Ministry for Primary Industries
Manatū Ahu Matua

Analysis of supplemental feed use in the new zealand sheep industry

MPI Technical Paper 2017/57

Prepared for the Ministry for Primary Industries

ISBN No: 978-1-77665-677-6 (online)
ISSN No: 2253-3923 (online)

May 2017

New Zealand Government

Growing and Protecting New Zealand

Disclaimer

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries website at
http://www.mpi.govt.nz/news-and-resources/publications/

ANALYSIS OF SUPPLEMENTAL FEED USE IN THE NEW ZEALAND SHEEP INDUSTRY

MPI Project 405376

Prepared for

Joel Gibbs

Ministry for Primary Industries

By

Jude Sise, Bruce McCorkindale and Peter Fennessy

AbacusBio Limited

29 May 2017

AbacusBio Limited
PO Box 5585
Dunedin
New Zealand

Phone: +64 (03) 477 6375
Fax: +64 (03) 477 6376
Email: jsise@abacusbio.co.nz
Website: www.abacusbio.com

Executive summary

This project has quantified historical supplemental feed demand, and evaluated the impact of potential future productivity gains on supplemental feed usage within the New Zealand dry-stock farming industry.

The Farmax decision support tool has been used to develop a sequential set of historical models that span the 1990-91 to 2014-15 production seasons. These models are based on the Beef + Lamb New Zealand (B+LNZ) Class 9 data and represent a weighted average of all the dry stock farm classes, and include sheep, beef, beef ex-dairy, dairy grazing and deer livestock enterprises. Data from a previous project[1], was used to optimize the historical Farmax models, according to improvements in on-farm productivity over time, with significant gains observed in both the sheep and dairy sectors between 1990 and 2015. A series of additional models were created, to evaluate potential changes in the percentage of feed demand met by supplement sin the future. These models were based on the 2030 "High" and "Low" scenarios used within the productivity report, with additional variants used to account for changes in the number of sheep, relative to the other class 9 enterprises. Excel models were used to track pasture and supplemental feed usage according to stock class, month and year. The average metabolizable energy (ME) content of feed consumed was also tracked to enable reporting of methane emissions relative to estimated feed quality and inventory values. Results are summarised for both sheep, and total farm values.

A summary of key results shows that over the last 25 years:

- There have been minor increases in summer and winter feed crop plantings, which have increased from 3.9 to 8.0 (summer) and 19.5 to 25 (winter) hectares per 1,000 hectares. However, the total volume of additional supplements had a minor impact on overall supplement usage.
- The estimated percentage of diet provided by supplemental feed within a Class 9 farm increased from 6 to 7 %. The rate of supplemental feed use was lower in sheep (5 to 6%) than the other Class 9 farm enterprises (7 to 9%).
    - o The main crops used in the historical model are pasture baleage, kale, swedes and leafy turnips. Baleage, kale and swedes are used extensively used over winter when pasture covers are low, and leafy turnips used to provide a summer boost to lambs. Whilst baleage and swedes are used across both sheep and cattle enterprises, practicalities associated with the height and stem thickness of kale, mean that this crop has not been included in the sheep supplemental feed allocations.
    - o Whilst supplemental feed is commonly used in both the ewe and lamb sheep classes, as a proportion of total diet it is predominantly used for hoggets and lambs (10 to 20% of diet). Supplemental feed usage is much lower in the ewes at 2 to 3% of total annual diet.
- Estimated supplement usage increase dramatically to meet the production requirements of the 2030 high scenarios. In sheep, supplement usage remains relatively low at 7 to 8%, whilst for the other Class 9 farm enterprises, it increases from 9 to 20% as large amounts of fodder beet are used in the beef, beef ex-dairy and dairy grazing enterprises.

[1] Analysis of the potential to increase emission intensity improvements through productivity gains. AbacusBio report (MPI tender 17893) by Jude Sise, Jason Archer, Tom Kirk, Brue McCorkindale, Tim Byrne, Peter Fennessy (June 2016).

    - Use of nitrogen fertiliser to increase the quality of pasture available, reduced the amount of fodder beet required in the 2030 scenarios. Use of additional nitrogen enabled achievement of the 2030 high production targets with a similar amount of supplemental feed as the 2030 low production models.

- The impact of supplemental feed usage was also quantified according to changes in the average ME content of feed consumed, and on methane emission estimates. Key outcomes from this analysis showed that:
    - The ME estimates for the historical Class 9 models varied relative to seasonal values used in the New Zealand greenhouse gas inventory estimates. Estimated ME values were lower than inventory estimates in winter and spring, but higher in summer and autumn.
    - The preferential feed allocation model resulted in higher ME in feed for lambs, and lower ME for feed in ewes compared to inventory values. This resulted in a 3% increase in total methane emissions for 1990-91 relative to the inventory. By 2014-15, there were no substantive differences and inventory values were closely aligned to the Class 9 model estimates.
    - Increased ME estimates in the 2030 scenarios resulted in an overall reduction in emissions relative to those estimated using the inventory values.
- With rates of supplementary feed use increasing at higher rates in cattle than sheep, further development is required to estimate the impact that these changes are likely to have at an individual stock class level with the beef, beef ex-dairy and dairy grazing enterprises. There are also opportunities to assess the impact that specialist pastures are likely to have on both feed quality and GHG emissions in the sheep sector.

Contents

Introduction

This report summarises work completed under MPI contract 405376 "Analysis of supplemental feed use in the sheep industry". It builds on work previously undertaken to evaluate the impact of productivity gains on emission intensity (MPI project tender 17893), with outcomes from the productivity project shown below:

- *Significant gains have been made in productivity over the last 25 years, and these have been accompanied by the expected reductions in emission intensity. The biggest gains have been seen in the sheep and dairy cow sectors, with gains of 46% and 44% in the volume of product per breeding female sold, whilst emission intensity has reduced by 11% and 25% respectively.*
- *Dairy expansion has resulted in a doubling of the dairy cow population over the last 25 years, whilst the sheep population has halved. Despite the drop in sheep numbers, the significant productivity gains made in lamb carcase production, has limited the total sheep production drop to 28%.*
- *As productivity has increased, feed demand has also increased and gross emissions have risen by 14% over the last 25 years. Looking forward, gross emissions are predicted to increase, with the modelled 2030 scenarios showing a 21% to 29% increase relative to the 1989/90 season. The primary driver for this increase is increased feed demand, with additional nitrogen fertiliser usage likely to account for a 1-2% of total gross emissions post 2015.*
- *Within the sheep, beef and dairy cow sectors, 40% to 50% of the productivity improvements have come about from the use of improved genetics, whilst in deer we estimate that 100% of the productivity gains are due to genetics, with improvements in management offset by changes in land class where the animals are typically run on harder hill country.*

With approximately half of the productivity gains in sheep due to improved management, the purpose of this project was to evaluate supplemental feed usage in sheep, and the impact that that may have on estimates of greenhouse gas emissions.

Whilst this project is primarily focused on sheep, there is a considerable variation in the average size and composition of New Zealand sheep and beef farms. With pasture management focused on maximizing pasture and supplemental feed opportunities over the entire farm operation, it is impractical to model the performance of sheep farms in isolation, and a decision was made to utilize the Beef + lamb New Zealand (B+LNZ) Class 9 All Farms class. This is a long-running model that provides a weighted average picture of all the farm classes in New Zealand. As such, it represents the best picture of the "NZ Sheep and Beef Farming Inc" situation. The trends over time in this model reflect the overall changes in the industry in terms of stock numbers, ratio of stock enterprises, stock performance and the scale properties. A summary of the farms contained within the B+LNZ Class 9 All Farms class is shown in Table 1. There were an estimated 11,295 farms Class 9 commercial sheep and beef farms in New Zealand in the 2014-15 financial year.

Table 1. Estimated number of commercial sheep and beef farms in 2014-15.

Farm Class	Location	Description	Effective area (hectares)	Estimated number of farms
1	South Island	High country	7,506	215
2	South Island	Hill country	1,430	810
3	North Island	Hard hill country	764	1,065
4	North Island	Hill country	431	3,640
5	North Island	Intensive finishing	292	1,275
6	South Island	Finishing breeding	423	2,505
7	South Island	Intensive finishing	223	1,290
8	South Island	Mixed finishing	418	495
Total all classes (Class 9)			**627**	**11,295**

The Farmax decision support tool has been used to develop a sequential set of models representing the B+LNZ Class 9 farm data. The production models developed for project 17893 were used as a starting point, with the 1990 and 2015 sheep, beef, ex-dairy and deer models imported into a new “Class 9 whole farm model” and then scaled to match the number of breeding stock in the B+L Class 9 data sets.

In addition to utilizing the Class 9 animal numbers and performance data, a number of other factors come into play when evaluating national pasture and supplemental feed demand. These are summarized in Figure 1 with the impact of historical changes in these factors summarized in the historical data analysis section below, with additional information provided within the appendices of this report.

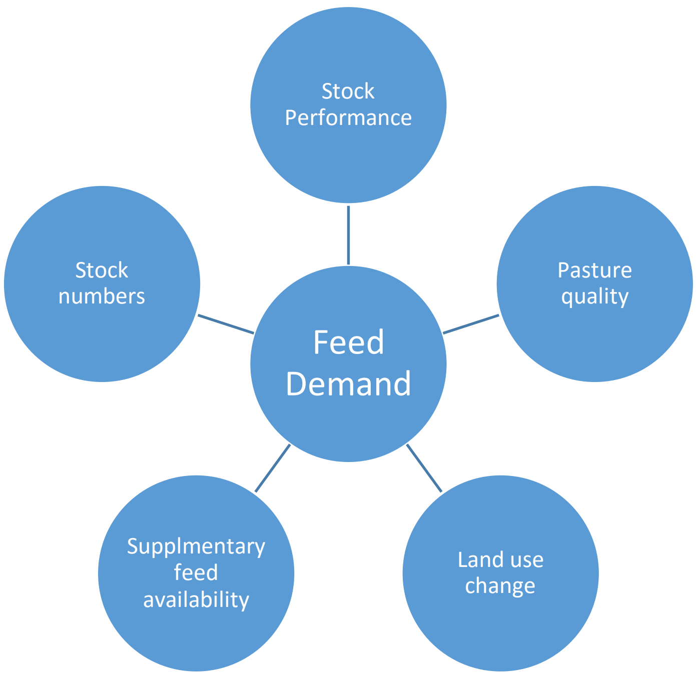


Figure 1. Factors impacting of national estimates of total feed demand over time.

Supplemental feed usage

Extensive research has revealed that there is no single source of data available to enable analysis of historical supplemental feed usage in the sheep and beef dry stock sector. With a large variety of options available for use by farmers (e.g. range of brassica feed types, and concentrates such as high energy feeds and grains), the B+LNZ Class 9 data summarised supplemental feed types under three broad headings. These include summer feed, winter feed, and hay & silage usage. To reduce complexity within the Farmax models for this analysis, the following crops were selected to represent “typical” supplemental feed usage.

Summer feed: Modelled as leafy turnips, but which could also include other commonly-used supplements such as rape crops.

Winter feed: Modelled as swedes, kale and fodder beet, but which would also include other commonly-used supplements such as winter turnips and cereal green-feeds.

Hay and silage: Modelled as baleage and barley silage.

Data supplied by the Farmax support group, show that sheep nuts are also commonly used as concentrates. While sheep nuts are excluded from the crop information provided by the Class 9 dataset, a small volume of supplementary nuts were included in some farm system models.

Report framework

Results from this analysis are presented in five broad sections as below.

1. **Historical data analysis**
   a. This section outlines data sources and assumptions used to set up the historical models for this analysis, and details the model frameworks used to estimate pasture and supplemental feed demand according to stock class, month and analysis year.
2. **Historical results (1990-2015)**
   a. Historical results are in section 2, with results presented according to total demand per farm, and scaled to account for differences in effective area, and demand from sheep relative to the other Class 9 farm enterprises.
3. **Future scenarios (2030**)
   a. Results for a range of future scenarios are presented in Section 3. With the initial 2030 low and high scenarios modelled on potential productivity gains from project 17893, additional scenarios were added to account for 5% increases or declines in total demand.
   b. The impact of fodder beet plantings and nitrogen fertiliser usage was also carefully evaluated, with fodder beet as a high-yielding crop used to represent the additional supplemental feed required to meet the 2030 production scenarios.
4. **Impact on methane emission estimates**

   a. This section shows the impact of feed quality on methane emissions, with results presented on a whole farm basis, and for the individual stock classes modelled within the sheep enterprise.

5. **Scaling to estimate national demand**
   a. This section provides estimates of national pasture and supplemental feed demand, methane estimates, and compares these with results presented under project 17893.

Note that due to the complexity of the data, results are primarily presented in figure format, with a comprehensive set of input data and results provided within the appendices of this report.

Historical data analysis (1990-2015)

Farm composition and land area

The Statistics NZ database (www.stats.govt.nz) was used as the source of data to estimate changes in stock numbers between 1990 and 2015, and these data were compared to sheep, beef cattle and deer number estimates obtained from the B+LNZ Economic Service Class 9 data sets. A summary of the Statistic NZ data is provided below with a full set of results and comparisons provided in Appendix 1.

Figure 2 summarises the Statistics NZ data and shows a 52% drop in total sheep numbers, whilst there was a 24% drop in beef cattle numbers, and the number of deer ranged from 1.75 million to 0.853 million over the same period.

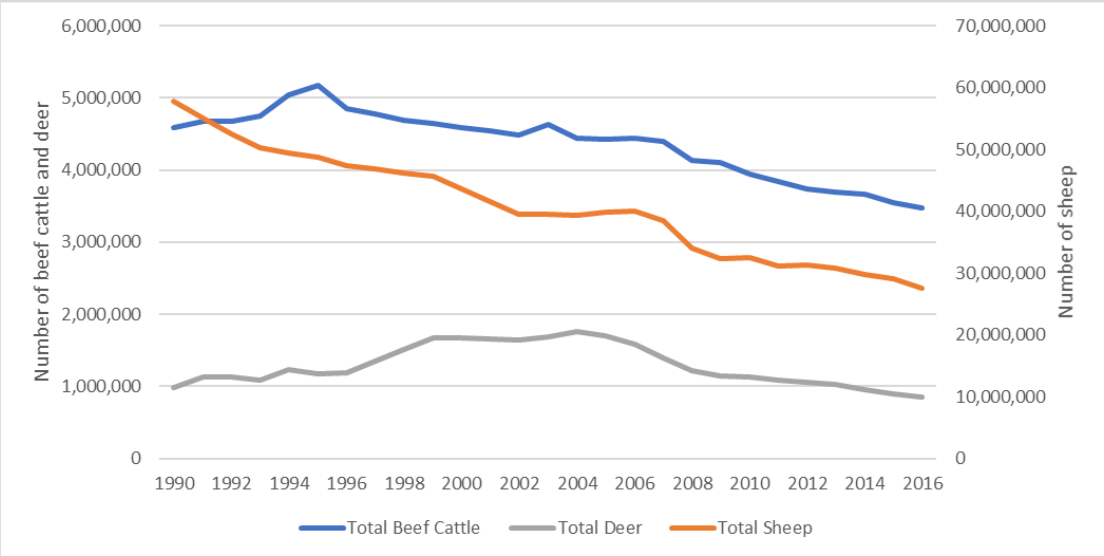


Figure 2. Statistics New Zealand data showing changes in the total numbers of sheep, beef cattle and deer reported over time.

The Class 9 data from B+LNZ Economic Service shows that in addition to the overall reductions in stock numbers, there have also been changes in the average size and structure of farms over time[2].

- Land area estimates (B+LNZ Economic Service database), shows that dry-stock land area declined from 12.45 million hectares in 1990 to 8.55 million hectares in 2015, with an estimated 1.0 million hectares lost to dairy production and 2.9 million hectares to alternate (non-grazing) land usage.
- Farm composition has also changed, with increases in the average number of sheep on hand at opening (1 July) reflecting the changes reported for average farm size until 2007 (see Figure 3), but then dropping due to increased numbers of beef, dairy grazing and ex-dairy bull beef on hand throughout the year.

