Mitigating the impacts of weather on lamb survival in Southern New Zealand

David R. STEVENS[1*] and Marie J. CASEY[2]
[1]*AgResearch Ltd, Invermay Research Centre, Private Bag 50034, Mosgiel New Zealand*
[2]*PGGWrightson Ltd, Private Bag 1960, Dunedin, New Zealand*
*Corresponding author: david.stevens@agresearch.co.nz

Abstract

Increased fecundity and improved feed management have doubled the number of lambs born in any three-day period in spring since 1990. Four farmer catchment groups were engaged to investigate options that farmers may use to reduce the impacts of weather at lambing time. After workshops identified potential mitigations, a lamb survival model was developed using data from the literature. This was applied at daily time steps to weather data over a 20-year period from 1980-1999, with chosen mitigations added to investigate their impact. Direct intervention by improving pre-lambing ewe nutrition increased live lambs by 7-8% (P<0.05). Policy development strategies to provide shelter increased live lambs by 8 and 17% with reductions in wind speed of 50 and 100% respectively (P<0.05). These results were consistent across all environments tested. Increasing fecundity increased the net number of lambs at docking, though also resulted in a greater number of lamb losses. Spreading risk by spreading lambing did not alter the net long-term lamb survival rate. Provision of shelter, both before and during lambing, and ensuring adequate pre-laming ewe nutrition were most effective at consistently improving lamb survival in all the environments tested.

Keywords: direct intervention, fecundity, lambing spread, nutrition, policy development, shelter, spreading risk

Introduction

Since 1990 sheep flock performance in New Zealand has markedly increased as farmers have adopted cross breeding, composite breeding and the introduction of new breeds (Fennessey et al., 2016). At the same time farmers have added other technologies such as pregnancy scanning to aid improved nutritional management and feeding (Johns et al., 2016). Flock scanning levels have increased markedly, from 120-125% to the extent that many flocks now consistently achieve pregnancy rates greater than 180% (Stevens and Young 2013).

Over the same period there has been little change in the commencement date for lambing (Stevens et al., 2022), although typically the lambing pattern is more condensed, and often 3rd cycle mated ewes are culled before lambing. This change is represented in Figure
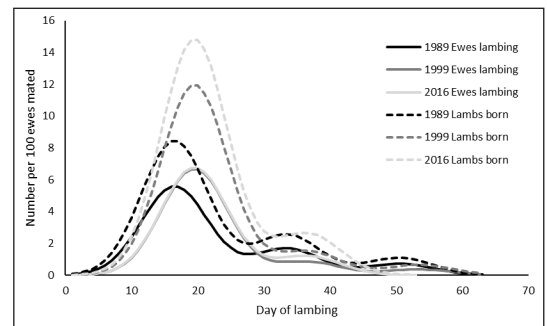

Figure 1   Predicted number of ewes lambing and number of lambs born each day during lambing (per 100 ewes mated) using data from 1989 (Grace *at al.,* 1989), 1999 (Nicoll et al., 1999) and 2015 (Johns et al., 2016) to demonstrate the increase in lamb numbers exposed to potential adverse climatic events at any one time.

1 where data from Grace et al. (1989), Nicoll et al. (1999) and Johns et al. (2016), with reported pregnancy rates of 1.50, 1.80 and 2.20 lambs/ewe, is plotted. The consequence is that, during the peak period of lambing, 20% more ewes in the flock will be lambing compared to the same period in 1990 (Figure 1). In the same period, it is estimated that the number of lambs born has almost doubled (Figure 1). Thus, at any period over lambing the consequence of a severe climatic event on lamb and ewe survival is now potentially more catastrophic than ever before. A comparison of lamb losses between the lower South Island and the North Island (Stevens and Young 2013) reported lamb losses of 18% and 27% for flocks in the North Island and South Island respectively, highlighting the greater risk created by climatic conditions facing sheep farming in South Island hill country. Catchments differ in their susceptibility to such adverse events, and an understanding of that variation provides insight into the types of management practices that may be successful over a range of landscapes.

