summary

Lamb survival to sale is the major driver of profit in our sheep farm systems. Global warming, land use change and increased lambing percentages threaten lamb survival. In any three day period of lambing the number of lambs born has been estimated to have doubled compared to 20 years ago. How will the climate of the future influence our lamb survival? Which managements can we apply to minimise any potential decline?

The Lamb Alive project used a full systems approach to examining the issue of lamb survival in the southern South Island of New Zealand. This approach worked from farmer workshops to identify regional problems and potential solutions, developed and used lamb survival software based on previous research to explore those solutions, integrated predicted present and future climatic data into those models and examined the relative impacts of different mitigations on lamb survival on-farm.

Farmer groups at 4 regions throughout Southern New Zealand (West Otago, Northern Southland, South Otago and South Canterbury) helped define the local conditions and provide an insight into the types of on-farm mitigation that may be effective against the climatic impact on lamb survival. Mitigations included adding shelter, increasing feeding in late pregnancy and changing lambing date and spread.

Lamb survival modelling using recent AgResearch lamb survival data sets was combined with climate modelling using the NIWA virtual climate station network to interpret global climate change trends for three future scenarios.

Variability in the current climate in southern New Zealand is already very large. The modelled changes to variability, particularly rainfall, provided little extra variation that farmers do not already manage for. The inability of the virtual climate station network to provide local wind run data creates a gap in the robustness of the predictions, as wind run is the greatest manageable variable that impacts on lamb survival. Future work to improve wind run prediction will improve the outcomes of such modelling.

Modelling the impacts of global warming and on-farm mitigations provided some significant insights into how management may change to improve lamb survival. Future global warming will increase temperature at lambing. Changes in rainfall will be relatively small. Overall the impacts of global warming will improve lamb survival if lambing dates remain where they are now. Conversely, farmers may have the opportunity to lamb up to 10 days earlier with no impact on lamb survival, while potentially improving their ability to finish lambs before the onset of summer drought.

Wind chill was the climatic factor that could be influenced the most through the provision of shelter. This long term mitigation against lamb loss provided

benefits both through sheltering the ewe before lambing and the lamb at lambing.

Improving feeding to the ewe in the final three weeks of pregnancy was the mitigation with the greatest potential as a short term solution. Further increases in lambing percentage will continue to provide more lambs for sale in some environments. The increase in spring temperatures at lambing may also help provide extra feed approaching lambing as spring pasture production will begin earlier in these regions of southern New Zealand. The modelled impacts of feeding, while supported by the literature, need field confirmation to ensure sound recommendations for farmers and so should be viewed with caution.

Farmer attitudes to various mitigation practices varied depending on their practical experience of the solutions. Feeding was recognised universally as the most appropriate solution, though was often the hardest to implement due to varying feeding conditions. Shelter was viewed as more problematic because farmer experience from poor shelter design saw lower lamb survival due to increased risk of disease and mismothering. Hill country farmers saw problems of scale impacting on the effectiveness of shelter in those environments.

Changing the spread of lambing did little to change to outcome for lamb survival, so while many more lambs are being born on any one day, the impacts of the climate on the whole lambing period are more important than single events.

This work provides a starting point to help farmers redesign on-farm systems to provide significant mitigations to improve lamb survival in the face of future climate change and increasing ewe flock fertility.

2. Introduction

Over the last 15 years sheep flock performance has markedly increased as farmers have adopted cross breeding, composite breeding and the introduction of new breeds. At the same time farmers have added other technologies such as improved nutritional management and feeding, scanning and fertility enhancing treatments such as Androvax and Ovastim. Flock scanning levels have increased markedly, from 120-125% to the extent that many flocks now consistently achieve 170-180%.

Over the same period there has been little change in the commencement date for lambing, although typically the lambing pattern is more condensed, and often 3rd cycle mated ewes are culled before lambing.

The consequence is that in any 3-day period of lambing in 2005, 20% more of the ewes in the flock will be lambing compared to the same period in 1990. In the same period, it is estimated that the number of lambs born has almost doubled.

So at any period over lambing, the consequence of a severe climatic event on lamb and ewe survival is now potentially more catastrophic, than was the case in 1990. Snowstorms and lamb losses across the lower South Island in spring 2004 highlighted the risks facing pastoral farming and sheep production in particular.

Climatic change is forecast to induce a greater risk of extreme events. More and/or heavier snowstorms are a possible consequence in these regions. The rapid dissemination of such adverse events through considerable media attention means that we must ensure that mitigations to improve lamb survival are as robust as possible.

Catchments differ in their susceptibility to such adverse events, and an understanding of what climate change will mean at regional, catchment and farm level is desirable.

Current expansion of the dairy industry is leading to a reduction in the area available for finishing lambs and so more hill country farmers need to keep and finish the lambs born on the property. This leads to different requirements for the system and may alter the drive for high lambing percentage.

We need to know just what the extra risk due to climate change is likely to be, in particular late winter-early spring storms and snow events; the options we have for managing flock performance and productivity; and the implications for modifying our farming systems that will still enable financial, animal welfare and social goals to be achieved.

A systems analysis approach was used to examine the issue of lamb survival in the southern South Island of New Zealand. This approach used farmer workshops to identify regional problems and potential solutions, and then developed and used lamb survival software based on previous research to explore those solutions. Predicted present and future climatic data was integrated into those models to examine the relative impacts of different mitigations on lamb survival on-farm.

This project will:

- Develop tools to estimate the impacts of severe weather events on lamb losses
- Help industry planners to understand the impacts of future climate changes
- Examine potential solutions that will improve lamb survival in a cost-effective way

The sheep farmers in the South Island will have tools and solutions available to help them mitigate against the potential impacts of storms during lambing. This is envisioned to be one of a number of tools that may be needed to meet future scenarios, making the farming systems more robust in the face of change.

3. Background

Climate change and its potential implications (MfE 2008) are summarised below.

‘A broad range of observations shows that the world has warmed during the 20th century. There is now stronger evidence that most of the warming observed over the last 50 years is attributable to human activities, namely the emission of greenhouse gases.

Climate models predict a global warming by 2100 between 1.4 and 3.8 degrees Celsius, compared to an observed warming of about 0.6 degrees Celsius during the 20th century.

Temperatures in New Zealand are likely to increase faster in the North Island than in the South Island, but generally less than global average temperatures. Rainfall is projected to increase in the west of the country and decrease in many eastern regions. While these general trends are considered relatively robust findings, the magnitude of the projected changes depends on the global greenhouse gas emission scenario and also varies considerably between different climate models, particularly for local rainfall patterns.

The full range of effects has not been quantified yet. The assessment of climate change impacts on agriculture has been greatly helped by the development of an integrated assessment programme (CLIMPACTS) which combines climate and agricultural expertise. However, information on regional climate change and its impacts is still too limited to quantify the overall economic effect on the agricultural sector. Adaptation to altered climate conditions would also influence future economic outcome through proactive utilisation of opportunities and mitigation of negative impacts.’

The variability in future potential climate change scenarios are the biggest risk to South Island sheep farmers because of their impact on the farming environment. One of the key drivers to financial success on sheep farms is the number of lambs that survive to sale. Variability in the climate during lambing is known to have a major influence on this key performance driver.

This project helps address one of the potential future impacts of climate change at a regional level, using the NIWA virtual climate station, by investigating the potential size of the problem and probable solutions to keep productivity high. Solutions such as the provision of extended shelter on-farm to mitigate against more severe weather events may also help in carbon footprint amelioration.

4. General Methodology

The Lamb Alive project used a systems analysis approach to examining the issue of lamb survival in the southern South Island of New Zealand. This approach had four phases:

1) **Farmer catchment groups**: The first phase was to work with farmers to identify regional problems and potential solutions.
2) **Climatic predictions and variations**: The second phase modelled present and future climatic data based on forecast climate change trends.
3) **Predicting lamb survival**: The third phase developed lamb survival software based on previous research to explore solutions offered by farmers.
4) **Improving potential lamb survival**: The fourth phase brought the other three phases together by integrating the mitigations offered by the farmers with the predicted present and future climatic data into the lamb survival model and examined the relative impacts of different mitigations on lamb survival on-farm.

This section provides the general methodology, while the detailed specific methodology is presented within the documentation for each phase

Farmer catchment groups

The first phase established a series of four catchment-focused groups of farmers to work through each stage of the project. Farmer groups identified the issues that caused variation in lamb survival in each catchment and suggested potential mitigations that may apply to their region. Specific methodology is found in Appendix 1.

Climatic predictions and variations

Forecasts for climate change were prepared by NIWA, using the Virtual Climate Network to interpret global climatic trends at a regional level around the South Island, with emphasis on assessing intra region variability in the nature and frequency of events. This phase is presented in detail in the accompanying documentation 'Projected climate data for three future scenarios for 2030-2049 for use in lamb survival modelling'. Differences at a catchment level are highlighted, so that the nature and probability of change can be better understood by farmers. Changes in climatic conditions were described and modelled across a 20 year time frame, and compared and contrasted with conditions over the period 1981 to 1999.

Predicting lamb survival

Databases of the AgResearch/Meat & Wool NZ/SFF lamb loss studies and Sheep Improvement Ltd were used to model the prediction of lamb loss in changing environmental conditions.

Improving potential lamb survival

Based on forecast change in climatic conditions, these models were used to assess and contrast the effect of climatic change on lamb survival and potential lambing percentage in these farming systems.

Changes in management using current tools and mitigation strategies to reduce the negative impact of climatic change on the farming risk, animal welfare and business viability due to changes in lamb survival were then modelled to demonstrate their potential.

5. Farmer catchment groups: Identification of issues and solutions

The first phase in the analysis to understand the impacts of present and future climatic influences on lamb survival was to bring four farmer groups together to examine the current issues that the farmers face. This was done through a workshop process where regional issues were first examined and then potential mitigations for that region were identified. The results of these workshops then provided the types of mitigation that were applied to the lamb survival modelling to investigate the relative importance of each mitigation in the face of the variable climate now and in the future.

Four regions volunteered to be part of the project and workshops were held between November 2008 and May 2009. These regions were:

1) West Otago,
2) Northern Southland,
3) South Otago and
4) South Canterbury.

The full documentation of the workshop plan and specific outcomes from each workshop are presented in Appendix 1. The general principles and outcomes from the workshops are presented here in summary.

Workshop plan

The farmer workshops began with a semi-structured discussion of the causes of variation in lamb survival. This led to the development of mitigations that could be implemented to improve lamb survival on farm. The groups then prioritised the mitigations according to the likelihood of implementation in each region. The top priority mitigations were then chosen for further investigation through modelling.

Workshop outcomes

Lamb survival continues to be a key to the future of sheep farming in hill country. The concept of lamb survival and its potential impacts on long term profitability in hill country was identified by all groups. Each group wanted to investigate practices that would potentially reduce lamb losses to improve profitability.

Factors affecting lamb survival

The discussions at all workshops were robust and wide ranging. Some groups provided a fuller list of factors than others, but the two primary causes were always listed as the climate and the feeding of the ewe.

Feeding

Most farmers suggested that feeding was the most important priority but had relatively few true measures of how much extra feeding was required. Optimising lamb size and ewe health through feeding were seen as two of the most important factors. The actual practice of getting this right was often an interaction between balancing the winter feed budget and the spring grass production. Managing feed leading up to lambing was a significant area where compromises were often made, and consequences often are not understood by farmers or scientists.

Shelter

Shelter was seen as important in most groups. The trade-offs between shelter and diseases were raised, as was the expense of shelter and poor shelter design. Problems with shelter design included wind chill due to the wind being channelled underneath trees and hedges, and the build-up of diseases in close proximity to shelter that induced stock camping. Farmers also cited experience with sheep moving away from shelter when weather conditions were particularly bad. Conversely others had found that mis-mothering may occur if there is too little shelter and many ewes access the shelter at once.

Natural shelter like tussocks was acknowledged as superior to other types of shelter. The opportunity to re-establish tussock is a technical problem that may need addressing.

Other observations from the farmers indicated that the interactions between shelter and behaviour were evident between shorn and unshorn sheep, making the use of shelter unpredictable.

Secondary factors

Many of the secondary factors that were raised were often related to either of the primary causes, climate or feeding. For example, managing the ewe and her movements was discussed by all groups. During each of the discussions reference was made to the use of shelter and the amount of feed on-offer. Thus the majority of the discussion about managing the ewe was also about managing the ability of the mitigations to influence climate risk or feeding. Discussions around metabolic illnesses like sleepy sickness were also related to the importance of feeding.

Genetics was also cited as significant by all groups, but was particularly stressed by the South Otago and South Canterbury groups. Anecdotal evidence of variations in lamb survival due to different sire and breed types were quoted. Farmers had often made their own decisions on the type of sheep they used on this basis.

Other factors such as abortion and trace elements were seen as identifiable issues that should be managed as a matter of course.

High lambing percentage was seen as one pragmatic way to overcome the problems of lamb losses. This would mean that, though the losses may be higher, the number of lambs would still be greater. As a result, in good years there would be plenty of extra lambs, while in bad years then there would still be more than if lambing percentage was lower. This view was countered by some farmers who already have high lambing percentages and now have practical problems with trying to improve the survival of an increasing number of triplet lambs.

Mitigations that may help improve lamb survival

Farmers chose three broad approaches to improve their tactical approach to lamb survival.

The first two were interventions to improve the status quo and the third to reduce risk:

1) Direct intervention through changing management or feeding strategies.
2) Long term development of policy, including shelter planting, increasing lambing percentage potential in the flock and improving lamb survival genetics.
3) Spread the risk by altering the balance of ewes lambing at any particular time.

Direct interventions

The major primary intervention chosen by all farmers was the use of increased feeding around lambing. While the farmers understand the general principle of the need for appropriate feed, the application may not be well executed.

The interaction between managing feed and managing the ewe was discussed by all groups. Trade-off occurs between feeding the ewe in the last two weeks and keeping feed for lambing. This is complicated by the requirement to spread ewes out to minimise number of ewes lambing at any one time and have the ewes become familiar with the lambing paddocks. Techniques used to help prioritise which ewes are fed more include using ram harnesses or scanning data to split mobs based on potential lambing date. The farmers questioned how much lamb survival was influenced by good feeding through rationing or good husbandry of allowing sheep the time to familiarise themselves with the lambing environment. Some farmers used the ‘feed management’ approach and others used the ‘animal management’ approach.