[2] Full explanation provided in the Class 9 farm size and composition of Appendix 1

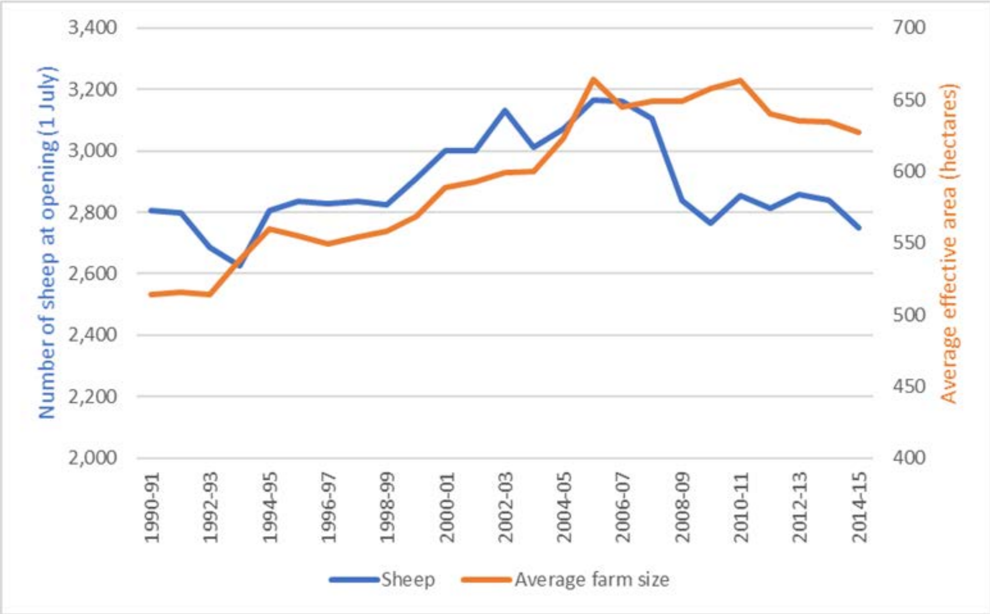


Figure 3. B+LNZ Class 9 data showing changes in the average number of sheep on hand at year end (30 June) relative to effective farm area.

Changes in terrain relative to total dry stock land area

The B+LNZ Economic Service data have also been used to evaluate changes in land usage (Figure 4), with data on changes in land area and terrain type documented in the Land Use change section of Appendix 1.

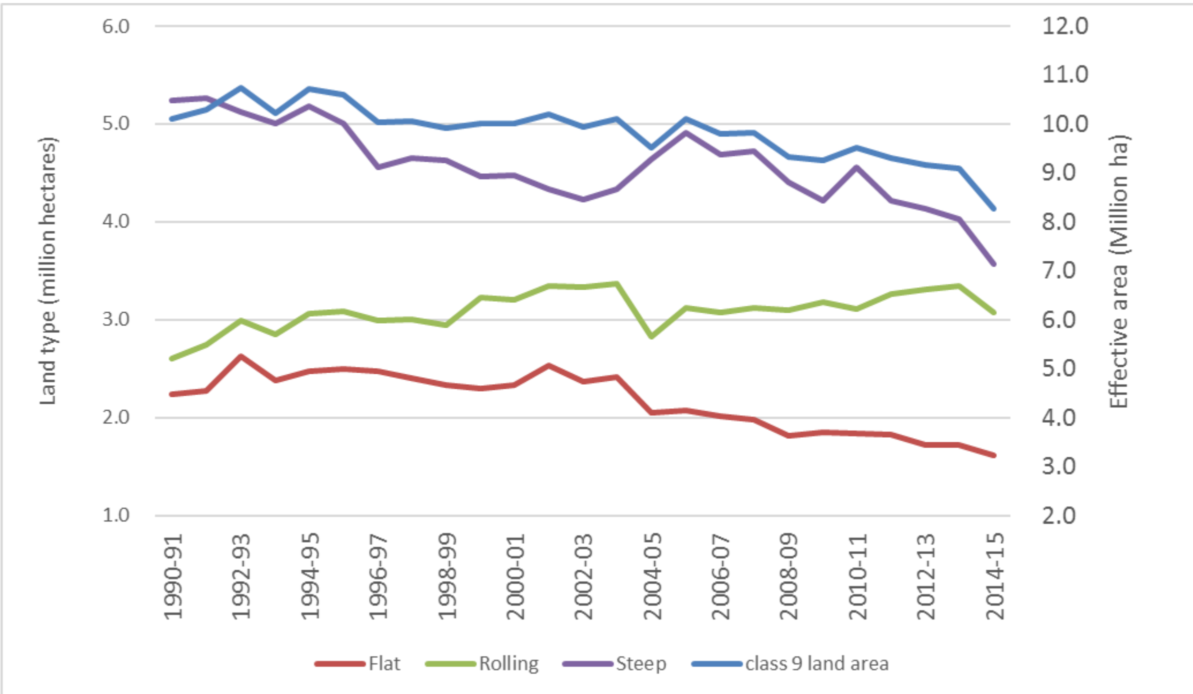


Figure 4. Changes in land type and effective dry stock land area.

Figure 4 shows the impact of changes in land type (flat, rolling & steep) when scaled according to average farm size, and then total dry-stock land area. The proportion of steep land declined at a similar rate to total land area, whilst rolling land area has remaining relatively constant and flat area has reduced. This fits with anecdotal evidence of sheep and beef farmers moving onto "harder hill country", conversion of some flatter land to dairying, and conversion of some steeper land to non-grazing uses e.g. forestry, with the productivity gains in sheep and beef (as identified in project 17983) achieved through a combination of improved genetics and management.

Supplementary feed usage

Industry data have been used to assess changes in supplementary feed usage over time, including data provided by the B+LNZ Economic Service, data provided by the Farmax business support team, and anecdotal data provided though consultation with industry experts and farm consultants. Within this, the B+LNZ data was judged to be the best source since:

i) it fitted with the approach of using the Class 9 farm model to estimate supplement usage; and
ii) despite extensive efforts, there was no single source of commercial data identified that could be used to estimate seed sales to the sheep and beef sector over time.

It is important to note that Farmax company data were used to refine the Class 9 data estimates with respect to concentrate and nut usage, but by default they do not reflect "typical" sheep and beef data, with many Farmax users likely to be at the higher performing end of the spectrum.

Class 9 data

The Class 9 data provided by B+LNZ has been used to estimate the average areas used for summer and winter feeds, hay and silage. Pasture replacement rates have been calculated according to the area of land planted in new pasture (flat and rolling terrain) or over-sown on the rolling or steep hill terrain[3].

Results are summarised in Figure 5 and show that there have been:

- Small increases in the amount of new grass sown, and summer and winter feed plantings, whilst rates of over-sowing and hay and silage production have remained relatively static over time.
- Pasture replacement rates (new grass plantings and over-sowing) range from 1.5 to 2.9 %, with the average pasture replacement rate over the entire period estimated at 2.1%, which is consistent with the 2% reported by BERL for 2006-07 sheep and beef farms[4].
- There have only been small changes in the area used for supplemental feed usage (summer feed, winter feed, hay/silage) with land area per 1,000 hectares increasing from 5 to 6%.

[3] See Appendix 2 – Historical feed data

[4] http://www.pasturerenewal.org.nz/resources/research-articles-and-literature-reviews/report-unearths-nz-pasture-riches/

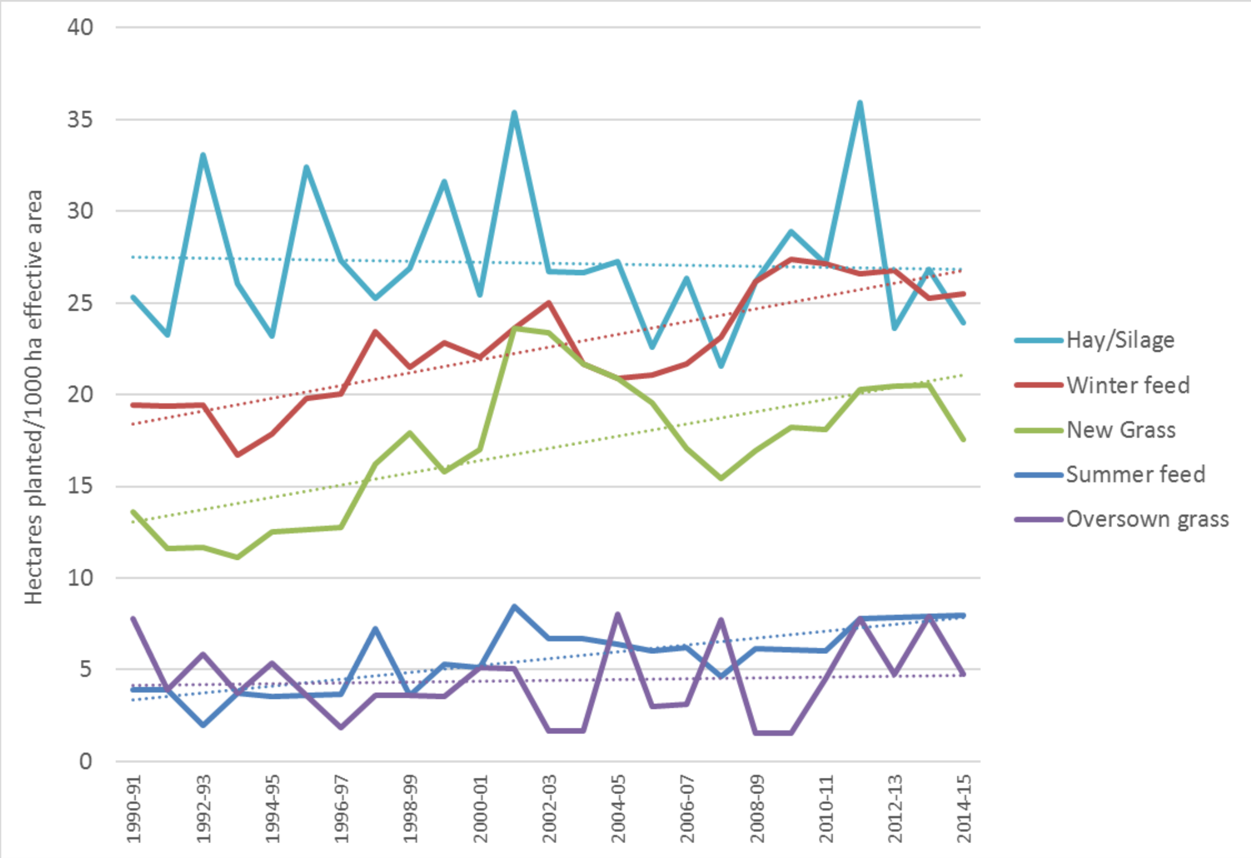


Figure 5. Estimated area of land (per 1,000 hectares) allocated to pasture renewal, over-sowing, hay & silage, winter and summer feed plantings.

Historical feed usage (1990-2015)

Model framework

Figure 6 shows a schematic of the model framework developed for this project. A brief description of each of these models is provided below with detailed descriptions of the assumptions and inner workings provided within the appendices of this report.

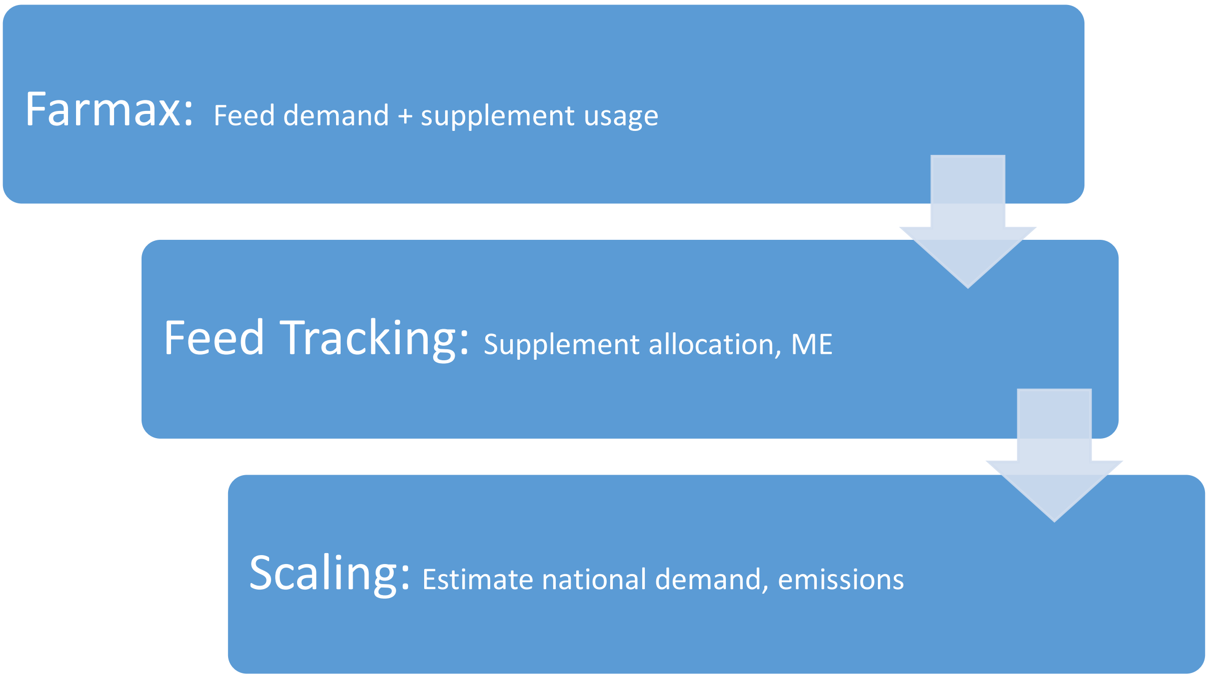


Figure 6. Model framework developed for this project

Farmax modelling

Farmax has been used to develop a sequential set of models representing the B+LNZ Class 9 farm data. The production models developed for project 17893 were used as a starting point, with the 1990 and 2015 sheep, beef, beef ex-dairy and deer models imported into a new "whole farm" and then scaled to match the number of breeding stock in the B+L Class 9 data sets.

Five additional "interim" models were then developed (based on the Class 9 data) to span the period from 1990-91 to 2014-15, with these models optimised to account for variations in in the Class 9 data versus expected levels of performance identified in project 17893. Pasture quality estimates were set according to the standard values applied in Farmax for flat, rolling and steep hill country terrain, and supplements were made available as reported within the B+LNZ Class 9 data extracts.

Feed tracking model

Farmax outputs were used to track total monthly feed demand, supplement usage and feed quality for each stock class, and season modelled. The model catered for a total of 39 individual stock classes including 9 sheep, 10 beef, 3 dairy grazing, 5 beef ex-dairy and 12 deer stock classes.

The key Farmax outputs used within the feed tracking model included:

1. Average daily demand per head
2. Average number of animals within each stock class for the given month and season
3. Percentage of monthly feed demand met by each of the supplementary feed types available

These values were used to calculate the total feed demand requirements for each enterprise on an annual basis. With Farmax utilising a "whole farm" approach, the Farmax models were optimised to ensure adequate pasture covers with respect to supplement availability and total feed demand. The percentage of feed provided by non-pasture supplement usage was used to calculate the total amount of dry matter provided by each supplement group, which was then allocated (within the feed tracking model) to individual stock classes according to the percentage of feed expected to be met by supplements each month.

The effective farm area was used to scale results to 1,000 hectares of effective area, thus enabling a comparison of changes in total feed demand and supplement usage over time. Results are presented for the whole farm, and for individual stock classes within the sheep enterprise. The model also enabled changes in the average quality of feed consumed over time, at both a whole farm level, and within the sheep enterprise.

Demand and feed quality estimates were also used to estimate greenhouse gas emissions for individual sheep stock classes over time.

Scaling model

This model was used to scale the Class 9 data outputs into national estimates of pasture and supplement usage over time, as well as estimates of emissions for individual sheep stock classes.

Historical results (1990-2015)

Historical feed demand

Figure 7 shows estimated changes in total feed demand for a typical Class 9 farm over time. Results are shown for changes in total demand, and for each of the different livestock enterprises, with the blue line used to show changes in average farm size (effective area) over the same period. These results show that between 1990-91 and 2006-07, increases in feed demand are loosely aligned with increases in farm size, with estimated demand peaking at 2,911 tonnes of dry matter (DM) intake in the 2006-07. In 2006-07 there was a minor increase in average farm size, which was accompanied by a minor drop in total feed demand, after which time there were drops in both farm size and demand. The 2006-07 anomaly was likely caused by a combination of weather events and economic conditions with a shift toward an increase in the average number of beef cattle and dairy grazers per farm.