The impacts of weather events on lamb survival associated with these changes in sheep fecundity may be significant and mitigations to improve lamb survival require examination. One of the key drivers to financial success on sheep farms is the number of lambs that survive to sale (Williams 2017). Farmers
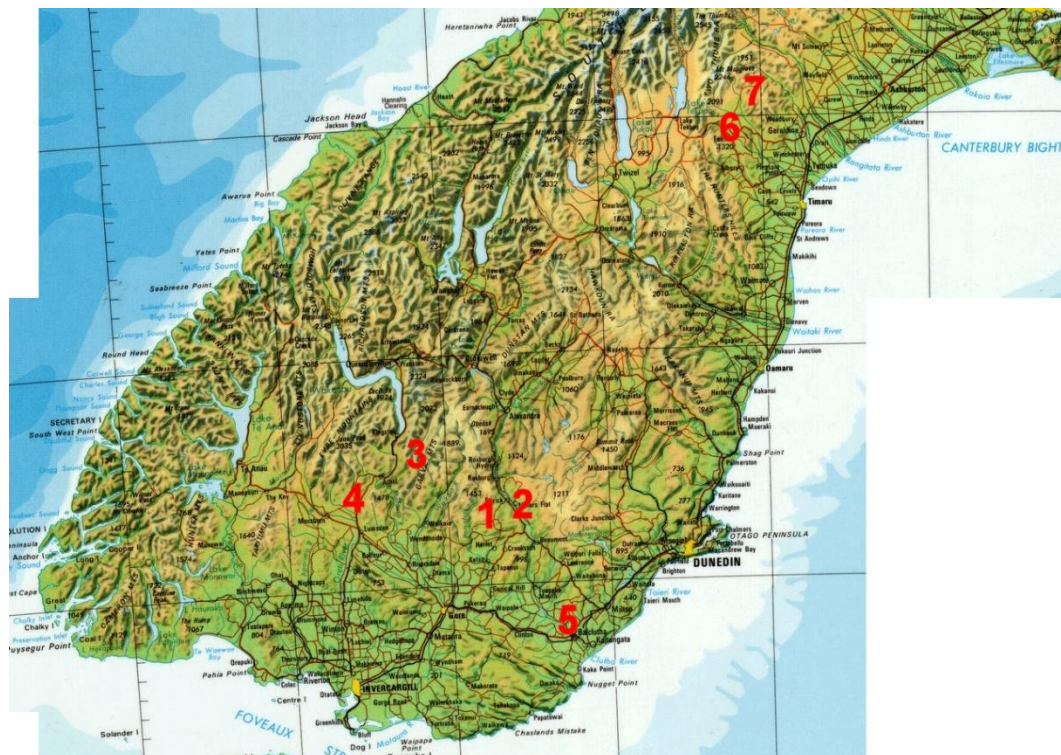
Figure 2   Map indicating locations of sites for lamb survival mitigation modelling (Key: 1) West Otago Hill; 2) West Otago Flat; 3) Northern Southland Hill; 4) Northern Southland Flat; 5) South Otago Flat; 6) South Canterbury Flat; 7) South Canterbury Hill

employ several options to manage their exposure to the risk of weather events. This study investigated the mitigations that farmers may use and tested the relative value of these mitigations in reducing lamb losses in four regions in southern New Zealand.

Materials and Methods

A Sustainable Farming Fund project, Lamb Alive, investigated the types of mitigations farmers considered to reduce lamb losses and quantified relative benefits of each approach using a model developed from local and international data. Weather records from a twenty-year period from 1980-1999 were used in the predictions. The outcomes were compared for their relative efficacy and reliability and reported back to farmers.

Farmer workshops

To develop a set of mitigations that farmers considered to reduce lamb losses around birth four regional groups of farmers were engaged in workshops between November 2008 and May 2009. These represented Northern Southland (eight attendees), West Otago (nine attendees), South Otago (nine attendees) and South Canterbury (nine attendees). Two sites within each region, except South Otago, were chosen to represent

different farming types (Figure 2), creating seven local climate zones for the modelling.