The full impact of variation in BCS may also not be fully understood. The concept of feeding conditions in the last 14 days of pregnancy on lamb survival needs to be better explored and explained

The stocking rate of lambing ewes was regarded as an important factor that may be underestimated, especially in triplet-bearing ewes. It was felt that relatively little is known about the social interactions between triplet-bearing ewes and the consequent impact on mismothering. More research into the impacts of managements to reduce paddock stocking rates was required. Mitigations may include mixing singles and triplets, preventing stock movement within a paddock to avoid mismothering, and using other stock classes to help reduce the density of lambing ewes in the paddock.

Shepherding practice was discussed as mitigation but the groups were divided on the benefits of active shepherding. Emphasis was placed on giving sheep the space and time to lamb. Appropriate feeding and watering was considered essential, as was the ability for the ewe to find shelter if required. Routine was also mentioned as important, as well as providing a settled environment.

The potential around managing parts of the flock based on using ram harnesses or foetal aging was discussed, often as a way to intensively manage only part of the flock. This could be through more shepherding, better use of shelter, and better use of feed

Temporary shelter using crops or grasses was mentioned. This may provide the ewe with a birthing site that also had a feed source with it and therefore would limit movement and provide shelter at the same time.

Long term policy development

Long term policy development strategies included shelter planting and investing in genetics, as well as managements such as housing of ewes, drainage and long term weather forecast use.

The impacts of shelter were viewed as an important factor that could assist in mitigating against the impacts of climate on lamb survival. Farmers were well aware of the need for effective design of shelter to prevent stock camping and ensure that full paddock shelter was achieved.

Shelter mitigation was thought to be a trade-off between reducing wind and increasing disease and mismothering. Some farmers noticed no difference between sheltered and un-sheltered paddocks. Others observed that weather drove the sheep away from shelter; some thought that shorn ewes (pre lamb) would use shelter better. Several farmers fenced shelter off (temporary electric) to push sheep out into paddocks (10-20m) to avoid disease, typically naval ill and watery mouth.

Providing significant shelter may also involve the use of farm forestry type tree blocks rather than conventional shelter belts in many cases, if the current guidelines on carbon sequestration are put in place. This has the potential to significantly change the pasture production, lamb survival and the carbon footprint of the farm. It also has the potential to reduce costs by removing maintenance centres, though will increase the capital infrastructure of the farm.

Farmers had heard of cold tolerance gene and wanted to know more. They were interested to understand the impacts of genetics generally.

Housing of triplet bearing ewes around the time of lambing was suggested as one potential intervention that may help. Many logistical issues were identified, such as cleanliness, feeding and feed changes and appropriate space for lambing. A further idea within specialist intervention was to hand-rear the third triplet, though most farmers thought that cost and labour requirements would preclude this option.

More accurate long term weather forecasting may help with determining the date to put out the ram. One farmer told of his experiences with trying to use long range weather forecasts to determine the date for an early lambing mob.

The impacts of drainage and a drier soil surface were raised, though generally it was taken as given that this should be a standard farm practice.

Spreading the risk

Spreading lambing out over a longer time was suggested as a method to spread risk by several groups. This would be done to improve lamb survival by having fewer lambs exposed to storms at any one time. One general concept was to change from the current lambing pattern, where approximately 85 to 90% of the lambs are born in the first 17 to 20 days while the remaining 10 to 15% is born in the second 17 to 20 days of lambing, to a more equal split across the lambing period.

Another popular concept was to split the lambing of the mob between two quite different dates. This provided a split in risk, as well as the potential to have lambs available for the market at distinctly different times.

A further concept was provided by farmers in more summer dry environments where feed for finishing lambs may run out in summer. They proposed the concept of tightening lambing even further, even to the extent of using natural synchronisation or induction to match weather predictions using natural triggers or supplements. This would provide early born lambs and also avoid weather extremes, without spreading lambing and, consequently supply to market, over a longer time frame.

Scenario development for modelling lamb survival

Scenario development followed on logically from mitigation discussions. Scenarios were chosen that were able to be modelled readily, and so mitigations such as shepherding intervention were excluded.

Major areas of interest were extra feeding, the provision of shelter and spreading lambing. As a consequence, both feeding and shelter were modelled for each catchment to provide a standard data set for comparison across the regions.

Within the regions, shelter was the chosen mitigation for the South Otago group, who also chose extra feeding. Changes in feeding were specifically chosen by the Northern Southland group. The Northern Southland group also chose to investigate altering the spread of lambing from 85% in the first cycle and 15% in the second cycle, to a 50/50 spread between the two cycles. The West Otago group chose splitting the lambing between early (late August) and late (early October) lambing. The South Canterbury group chose to investigate the impact of increasing lambing percentage as their major mitigation, while also chose to investigate the potential impact of genetics.

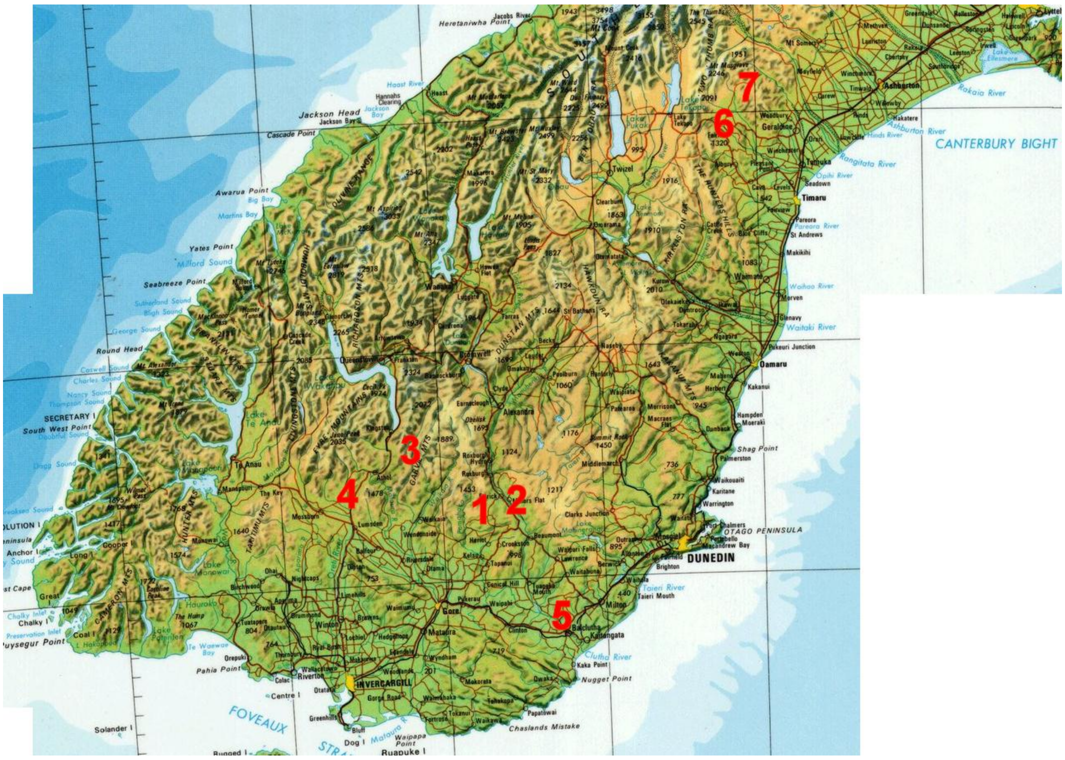
The mitigations chosen from the workshops for each region to examine the potential impacts on lamb survival are presented in Table 1. Two sites within each region, except South Otago) were chosen to represent different farming types (Figure 1), creating seven catchment types for the modelling.

Table 1. Mitigations chosen for each site

	Mitigations				
Site	Mating Date	Feeding	Shelter	Lambing percentage	Lambing spread
West Otago High Hill	Yes	Yes	Yes	No	Yes
West Otago Low Hill	Yes	Yes	Yes	No	Yes

Northern Southland Hill	Yes	Yes	Yes	No	Yes
Northern Southland Flat	Yes	Yes	Yes	No	Yes
South Otago Rolling	Yes	Yes	Yes	No	No
South Canterbury Basin	Yes	Yes	Yes	Yes	No
South Canterbury Hill	Yes	Yes	Yes	Yes	No

Figure 1. Map indicating locations of sites for lamb survival mitigation modelling



Key: 1) West Otago High Hill; 2) West Otago Low Hill; 3) Northern Southland Hill; 4) Northern Southland Flat; 5) South Otago Rolling; 6) South Canterbury Basin; 7) South Canterbury Hill

6. Climatic predictions and variations

The second step of this systems approach to understanding the influence of climate change on lamb survival was to generate predictions of the climate over the past 20 years (1980-1999) and for the future (2030-2049). To create climate data for the sites chosen (Figure 1), the NIWA virtual climate station network was used. This data could then be examined to understand current and future trends and variability and be applied to the lamb survival modelling.

Predicting the climatic variation now and in the future

Climate data was generated to match local sites within the four regions of the catchment groups by the National Institute of Water and Atmospheric Research (Hendrikx *et al.* 2009). NIWA used the Virtual Climate Station (VCS) network (Tait 2008; Tait *et al.* 2006) to extract current climate data (1980-1999) from the closest grid points to appropriate locations within each catchment. These locations (Figure 1, Table 2) are indicative of the relative locations of climatic zones of interest within each catchment.

Climate information was also generated for three future (2030-2049) climate projections, associated with the A1B, A1F1 and B1 emissions scenarios used by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007). These future climates, based on different emission scenarios, are 'middle of the road' (A1B), 'upper emissions' (A1F1), and 'lower emission' (B1). The current changes in temperature are reflecting the A1F1, upper emissions, scenario.

The output of the global climate model has a low spatial resolution and is therefore not appropriate to apply at the scale that was required for the type of local climate modelling required for this study. Therefore the global model output was statistically downscaled to the 5km grid intervals used in the VCS network as described in (MfE 2008).

Further variability was added to the future climate data by adjusting rainfall events. The percentage increase in extreme rainfall depths is expected to be approximately 8% per degree Celsius of temperature increase (MfE 2008) and the data sets were adjusted accordingly, by removing small rainfall events and adding them to large events at the quoted amount.

Unfortunately the VCS network has not yet included wind run. Therefore, the wind run at each location was chosen from the nearest weather station of similar altitude and aspect. With relatively little known about the predictability of average wind run

variation, the current and future models of climate used the same wind data. When records were incomplete, data from the same period in other years was substituted.

A full description of the climate modelling and data outputs is given by Hendrikx *et al.* (2009) in the accompanying report. Further descriptions of the wind run data and its selection are given in the methodology for the modelling at each site.

Climate modelling outcomes

Predicted climate and variability

The projected climate data for three future scenarios for 2030-2049 was modelled from the global climate models provided by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007), based on three different emission scenarios. Daily historical (1980-1999) and future temperature and rainfall data was generated for seven locations representing a range of sheep farming environments in the lower South Island (Table 2). This data was generated from the NIWA virtual climate station (VCS) which predicts the climate on a grid at 5 km spacing's. This downscaling of the global climate models provided enough detail to examine potential climate changes at a regional scale. As such it is the changes in lamb survival, rather than the actual values that will be comparable between now and the future.

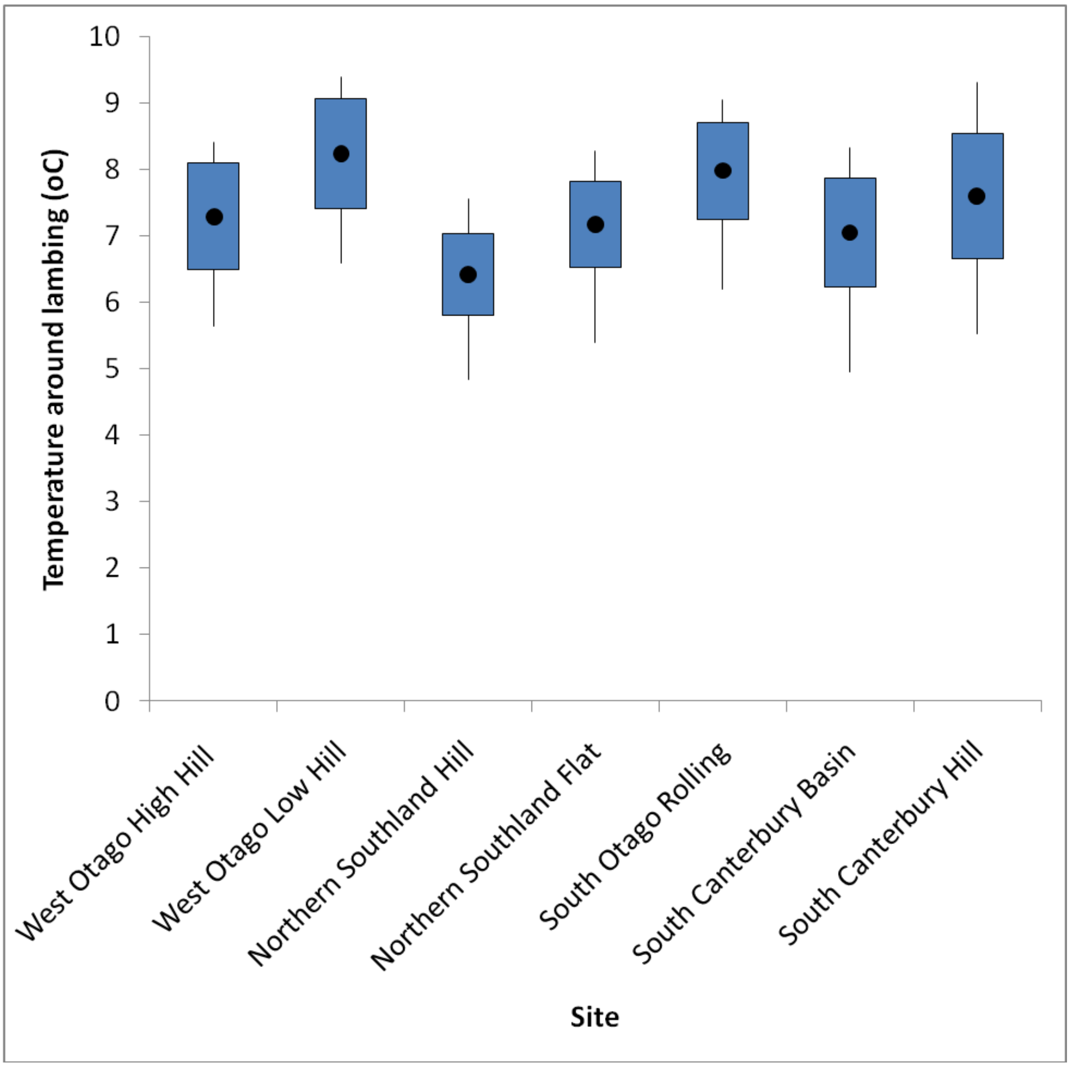
Table 2. Sites chosen for climate prediction and lamb survival studies

	Longitude	Latitude	Altitude	Scanning percentage	Normal Mating date
West Otago High Hill (Wohelo/Wilden)	-45.725	169.175	626	177	10-May
West Otago Low Hill (Raes Junction/Island Block)	-45.725	169.425	422	177	1-May
Northern Southland Hill (Athol Hill)	-45.425	168.575	480	174	15-Apr
Northern Southland Flat (Mossburn/Five Rivers)	-45.675	168.325	256	174	15-Apr
South Otago Rolling (Te Houka/Balclutha)	-46.225	169.675	70	184	6-Apr
South Canterbury Basin (Farilie Basin)	-44.125	170.825	300	172	9-Apr
South Canterbury Hill (Fairlie Hill)	-43.975	170.925	577	155	25-Apr

Temperature

The average and variation in current temperatures (1980-1999) around lambing, presented in Figure 2, indicate that the temperature into which lambs are being born is relatively constant across the regions. This mainly reflects the seasonal growth pattern of pastures and will represent the timing of the beginning of significant spring growth to support the increasing feed demand of a ewe once lactation begins.