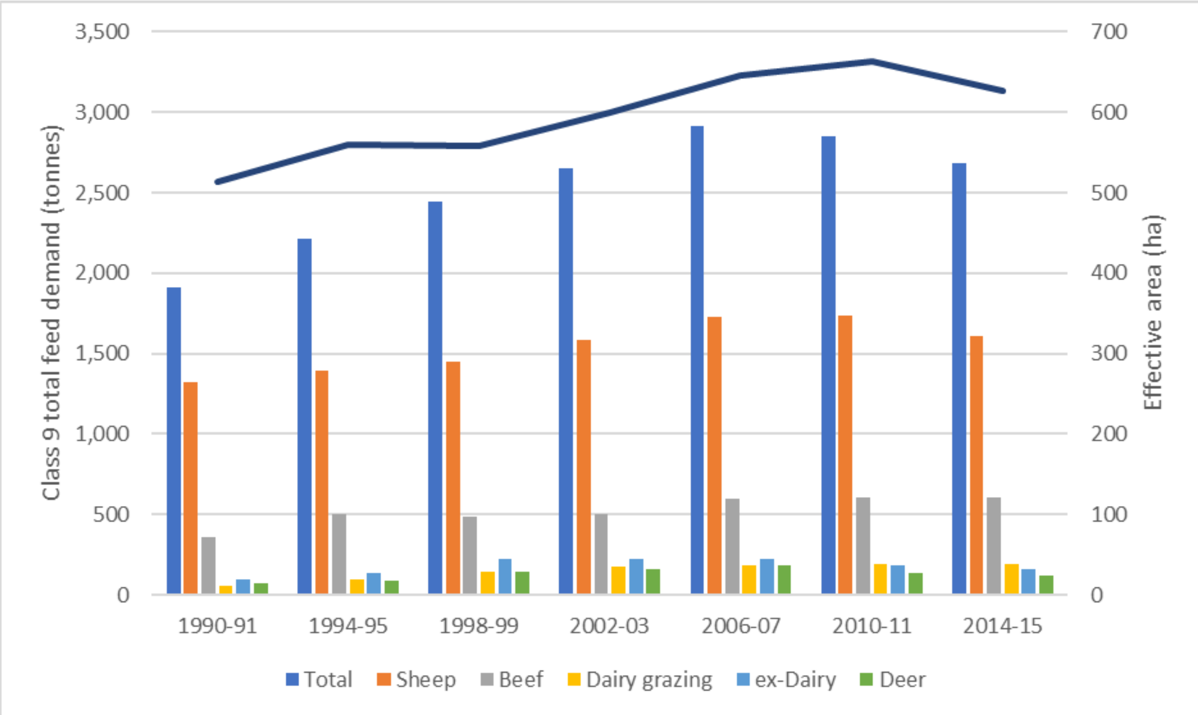


Figure 7. Estimated feed demand (per farm) for the historical Class 9 farm systems.

Results for each farm system model were then scaled to 1000 hectares to enable a comparison of changes in total feed demand over time. Figure 8 shows estimated total feed demand per hectare, where demand from sheep has remained relatively constant at 2.48 to 2.67 tonnes per hectare, with small increases in all other enterprises modelled. Total feed demand increased from 3.7 to 4.3 tonnes per hectare, including feed provided through supplement usage which ranged from 6 to 7% of total demand (see Figure 13 in the Historical supplement usage section below).

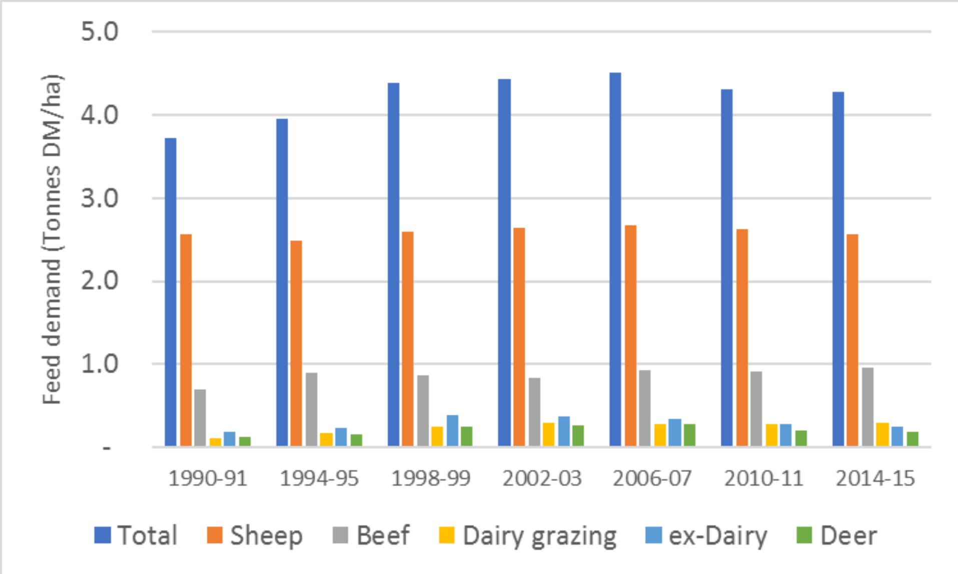


Figure 8. Estimated feed demand (Tonnes of dry matter per hectare).

With the average enterprise composition and productivity of Class 9 farms changing over time, the relative proportions of feed demand from each of the different enterprises have also changed. Table 2 shows the relative proportion of feed demand within each of the Class 9 models, with sheep dominating at 69% of feed in the 1990-91 season, and dropping to 59 to 61% from 1998-99 forwards.

Table 2. Proportion of feed demand from the Class 9 sheep, beef, dairy grazing, ex-Dairy beef and deer enterprises modelled.

	Sheep	Beef	Dairy grazing	ex-Dairy	Deer
1990-91	69%	19%	3%	5%	4%
1994-95	63%	23%	4%	6%	4%
1998-99	59%	20%	6%	9%	6%
2002-03	60%	19%	7%	9%	6%
2006-07	59%	21%	6%	8%	6%
2010-11	61%	21%	7%	7%	5%
2014-15	60%	23%	7%	6%	4%

Impact of productivity changes in sheep

Figure 9 shows the relationship between total sheep demand, and the number of mixed age and two tooth ewes mated per hectare[5]. Reductions in the average numbers of ewes mated would generally be expected to be accompanied by a reduction in total demand, but major productivity gains, including a 30% increase in both the number of lambs weaned per ewe mated, and average lamb carcase weight over this period, having resulted in increases in demand per hectare from the 1994-95 to 2006-07 seasons.

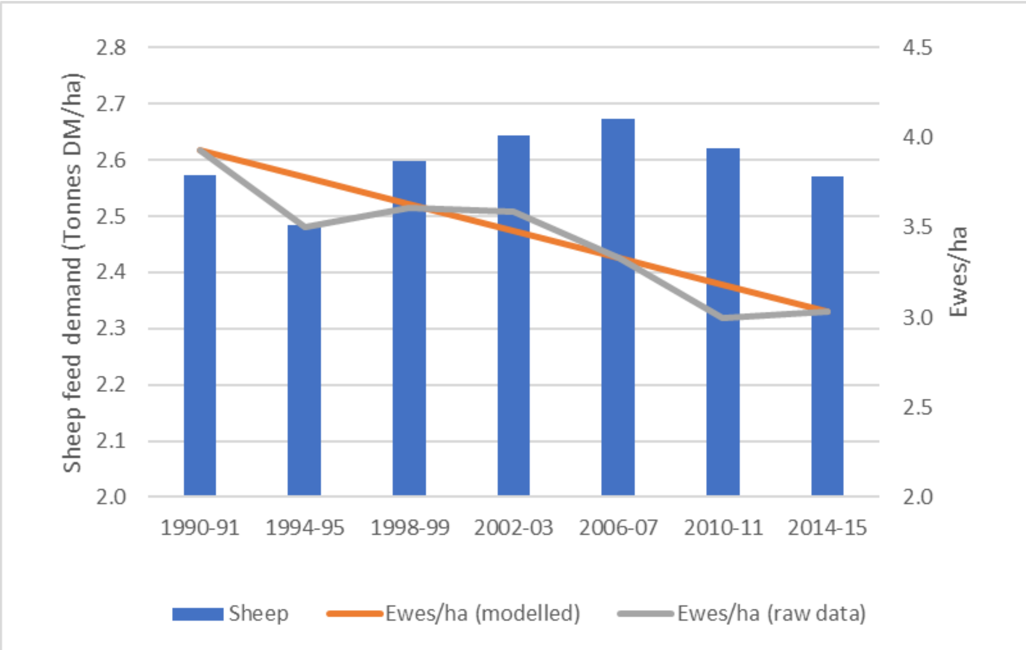


Figure 9. Total estimated feed demand for sheep relative to the number of ewes mated per hectare.

To enable a more accurate comparison, the demand values per hectare were further scaled to account for differences in Class 9 farm composition. With total sheep demand comprising 69% of total demand in the 1990-91 season, but dropping to 60% of total demand by 2014-15, demand estimates were scaled relative to the 1990-91 values, enabling comparisons per “sheep hectare”. Figure 10 shows the impact of this, through changes in the total demand per “sheep hectare” for each stock class. Results show that the combined ewe flock[6] accounts for over 65% of total sheep demand, and that there are noticeable increases in demand from the mixed lamb classes grown out for slaughter.

[5] With annual differences in the class 9 data resulting in quite a lot of “noise”, a linear trend was used to ensure that the farm system models reflected ongoing changes, where the number of ewes mated per hectare dropped from 3.9 to 3.0 ewes between 1990-91 and 2014-15 seasons.

[6] Includes both the ewe and terminal ewe classes (which are ewes mated to terminal sires).

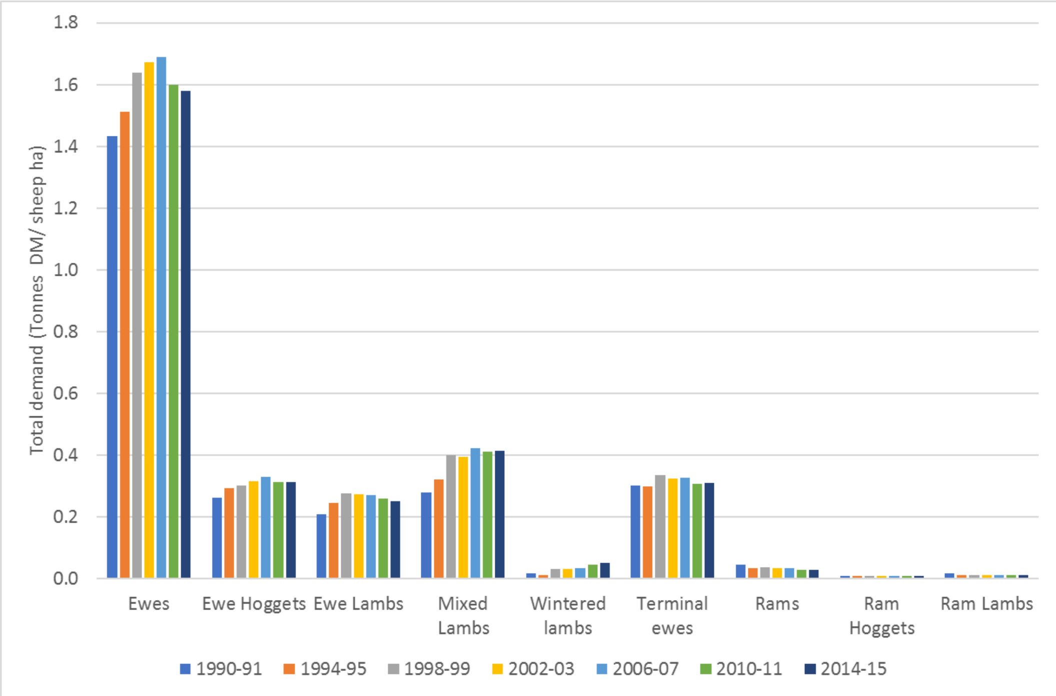


Figure 10. Total estimated demand for each stock class within the Class 9 sheep models.

Historical supplement usage

Figure 11 shows the total supplemental feed estimated from the linear trends (ex B+LNZ Class 9 statistics for the historical Class 9 system models). Supplements increased from 122 to 189 tonnes (1990-91 to 2014-15. Results were then scaled to 1000 hectares, to enable a fair comparison of changes in pasture and supplement usage per hectare over time (see Figure 12).

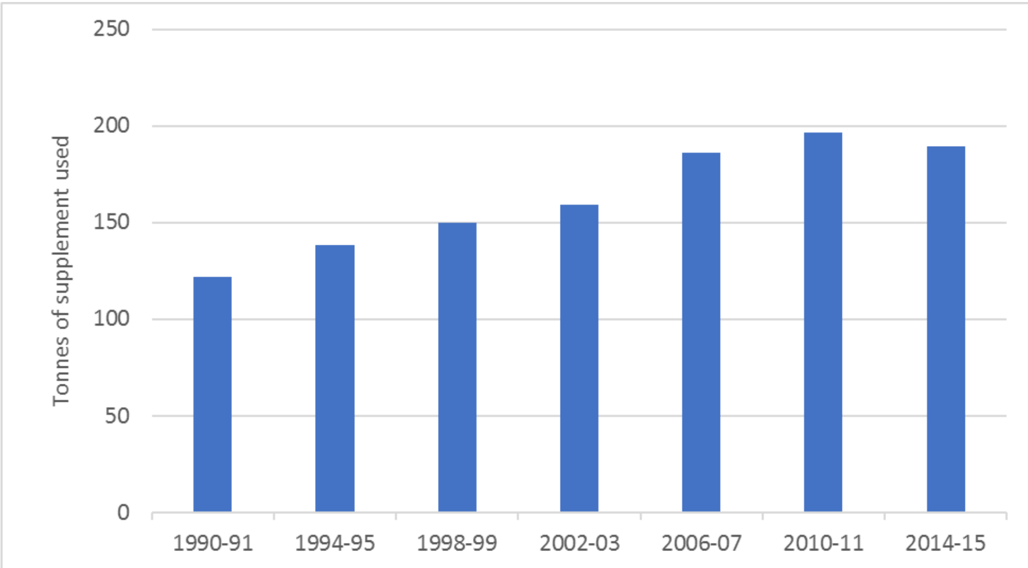


Figure 11. Changes in total supplemental feed usage per Class 9 Farm

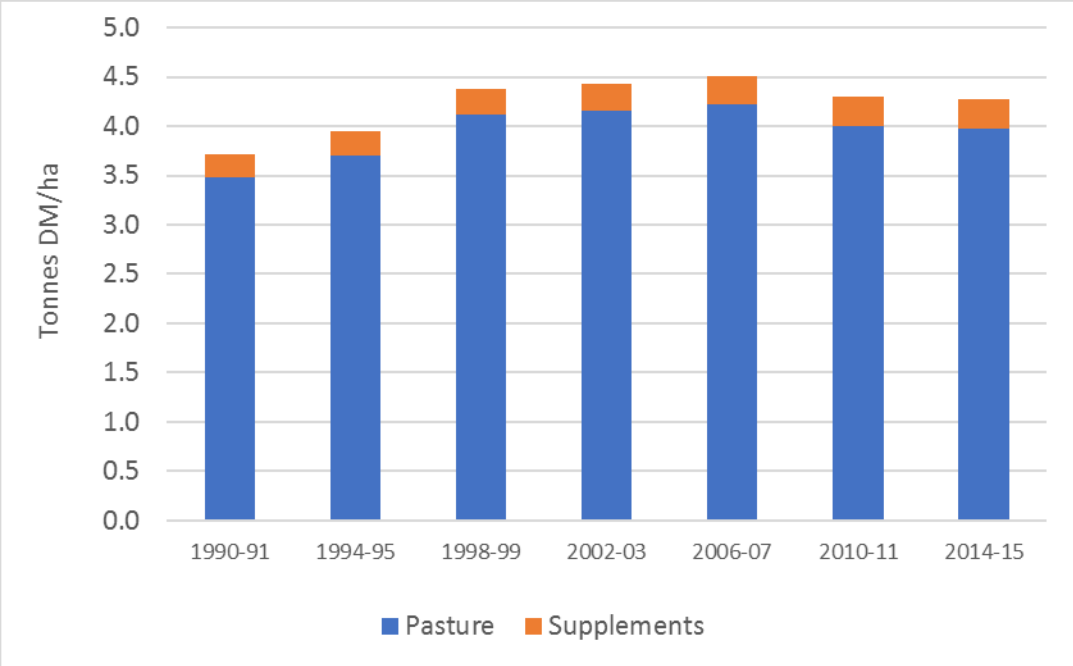


Figure 12. Breakdown of demand as pasture and supplements for Class 9 systems modelled.