The farmer workshops of approximately 1 h duration began with a semi-structured discussion of the causes of variation in lamb survival. Mitigations that could be implemented to improve lamb survival on farm were developed and prioritised according to the likelihood of implementation in each region. The top priority mitigations were then chosen for further investigation through modelling.

Weather data prediction

Sites chosen in the farmer workshops were used to determine the location of weather data generation (Table 1). The NIWA virtual climate network (Tait et al. 2006) was used to generate daily maximum and minimum air temperatures and rainfall, from two weeks before until 3 weeks after the mean lambing date, for the period 1980-1999. Wind run was generated from the closest meteorological site (Table 1), with missing data replaced with data collected in an adjacent year.

Predicting lamb losses

Lamb losses due to climatic conditions were predicted using a lamb survival model based on heat loss in the

two weeks before lambing and the three days post-lambing, using daily temperature, rainfall and wind velocity (Stevens and Casey 2022). The number of lambs born on a single day was calculated using the scanning percentage and the distribution of lambs likely to born using functions derived from Davis et al. (1983). Daily potential lamb losses due to thermal stress were then summed to predict total lamb losses during any lambing period. A full description is provided in Stevens and Casey (2022). Predicted and actual losses were compared to validate the calculations (Stevens and Casey 2022) and the model was then applied to mitigations chosen by the farmer groups.

Mitigations included changing mating date, altering lambing spread, adding shelter, increasing pre-lambing nutrition and altering lamb survival genetics. The lamb loss model (Stevens and Casey 2022) was then applied depending on the specification of the mitigations (Table 2).

Predicting the effects of mitigations

Potential mitigations added to the model included those that could influence the ability to mitigate heat loss. Adding shelter was accounted for by reducing the wind run by either 50 or 100% and adjusting the heat loss accordingly.

To account for the mitigation of increased pre-lambing nutrition during the 2 weeks prior to birth an energy intake supplement of 0.2 kg DM/d was converted to its potential heat production using Equation 1 and

Table 1   Description of sites chosen for weather and lamb loss prediction, including current lambing statistics

	Site Longitude /Latitude	Wind data site Longitude /Latitude	Altitude	Scanning percentage	Normal Mating date	Lambing percentage	Lamb survival
West Otago Hill (Wohelo/Wilden)	-45.725/169.175	-45.883/169.975	626	177	10-May	134	75.7
West Otago Flat (Raes Junction/Island Block)	-45.725/169.425	-45.883/169.975	422	177	1-May	130.1	73.5
Northern Southland Hill (Athol Hill)	-45.425/168.575	-46.115/168.887[1]	480	174	15-Apr	126.2	72.5
Northern Southland Flat (Mossburn/Five Rivers)	-45.675/168.325	-46.115/168.887	256	174	15-Apr	144.2	82.9
South Otago Flat (Te Houka/Balclutha)	-46.225/169.675	-46.273/169.739	70	184	6-Apr	141	76.6
South Canterbury Hill (Fairlie Hill)	-43.975/170.925	-44.002/170.443	577	155	25-Apr	121.3	78.3
South Canterbury Flat (Farilie Basin)	-44.125/170.825	-44.103/170.825	300	172	9-Apr	144.2	83.9

[1] The nearest meteorological site was at 256 m.a.s.l so wind speed was increased for altitude by 22.4% or 10%/100m, as per Dawber and Edwards (1978)

Table 2   Mitigations chosen for each site

	Mitigations				
	Direct intervention	Policy development		Risk spreading	
Site	Feeding	Shelter	Fecundity	Mating date	Lambing spread
West Otago High Hill	Yes	Yes	No	Yes	Yes
West Otago Low Hill	Yes	Yes	No	Yes	Yes
Northern Southland Hill	Yes	Yes	No	Yes	Yes
Northern Southland Flat	Yes	Yes	No	Yes	Yes
South Otago Rolling	Yes	Yes	No	Yes	Yes
South Canterbury Hill	Yes	Yes	Yes	Yes	Yes
South Canterbury Basin	Yes	Yes	Yes	Yes	Yes

then subtracted from the calculated heat loss.