Figure 2. Variations in the present average temperature from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



The variation of temperature is represented by the box and whisker plot. The box represents one standard deviation from the mean, or approximately two thirds of the seasons recorded. The whiskers indicate the maximum and minimum temperatures. The data indicates that the minimum temperature recorded is more the exception that the norm, as the majority of the readings are clustered more towards the maximum, as represented by the relative lengths of the minimum and maximum lines.

Average temperatures (Table 3) during lambing rose in all regions by between 0.6 and 1.2^{o}C, as predicted by the global models. This provided an opportunity for farmers of changing lambing date, by, on average 10 days. In regions where summer moisture deficits are now, or will be an issue in the future, this advancement will be particularly important to continue a supply of finished lambs before the onset of the summer dry period.

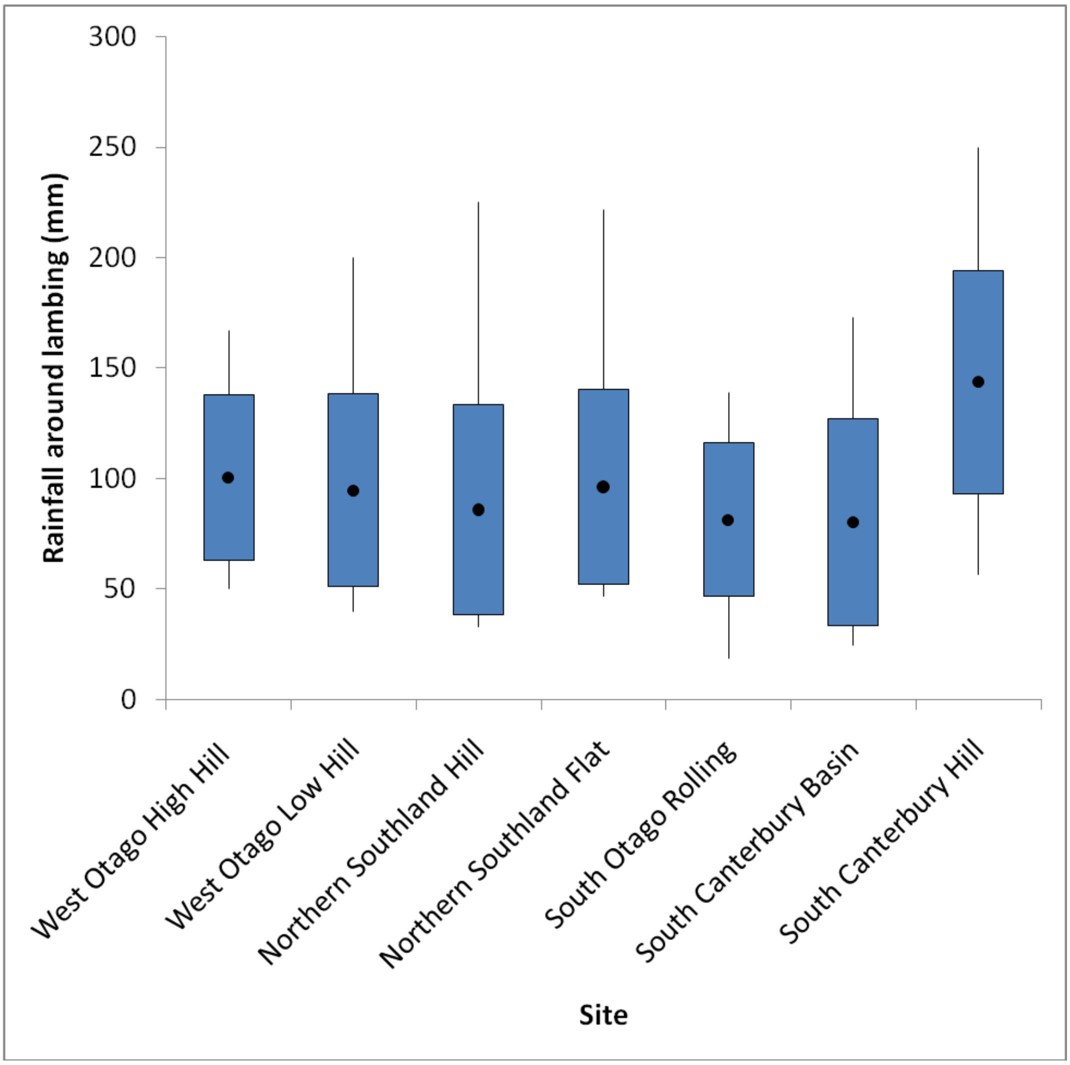
Table 3. Mean temperature before and during lambing at 7 sites throughout the lower South Island at present (1980-1999) and in three future (2030-2049) climate change scenarios

	Average temperature (^{o}C)			
Site	Present	Future B1	Future A1B	Future A1F1
West Otago High Hill	7.29	7.74	7.99	8.30
West Otago Low Hill	8.24	8.69	8.94	9.27
Northern Southland Hill	6.42	6.92	7.21	7.58
Northern Southland Flat	7.17	7.68	7.98	8.35
South Otago Rolling	7.98	7.82	8.12	8.50
South Canterbury Basin	7.05	7.65	7.99	8.41
South Canterbury Hill	7.60	8.11	8.39	8.75

Rainfall

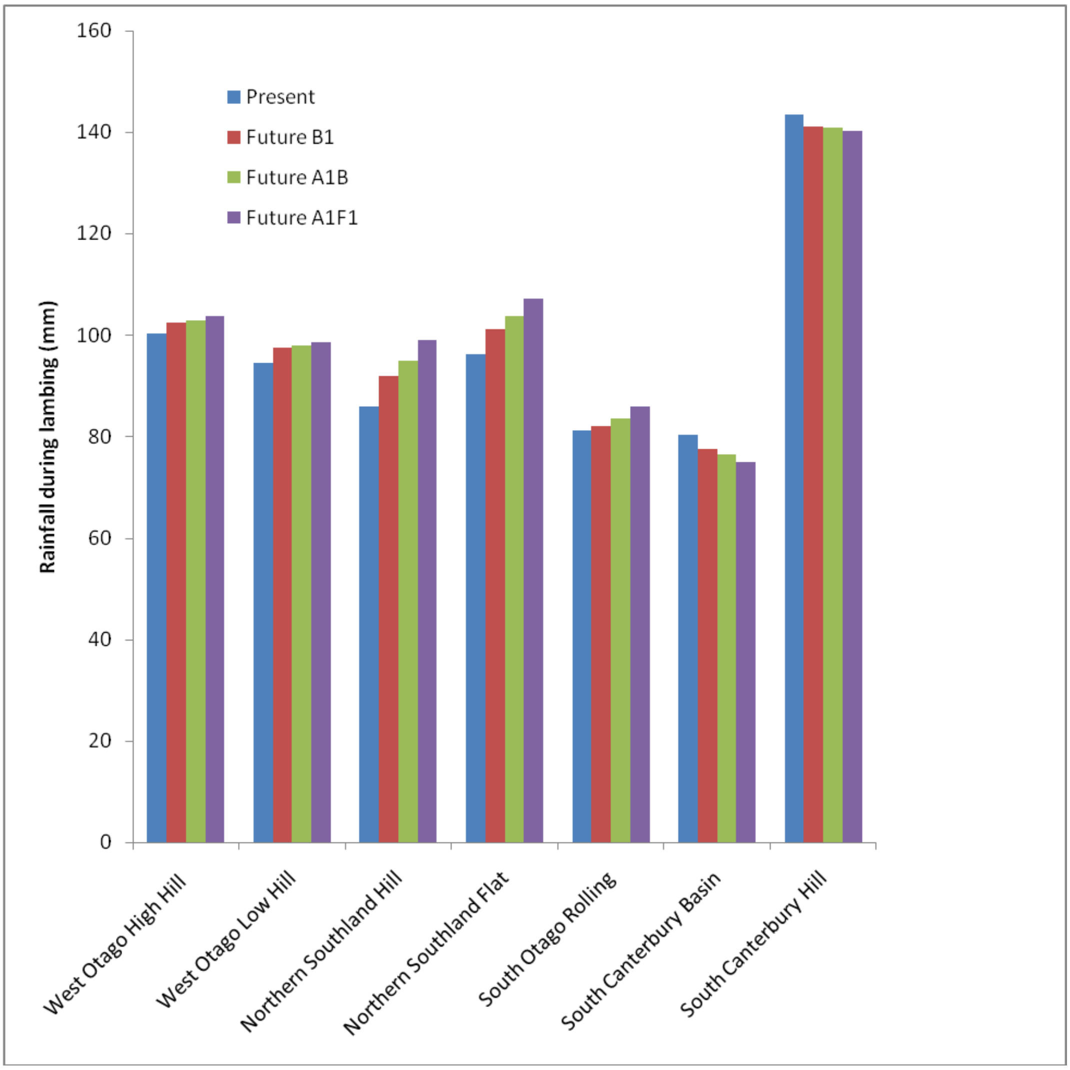
Rainfall during lambing was variable, depending on region (Figure 3). South Otago and South Canterbury Basin were slightly lower than Northern Southland and West Otago, while South Canterbury Hill had the highest average rainfall. The most variable rainfall amounts were at the Northern Southland and South Canterbury Hill sites. South Otago was the least variable. Of note with these rainfall patterns is the high variability in all results. The difference in rainfall around lambing from year to year ranged by between 120 and over 200 mm between years at any one site. This extreme range in rainfall means that farmers are already dealing with high variability in the current climatic extremes.

Figure 3. Variations in the present average rainfall from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



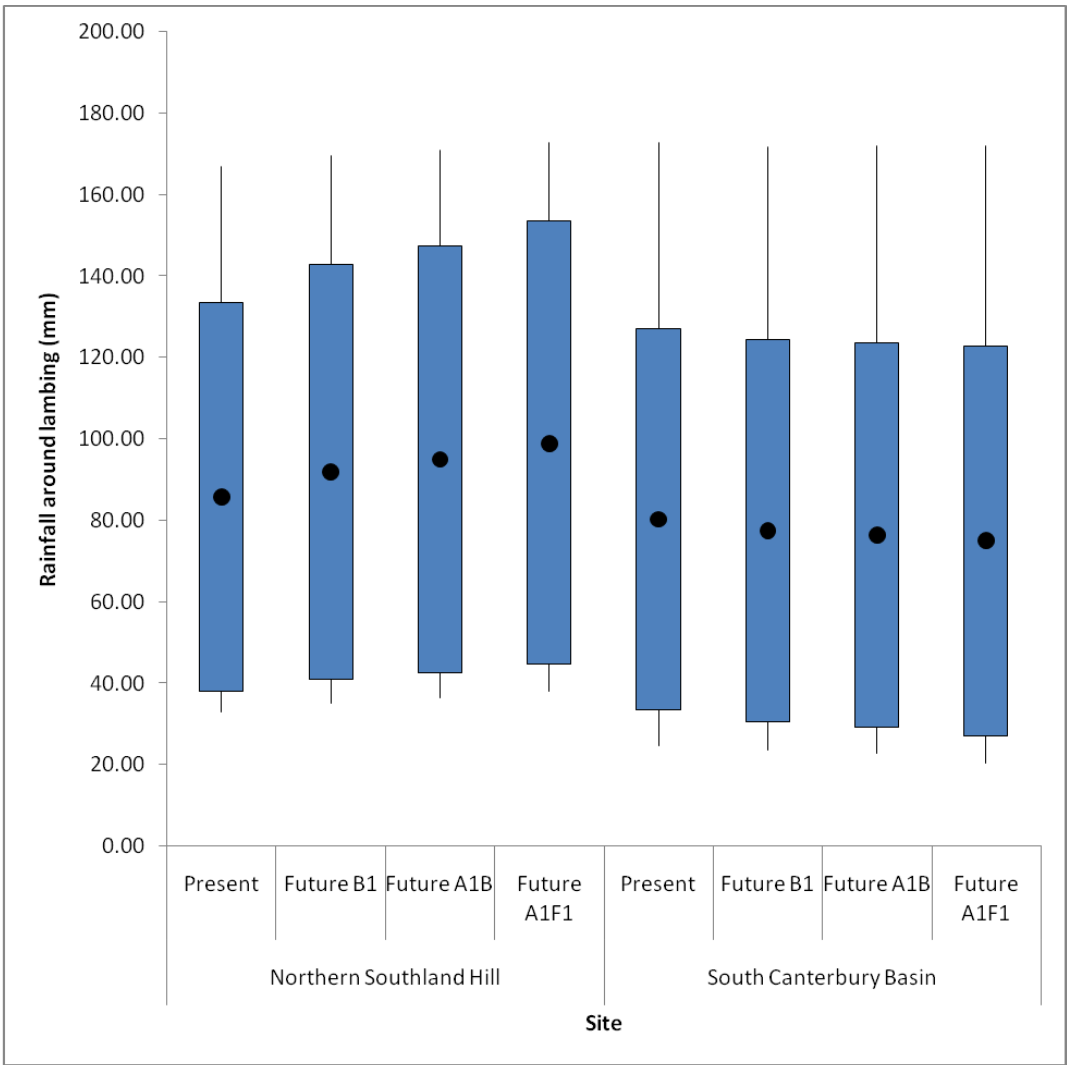
When predicting potential rainfall for the future the more southern and western sites had small increases in the average amount of rain during lambing, while the South Canterbury sites had mild decreases (Figure 4).