Historic feed demand met through supplement usage ranges from 6 to 7% (Figure 13). There was a small decline in overall supplement usage from 1990-91 to 2002-03, maybe due to improved pasture management leading to better utilisation of pastures, followed by an increase in usage as livestock productivity increased, increasing feed demand [7].

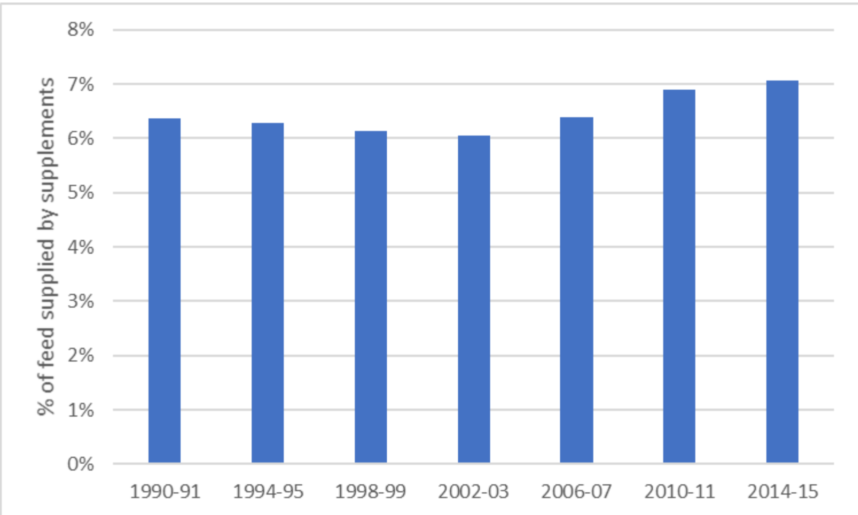


Figure 13. Proportion of demand met through supplement usage for the Class 9 systems modelled.

[7] The 2002-03 value is comparable to that reported by Farmax (6.0%). Supplements made up an average 10.2%, 8.8% and 8.4% of the feed for 2006-07, 2010-11 and 2014-15 seasons respectively; values are expected to be higher than a "typical" sheep and beef farm, as Farmax users are likely to be a higher-performing sub-group as previously noted.

Supplement type

Figure 14 shows a breakdown of results for supplement usage by type, as quantity of supplement (kg per hectare) utilised within the whole farm system Class 9 models. Increases were observed in both winter kale and swedes) and summer feed (leafy turnip) with little change in the other classes of supplementary feed modelled.

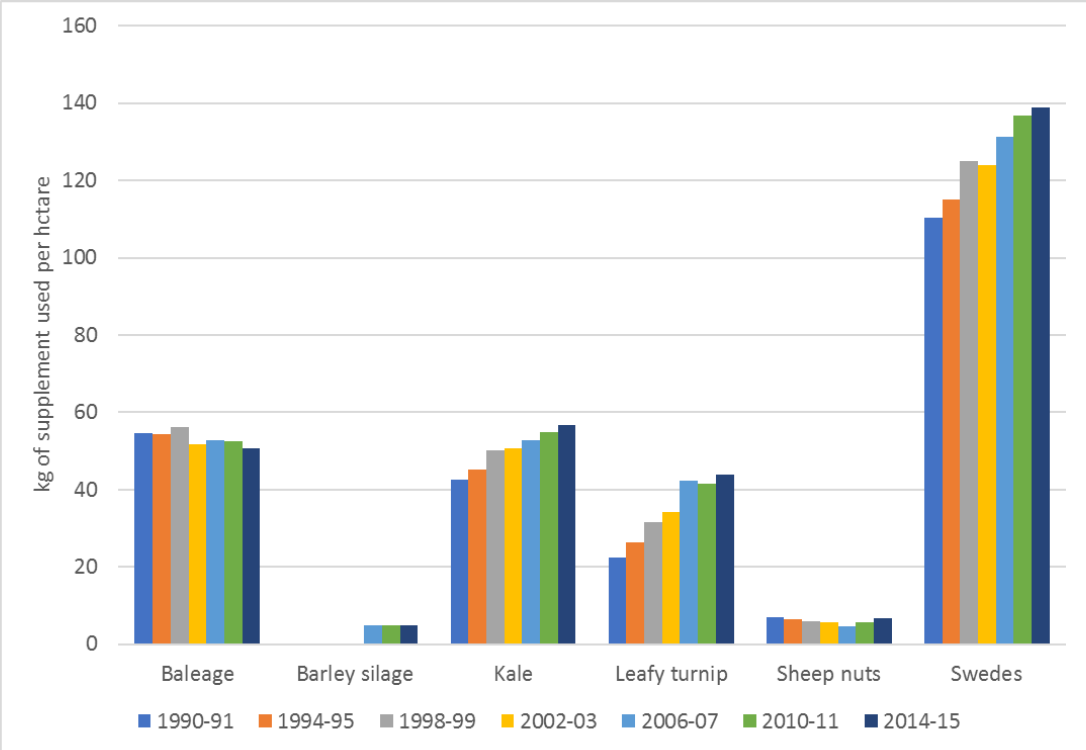


Figure 14. Changes in total supplement usage per hectare.

Seasonal pattern of usage

Figure 15 shows the seasonal pattern of supplement usage relative to demand for the 2014-15 season. Supplemental feed usage is highest in winter when pasture covers are low, and then drops down in summer as new growth results in a surplus of pasture and typically no supplementation is required over the December-January period. Feed supply then starts to diminish as the mixed lambs are being grown out for slaughter with leafy turnips providing a boost in summer for the growing lambs.

Figure 16 shows the seasonal pattern of supplement feed usage for the 2014-15 season expressed as tonnes of dry matter consumed for each type of feed.

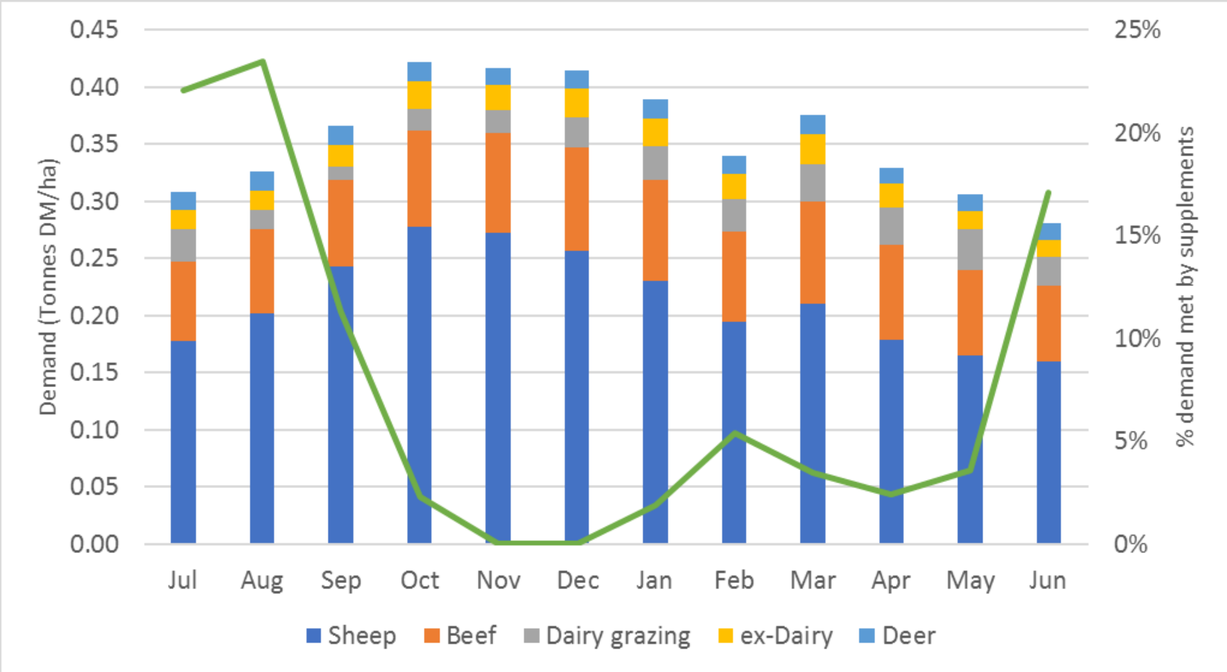


Figure 15. Seasonal pattern of supplement usage relative to demand for 2014-15 farm system model. Note that the green line shows the % of demand met through supplement usage whilst the stacked bar outputs shows total demand for each of the livestock enterprises modelled.

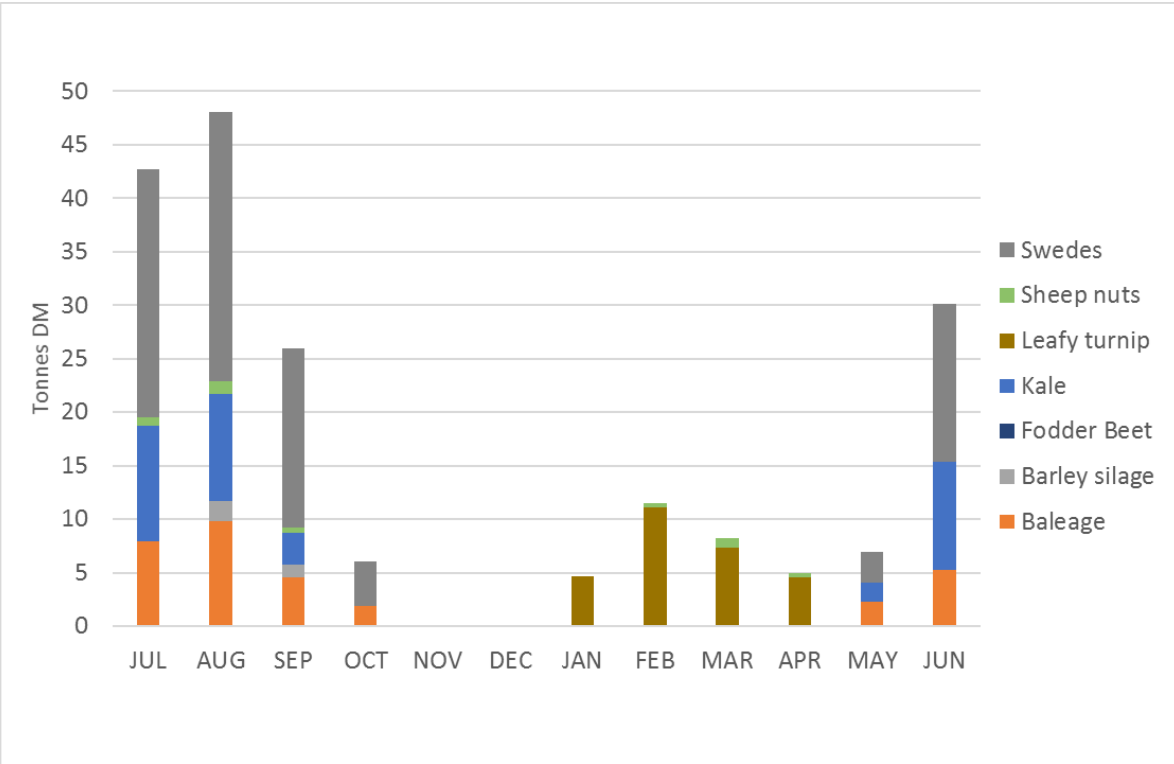


Figure 16. Seasonal pattern of supplement feed usage for the 2014-15 season (Tonnes of dry matter consumed).

Supplement allocation

Within Farmax, supplements are applied to the whole farm, and usage is tracked according to the total percentage of monthly demand met by supplements. The feed tracking model developed for this project allows allocation of supplements to individual stock classes, and enables accurate tracking of what stock classes are consuming supplements according to month and year.

Figure 17 shows changes in the overall percentage of feed demand met by supplements for sheep relative to the other farm enterprises within a typical class 9 farm. Whilst the average rate of supplement usage ranges from 6 to 7% of feed demand over the whole farm, sheep usage was lower at approximately 5 to 6 % of total demand, compared to 7 to 9 % in the other non-sheep enterprises[8].

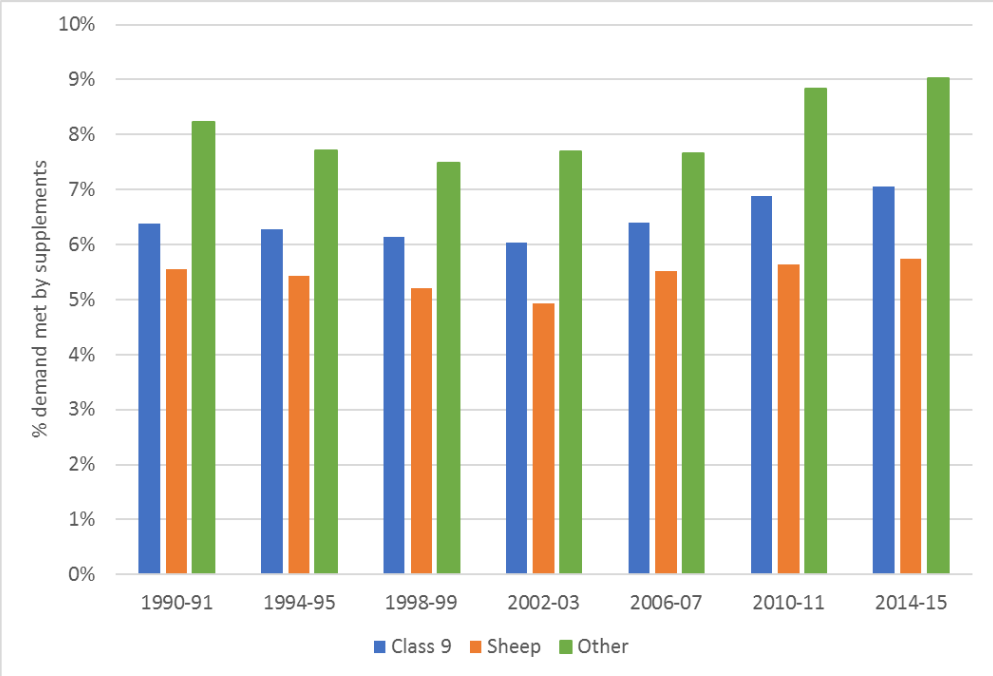


Figure 17. Supplement usage in sheep relative to the other livestock enterprises.

Figure 18 shows changes in supplemental feed allocation within the major sheep stock class groups (with both terminal ewes and ram stock classes assumed to be fed pasture only with no supplemental feed allocations made). Increases are evident in the total supplements fed to ewes and mixed lambs over time, with the low supplement usage in the 2002-03 season reflecting the dip in the total volume of supplement available relative to total feed demand for that year, with the available supplements being preferentially fed to the cattle stock classes.

[8] With a focus on sheep supplemental feed usage, the models required to estimate supplement usage by stock class for the beef, dairy grazing, and beef ex-dairy enterprises have not been developed as part of this project. However, the underlying infrastructure used to extract the sheep data could be extended to include other enterprises if required.

