Testing the potential for lamb survival

Overall conclusions

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 3). 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.

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 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.

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.

Developing the types of mitigation that farmers might use

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.

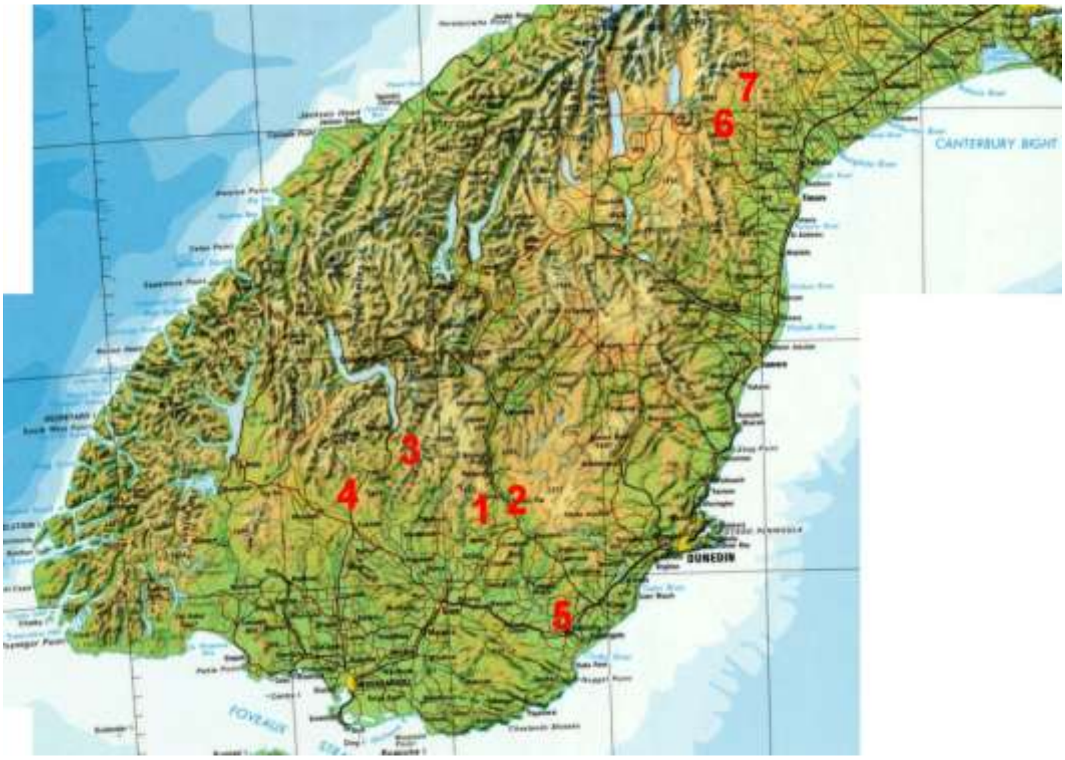
Within the regions, shelter was the chosen mitigation for the South Otago group, who also chose extra feeding. Changes in feeding were specifically chosen by the Northern Southland group. The Northern Southland group also chose to investigate altering the spread of lambing from 85% in the first cycle 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

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). 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). 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**Error! Reference source not found.**). 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). 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, **Error! Reference source not found.**). 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 2. 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	136	134	133	132	1.6	

Flat					
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

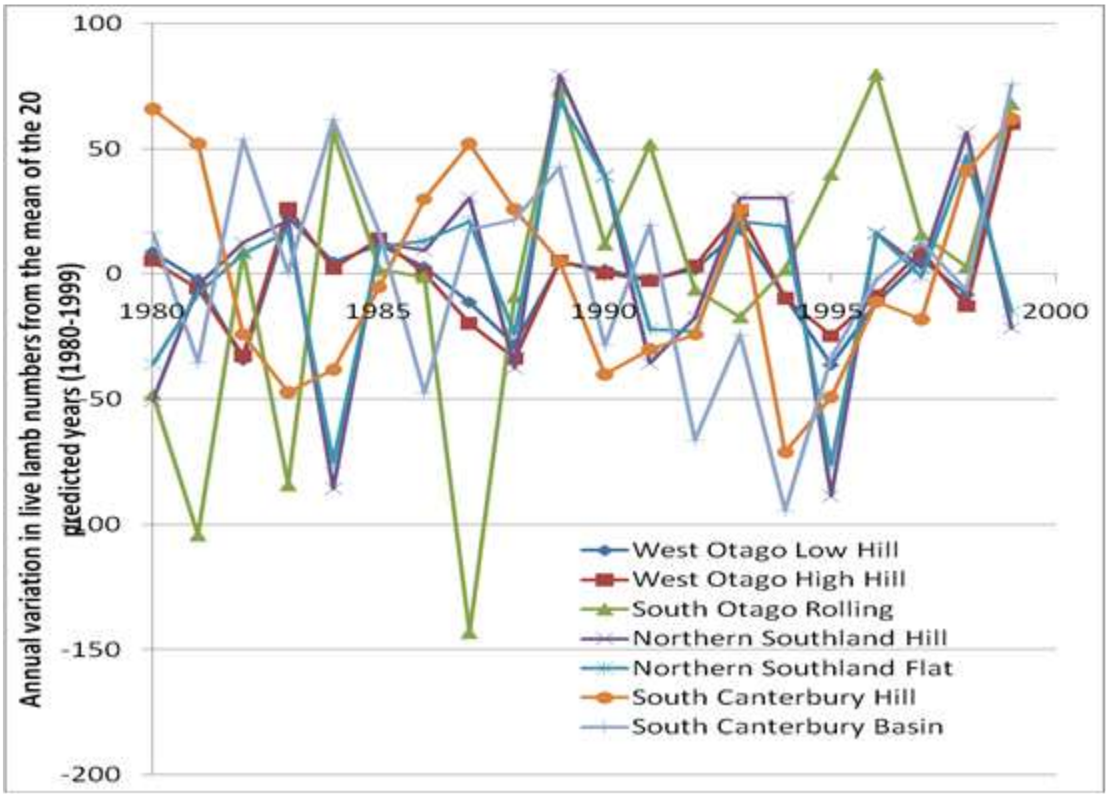
[1]lsd: Least Significant difference

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 2). The more severe climates generally had higher lamb losses, though the South Otago Rolling data indicated a more variable result (Figure 2), 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 2. 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 3) 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 3. 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 are similar across the regions. Therefore, it is logical that wind run will be the major factor determining lamb losses.