Figure 4. Current (1980-1999) and future predicted (2030-2049) average rainfall around the time of lambing for 7 sites throughout the lower South Island.



The variability in rainfall is compared at the Northern Southland Hill and South Canterbury Basin sites (Figure 5). These are chosen because they have the greatest increase and decrease in rainfall respectively. In general the actual variability in rainfall and the extremes are affected only slightly, though the standard deviation (where approximately 66% of the rainfall values will fall) does increase. It is thought that this relatively small shift in extremes is due to an already highly variable climate.

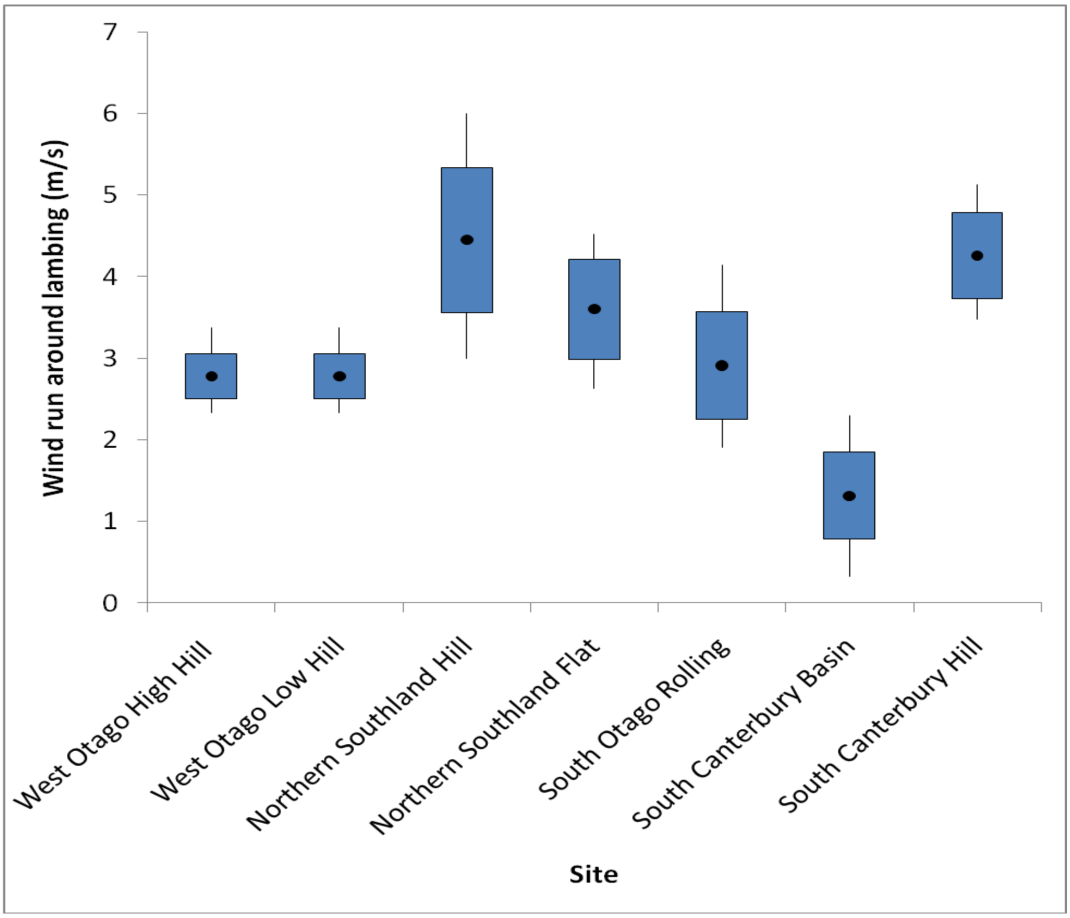
Figure 5. Variability of the rainfall in future (2030-2049) climate predictions compared to that of the present (1980-1999) for 2 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



Wind run

Wind run is not predicted by the NIWA VCS and therefore actual records from meteorological stations close to the chosen sites, or representative of the sites were used. Therefore, this information is less accurate, though does provide some degree of information about the variability of the impacts of wind chill. The windiest sites were the Northern Southland and South Canterbury hill sites (0). This is consistent with previously reported summaries of wind run, noting that wind run increases with elevation at a rate of 10% for every 100 m increase in altitude (Dawber & Edwards 1978). This does not appear to be reflected in the West Otago Hill predictions, which may reflect the site of the met station from which the records were taken. Another reason for lower wind run than expected may be the point nature of the data, having been extrapolated from a single reading at 9 am each morning, rather than a full daily wind run. This highlights the problems that the VCS has in attempting to predict wind run, as very few stations have full records for actual wind run.

Figure 6. Variations in the present average wind run from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).



The calmest site was the South Canterbury Basin, reflecting previous observations that the inland South Island basins are much calmer than surrounding hills and more exposed sites (Cossens 1987).

Climate modelling conclusions

Variability in New Zealand climate is a given. Future trends towards more variability will only reinforce the types of resilient farms systems that are now in place.

Increases in temperature due to predicted global warming will aid in improving lamb survival, or will provide the opportunity for farmers to lamb slightly earlier in the cool southern climates.

Changes in rainfall are small, and current variability seems to be conserved, with maximum and minimum rainfall amounts over lambing remaining relatively similar.

Wind run records are limited and prediction of future wind run is not currently available. However, given the trends with temperature and rainfall, variation in current wind run may be adequate to help predict future lamb survival.

7. Predicting lamb survival

The third step in the systems analysis was to develop a lamb survival model based on New Zealand data. This would then help in predicting lamb losses and could be modified to apply different mitigations. The results from these modifications were then compared to current practice to provide information for farmers who wanted to make changes to improve lamb survival.

Lamb survival model verification process

Lamb losses as a result of exposure to the climate were modelled using two approaches. The first was to use functions in the Australian GRAZPLAN sheep biology model (Donnelly *et al*. 1997) in an EXCEL spreadsheet to predict day by day lamb losses due to heat loss (rain, temperature and wind) and ewe body condition score.

The second approach was to develop a New Zealand based model using functions derived from data sets from lamb survival research done in Otago and Southland. The local data sets comprised of 15,821 lambs born over 2 lambings in 2003 and 2004 (Everett-Hincks & Dodds 2007). The New Zealand model used three factors which were significantly related to climate around the birth of the lamb. They are heat loss in the 2 weeks before birth, on the day of birth and during the three days after birth. Heat loss was calculated using the sheep heat loss calculation described by Coronato (1999).

The results of the Australian functions were compared to the New Zealand model. The primary purpose of this test was to see if the predicted variation in lamb survival on a day to day basis was similar using both models.

Lamb survival model testing protocols

1. Run the Australian and the AgResearch Lamb Survival software for each data set and compare the predicted outputs from each model.
2. Examine the outputs for trends that may be used to understand the differences between the two models.
3. Choose the appropriate model for the regional simulations.

Lamb survival model verification results

The test scenarios used the climate data for the Gore automatic weather station over 11 years from 1998 to 2008 inclusive, and compared the predicted outcomes from both models using mean birth dates of 1 August, 15 September and 30 October each year to generate 33 predictions over a range of climatic extremes (Figure 1).

The two models were compared at several levels. The first was an examination of the functions that were used to derive a chill factor. The Australian model uses a chill factor (modified from Nixon-Smith; Donnelly 1984) and relative ewe condition in a logistic model (Equations 1 and 2; Donnelly 1984) derived from Australian Merino and Merino x Border Leister data, over two years, from 1,554 lambs born, compared to the 15,821 lambs in the New Zealand study. The AgResearch Lamb Survival model is linear and directly related to a chill factor developed in Patagonia (Equation 3; Coronato 1999). The AgResearch Lamb Survival model used three factors which were significantly related to climate around the birth of the lamb. They are heat loss in the 2 weeks before birth, on the day of birth and during the three days after birth. These provided the opportunity to test the impacts of climate on the ewe, independently from the effects on the lamb, and provided a measure of the influence of the ewe and her energy balance on the survival of the lamb. In effect, this may have provided a factor similar to the relative ewe condition in the Donnelly (1984) model.

Chill index CH (kJ/m^2/hr) = $(11.7 + 3.1V^{0.5}) * (40 - T) + 481 + R$ (**Equation 1**)

V = daily mean wind velocity ($m.s^{-2}$)

T = mean daily temperature (^oC)

R = $418(1-e^{-0.04x})$

where x = daily rainfall

Lamb loss (proportion of those born) XR = exp(XO)/(1-exp(XO)) (**Equation 2**)

XO = -8.9 – 1.49RC + 0.0081CH + 0.82L

RC = relative condition (current weight/normal weight) of the ewe

CH = chill index

L = 0 for single and 1 for multiple born lambs

Heat Loss HL (W/m^2) = 40.38 – 2.12T + 5.84V + 0.73x (**Equation 3**)

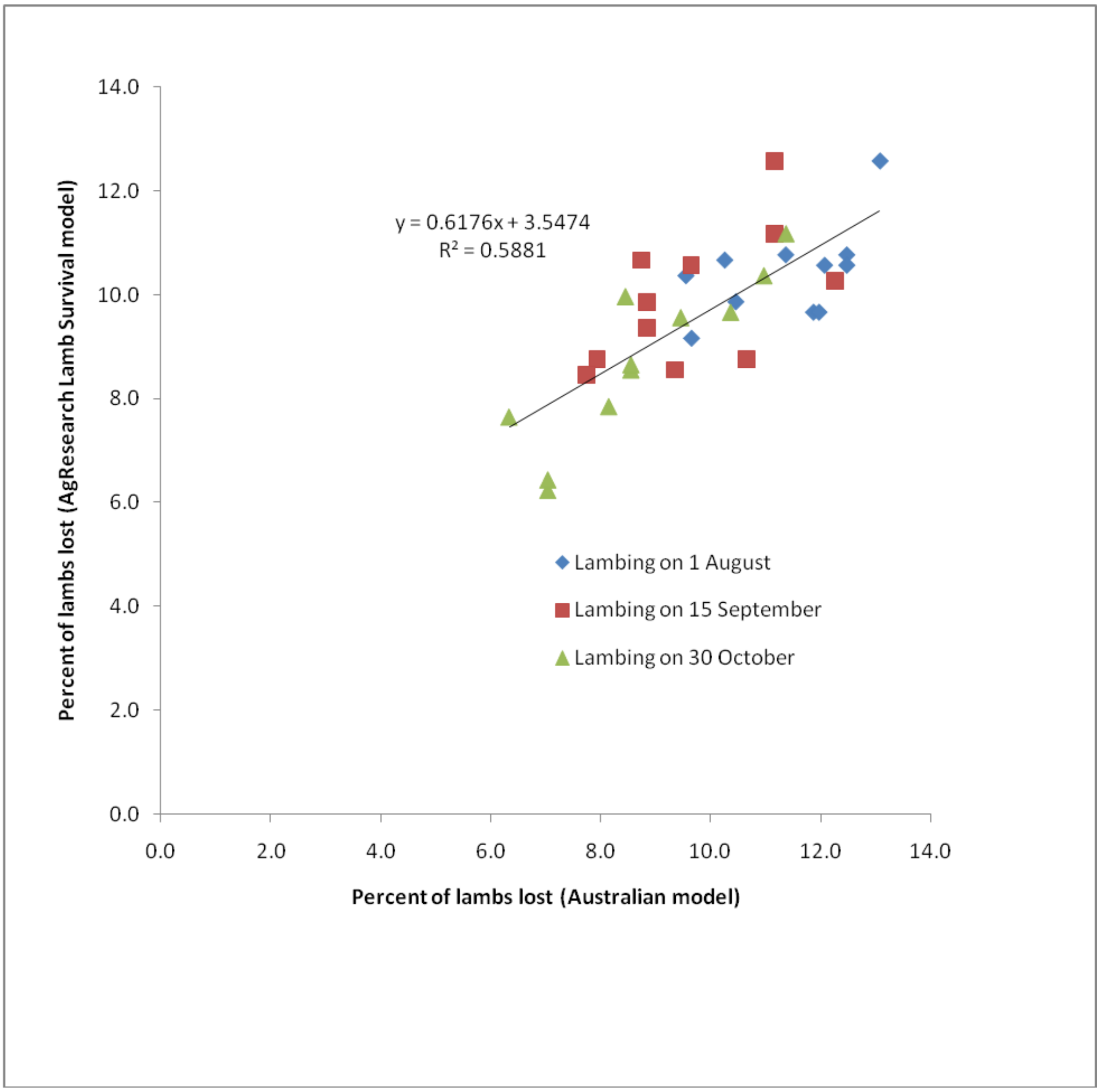
T,V and x are the same as Equation 1.

Note the different units for each predictor.