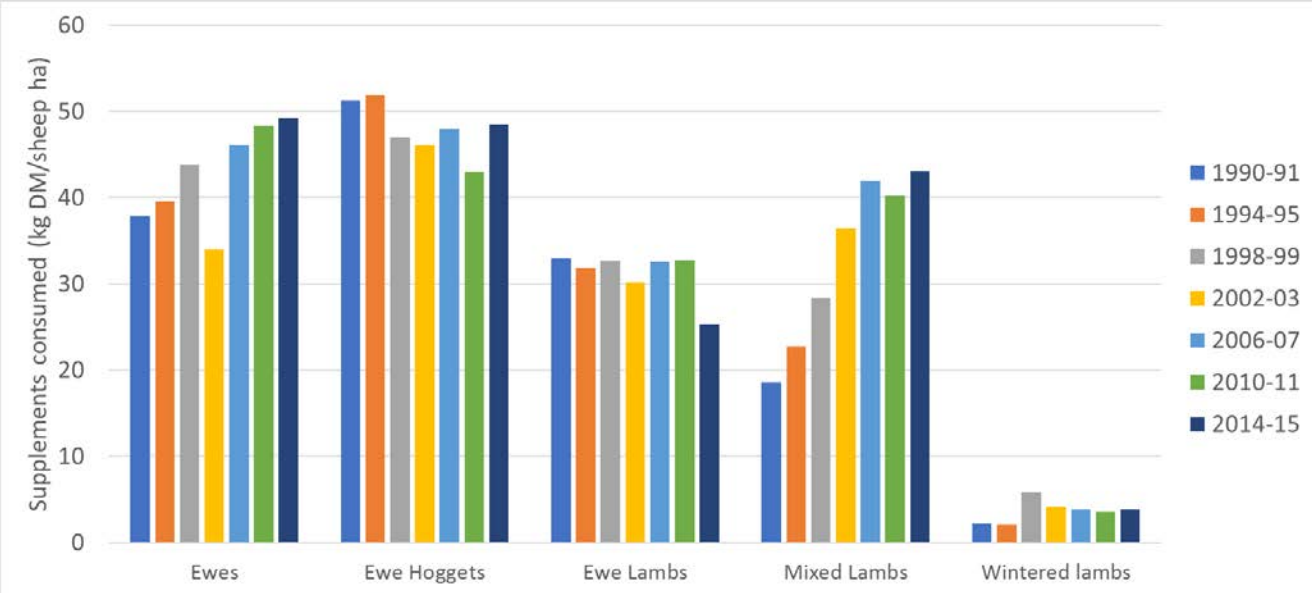


Figure 18. Total supplement usage per "sheep hectare" for the different sheep stock classes within a typical class 9 farm.

Figure 19 shows supplement usage as a percentage of demand within each main sheep stock class. While the total supplements fed to the ewe and ewe hogget stock classes per "sheep" hectare is similar, as a percentage of diet, supplement usage is dominated by the growing hogget and lamb stock classes, with ewes receiving less than 3% of their total annual diet through supplemental non-pasture feed.

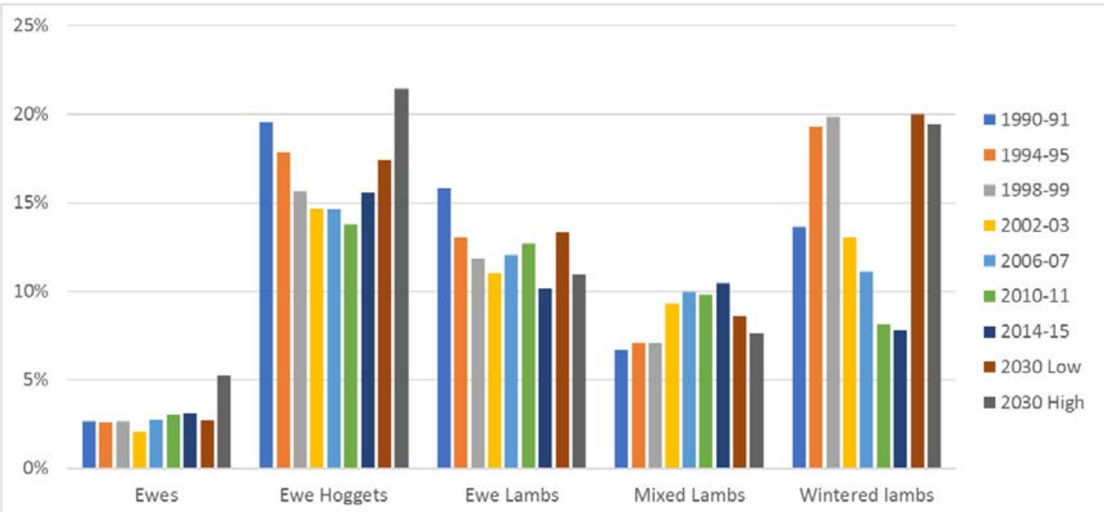


Figure 19. Supplemental feed allocation as a percent of total demand for each of the sheep stock classes.

An example of the distribution of supplements to the individual stock classes is provided in Table 3, with a full summary of all allocations detailed in Table 48 of Appendix 5. Note that practicalities associated with the height and stem thickness of kale, means that this crop has been used exclusively for cattle, and therefore has not been included in the sheep supplemental feed allocations.

Table 3. Quantities (kg dry matter) of supplements allocated to the sheep stock classes and other enterprises for the 2014-15 farm system model.

2014-15							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,989	0	0	0	0	22,418	26,407
Ewe Lambs	1,881	0	0	6,647	0	5,275	13,803
Ewes	9,691	2,988	0	0	4,239	9,909	26,827
Mixed Lambs	0	0	0	20,689	0	2,786	23,475
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	**15,561**	**2,988**	**0**	**27,336**	**4,239**	**42,494**	**92,618**
Other Enterprises	16,214	0	35,600	219	0	44,533	96,566
Total	**31,775**	**2,988**	**35,600**	**27,555**	**4,239**	**87,027**	**189,184**
Percentage for sheep	**52%**	**100%**	**0%**	**99%**	**100%**	**51%**	**51%**

Future scenarios (2030)

To assess the impact of future supplement usage, the 2030 “High” and “Low” production models of the sheep, beef, beef ex-dairy and deer enterprises under project 17893 were used, and combined to produce 2030 Class 9 “High” and “Low” models by scaling to match the number of breeding stock in the 2014-15 B+L Class 9 data set. The high and low models are described below, with the full productivity increases described under these models incorporated into the 2030 scenarios modelled.

a. High scenario: This ambitious scenario sees the total increase in production per breeding female over the last 25 years, taken as the increase over the next 15 years. This translates to a 67% increase over and above what would be expected at current rates of gain.

b. Low (conservative) scenario: Half of the total increase in production per breeding female over the last 25 years is taken as the increase over the next 15 years. This translates to a 17% decrease relative to what would be expected at current rates of gain.

As for project 17893, Farmax feed intake was adjusted to meet the increased production demands, with models optimised according to expected pasture availability and supplemental feed requirements. Pasture improvements were modelled by increasing the average quality of feed on offer[9], and additional feed demand met through increased supplement usage.

Future feed demand

Figure 20 shows a breakdown of the total feed demand calculated for the future Class 9 high and low scenarios. Feed demand is expected to increase from 4.3 to 4.8 and 5.0 tonnes per hectare by 2030 for the low and high scenarios respectively, primarily driven by sheep (2.6 to 3.1 tonnes per hectare) and beef ex-dairy, where demand per head remains constant, but where the number of beef ex-dairy animals entering the system increases due to relative profitability of the different farming enterprises (i.e. beef ex-dairy versus sheep).

[9] Appendix 3 – Farmax Modelling: Future pasture quality estimates

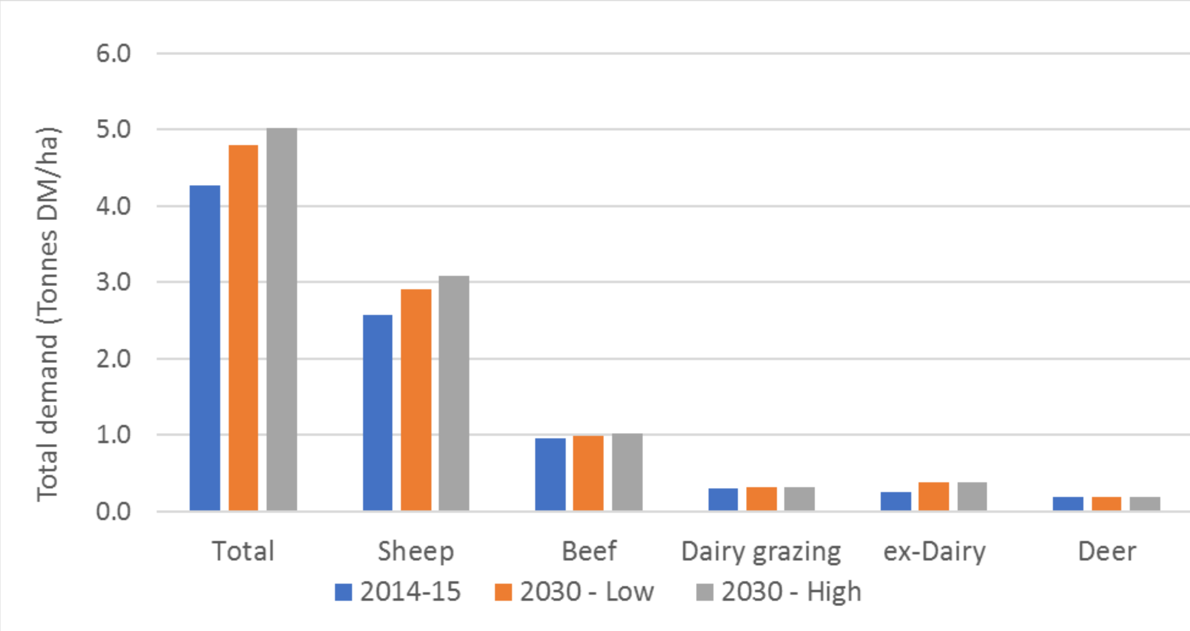


Figure 20. Future feed demand for the 2030 low and high scenarios for a typical class 9 farm.

Figure 21 shows total demand per hectare for each stock class in the 2030 Class 9 sheep scenarios. The biggest increases are in the mixed lamb classes, as increased growth rates result in an 18 and 23% increase in average weight of carcase sold per ewe mated. Demand by ewes also increases with 4 to 8% increases in ewe weight (reflected in cull ewe carcase weight), and increased intake required to meet the demands of pregnancy and lactation from higher ewe reproductive rates and lamb growth rates pre-weaning.

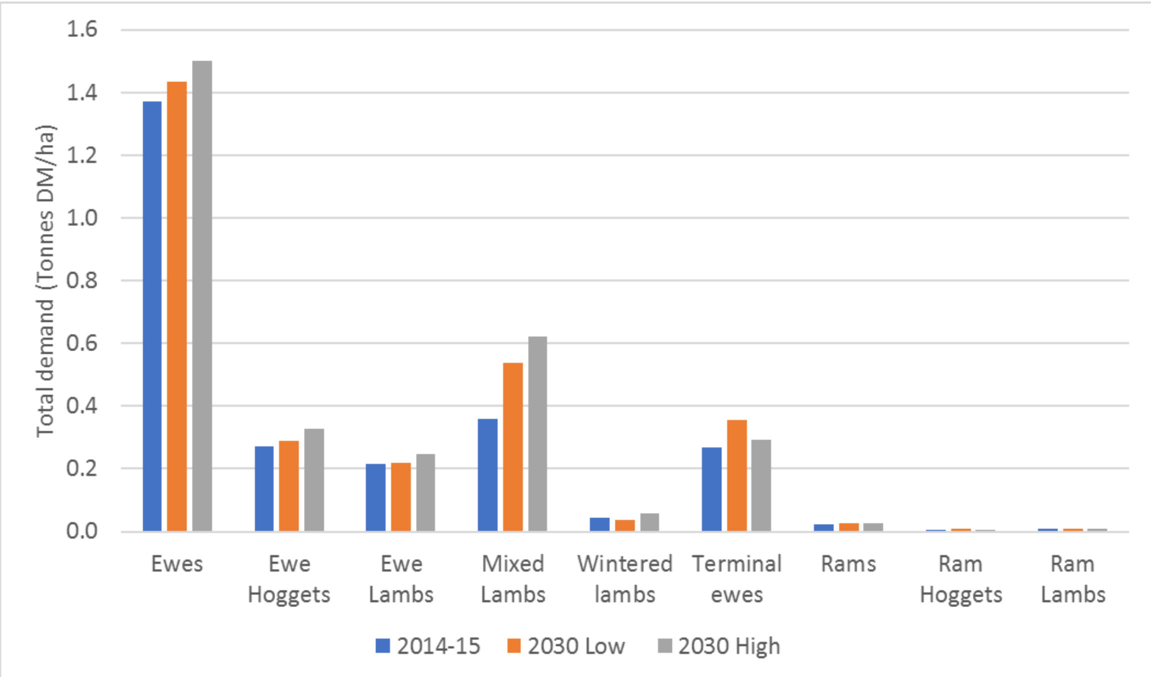


Figure 21. Breakdown of the future Class 9 feed demand estimates for the sheep stock classes.

Future supplement usage

The percentage of feed supplied by supplements for the 2030 scenarios is shown in Figure 22, with a large increase in supplemental feed primarily allocated to the beef, dairy grazing and ex-dairy stock classes. The main drivers of this are increased feed demand in the critical September-October period, with the sheep remaining on pasture during lambing, whilst the supplemental feed is used more heavily in cattle.

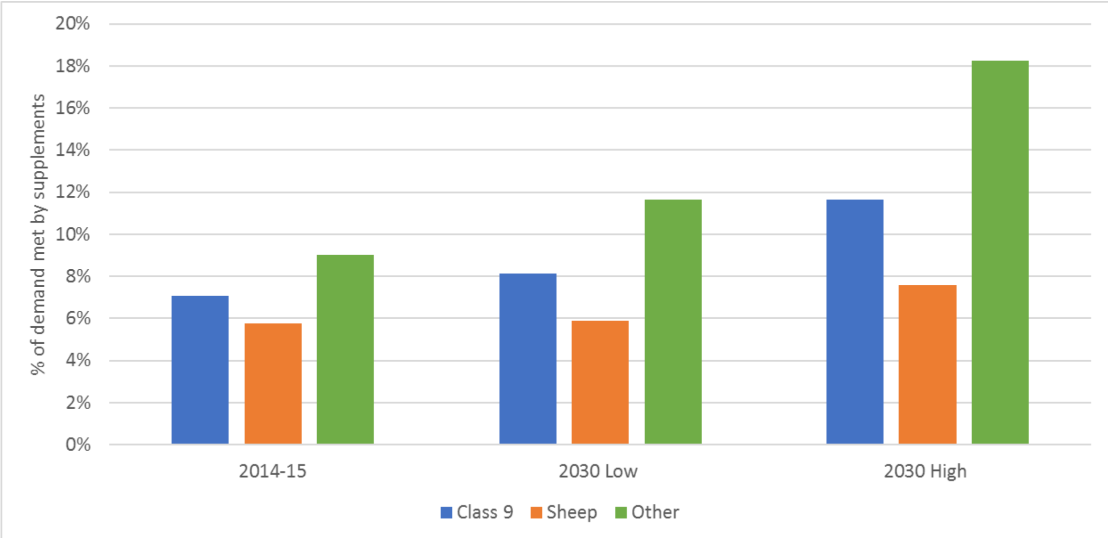


Figure 22. Supplement allocation for the future 2030 scenarios modelled relative to 2014-15.

Alternate future scenarios

With the 2030 scenarios assuming no change in stock numbers, additional models were developed to assess the impact of changes in the proportion of sheep relative to the other Class 9 farm enterprises.

1. The first approach was to model a 5% **reduction** in total feed demand, through a scaling down of the sheep enterprise in both the 2030 low and high scenarios. The model was then re-optimised to increase demand from ex-dairy beef, whilst maintaining the size of all other enterprises to fully utilise the original feed resource. This resulted in an 8% reduction in sheep relative to total demand, and 70 to 71% increase in demand from ex-dairy beef as shown in Table 4 below. This model was designed to reflect the changing trends towards increased dairy production, and a resulting increase in animals exiting the dairy system for slaughter.
2. The second approach was to model a 5% **increase** in total feed demand for sheep. In this model, the increase in ex-dairy beef production was limited to approximately one-half of the additional ex-dairy beef added above, and the beef cattle herd also reduced to allow for the additional feed requirements from sheep. This resulted in a 36 to 37% increase in beef ex-dairy, and a 29 to 33% decrease in beef demand relative to the 2030 base scenarios.

Table 4. Impact of changes to the farm composition on percentage of total feed demand relative to the base 2030 high and low scenarios.