Heat production (W/d) = Energy intake (MJ/d) * 10^6 / 86,400 (s) / surface area   (Equation 1)

This equation converts MJ/d into heat available for combating heat loss via the surface area of a sheep, based on the relationship that a heat loss of 1 Watt = 1 Joule per second and there are 86,400 s/d

Where surface area = 0.09 * ewe liveweight$^{0.66}$ (Bennett 1973)

The genetics of lamb survival were incorporated into the model using an approach similar to that used for the pre-lambing nutrition. The production of heat at summit metabolism in new-born lambs is directly related to birth weight (Alexander 1962). Summit metabolism is the total heat that a lamb can produce to mitigate heat loss. 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 as 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.

Results of the impacts of the 20 years of weather data on potential lamb survival were analysed separately for each region. Mitigations were applied in a factorial design to represent every combination of mitigation chosen (Table 2). Weather data was summarised to provide a mean, standard deviation, and maximum and minimum conditions. A general analysis of variance was used (Genstat 11.1 2009) using year as the replication and chosen mitigations as the treatments in a factorial design.

Results and Discussion
Farmer identified lamb loss mitigations
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 to identify when a ewe will lamb can be used to help prioritise which ewes are fed more as lambing approaches. These 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. Using a feed management approach often means that the animal itself is used as a buffer when feed supplies are low. The body condition of the ewe then declines. Farmers using this approach trade off the current use of body condition to fill a pre-lambing feed gap, with the potential of that body condition to increase in milk production (Stevens et al., 2011). The concept of feeding conditions in the last 14 d 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. 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 were 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 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.

Housing of triplet bearing ewes around the time of lambing was also suggested as a potential intervention. This spans direct intervention and policy development as infrastructure inputs are initially required. 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.

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 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 involve the use of farm forestry type tree blocks rather than conventional shelter belts in many cases, capturing value from carbon sequestration. 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 areas of the farm with high maintenance costs such as steep or eroding land, though will increase the capital infrastructure of the farm.

Increasing fecundity was identified as a potential opportunity, as the marginal increase in number of live lambs may provide an economic benefit. While there may be greater risk due to an increase in multiple-born lambs, the gains may outweigh the losses. There may be significant risks in this approach as an increase in lamb losses presents significant animal welfare implications. This approach may need to be coupled with housing of triplet-bearing ewes as a long-term policy to mitigate this risk.

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.

Risk spreading
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 d while the remaining 10 to 15% is born in the second 17 to 20 d of lambing, to a 50:50 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 avoid weather extremes, without spreading lambing, and consequently supply to market, over a longer time frame.

Scenario development to test mitigations
The suite of mitigations identified was similar for each region (Table 2). Specific interests were expressed by each region. The West Otago group chose splitting the lambing between early (late August) and late (early October) lambing. The Northern Southland group 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. Shelter was a specific interest of the South Otago group with investigations into 50 and 100% wind run reduction requested. The South Canterbury group wanted to investigate the role of genetics as increasing fecundity.

Weather data
Temperature
The average and variation in temperatures (1980-1999) around lambing, (Figure 3), indicated that the temperature into which lambs are being born is relatively consistent with a standard deviation of approximately 1.5°C within each site.