The live weights used to calibrate the Australian model ranged from 47 to 72 kg and were induced by a controlled stocking rate experiment. This experiment used a range of different stocking rates that created significant nutritional differences and provided the opportunity to examine the impacts of body condition score in a controlled way. The AgResearch Lamb Survival model used body condition score as a guide, but found the range within the flocks tested to be relatively low and added little value to the analysis. The impact of nutrition during pregnancy has been demonstrated in altering the fat content of the new born lamb (Alexander 1962b) and this may be reflected in the relationship between lamb birth weight and survival in the AgResearch Lamb Survival model, rather than as a relative body condition effect. The AgResearch Lamb Survival model also found a significant effect of the climate during the two weeks

before lambing on lamb survival and this may also, in part, be a reflection of the nutritional status of the ewe in late pregnancy.

Figure 7. A comparison of the losses of lambs born as multiples due to climatic conditions at birth when predicted by the Australian model or the AgResearch Lamb Survival model



The AgResearch Lamb Survival model predicts higher losses at lower heat loss or chill index, and lower losses at higher values (Figure 7) than the Australian model. Over the range of losses predicted this was 1.2% higher when the Australian model predicted 6% and 1.1% lower when the Australian model predicted 12%. However, this variation is much higher on a day to day basis. This is due to the logistic function that was seen to be required in the Australian model. This did not appear to be the case in the AgResearch Lamb Survival model, or in the data examined by Coronato (1999). This may be related to the effects in the AgResearch model being expressed at the flock and regional level, rather than the individual ewe level as in the Australian model. There may have also been greater selection pressure towards improved lamb survival

in New Zealand circumstances over the past 150 years of sheep farming compared to the Australian flock due to the harsher lambing conditions that prevail in New Zealand. The sheep breeds examined here were mainly of British origin, based around the Romney, and so may also have more inherent tolerance of climatic extremes. The AgResearch Lamb Survival model may also reflect larger average lamb size for the current New Zealand flock, as it has increased significantly since the calibration of the Australian model.

The two models also differ in the influence of wind. To get the models to provide relatively similar total numbers of lamb losses, the influence of wind in the AgResearch lamb survival model needed to be reduced to 1% of the measured wind run. The differences between the models again may be due to the predominant breed used and the on-going selection pressure in the New Zealand environment.

Lamb survival modelling conclusion

While the two models predicted slightly different outcomes, the AgResearch model was chosen as a potentially better fit for the regional and flock-based predictions that were required. The larger data set from actual on-farm data used in the AgResearch model was thought to provide a closer reflection of field conditions. The AgResearch model was also calibrated using local conditions and records which could be readily sourced for the final lamb survival model section.

8. Improving potential lamb survival

The final step in the systems analysis was to use the lamb survival model and the predicted climatic data to examine three factors. The first factor was the impacts of present and future climatic trends on lamb survival. The second factor was the impacts of variability on lamb survival from year to year within each region. The third factor was the impact of various mitigations on lamb survival, both now and in the future.

Modelling the lamb survival mitigations for each region

Seven locations over four regions were chosen to represent the farming catchments of the focus groups (Figure 1, Table 2). The climate in each of these locations was generated for 20 current years and three scenarios of 20 future years.

In each region the status quo was modelled and compared to a preferred mitigation option for every climate data set. The status quo and mitigations chosen are documented in Table 1.

Each region chose different scenarios for the modelling of lamb survival. However, some features were modelled across all regions to enable a comparison of the impacts of a range of mitigations.

These factors included changing lambing date. Lambing date was altered in 5 to 7 day time steps for two increments around the current lambing date used in each region. This was included to allow for the impacts of climate change on increasing spring temperatures and the concurrent onset of spring growth.

The provision of shelter was also modelled at all sites to help understand the variations due to wind run. Shelter was set at 0, 50% and 100% reduction in wind run.

Modelling feeding

The use of improved feeding in the final two weeks of pregnancy was investigated at each site. Levels chosen were 0 and +0.2 kg DM/d, fed for two weeks before lambing and throughout the lambing period. The extra feed intake was converted to heat to combat the impact of heat loss due to exposure to the climate and used to reduce the impact of the ewe effect on lamb survival (Everett-Hincks & Dodds 2007). The conversion of daily feed intake energy (MJ) to the mitigation of heat loss (W/m^2) was done using the following equation,

Mitigation of heat loss (W.h) = (I*NE*0.277777/SA)/24

Where I = Feed intake (kg)

NE = net energy for maintenance assuming a metabolisable energy content of 10MJ/kg and a conversion to net energy of 0.7

0.2777 = conversion of kJ to W.h

SA = surface area (surface area = $0.09*BW^{0.66}$),

24 hours/d to convert energy/d to W.h

The heat produced from the extra feed intake was then subtracted from the calculated heat loss of the ewe, lowering the impact of the pre-lambing climate on the lamb losses due to ewe effects. This approach requires field validation before full confidence can be placed in the modelled outcomes.

Modelling genetics

Changing the genetics of the lamb was approached using a similar consideration of increasing heat production of the lamb during the first three days from birth. The changes due to genetics were added to multiple born lambs only, as losses in single lambs due to climate were determined to be minor.

The production of heat at summit metabolism was compared for lambs of birth weight 2 kg and 5 kg (Alexander 1962a). Summit metabolism is the total heat that a lamb can produce to mitigate heat loss in the face of climatic challenge. The extra heat output from a lamb is approximately 18 W/m^2 for every 1 kg increase in birth weight.

The genetics parameter was applied to represent an increase in birth weight of 0.5 kg, increasing the heat loss threshold before death by 9 W/m^2. This is one of many potential pathways of improving lamb survival through genetics and as such the results should not be transferred to genetic improvement overall.

West Otago modelling methods

Two sites were chosen to represent the West Otago hill country. These were West Otago High Hill and West Otago Low Hill (Figure 1, Table 2). Wind speed for both sites was calculated from the 24 h wind run data for Mahinerangi (lat. -45.883, long. 169.975, alt. 396 masl) weather records after comparison with 9am NZST records from Tapanui and Moa Flat. The Mahinerangi site is of similar elevation and exposure on the Otago Plateau and had a more complete set of records for use. Records from 1980 to 1990 were available and were supplemented by records from 1972-1980.

Both sites used the same scanning percentage, ewe liveweight, mating dates and lambing spread (Table 1). Modelling investigated the use of early lambing (mid-August) compared with standard lambing (early October).

Northern Southland modelling methods

The Northern Southland group chose mitigations of extra feeding and spreading lambing equally over two mating cycles (Table 1). Extra feeding is modelled as per the section ‘Modelling feeding’. Currently approximately 85% of ewes are mated during the first mating cycle of 17 days after joining date, with 15% during the second cycle. This concentrates the number of lambs being born. The mitigation chosen here investigated whether shifting the spread of lambs being born to 50% in each cycle would alter potential survival by reducing the threat of single catastrophic weather events during lambing.

The diversity of geographic conditions again saw the use of two sites to represent Northern Southland, one on the flat and the other in steep hill country (Figure 1, Table 2). Wind run (for 24h) was taken from the Gore automatic weather station (lat. -46.115, long. 168.887, alt. 123 masl) for the period 1998-2008 and repeated. This was compared to the less complete data from the Lumsden station (Lat -45.748, long. 168.448, alt. 187 masl) and found to be similar. The Gore data was applied directly to the Northern Southland Flat model, and was increased by 10% per 100 m increase in altitude as per Cossens (1987) to be applied to the Northern Southland Hill model, an increase in 23% for the 230m gain in altitude.

South Otago modelling methods

Shelter was the main emphasis of the South Otago group (Table 1). Mitigations chosen were reducing wind run by 50 and 100%. Shelter modelling did not attempt to account for variations in wetting of the lamb or changes in soil conditions.

Only a single site was chosen for the South Otago model to represent the majority of the region (Figure 1, Table 2). Wind run data from the Balclutha meteorological station (lat -46.273, long. 169.739, alt. 6 masl) for the period 1980-1999 was used to calculate average wind speed with minor missing data events being replaced with data from similar periods in other years.

South Canterbury modelling methods

The South Canterbury group chose increasing lambing percentage as the principle mitigation (Table 1). The impacts of climate were modelled on the current average scanning percentage for the basin and hill country and were compared to the top 15% of farmer results. These values were sourced from the FT2000 benchmarking project (T. Fraser, personal communication).

The use of genetics to improve lamb survival was also investigated as per the methodology in the section ‘Modelling genetics’. It must be emphasised that this only one way of assessing the impacts of genetics. Given that lamb survival is highly variable and has only a low heritability when estimated using broad parameters such as number of lambs weaned, then it is logical to assume that many individual factors are interacting to provide a final outcome.

Two sites were chosen to represent the diversity of the sheep farming in the region (Figure 1, Table 2). These are representative of the inland basin region (South Canterbury Basin) and the hill country (South Canterbury Hill).

Wind speed data (8 am NZST) from the Fairlie (lat. -44.103, long. 170.824, alt. 300 masl) and Fairlie Riverview (lat. -44.101, long. 170.883, alt. 304 masl) stations was used to represent the South Canterbury Basin model. Data from the Fairlie, Riverview station covered the period 1980-1990, while the period 1992-1999 were covered by the Fairlie station. The missing period 1990-1992 was replaced by a repeat of the 1986-1988 data.

Wind run data from the Lake Tekapo electronic weather station (lat. -44.00173, long. 170.443, alt. 762 masl) for the period 2003-2009 was used to calculate average wind speed to represent the South Canterbury Hill model and was repeated as required to match the 20 year modelling period.

General trends from regional modelling results

The sites and system characteristics such as scanning percentage and mating dates chosen for each region are representative of local farms.

Table 4. Changes in lamb losses and live lambs at tailing due to predicted future (2030-2049) changes in climatic conditions around lambing at seven sites in the lower South Island.

	Climatic Scenarios					
	Present	Future 1	Future 2	Future 3		
Site	**Lambs lost/1000 ewes (exposure of the ewe)**				**lsd[1]**	**Scan %**
West Otago High Hill	299	292	288	284	5.2	177
West Otago Low Hill	285	278	275	270	5.1	177
Northern Southland Hill	320	314	311	307	4.9	174
Northern Southland Flat	279	272	269	264	4.2	174
South Otago Rolling	259	252	247	242	10.2	184
South Canterbury Basin	245	236	231	225	8.5	182
South Canterbury Hill	344	336	332	327	9.5	170
	Lambs lost/1000 ewes (exposure of the lamb)					
West Otago High Hill	129	127	125	124	1.9	
West Otago Low Hill	124	122	120	119	1.8	
Northern Southland Hill	150	148	147	146	1.8	
Northern Southland Flat	136	134	133	132	1.6	
South Otago Rolling	136	133	132	130	4.1	
South Canterbury Basin	111	108	106	103	3.4	
South Canterbury Hill	140	137	136	135	3.3	
	Live lambs (/1000 ewes lambing)					
West Otago High Hill	1340	1350	1355	1361	7.0	
West Otago Low Hill	1359	1368	1373	1379	6.8	
Northern Southland Hill	1268	1276	1280	1286	6.6	
Northern Southland Flat	1323	1331	1336	1342	5.7	
South Otago Rolling	1444	1454	1460	1467	14.2	
South Canterbury Basin	1463	1475	1482	1491	11.8	
South Canterbury Hill	1218	1227	1232	1239	12.5	

[1]lsd: Least Significant difference

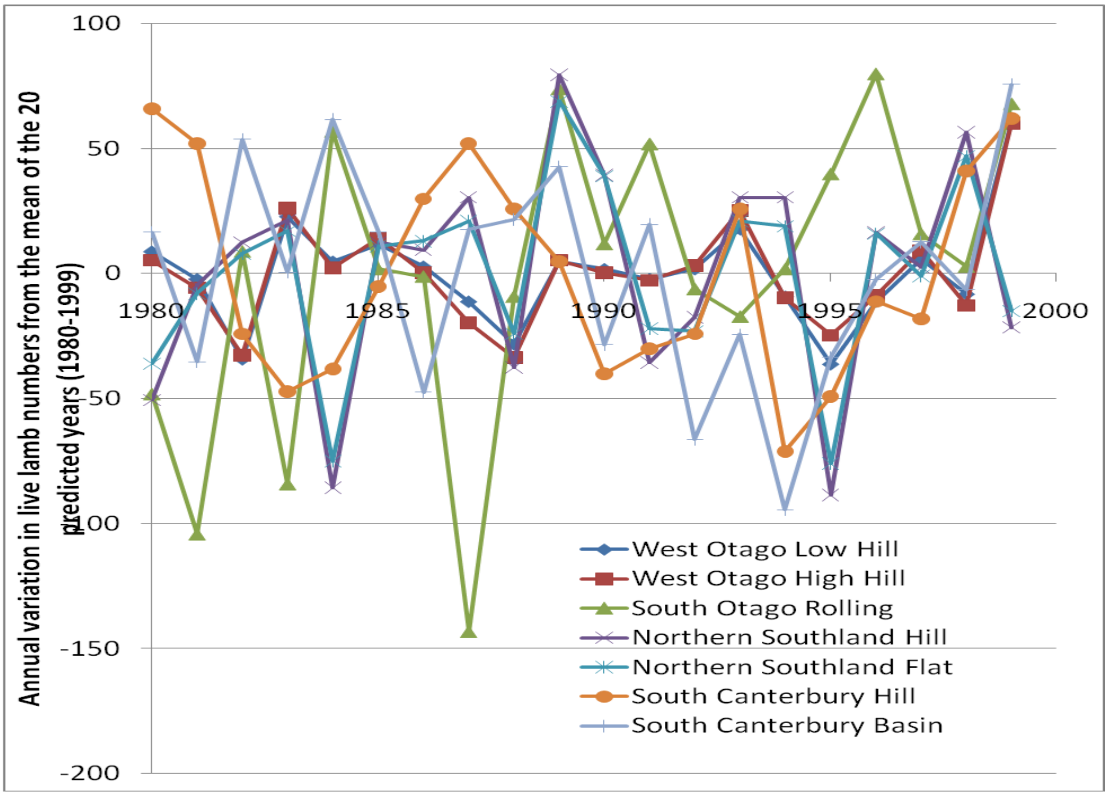
The lamb survival model predictions of live lambs per 1000 ewes were relatively similar to the actual tailing percentages recorded by the farms represented. For example, the West Otago High Hill site was representative of the West Otago Monitor

Farm property. The scanning percentage of 177% has, on-farm, returned tailing percentages of between 130 and 138%, or 1300 to 1380 lambs per 1000 ewes mated, which is similar to the predictions of the Lamb Survival modelling which average 1340 lambs per 1000 ewes.