Model		Percentage of feed required within the 2030 model scenarios					
		Total	Sheep	Beef	Dairy grazing	ex-Dairy	Deer
2030 Low	-5%	101%	92%	100%	100%	171%	99%
	+5%	102%	108%	71%	100%	137%	99%
2030 High	-5%	101%	92%	100%	100%	170%	99%
	+5%	101%	108%	67%	100%	136%	99%

Feed demand

The impact of changes in farm composition on feed demand are shown in Figure 23 below. The 2030 results are plotted according to the relative size of the sheep enterprise. With no changes in effective area, the 2030 low scenarios show a 12 to 14% lift, and the 2030 low scenarios a 17 to 18% lift in total demand relative to the 2014-15 season.

- The reductions in beef demand are clearly visible in both the 2030 +5% scenarios.
- The increases in ex-dairy beef production are also clearly identified with the ex-dairy beef data for the -5% and +5% scenarios all noticeably higher than the 2030 base results.

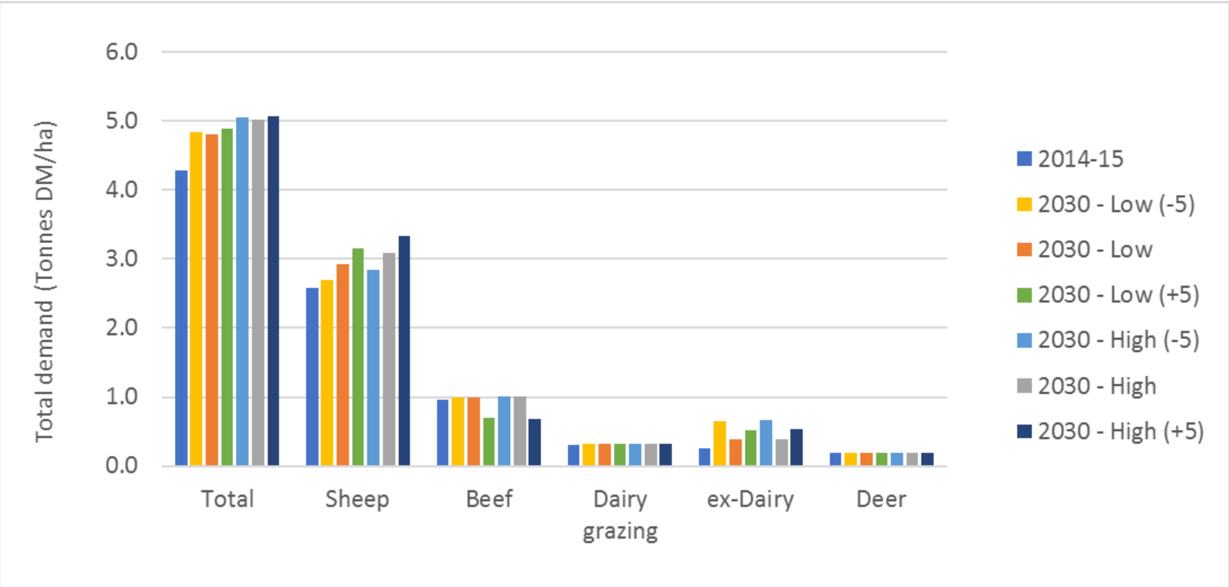


Figure 23. Impact of potential changes in farm composition on total feed demand on a per-farm basis.

Supplement usage

Figure 24 shows changes in supplement usage by type for the 2030 scenarios modelled, and Table 5 the changes in total demand and supplement usage relative to the 2014-15 farm system model.

Supplement usage is significantly higher in the 2030 high than the 2030 low scenarios. Improvements in the average quality of pasture consumed[10] within the 2030 scenarios have resulted in the requirement for additional supplemental feed being limited to 4 to 5% in the 2030 low models. With no ability to meet the additional demand required for the 2030 high scenarios through pasture (relative to the 2030 low), supplement usage dramatically increases to 45 to 48 % over what was used in 2014-15.

- With no change in effective area, the planting of winter crops such as kale and swedes has been maximised, with all other supplementary feed provided through fodder beet, which was not incorporated within the historical farm system model assumptions.
    - With the use of fodder beet, sheep nuts (typically used in difficult autumn/ winter feed situations) are no longer required, and have not been included within the 2030 scenarios.
- The additional ex-Dairy cattle in the 2030 -5 and +5 scenarios result in additional fodder beet required to meet nutrient demands, with this clearly visible in the 2030 low scenarios.

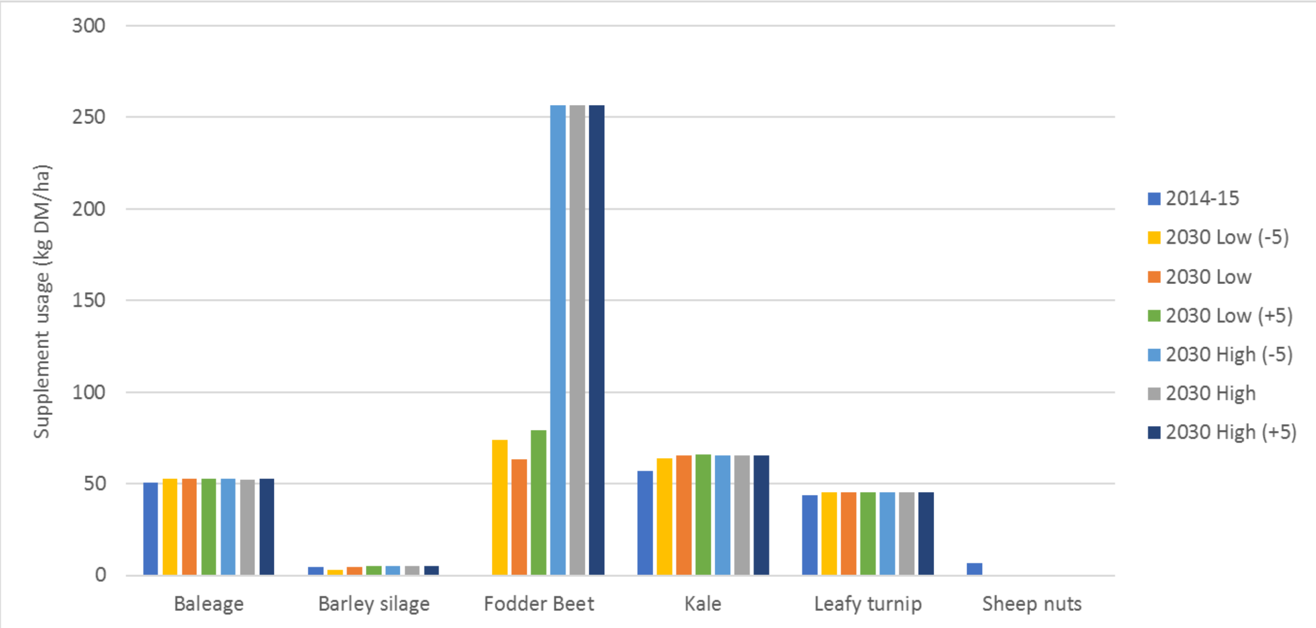


Figure 24. Changes in supplement usage per hectare of effective area for the 2030 Class 9 scenarios relative to 2014-15.

[10] See the section on Future pasture quality estimates in Appendix 3 – Farmax Modelling

Table 5. Relative values for total demand and supplements within the 2030 scenarios compared with the 2014-15 farm systems model.

2030 scenario	Demand relative to the 2014-15 farm system model		
	Total Demand	Total supplements	Supplement: demand
2030 Low (-5%)	111%	117%	105%
2030 Low	111%	115%	104%
2030 Low (+5%)	113%	119%	105%
2030 High (-5%)	112%	164%	147%
2030 High	112%	165%	148%
2030 High (+5%)	113%	164%	145%

Supplement allocation

Figure 25 shows supplement allocation to sheep relative to the other enterprises. The percentage of supplement used by sheep remains relatively static at 5 to 6% for the 2030 low scenarios and 7 to 8% for the high scenarios, whilst supplemental feed allocated to the other enterprises increases from 9 to 20%.

Figure 25. Supplement usage in sheep relative to the other livestock enterprises.

Figure 26 shows changes within the individual sheep stock classes for the 2030 scenarios. Whilst there is some “noise” evident, the increased intake required to meet the high productivity gains in the ewe and ewe hogget classes is clearly evident, whilst the overall percentage of supplements fed to the mixed lamb class is reduced. This is due to improvements in summer pasture quality, resulting in a reduction in the total volume of leafy turnip required relative to demand.

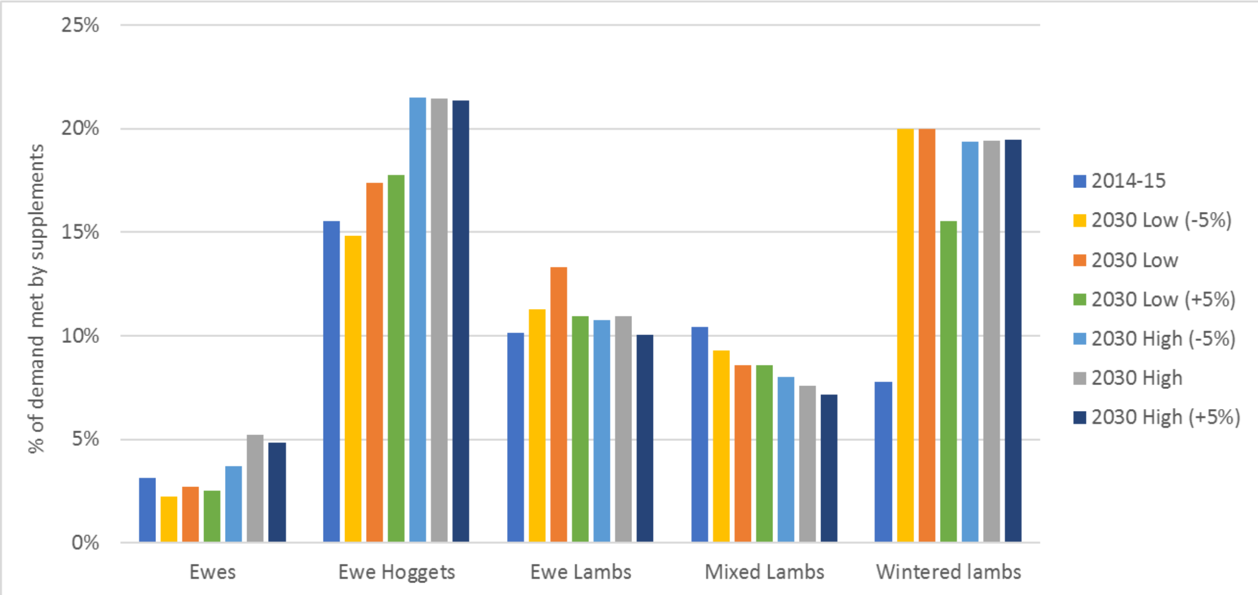


Figure 26. Feed given as supplements (percentage) within the sheep stock classes for the 2030 scenarios relative to the 2014-15 farm system model.

Fodder beet in farm systems

Fodder beet has leapt to prominence as a supplementary feed for livestock in New Zealand over the last 5 years, with industry sources estimating that it would make up 2% of the winter crops in summer reliable areas and around 5% in summer dry areas.

While there has been some use of beet for sheep, it has been used mainly for finishing cattle and for wintering dairy cattle/cows. It is therefore of minor relevance to the historical sheep analysis, but is likely to be a key factor in enabling farmers to maintain stock numbers, as future feed demand from bigger and higher-performing sheep increases. Whilst future sheep feed demands will be met, in part, by manipulating the cattle system, fodder beet is also likely to be used increasingly for sheep. It is the only feed crop that provides high volumes of high quality *in situ* feed through the critical September to October bottleneck. However, new management techniques for feeding beet to sheep will be needed if beet is to be supplied to sheep through the lambing period.

Table 6 shows a summary of the supplemental feed estimates for sheep, with models showing that large volumes of fodder beet are required to meet the feed demand for sheep within the 2030 high scenarios.

Table 6. Summary of supplemental feed estimates used within sheep (kg of DM).

	Baleage	Barley silage	Fodder Beet	Leafy turnip	Sheep nuts	Swedes	Total
1990-91	16,264	0	0	11,545	3,565	42,043	73,417
1994-95	18,111	0	0	14,780	3,624	38,928	75,443
1998-99	16,732	0	0	17,201	3,296	38,129	75,358
2002-03	14,015	0	0	20,426	3,358	40,137	77,936
2006-07	16,963	2,554	0	26,964	2,955	45,737	95,173
2010-11	18,463	3,188	0	27,133	3,806	45,379	97,968
2014-15	15,561	2,988	0	27,336	4,239	42,494	92,618
2030 Low (-5%)	11,902	3,012	0	28,481	0	50,878	94,273
2030 Low	16,866	2,964	0	26,864	0	59,634	106,328
2030 Low (+5%)	15,870	3,049	0	28,465	0	63,251	110,635
2030 High (-5%)	11,866	3,194	8,586	28,377	0	71,367	123,390
2030 High	13,436	3,185	26,745	28,417	0	74,813	146,596
2030 High (+5%)	14,263	3,234	31,476	28,453	0	73,735	151,161

At a whole farm level, the volume of fodder beet required to meet demand requires additional plantings, with Figure 27 showing fodder beet plantings per 1,000 hectares relative to the crops such as baleage (from pasture), leafy turnips, kale and swedes.

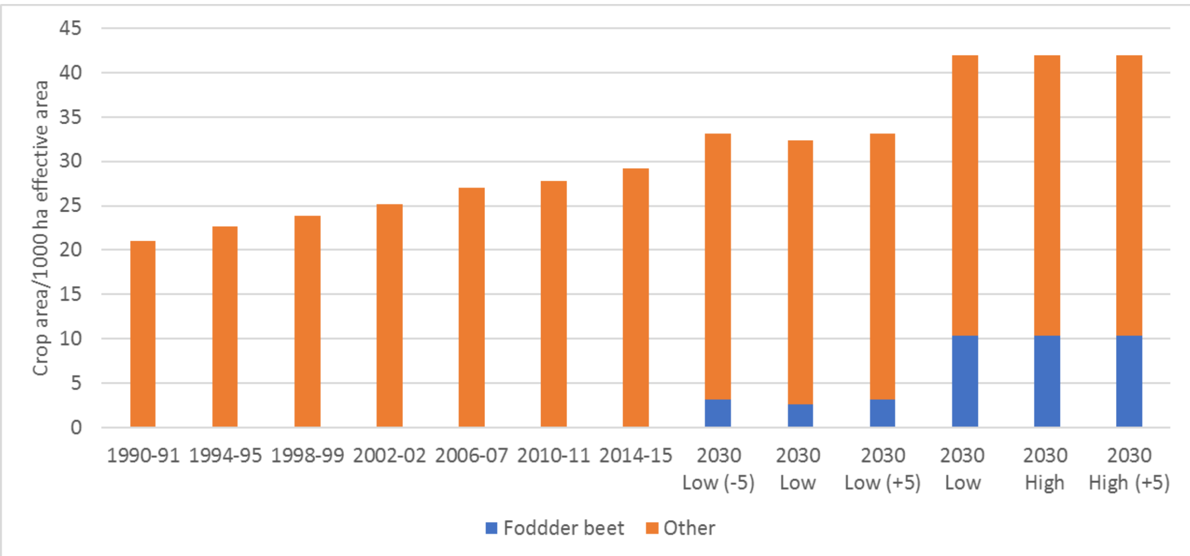


Figure 27. Area of crop planted in feeder beet and other crops including leafy turnip, kale and swedes.

Impact of Nitrogen fertiliser usage

Within this analysis, we have used fodder beet as a model to meet future feed demand, however this may not be the sole answer, and it is likely that a combination of fodder beet and other crops, combined with increased nitrogen (N) fertiliser would be used in practice. To account for this, an alternative model was

developed to assess the impact of increased N fertiliser usage, leading to increased pasture production at a response rate of 10 kg of DM to 1 kg of elemental N applied.

Based on the 2030 High model, use of additional N allows fodder beet plantings to reduce from 10.4 to 3.2 hectares per 1,000 hectares, and total supplemental feed usage approaches that observed within the 2030 low +5% scenarios (see Figure 28). This model has been included for comparison in estimates of GHG emissions, and within the scaling model used for future national prediction estimates.