Rainfall
Average rainfall from 14 d before until 51 d after the start of lambing, (Figure 4) was lowest at the South
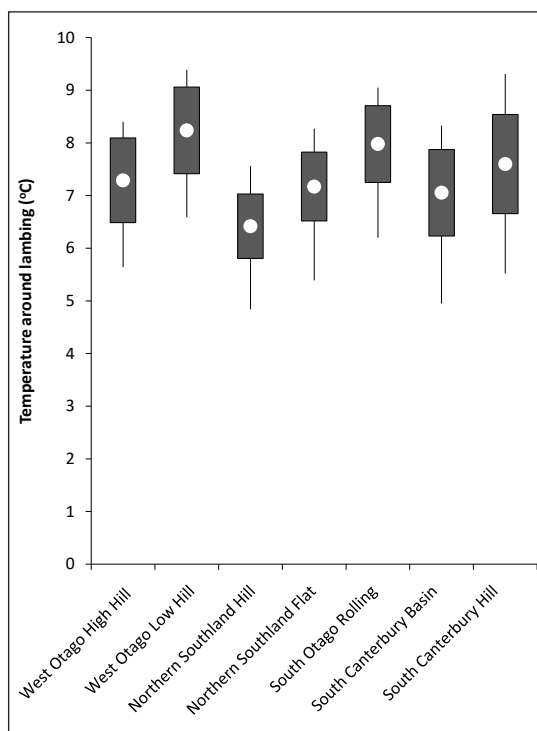
Figure 3   Variations in the present average temperature from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for seven sites (box represents 1 SD around the mean, lines represent maximum and minimum readings).
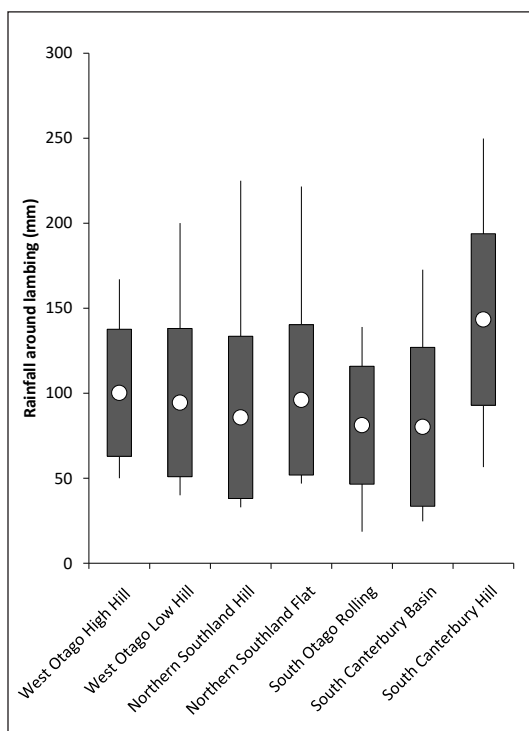

Figure 4   Variations in the present average rainfall from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).

Otago and South Canterbury Basin sites, intermediate in Northern Southland and West Otago and greatest at the South Canterbury Hill site. The most variable rainfall amounts were seen at the Northern Southland and South Canterbury Hill sites. South Otago was the least variable. The high variability in all results should be noted. The difference in rainfall around lambing from year to year ranged by between 120 and over 200 mm between years at any one site. However, the mean rainfall is clustered towards the lower end of the extremes, indicating that these seasons of high rainfall are unusual. This range in rainfall means that farmers are already dealing with high variability in the current climatic extremes.

Wind run
Wind run was not predicted by the NIWA VCS for the period considered 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 (Figure 5).

The calmest site was the South Canterbury Basin.

This was 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 and Edwards 1978). This did not appear to be reflected in the West Otago Hill predictions, which may have been due to 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 0900 each morning, rather than a full daily wind run. This highlighted the problems that the VCS has in attempting to predict wind run, as very few stations have full records for actual wind run. 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)

Impacts of mitigations
Predicting lamb losses
The more severe climates generally had higher lamb losses (Table 1), though the South Otago Rolling data indicated a more variable result with a range of +4
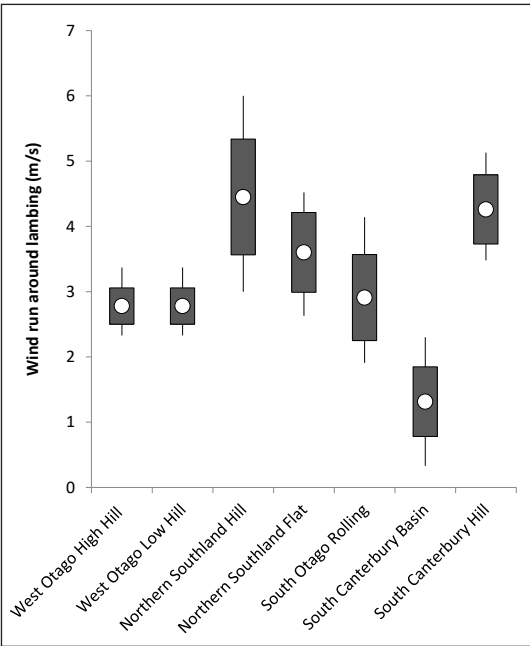
Figure 5   Variations in the present average wind run from two weeks before until three weeks after mean lambing date over twenty years (1980-1999) for 7 sites (box represents 1 standard deviation around the mean, lines represent maximum and minimum readings).