An examination of Northern Southland tailing percentages that were supplied by the local farmer group indicated that hill country farms returned 1265 live lambs at tailing per 1000 ewes mated. This is very similar to the 1268 lambs per 1000 ewes mated predicted by the modelling. The results for farmers on the flats returned an average of 1440 lambs per 1000 ewes mated which is higher than the modelling result (1323 lamb/1000 ewes) and may be a reflection of mitigations that the farmers already have in place.

Future predicted changes in climate increased the average temperature around lambing resulting in small increases in the number of live lambs per 1000 ewes mated (Table 4). The more severe climates generally had higher lamb losses, though the South Otago Rolling data indicated a more variable result (Figure 8), considering the apparently benign climatic conditions. This variability is common in sheep farming and indicative of the combination of conditions on any given day. It reinforces the view that actual impacts of climate cannot be readily estimated from averages on the climatic parameters.

Figure 8. Variation in live lambs (per 1000 ewes) due to the climatic variation at each site, predicted for the present climatic scenarios over twenty years (1980-1999).



When examining predicted lamb losses from the effects of climate before (exposure of the ewe) and after (exposure of the lamb) lambing (Table 5) there is a trend toward greater declines in lamb losses from the effects of climate before lambing (5.6% less

lamb deaths) than at lambing (4.1% less lamb deaths). This may be due to the relative temperature before lambing being lower than at lambing. It may also be due to a mathematical effect where more lambs are born alive and therefore subject to the potential for exposure death.

Table 5. The results of common mitigations at each of the seven sites on lamb losses due to the ewe, the lamb after birth and the expected number of lambs at tailing, for the present (1980-1999) climatic conditions.

	Mitigations			
	Standard	**Feeding[1]**	**50% shelter**	**100% shelter**
Sites	**Lambs lost/1000 ewes (exposure of the ewe)**			
West Otago High Hill	288	208	234	179
West Otago Low Hill	275	195	220	165
Northern Southland Hill	360	286	273	185
Northern Southland Flat	319	245	248	176
South Otago Rolling	299	219	237	174
South Canterbury Hill	308	242	233	155
South Canterbury Basin	226	150	200	175
lsd	15.5			
	Lambs lost/1000 ewes (exposure of the lamb)			
West Otago High Hill	126	133	106	85
West Otago Low Hill	121	128	101	79
Northern Southland Hill	149	157	119	85
Northern Southland Flat	136	143	110	83
South Otago Rolling	131	138	108	83
South Canterbury Hill	118	124	94	68
South Canterbury Basin	101	106	91	81
lsd	5.6			
	Live lambs (/1000 ewes lambing)			
West Otago High Hill	1354	1427	1427	1504
West Otago Low Hill	1372	1445	1446	1523
Northern Southland Hill	1230	1296	1345	1469
Northern Southland Flat	1283	1351	1379	1481
South Otago Rolling	1409	1482	1494	1582
South Canterbury Hill	1127	1187	1226	1330
South Canterbury Basin	1391	1462	1427	1463
lsd	20.9			

Significant interactions also occurred when mitigations were applied. Losses due to the exposure of the ewe were reduced at all sites when mitigations were applied. The range of losses without mitigation was large with the greatest losses at the windier and colder sites, such as South Canterbury Hill and Northern Southland Hill and Flat. The impact of feeding had a greater effect than 50% shelter on the calmer, warmer sites, West Otago High Hill and Low Hill, South Otago Rolling and South Canterbury Basin, while feeding and 50% shelter gave similar reductions in lamb loss at the other windier, colder sites. Complete shelter from the wind (100%) gave the greatest reduction in lamb losses at all sites. The variability between sites was also reduced as the number of lambs lost per 1000 ewes reduced from 134 between best and worst in the control situation to a range of 30 with 100% shelter. The order of the sites also changed as mitigations were applied with the South Canterbury Hill site shifting from the third highest losses to the lowest losses when 100% shelter was applied.

Lamb losses due to the exposure of the lamb also varied across the sites, and as the effects of mitigation increased then the variability between the sites reduced. The range of 48 lambs lost between highest and lowest loss with no mitigation was reduced to 17 lambs lost when 100% shelter was introduced. Again the South Canterbury Hill losses went from average amongst the sites to lowest when 100% shelter was applied, while all other sites were not significantly different from one another once 100% shelter was applied. This provides an insight to the importance of wind chill in lamb survival. Current farm practices in each region have seen farmers chose lambing times that coincide with the onset of spring pasture growth and as such have also chosen times when ambient temperatures (Figure 2) are similar across the regions. Therefore, it is logical that wind run will be the major factor determining lamb losses.

When considering the final productive outcome, live lambs, similar trends appear. Variation is reduced and sites become more similar in final live lamb numbers as the degree of mitigation increases (Table 5). Providing extra feed has a similar impact to 50% shelter in many cases, though again is most effective at the calmer sites. When 100% shelter is applied then variations become small and actual scanning percentage plays a greater role in the final outcome. For example, the South Canterbury Hill result clearly stays the lowest throughout, even though lamb losses have been reduced to a greater extent at that site than others.

Individual results from each region

West Otago

Of specific interest to the West Otago group was the concept of having flocks lambing much earlier than current practice. The system of early lambing (mid-August) was compared to the current practice of late lambing (early October). The result was significantly greater numbers of lambs lost both due to exposure of the ewe and the lamb, and fewer live lambs. This decrease was greater at the High Hill site (6.7%) compared to the Low Hill site (4.2%).

Critical factors which need to be considered before deciding the economic significance of the result are the feed supply and the market price of the lamb. The reason for

exploring the option to lamb early is to sell those lambs prime or store into an early market which provides a greater return relative to later in the summer.

Table 6. West Otago High Hill

Site					
West Otago High Hill			**Time**		
Scanning percentage = 177%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	299	292	288	284	5.2
Lambs lost (exposure of the lamb)	129	127	125	124	1.9
Live lambs per 1000 ewes lambing	1340	1350	1355	1361	7.0
		System			
	Early	Late			lsd
Lambs lost (exposure of the ewe)	316	281			5.9
Lambs lost (exposure of the lamb)	134	123			2.1
Live lambs per 1000 ewes lambing	1305	1372			7.8
			Mating Date		
	25-Apr	1-May	5-May	10-May	lsd
Lambs lost (exposure of the ewe)	289	284	283	281	5.9
Lambs lost (exposure of the lamb)	125	124	124	123	2.1
Live lambs per 1000 ewes lambing	1354	1359	1362	1364	7.8

Table 7. West Otago Low Hill

Site					
West Otago Low Hill			**Time**		
Scanning percentage = 177%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	285	278	275	270	5.1
Lambs lost (exposure of the lamb)	124	122	120	119	1.8
Live lambs per 1000 ewes lambing	1359	1368	1373	1379	6.8
		System			
	Early	Late			lsd
Lambs lost (exposure of the ewe)	303	271			5.7
Lambs lost (exposure of the lamb)	130	119			2.1
Live lambs per 1000 ewes lambing	1336	1378			7.6
			Mating Date		
	25-Apr	1-May	5-May	10-May	lsd
Lambs lost (exposure of the ewe)	276	271	269	267	5.7
Lambs lost (exposure of the lamb)	120	119	119	118	2.1
Live lambs per 1000 ewes lambing	1372	1378	1381	1382	7.6

The loss of a small number of lambs needs to be weighed against the value of the live lambs and to their cost on the system. Providing adequate feed for those ewes and lambs at a time of the year when pasture production is less than feed demand has a relatively high cost and so market premiums must be significant. It will be this relationship of cost to value that will be more important than the relatively small drop in lamb survival.

Variations in mating date around the current practice of 10 May showed relatively small reductions in lamb survival. These values have been calculated using all climate scenarios, both present and future. The variation is very small with only 1% difference, or 10 lambs per 1000 ewes lambing, in final live lamb number, even though lambing is up to 15 days earlier.

Northern Southland

Improved feeding was recognised as a major mitigation that may help improve lamb survival in the Northern Southland region. The addition of 0.2 kg DM/ewe/d for a period of 3 weeks before lambing and through the first lambing cycle (another 17 days) did provide an extra 34 live lambs per 1000 ewes (Table 8, Table 9). To provide this extra feed an extra 76 kg DM/ha would be required at the average district stocking rate of 10 ewes/ha. This higher pasture cover target would have to be factored in to winter feeding plans to ensure its availability for lambing ewes. Again the effect of reducing the number of lambs lost due to exposure of the ewes also resulted in a small increase in lamb loss due to the exposure of the lamb, because of the greater number of viable lambs born.

The split in ewes lambing the first and second cycle was one point of investigation for the Northern Southland sites. The current expected split of 85% of ewes conceiving in the first cycle and 15% conceiving in the second cycle was compared to having a 50/50 split. This shift was to investigate the opportunity to reduce the impacts of single storm events by having fewer lambs exposed on any single day. Small increases in live lamb numbers were present for the 50/50 split, being 8 and 7 lambs/1000 ewes for the Hill and Flat sites respectively. While this result is statistically significant, the practicality of creating a 50/50 split would probably require a labour input in excess of the benefits gained from the relatively few extra lambs.

Table 8. Northern Southland Hill

Site					
Northern Southland Hill	**Time**				
Scanning percentage = 174%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	320	314	311	307	4.9
Lambs lost (exposure of the lamb)	150	148	147	146	1.8
Live lambs per 1000 ewes lambing	1268	1276	1280	1286	6.6
	System				
	85/15	50/50			lsd
Lambs lost (exposure of the ewe)	316	310			3.5
Lambs lost (exposure of the lamb)	149	146			1.3
Live lambs per 1000 ewes lambing	1273	1281			4.7
	Mating Date				
	15-Apr	22-Apr	30-Apr		lsd
Lambs lost (exposure of the ewe)	315	318	307		4.3
Lambs lost (exposure of the lamb)	149	149	144		1.6
Live lambs per 1000 ewes lambing	1274	1271	1287		5.7
	Feeding				
	Standard	Plus 0.2 kg DM			lsd
Lambs lost (exposure of the ewe)	350	276			3.5
Lambs lost (exposure of the lamb)	144	151			1.3
Live lambs per 1000 ewes lambing	1244	1310			4.7

When comparing mating dates at this site, later dates than the current standard of 15 April were chosen. This was to check the alignment with future predictions of increased rainfall in this region. The current 15 April date relates to the lowest temperatures at lambing of any region (Figure 2). This is a strategy that farmers in this region have chosen to attempt to have lambs ready for sale before the onset of dry summer conditions restricts feed availability. With a predicted increase in rainfall this requirement may be eased. The movement of lambing date 7 days later provided no improvement in lamb survival at either site. A fifteen day later lambing did significantly improve live lamb numbers (13 at both sites per 1000 ewes). This statistically significant result may provide no net benefit unless feed supply was improved as a result.

Table 9. Northern Southland Flat

Site					
Northern Southland Flat	**Time**				
Scanning percentage = 174%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	279	272	269	264	4.2
Lambs lost (exposure of the lamb)	136	134	133	132	1.6
Live lambs per 1000 ewes lambing	1323	1331	1336	1342	5.7
	System				
	85/15	50/50			lsd
Lambs lost (exposure of the ewe)	273	269			3.0
Lambs lost (exposure of the lamb)	135	133			1.2
Live lambs per 1000 ewes lambing	1329	1336			4.0
	Mating Date				
	15-Apr	22-Apr	30-Apr		lsd
Lambs lost (exposure of the ewe)	273	275	265		3.6
Lambs lost (exposure of the lamb)	136	135	131		1.4
Live lambs per 1000 ewes lambing	1329	1328	1342		5.0
	Feeding				
	Standard	Plus 0.2 kg DM			lsd
Lambs lost (exposure of the ewe)	308	234			3.0
Lambs lost (exposure of the lamb)	131	137			1.2
Live lambs per 1000 ewes lambing	1299	1367			4.0

South Otago

Of major importance to this region was the provision of shelter. Of note in the regional comparisons was the high degree of variability at this site (Figure 8). Thus the provision of shelter is important to help reduce that variability. Providing both partial (50%) and full (100%) shelter from the wind increased the number of live lambs by 81 and 145 per 1000 ewes respectively (Table 10). These indicative values provide significant incentives to investigate the use of shelter in this environment. Planting of effective shelter will provide permanent benefits in lambs survival that may also have benefits in pasture production and carbon sequestration. Of interest are the effects of shelter on the ewe before lambing as well as the lamb at lambing. Reducing the climatic stress of heat loss on the ewe has a greater impact on lamb survival than that on the lamb at birth. This may be due to greater duration of exposure that is applied.

Variations in mating date before the current standard of 16 April provided no change in the number of live lambs (Table 10).

Extra feeding did provide some relief from lamb losses, though was more variable than providing a similar mitigating effect with extra shelter (Table 10).

Table 10. South Otago Rolling

South Otago					
Scanning percentage = 184%			**Time**		
	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	259	252	247	242	10.2
Lambs lost (exposure of the lamb)	136	133	132	130	4.1
Live lambs per 1000 ewes lambing	1444	1454	1460	1467	14.2
		Feeding			
	Standard	Plus 0.2 kg DM			lsd
Lambs lost (exposure of the ewe)	290	210			7.2
Lambs lost (exposure of the lamb)	129	136			2.9
Live lambs per 1000 ewes lambing	1420	1493			10.0
		Mating Date			
	6-Apr	11-Apr	16-Apr		lsd
Lambs lost (exposure of the ewe)	248	252	251		8.8
Lambs lost (exposure of the lamb)	133	134	131		3.5
Live lambs per 1000 ewes lambing	1459	1453	1457		12.3
		Shelter			
	0%	50%	100%		lsd
Lambs lost (exposure of the ewe)	290	231	171		5.1
Lambs lost (exposure of the lamb)	129	107	83		2.0
Live lambs per 1000 ewes lambing	1420	1501	1585		7.1

South Canterbury

Increasing lambing percentage and the use of genetics were important mitigations for the South Canterbury region.

Variations in mating date by up to 10 days before the current date of 9 April saw very little practical variation in live lamb numbers (Table 11, Table 12).