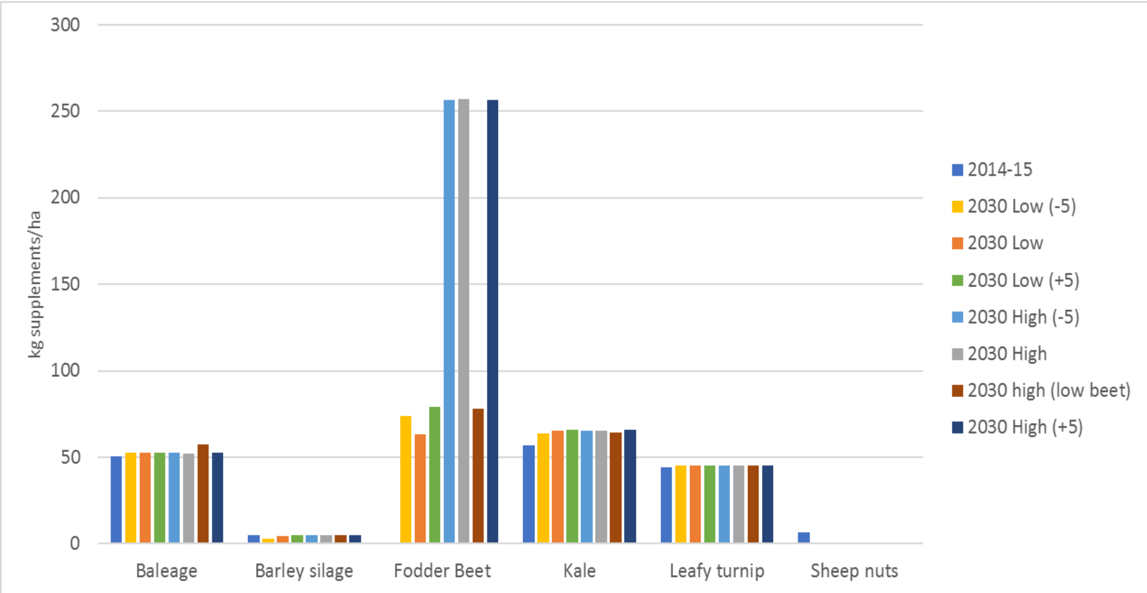


Figure 28. The impact of rebalancing the 2030 high model through the application of N fertiliser at a response rate of 10 kg dry matter per kg of elemental N applied.

Impact on methane emission estimates

The impact of supplement usage within the sheep enterprise has been determined by comparing the average feed quality of pasture utilised versus the average feed quality of pasture plus supplements for each of the different sheep stock classes.

Feed quality (ME) estimations

The average quality of feed consumed is tracked monthly for each livestock class, with quality estimated as a weighted average of the ME content of the pasture[11] and different supplement types used. Figure 29 and Figure 30 show the estimated ME content of feed consumed in historical Class 9 and 2030 scenarios.

- The steady increase in average ME content observed within the historical scenarios reflects the increase in ME required to realise the productivity gains made between 1990 and 2015.
- The large increase in supplemental feed intake required for the 2030 high scenarios, results in a large increase in average ME values in the July to November period. Winter and spring ME values remain lower than that applied in the inventory, whilst summer and autumn values are higher.

[11] A full description of the pasture ME quality estimates is provided in the "Pasture quality assumptions" section of Appendix 3.

- The reduction in fodder beet in the 2030 High (low beet) is evident, with the average ME for July and August dropping from 10.78 to 10.61 as a large amount of fodder beet is removed the system.

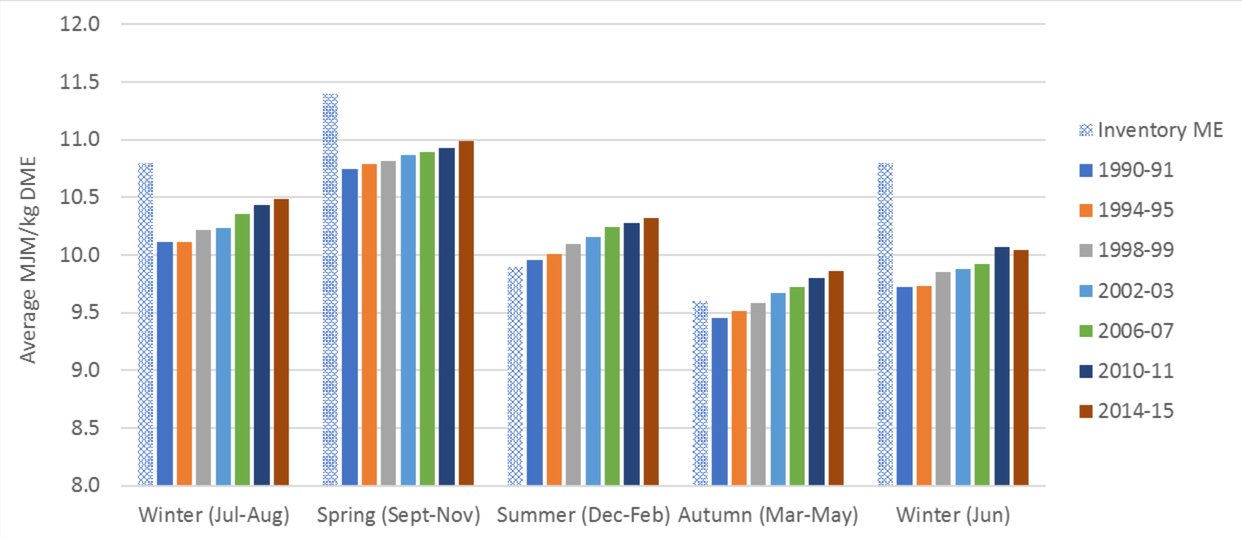


Figure 29. Average seasonal estimates of feed quality (MJME per kg of dry matter intake) calculated in the historical Farmax models, relative to inventory values.

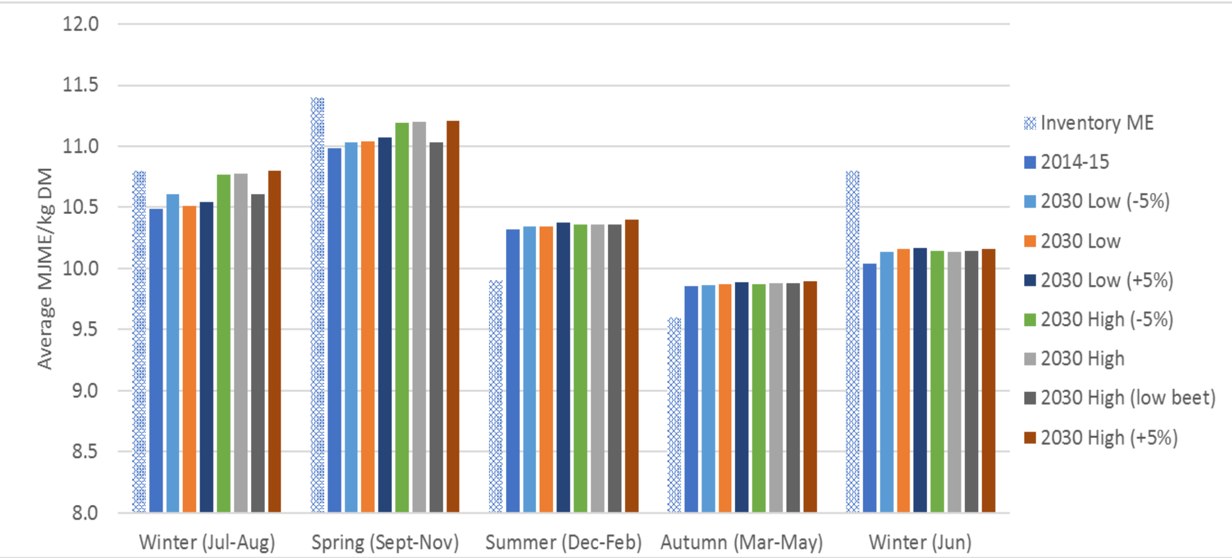


Figure 30. Average estimated quality of seasonal feed intake (MJME per kg of dry matter intake) calculated for the 2030 scenarios, relative to inventory values.

Methane estimations

The impact of changes in supplemental feed usage, and the resulting changes in ME have been used to model the impact on emissions in the sheep enterprise, and in the Class 9 farm system. Because the models have not specifically allowed for the tracking of both products (carcase and wool) and N fertiliser usage, emissions have been tracked according to methane emissions only.

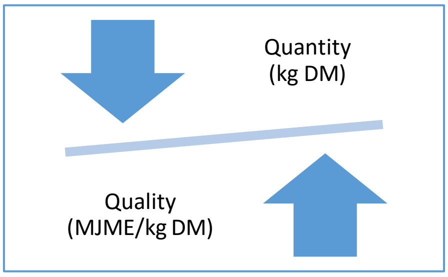
Total feed demand and average ME values were tracked by month and stock class, and used to estimate methane using three different sets of ME values.

1. Average estimated **pasture ME**, where pasture values have been adjusted to allow for preferential feeding of some stock classes over others.[12]
2. Average **estimated ME of food consumed**, including pasture and supplemental feed[13].
3. Average **ME estimated according to the New Zealand Greenhouse Gas inventory values**.

Note that to ensure a fair comparison, demand values for the second and third estimates were scaled according to the modelled Farmax demand and ME. This results in the pasture demand estimates always exceeding the pasture + supplemental feed estimates, and the inventory estimates coming in higher or lower depending on the average ME value used within the inventory, relative to those calculated by the Farmax models. An example of this is given below where as feed quality goes up, the total volume of dry matter required to meet the energy demand of the animals reduces, where a 5% lift in average ME of feed consumed results in a 5% reduction in the total voume of requried to

For 1000 MJME required by an animal:

- If ME = 10.0, then 1,000 MJME/10.0 = 100 kgDM
- If ME = 10.5; then 1,000 MJME/10.5 = 95 kgDM



Enteric and dung[14] methane was then estimated according to the NZGHG methodology as outlined in Appendix 4.

Methane estimates relative to inventory

Sheep: Figure 31 shows average methane emissions using estimated ME values relative to those using inventory values for each of the sheep stock classes within the historical Class 9 systems. Adjustments used to account for preferential feeding result in ME estimates for lambs being higher than those reported by the NZGHG inventory, and all other classes lower than that estimated using the inventory values.

The net result is that the total estimates for 1990-91 are 3.4% higher than what would have been reported using inventory values. Total differences then drop to zero with no substantive differences in the estimated and inventory ME values for the 2014-2015 Class 9 model.

[12] See notes on Stock class adjustments contained within the Pasture quality assumptions section of Appendix 3 – Farmax Modelling.
[13] See notes on the Estimation of ME intake within Appendix 4 - Feed tracking model.
[14] Dung methane resulting from the deposition of manure on pasture

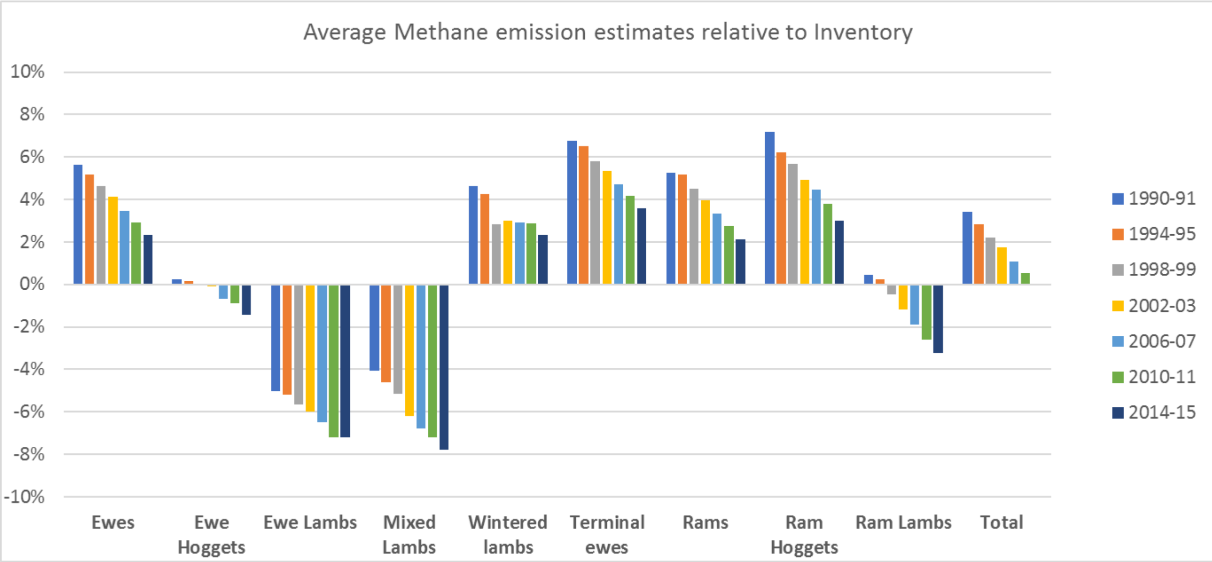


Figure 31. Estimated methane emissions using estimated ME values relative to those using inventory values for each sheep stock class within the historical Class 9 systems.

Figure 32 shows the same data for the 2030 scenario estimates. Whilst there is some "noise" within the allocation of the supplemental feed between sheep and cattle in the 2030 scenarios that has an impact on ME, the same picture is evident, with use of the additional supplements resulting in estimates of up to 1% lower than what would have been reported using inventory values.

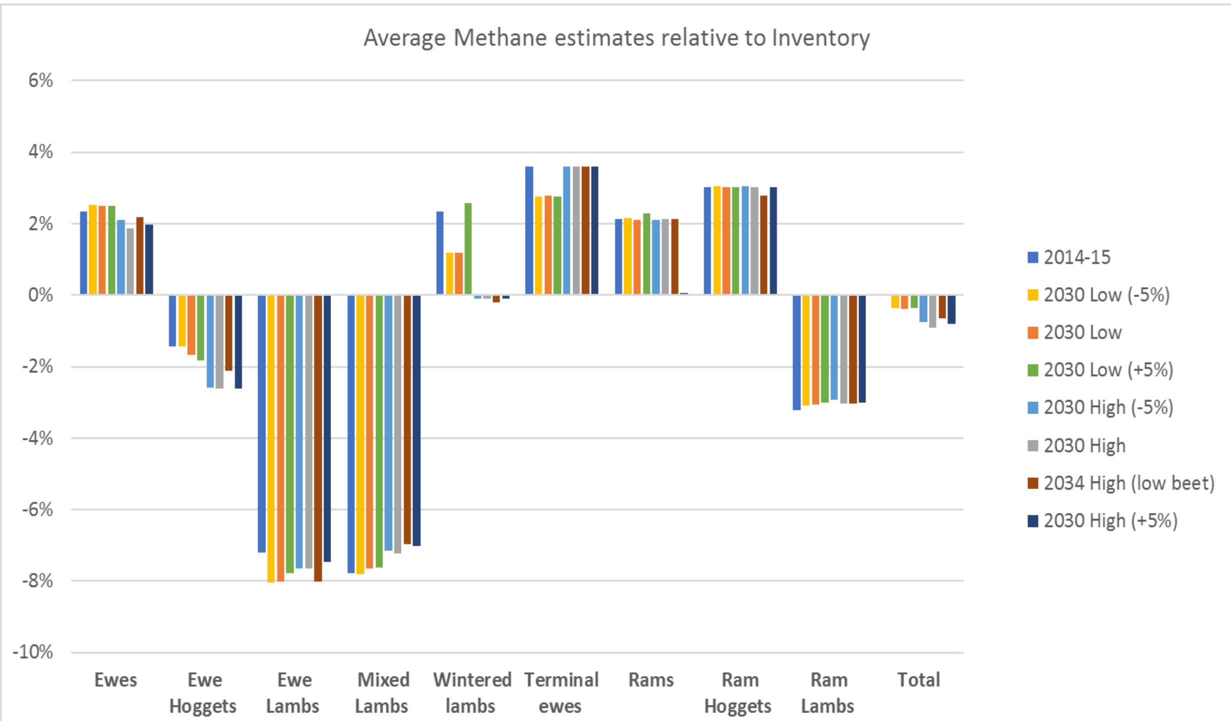


Figure 32. Methane emissions using estimated ME values relative to those using inventory values for each of the sheep stock classes within the 2030 scenarios.