Direct interventions

The direct intervention of extra feeding significantly increased the number of live lambs at every site (Table 3). Some variation existed between sites with more exposed sites having a lower increase than more benign sites. The addition of 0.2 kg DM/ewe/d for a period of three weeks before lambing and through the first cycle (another 17 d) provided an extra seven live lambs per 100 ewes (Table 3). The extra feed requirement would be 7.6 kg per ewe or 760 kg per 100 ewes which may have a cost of $0.50/kg DM. At these costs, the extra lambs would have to be worth approximately $55 each to cover the extra feed costs. Case studies which have reported the impacts of extra feeding (Johns et al. 2016) have demonstrated the value of this approach.

Feeding was seen by all farmers as an effective mitigation. However, they 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 need to make some changes in management of their feed supply before it becomes an on-going management strategy.

Policy development

Policy development to provide shelter and the resultant decrease in wind speed by 50% provided a similar increase in live lambs to adding extra feed, in many
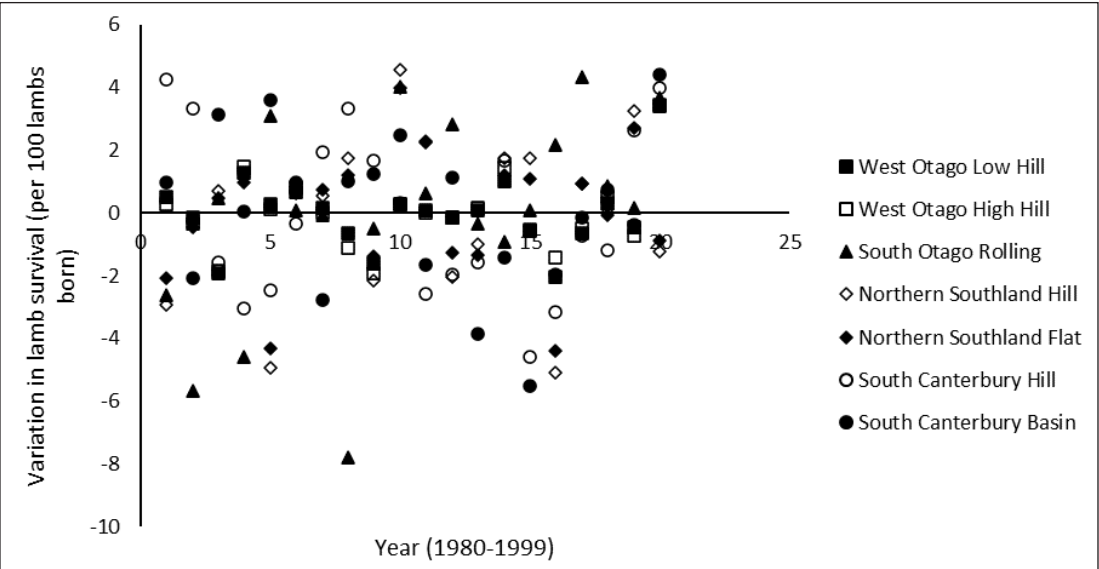

Figure 6   Variation in lamb survival (per 100 lambs born) due to the climatic variation at each site, predicted for the weather scenarios over twenty years (1980-1999).

to -8% (Figure 6), considering the apparently benign climatic conditions. Such variability is common in sheep farming and indicative of the combination of conditions on any given day.

cases (Table 3). When 100% shelter was applied, lamb survival doubled (Table 3). Effective shelter needs to be well designed, with many traditional shelter belts providing little reduction in wind run at ground level (Pollard 2006)