Increasing scanning percentage from the regional average to that of the highest 15% in the region was used as an achievable target. While the number of lambs lost increased in all cases, at both the Basin and Hill sites, the overall number of live lambs per 1000 ewes still increased significantly, by 156 and 200 respectively (Table 11, Table 12). The increase of 156 lambs at the Basin site related to a potential 200 lambs, resulting in a survival rate of approximately 75%, whereas the 200 lambs at the Hill site related to a potential 300 lambs or a survival of 67%, highlighting the greater impact of wind run at the Hill site.

Table 11. South Canterbury Basin

Site					
South Canterbury Basin	**Time**				
Scanning percentage = 172%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	245	236	231	225	8.5
Lambs lost (exposure of the lamb)	111	108	106	103	3.4
Live lambs per 1000 ewes lambing	1463	1475	1482	1491	11.8
Top 15% scanning percentage = 192%	**System**				
	Median	Top 15%			lsd
Lambs lost (exposure of the ewe)	220	249			6.0
Lambs lost (exposure of the lamb)	98	116			2.4
Live lambs per 1000 ewes lambing	1400	1556			8.3
	Mating Date				
	30-Mar	4-Apr	9-Apr		lsd
Lambs lost (exposure of the ewe)	240	233	230		7.3
Lambs lost (exposure of the lamb)	108	106	106		2.9
Live lambs per 1000 ewes lambing	1471	1480	1483		10.2

Table 12. South Canterbury Hill

Site					
South Canterbury Hill	**Time**				
Scanning percentage = 155%	Present	Future 1	Future 2	Future 3	lsd
Lambs lost (exposure of the ewe)	344	336	332	327	9.5
Lambs lost (exposure of the lamb)	140	137	136	135	3.3
Live lambs per 1000 ewes lambing	1218	1227	1232	1239	12.5
Top 15% scanning percentage = 185%	**System**				
	Median	Top 15%			lsd
Lambs lost (exposure of the ewe)	305	365			6.7
Lambs lost (exposure of the lamb)	119	155			2.3
Live lambs per 1000 ewes lambing	1129	1329			8.9
	Mating Date				
	20-Apr	25-Apr	2-May		lsd
Lambs lost (exposure of the ewe)	335	340	330		8.2
Lambs lost (exposure of the lamb)	140	138	133		2.8
Live lambs per 1000 ewes lambing	1226	1223	1238		10.9

The investigation of the impacts of genetics had a very narrow focus using the potential heat production likely from a heavier birth weight as one factor that may influence lamb survival. Using this approach the resulting increase in live lambs per 1000 ewes was small, ranging from 8 to 16 lambs depending on the site and the system (Table 13). Interestingly greater benefit was derived from this parameter at the less exposed site (Basin) and at higher scanning percentages (Top 15%). The influence of genetics on lamb survival is multifaceted and will be much more complicated than this simple example. Further research will provide a clearer understanding of how the influence of genetics may be applied in models such as these in the future.

Table 13. South Canterbury genetics

Change in live lambs/1000 ewes	**South Canterbury Sites**		
System	Basin	Hill	lsd
Median	13.2	7.7	
Top 15%	15.9	10.9	
			0.54

9. Discussion

The process of using farmer workshops to define problems and mitigations combined with climate and lamb survival modelling to understand variation and potential impacts of those mitigations provided a significant insight into lamb survival.

Regional workshops

Understanding the regional variations in farmer attitudes and views on various problems and mitigations has given a fuller insight into lamb survival. An example of this is how the attitude to shelter varies between regions. Northern Southland saw shelter as providing no net benefit because of their experience of traditional single lane, mature shelter, usually based on Macrocarpa or Pine. These shelter belts have significant areas of stock camping and associated disease risk (such as Watery Mouth or Navel Ill, associated with faecal bacteria), while having an open understory, creating extra wind run near the shelter belt. The South Otago group saw a significant benefit from shelter due to their experience with multi-tiered shelter that provides significant shelter across large parts of the paddock. Hill country farmers regarded natural contour and aspect as shelter and saw few ways of effectively planting traditional shelter belts.

Feeding was seen by all farmers as an effective mitigation. However, they also recognised the problems of providing that extra feed at a time of the year when feed supplies are at an annual low on-farm. While this mitigation has significant potential, farmers will need some changes in management of their feed supply before it becomes an on-going management strategy.

Climate modelling

Climatic variation is the most pressing issue for farmers with the potential for future climate change. Using the virtual climate station network, in conjunction with future climate change predictions, has provided some insight into the nature of those changes. The variable nature of our current climate already provides significant challenges for farmers and their understanding of managing that variation is already high. Future predicted changes appear to add little extra challenge to those farmers already face from year to year.

A significant gap in future predictions is wind run. Given that this has a major impact on lamb survival, as well as potential evapotranspiration and hence pasture production, this required future investigation to help our understanding of future impacts.

The data provided by the NIWA modelling has the potential for many other applications as we begin to improve our understanding of the impacts of climate variations on the sustainability of farm production systems into the future.

Lamb survival model verification

While the models have a relatively close correlation on average it has been decided that the AgResearch Lamb Survival model would be used in this project as it has been calibrated directly from local data and across a much larger data set than the Australian model. While relative body condition is not a direct factor in the model, the relationship between climatic conditions leading up to lambing and lamb survival that was discovered in this research can be used as an indicator of nutritional conditions of the ewe, as per the outcomes from the farmer workshops.

Calculating the number of lambs lost due to, either the exposure of the ewe before lambing, or the lamb at birth, as separate statistics provided the opportunity to investigate the dynamics of climatic impacts throughout the lambing season. It enabled a clear differentiation of the potential benefits of different mitigations on lamb survival, and some insight about how such mitigations may be applied. For example, it has enabled the opportunity to investigate the potential changes that may be captured by feeding compared to shelter, and between shelter before and after lambing, although the second opportunity has not been captured in this data set.

Understanding lamb survival modelling

The results of this investigation have provided some significant insights to the use of various mitigations and the interactions between mitigation and climatic factors at each site.

The choice of mating/lambing date in each region coincides with the onset of significant pasture growth. This has led to temperature conditions (Figure 2) being very similar at each site. This then means that the major climatic influences that create variation in lamb survival are rainfall and wind run. The impacts of rainfall are relatively hard to counteract, except through interventions such as adequate soil drainage and feeding levels. The impacts of wind run are more easily mitigated against through shelter and so are seen to provide that greatest benefits to lamb survival. The economic benefits to shelter, however, vary from site to site depending on the total wind run and year to year variation.

An illustration of the total wind run is the difference between the South Canterbury Basin and the South Canterbury Hill sites, where shelter has a relatively small impact in the Basin but a much greater impact on the Hill. However, an example of the reduction in variability comes from the South Otago Rolling site where shelter has a significant effect even though the wind run is average (0).

Variations in mating date saw very little change in lamb survival due to changing climatic conditions. These changes will have a much greater impact on the whole farm feed supply. Given that increasing feeding levels has such a significant impact on lamb survival then this is the likely factor that would explain variation in lamb survival due to

changes in lambing date. Farmers can investigate the variations in whole farm feed supply as the primary factor producing changes in productivity without needing to place a significant emphasis on the climate in lamb survival.

10. Conclusions

Bringing together lamb survival modelling with climatic predictions has provided a powerful tool to investigate the role of potential mitigations to help farmers improve lamb survival.

Understanding the context in which farmers make their decisions about which mitigations to apply has provided the opportunity to investigate those mitigations and provide farmers with information about how less preferred or longer term options, such as shelter, might improve their farming business.

Modelling different climatic and mitigation scenarios has given a better understanding of how various factors such as lambing date, lambing spread, shelter, feeding and genetics can influence lamb survival.

Future predictions of climate change may provide farmers with the opportunity to lamb slightly earlier, bringing future lamb supply to the market forward and helping mitigate against the potential for greater summer drought.

The greatest practical mitigation to improve lamb survival from this study was good shelter, due to the variability introduced from wind run. Lambing dates across the regions have been chosen by farmers to coincide with the spring pasture growth and so are relatively similar in ambient temperature. Therefore, the next most significant variable that can be controlled is wind run.

Extra feeding provided increased lamb survival. This factor was modelled on its potential to provide heat for the ewe to offset heat loss due to the climate. Therefore this impact remains theoretical, though lamb survival is known to be related to late pregnancy feeding levels (Litherland *et al.* 1999). Further field work is required to validate this result.

Further work is required to improve our understanding of local wind run and its impact on lamb survival, as this factor has the greatest variability and therefore impact on lamb survival at a local level.

This work provides a starting point to help farmers redesign on-farm systems to provide significant mitigations to improve lamb survival in the face of future climate change.

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12. Appendix 1

Farmer catchment groups: Identification of issues and solutions

A first step in the process of understanding the impacts of present and future climatic influences on lamb survival was to bring four farmer groups together to examine the current issues that the farmers face. This was done through a workshop process where regional issues were first examined and then potential mitigations for that region were identified. The results of these workshops then provided the types of mitigation that were applied to the lamb survival modelling to investigate the relative importance of each mitigation in the face of the variable climate now and in the future.

Workshop Plan

The agenda for the farmer workshops allowed for a semi-structured discussion of the causes of variation in lamb survival and mitigations that could be implemented to improve lamb survival on farm. The groups then prioritised the mitigations according to the likelihood of implementation in each region. The top priority mitigations were then chosen for further investigation through modelling.

Agenda

- Introduction (5-10 minutes)
    - The project was introduced and put into context of the region
    - The potential for future climate changes and other influences such as changing land use and consumer requirements were introduced
    - The current status of other catchment groups was described
    - The outcomes that were needed from the meeting were outlined
- What factors affect lamb survival on our farms? (20-40 minutes)
    - The question was brainstormed to develop a list of influences and then experiences were discussed to provide context around mitigations that had been tried in the region and to understand the limitations that may be operating in each environment
    - The context provided from the discussions led to determining what could be changed to improve lamb survival
    - Open discussion to record options that are bought up
- Priorities and choose local option (10-15 minutes)

- The management mitigation options were prioritised and one or two were chosen to represent the needs of the region

- Conclusion (10 minutes)
  - Closing statements of the participants were sought regarding the usefulness of the meeting
  - The time frame for future reporting back to the community were outlined and a potential future meeting date determined
  - Outcomes that would be produced from the workshop and modelling were discussed
  - Thanks

Workshop outcomes

West Otago Monitor Farm

This workshop was held on 13 November 2008 with seven farmers and 2 agribusiness representatives.

The concept of lamb survival and its potential impacts on long term profitability in this type of hill country has been identified by this group in the previous Monitor farm programme and the group wanted to investigate practices that would potentially reduce lamb losses to improve profitability.

Factors (West Otago)

Of greatest importance was the influence of storms on lamb loss. Feeding was acknowledged as very important. Optimising lamb size and ewe health through feeding were seen as two of the most important factors. The actual practice of getting this right was often an interaction between balancing the winter feed budget and the spring grass production. Managing feed leading up to lambing was a significant area where compromises were often made, and consequences often are not understood by farmers or scientists.

Shelter was seen as important in this hill country at altitude. The trade-offs between shelter and diseases were raised, as was the expense of shelter in this more extensive country. Natural shelter like tussocks was acknowledged as superior to other types of shelter. The opportunity to re-establish tussock is a technical problem that may need addressing.

The issue of significant storms that arrive at the peak of lambing was raised as an important problem that may need addressing.

Mitigations (West Otago)

Options that may have a direct place in West Otago include the provision of significant shelter and the spreading of lambing over a longer time frame. Spreading lambing may also have other benefits such as the ability to supply young lambs for winter finishing.

Providing significant shelter will involve the use of farm forestry type tree blocks rather than conventional shelter belts in many cases, if the current guidelines on carbon sequestration are put in place. This has the potential to significantly change the

pasture production, lamb survival and the carbon footprint of the farm. It also has the potential to reduce costs by removing maintenance centres, though will increase the capital infrastructure of the farm.

Spreading lambing out over a longer time needs to be investigated to see if any benefits in lamb survival can compensate for potential losses due to later kill dates, more store lambs sold late, and potentially lower winter feed reserves due to later lamb sales. However, more early lamb sales may also result due to a better fit of feed supply and demand during early spring.

Scenarios (West Otago)

This group are going to use this analysis as a basis for some of the future Monitor Farm programme. Two areas for study were shelter and lambing spread.

The provision of introduced shelter, such as shelter belts, was of specific interest as the benefits were perceived as large, but this had to be offset against the high establishment and maintenance cost of shelter. Answers to the question of shelter can be done by desktop analysis and by detailed examination of case study farms.

Changing the lambing date of some or all of the flock needs to be done firstly via desktop study and then by demonstration and monitoring of the outcomes especially of the impacts on feed supply and demand, finishing potential and labour demand.

This project will examine the use of two distinct lambing dates on one farm (Mid-August and Early October) on lamb survival and feed flows and on-farm consequences. Lamb survival will be modelled through the Lamb Alive project and data relayed back to the farmer group. One farmer in the group is also putting the practical application of changing lambing date into an on-farm demonstration by lambing part of the flock earlier than the main flock to investigate potential changes in lamb survival and in the provision of appropriate pasture covers and feed supply to achieve the aim of improving overall farm performance.

Northern Southland Monitor Farm

This workshop was held in conjunction with a management committee meeting on 23 March 2009 with seven farmers and the consultant.

The project was outlined and future climate scenarios explained. There was a general discussion about lamb survival and the importance allocated by farmers to various practices.

Factors (Northern Southland)

Most farmers suggested that feeding was the most important priority but had relatively few true measures of how much extra feeding was required.

Some farmers thought shelter was useful but most could cite many problems with shelter design, including wind chill due to the wind being channelled underneath trees and hedges, and the build-up of diseases in close proximity to shelter that induced stock camping. Farmers also cited experience with sheep moving away from shelter when weather conditions were particularly bad. Conversely others had found that mis-mothering may occur if there is too little shelter and many ewes access the shelter at once.

Natural shelter and contour and aspect were considered much more appropriate. Other observations from the farmers indicated that the interactions between shelter

and behaviour were evident between shorn and unshorn sheep, making the use of shelter unpredictable.