Table 3   Changes in lamb numbers surviving to weaning from testing a range of mitigations, chosen by four farming groups in the lower South Island of New Zealand with potential to increase lamb survival, were modelled

			Mitigation								
			Direct intervention	Policy development			Risk spreading				
				Shelter		Fecundity	Lambing Date			Lambing spread	
Topography	Region	Current lambing (%)	Feeding	50	100	Change in lambing %	Early	Mid	Late		LSD
Flat	West Otago	137	8	8	15		-5	-1	0[1]		0.76
	Northern Southland	128	7	10	20		0	0	1	1[2]	0.45
	South Otago	141	7	8	17		0	-1	0		1.12
	South Canterbury	139	7	4	7	16[3]	0	0	-1		0.89
Hill	West Otago	135	8	8	15		-5	-1	0[1]		0.74
	Northern Southland	123	7	12	24		0	-1	1	0[2]	0.51
	South Canterbury	113	6	10	20	20[3]	0	-2	-1		1.08

[1] Lambing date: Late = early October lambing; Future = mid-August lambing
[2] Proportion of ewes lambing in the first or second cycle: Standard = 85/15; Future = 50/50
[3] Changing fecundity: Current = 172%; Future = 192%

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 was how the attitude to shelter varied 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.

Chosen lambing dates have meant that average temperature conditions (Figure 3) were similar at each site, as farmers attempted to match increases in pasture growth with increasing animal demand. This meant that variations in rainfall and wind speed became potentially more important. 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 those 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 (Pollard 2006).

Increasing scanning percentage in the South Canterbury region

from the regional average (172%) to that of the highest 15% in the region (192%) was deemed 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 100 ewes still increased significantly, by 16 and 20 respectively (Table 3). The increase of 16 lambs at the Basin site related to a potential 20 lambs, which resulted in a survival rate of approximately 75%, whereas the extra 20 lambs at the Hill site allowed potentially 30 lambs, or a survival of 67%, which highlighted the greater impact of wind run at the Hill site.

Risk spreading
Spreading the risk using variations in mating/lambing date in each region provided little change in number of live lambs being often zero and up to five per 100 ewes mated (Table 3). While these changes were occasionally significant, they provided no net benefit unless feed supply was improved. In Northern Southland, for example, later dates than the current standard of 15 April were chosen to check the alignment with future predictions of increased rainfall in this region. The current standard date relates to the lowest temperatures at lambing of any region (Figure 3). This is a strategy that farmers in this region have chosen to attempt to have lambs ready for sale before the potential onset of dry summer conditions restricts feed availability. The one extra lamb surviving per 100 ewes mated would not be enough financial reward to offset the potential lamb liveweight gain lost by lambing 15 d later.

Variations in mating date saw very little change in lamb survival due to the weather. Altering the balance of ewes lambing in the first and second cycles was ineffective in altering lamb survival (Table 3). With significant variations in lamb survival being driven by feeding and shelter, farmers can investigate these options without needing to place a significant emphasis on timing of lambing.

Conclusions
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 mitigations provided a significant insight into lamb survival. Understanding the context in which farmers make their decisions about which mitigations to apply provided the opportunity to provide farmers with information about how less preferred or longer-term options, such as shelter, might improve their farming business. More research into the impacts of managements to reduce paddock stocking rates may be required.

Of the types of intervention chosen, direct intervention providing extra feeding was of intermediate impact.

Providing shelter and increasing fecundity, as long-term policy choices provided the greatest gains overall. Risk spreading was the least effective at mitigating the effects of weather around lambing. Modelling different climatic and mitigation scenarios provided a better understanding of how various factors such as lambing date, lambing spread, shelter, feeding and fecundity can influence lamb survival.

The greatest practical mitigation to improve lamb survival from this study was good shelter, due to the variability introduced from wind run, which additionally could mitigate the impact of rainfall in some instances. Soil drainage may provide benefits by keeping lambs drier in wet conditions. Lambing dates across the regions have been chosen by farmers to coincide with the spring pasture growth and so were relatively similar in ambient temperature. Therefore, the next most significant variable that can be controlled is wind run.

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