The various parts of the influence of climate were considered to have different effects on lamb survival. For example, a snow fall was thought of as less harmful than rain, but the impact of a snowfall depended on the duration of the snow on the ground and follow on impacts on feed supply. Also of note was whether the snow was ‘wet’ and came with a wind chill. Wet soil conditions were acknowledged as having the greatest impact on lamb survival.

The farmers present reported a range of lambing percentages over the past five years of between 118 and 168%. The range of lambing percentages between years and within each farm was smallest in lowland farms (6-17%), and was greater on hill country farms (14-20%).

Mitigations (Northern Southland)

Predominant mitigations discussed were feeding and feed levels, cold tolerance genes, and potential to spread lambing fully over 2 cycles.

Shelter mitigation was thought to be a trade-off between reducing wind and increasing disease and mismothering. Some farmers noticed no difference between sheltered and un-sheltered paddocks. Others observed that weather drove the sheep away from shelter; some thought that shorn ewes (pre lamb) would use shelter better. Several farmers fenced shelter off (temporary electric) to push sheep out into paddocks (10-20m) to avoid disease, typically naval ill and watery mouth.

While the farmers understand the general principle of the need for appropriate feed, the application may not be well executed. The full impact of variation in BCS may also not be fully understood. The concept of feeding conditions in the last 14 days of pregnancy on lamb survival needs to be better explored and may be a future focus for this group.

The interaction between managing feed and managing the ewe was discussed. The trade-off appears to be between keeping feed up to the ewe in the last two weeks and the requirement to spread ewes out to minimise number of ewes lambing at any one time and have the ewes become familiar with the lambing paddocks. Techniques used to help prioritise which ewes are fed more include using ram harnesses or scanning data to split mobs based on potential lambing date. The farmers questioned how much lamb survival was influenced by good feeding through rationing or good husbandry of allowing sheep the time to familiarise themselves with the lambing environment. Some farmers used the ‘feed management’ approach and others used the ‘animal management’ approach.

Farmers had heard of cold tolerance gene and wanted to know more. They were interested to understand the impacts of genetics generally.

Scenarios (Northern Southland)

Two scenarios were chosen. The first was investigating the impacts of improved feeding in the final two weeks before lambing.

The second scenario was to spread lambing to get a 50/50 split over two cycles. This could be controlled by a staggered introduction of the ram. The trade-off between feeding before and after lambing on lamb survival and lamb growth, within the aspect

of a 50/50 split between two cycles was also suggested as an option where greater understanding was required.

South Otago Monitor Farm

This workshop was held in conjunction with a management committee meeting on 25 March 2009 with seven farmers and the consultant and vet.

The project was outlined and future climate scenarios explained. There was a general discussion about lamb survival and the importance allocated by farmers to various practices.

Factors (South Otago)

The South Otago group produced the following list of potential factors that influenced lamb survival.

- Number of triplets
- Shelter – better quality shelter
    - Type of tree species
    - Placement of shelter
    - Type of shelter
    - Full paddock coverage
    - Fencing out from shelter to prevent disease
    - What is the role of short shelter, tussocks/long grass?
- Lambing date x pasture cover
    - Farmers are aware that higher pasture covers do improve lamb survival but need to trade this off with the potential for dry conditions in January and February which may affect the ability to finish lambs
    - The variability of autumn rainfall can influence how many lambs can be finished
- Determination of survival by pre-lamb nutrition/treatment of the ewe was seen as important and again interacted with the amount of feed available in late winter
- Abortion – the type and extent of the impacts are relatively unknown on individual farms, though average responses have been worked out through large regional studies.
- Trace elements including selenium, iodine, vitamin E (on brassicas) were identified as particularly important in conjunction with winter feeding systems that included rationing of sub-maintenance rations and brassica crop feeding.
- Sleepy sickness was seen as a potential cause of lamb loss through mothers who were not in good condition to have lambs or died prior to or during lambing. This was an important outcome from the nutrition and energy provided to the ewe.
- Brassica feeding in winter and early spring was seen as important. Issues with protein, red blood cell counts and low dry matter concentration were raised though relatively little is known of the effects of those factors on lamb survival. The use of brassicas inters with the amount of grass available as farmers trade off high crop yields with poor grass growth in winter to provide an energy rich brassica which may be low in other nutrients.
- Poor ewe udder condition was seen as one potential problem reducing lamb survival. Udder health checks one month after weaning were important to ensure that ewes could rear two or three lambs. Some training of farmers may be required.

Mitigations (South Otago)

Of greatest concern for this group was the survival of triplets and many farmers were indentifying significant numbers of triplets occurring in their flocks.

Housing of triplet bearing ewes around the time of lambing was suggested as one potential intervention that may help. Many logistical issues were identified, such as cleanliness, feeding and feed changes and appropriate space for lambing. A further idea within specialist intervention was to hand-rear the third triplet, though most farmers thought that cost and labour requirements would preclude this option.

The impacts of drainage and a drier soil surface were raised, though generally it was taken as given that this should be a standard farm practice.

The stocking rate of lambing ewes was regarded as an important factor that may be underestimated, especially in triplet-bearing ewes. It was felt that relatively little is known about the social interactions between triplet-bearing ewes and the consequent impact on mismothering. The group indicated that more research into the impacts of managements to reduce paddock stocking rates was required. This may include mixing singles and triplets, preventing stock movement within a paddock to avoid mismothering, and using other stock classes to help reduce the density of lambing ewes in the paddock.

Finally the impacts of shelter were viewed as an important factor that could assist in mitigating against the impacts of climate on lamb survival. This was viewed as very important and farmers were well aware of the need for effective design of shelter to prevent stock camping and ensure that full paddock shelter was achieved.

Scenarios (South Otago)

The group decided that modelling shelter was most important in their environment. This may need to involve the impacts of shelter on pasture growth as well as use of different parts of the farm landscape in this rolling country. There are some case studies within the South Otago catchment that may be able to be used as examples.

A further scenario of interest was lambing triplets indoors. This would require a significant change in practice and up skilling to investigate the overall impacts on the farm system. Some modelling of feed flow on-farm and feed and labour costs could be done. There are many practical issues that would have to be solved before this would be a viable practice.

South Canterbury Monitor Farm

This workshop was held in conjunction with a management committee meeting on 13 May 2009 with eight farmers and the consultant.

The project was outlined and future climate scenarios explained. There was a general discussion about lamb survival and the importance allocated by farmers to various practices.

Factors (South Canterbury)

The potential for genetics to improve lamb survival had a high importance with this group. One farmer recounted his experiences with trying to identify rams that responded rapidly to stress by increasing their conversion of energy to heat by injecting them with adrenalin and measuring before and after body temperature, then checking those rams for the presence of the cold tolerance gene. Unfortunately all

rams had the gene but only some responded to the adrenalin by producing a high temperature. One observation was that some rams got hot on the outside, rather than in the core body temperature, but no-one knew what the cause and effect was.

Shelter was seen as a definite factor involved with improving lamb survival. Farmers suggested that shelter had to go all the way to the ground and that natural low cover like tussocks were preferable to other shelter types. The problem of disease associated with shelter was a concern. The use of limited shelter by shedding lambing ewes into sheltered areas was discussed and seen as a potential solution, especially if conditions were to change rapidly.

High lambing percentage was seen as one pragmatic way to overcome the problems of lamb losses. This would mean that, though the losses may be higher, the number of lambs would still be greater. As a result, in good years there would be plenty of extra lambs, while in bad years then there would still be more than if lambing percentage was lower.

Feeding was considered most important, in making sure there was enough feed available so that the ewe did not walk away from the lambs when she was hungry. The other perceived benefit to extra feeding was to produce a lamb of greater birth weight that was more able to survive in adverse weather.

The issues around managing the ewe and her movements at lambing was also mentioned in the provision of a centrally located, or more than one water source, so that the ewe did not have to go too far, and therefore lose contact with her lambs just after birth. This was also talked about in the provision of temporary subdivision to prevent ewes moving too far in larger paddocks, and to prevent them from congregating in preferred areas in adverse weather.

There was a question over the use of iodine to improve lamb survival. Some farmers used it as a matter of course while others had tested or done their own investigations to prove to themselves that it provided no benefit.

Mitigations (South Canterbury)

Several mitigations were mentioned.

More accurate long term weather forecasting may help with determining the date to put out the ram. One farmer told of his experiences with trying to use long range weather forecasts to determine the date for an early lambing mob.

The potential around managing parts of the flock based on using ram harnesses or foetal aging was discussed, often as a way to intensively manage only part of the flock. This could be through more shepherding, better use of shelter, and better use of feed

Split lambing was mentioned as a potential mitigation though was seen as potentially negative considering the tendency to dry summer conditions. One question was around the speed of lambing and how much difference it would make to the average lambing percentage and the variation between years. Most farmers wanted lambs to arrive quickly so that they had an even lamb crop that would all be sold in a relatively short timeframe by mid to late December before the onset of dry summer conditions.

Further to this debate was the opportunity to use natural synchronisation to match weather predictions or the use of some intervention to get ewes to lamb within the potential fine spells in the spring, like inductions in dairy cows, only using natural

triggers or supplements. Part of this was to get lambs born when expected. For example, those lambs that were supposed to be born within the 7 day ram harness mark cycle ended up being born then with no overlaps with the previous or following groups. This again provided the farmers with the confidence to only have to concentrate on one cohort of ewes with their management.

Temporary shelter using crops or grasses was mentioned. This may provide the ewe with a birthing site that also had a feed source with it and therefore would limit movement and provide shelter at the same time.

Shepherding practice was discussed as mitigation, though, as with other meetings, the group was divided on the benefits. Emphasis was placed on giving sheep the space and time to lamb. Appropriate feeding and watering was considered essential, as was the ability for the ewe to find shelter if required. Routine was also mentioned as important, as well as providing a settled environment.

Lambing indoors was mentioned but would have to be investigated to understand how it might be able to be done cost effectively without major disruption to feeding and behaviour of the ewe, while not increasing disease risk.

Scenarios (South Canterbury)

The group decided that two areas were of greatest interest.

The first was lambing as fast as possible (naturally) to get an even crop of lambs to sell before drought. It was thought that a 90/10 percent split between the first and second cycle was appropriate to achieve without intervention at mating.

The impact of improved genetics of lamb survival was important. For example, current practices such as cross-breeding with terminal sires have been shown to increase lamb survival. The physiological mechanism which is responsible for this is unknown. An attempt to model one of the mechanisms that might be altered by genetics was chosen for modelling and is described in the methods (0).

Scenario development

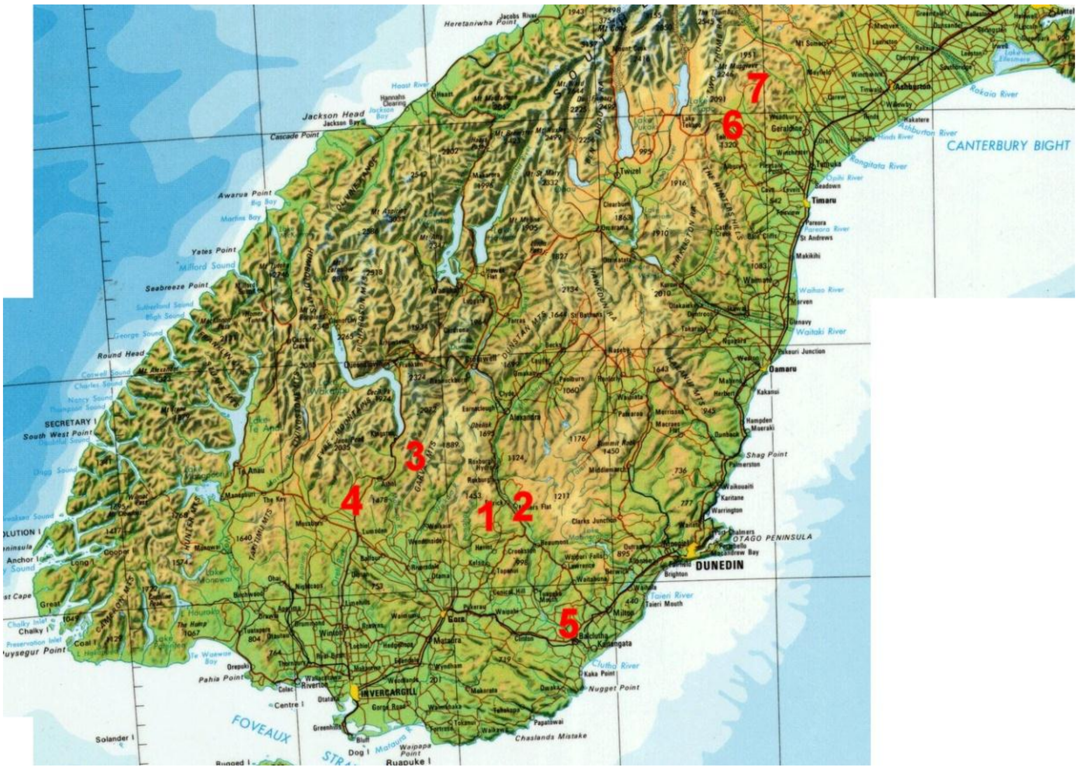
From the workshop outcomes mitigations were chosen for each region to examine the potential impacts on lamb survival. These are presented in Table 1.

Table 14. Mitigations chosen for each site

	Mitigations				
Site	Mating Date	Feeding	Shelter	Lambing percentage	Lambing spread
West Otago High Hill	Yes	Yes	Yes	No	Yes
West Otago Low Hill	Yes	Yes	Yes	No	Yes
Northern Southland Hill	Yes	Yes	Yes	No	Yes
Northern Southland Flat	Yes	Yes	Yes	No	Yes
South Otago Rolling	Yes	Yes	Yes	No	Yes

South Canterbury Basin	Yes	Yes	Yes	Yes	Yes
South Canterbury Hill	Yes	Yes	Yes	Yes	Yes

Figure 9. Map indicating locations of sites for lamb survival mitigation modelling



Key: 1) West Otago High Hill; 2) West Otago Low Hill; 3) Northern Southland Hill; 4) Northern Southland Flat; 5) South Otago Rolling; 6) South Canterbury Basin; 7) South Canterbury Hill