Class 9: Class 9 whole farm estimates are shown in Figure 33, where the high use of supplemental feed in the beef, dairy grazing and ex-dairy cattle result in the potential underestimation of methane emission by up to 5% in 1990, and overestimation by up to 1.3% in the 2030 scenarios as compared with the inventory.

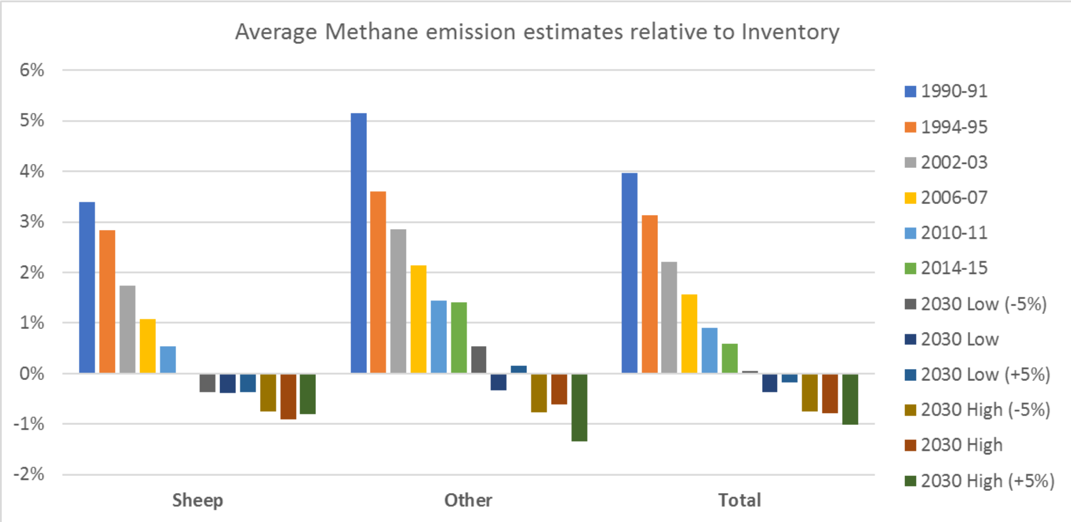


Figure 33. Average methane emissions estimated using estimated ME values relative to those estimated using inventory values for the sheep, and other Class 9 enterprises modelled.

Methane estimates relative to pasture usage

The impact of supplemental feed usage on methane emissions was modelled using methane emissions derived using total demand and estimated ME of feed consumed, versus adjusted values reflecting the total demand and average ME if no supplemental feed was available.

Figure 34 and Figure 35 show the impact of additional feed to meet energy requirements of the historical and 2030 scenarios, when average ME is lowered to reflect pasture alone. Whilst this is not realistic in terms of reported farm practice, it highlights the impact of supplemental feed usage in the hogget and lamb classes. In these classes, if supplemental feed had not been available, then pasture consumption would have increased, resulting in an increase of up to 5% in methane emission estimates. However, with limited supplement usage in the ewes, the overall impact is limited to around 1 to 1.5% of total sheep methane emission estimates.

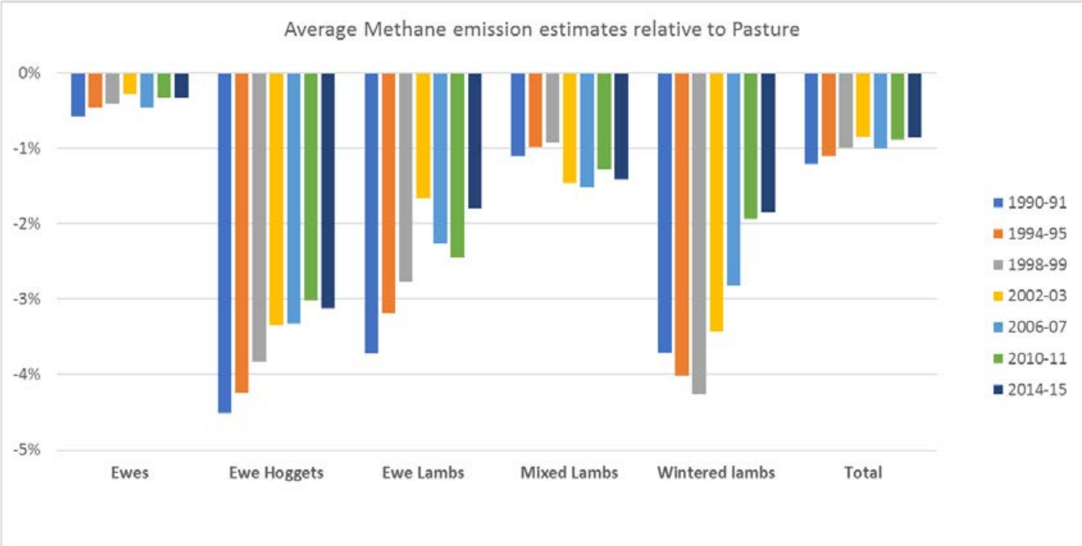


Figure 34. Average methane emissions for the historical Class 9 sheep stock classes, relative to methane estimates if all feed had been supplied by pasture alone.

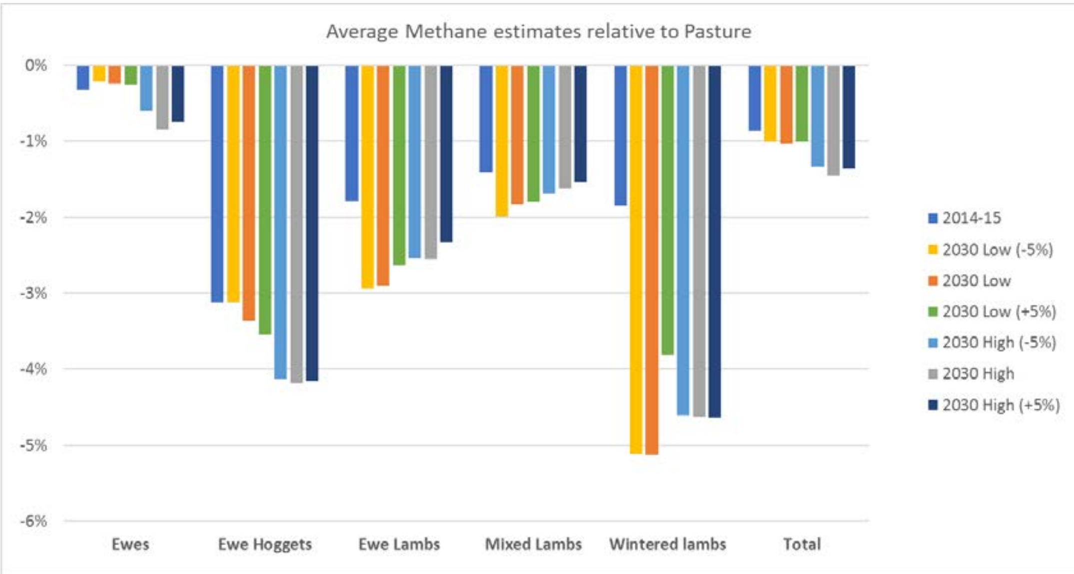


Figure 35. Average methane emissions for the 2030 scenario sheep stock classes, relative to methane estimates if all feed had been supplied by pasture alone.

Scaling to estimate national demand

The scaling model has been developed to account for total pasture and supplement usage at a national level. Because the number of future farms is unknown, the scaling model has been developed to account for either land use change OR a change in the number of farms, but the effective area and composition of the farms is assumed to remain constant within the scenarios modelled.

Class 9

Total feed demand: Figure 36 shows changes in total Class 9 demand relative to the number of farms in the historical farm system models. Dry stock demand peaked at around 40 million tonnes DM through the early 2000's then dropped to around 30 million tonnes in 2014-15 with reductions in the number of Class 9 farms. Figure 37 shows national demand estimates for the 2030 scenarios, assuming no changes in either the number or average size of the class 9 farm relative to the 2014-15 season.

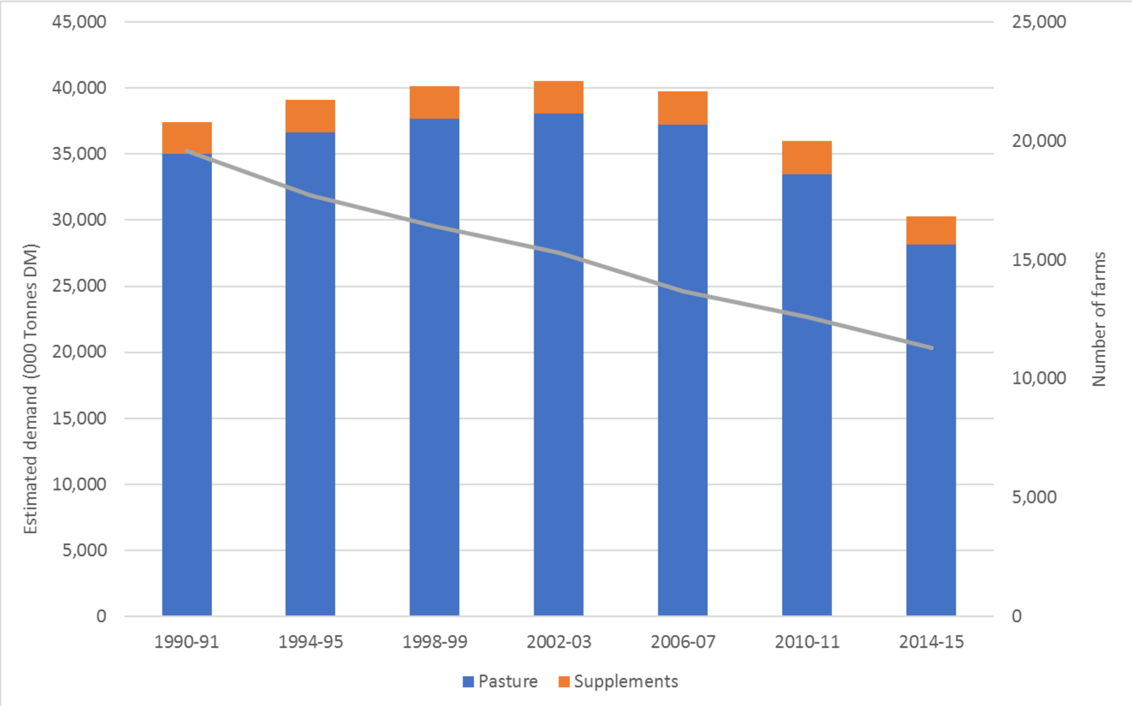


Figure 36. Estimated total national feed demand for the historical Class 9 and 2030 scenarios modelled, relative to the number of farms (grey line).

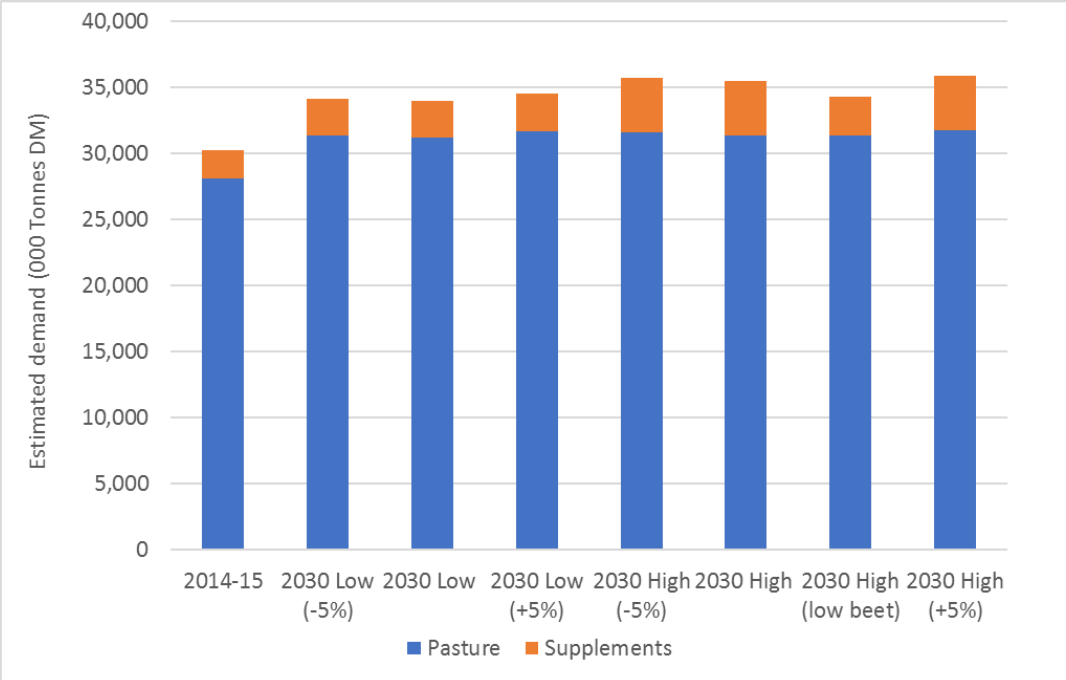


Figure 37. Estimated total national feed demand for the 2030 scenarios modelled, assuming no changes in either the number of farms (or average farm size) relative to the 2014-15 season.

Supplement usage: Figure 38 shows historical supplemental feed usage for the class 9 farm systems and, with this predicted to increase to over 4 million tonnes in the 2030 high scenarios (Figure 39). Increased fertiliser nitrogen usage in the 2030 high (low fodder beet scenario), sees total supplement usage reduce to around 3 million tonnes. This option is the more likely outcome if we are to reach the ambitious 2030 high production targets. However, if the changes in land use continue, and dry stock land area was to reduce by 20% over the next 15 years, total supplement usage and feed demand would both also decrease to an estimated 3.3 and 25 million of tonnes of pasture respectively.

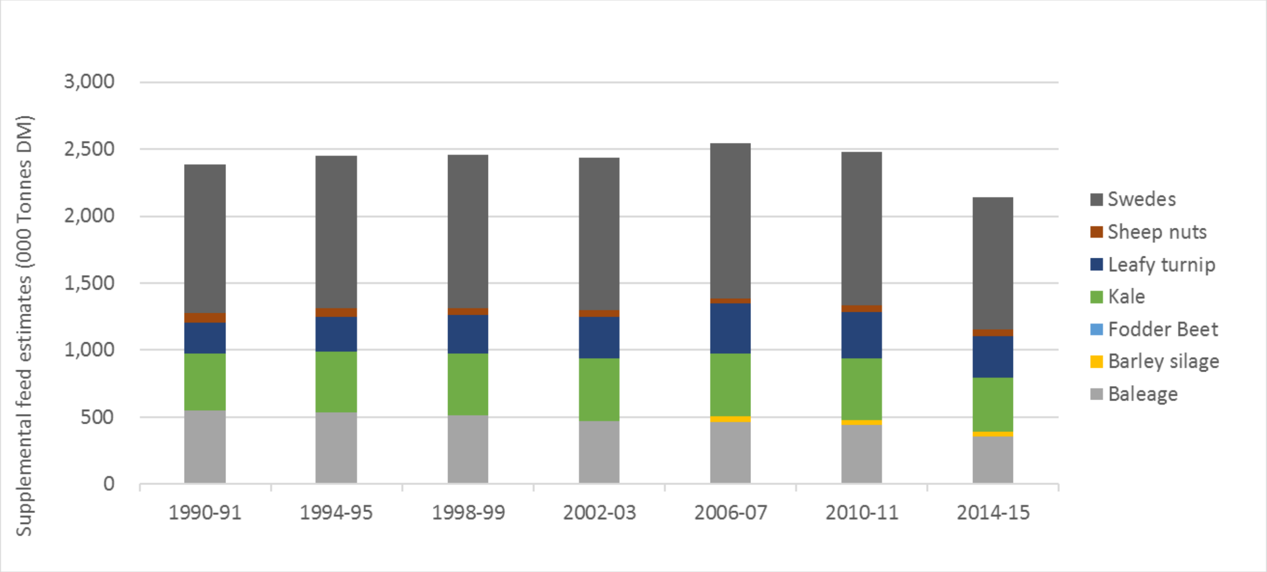


Figure 38. Estimated total national usage of supplements in historical Class 9 models and predicted demand in the 2030 scenarios (shown on the right-hand side of the dotted line), assuming no change in land area or farm numbers since the 2014-15 season.

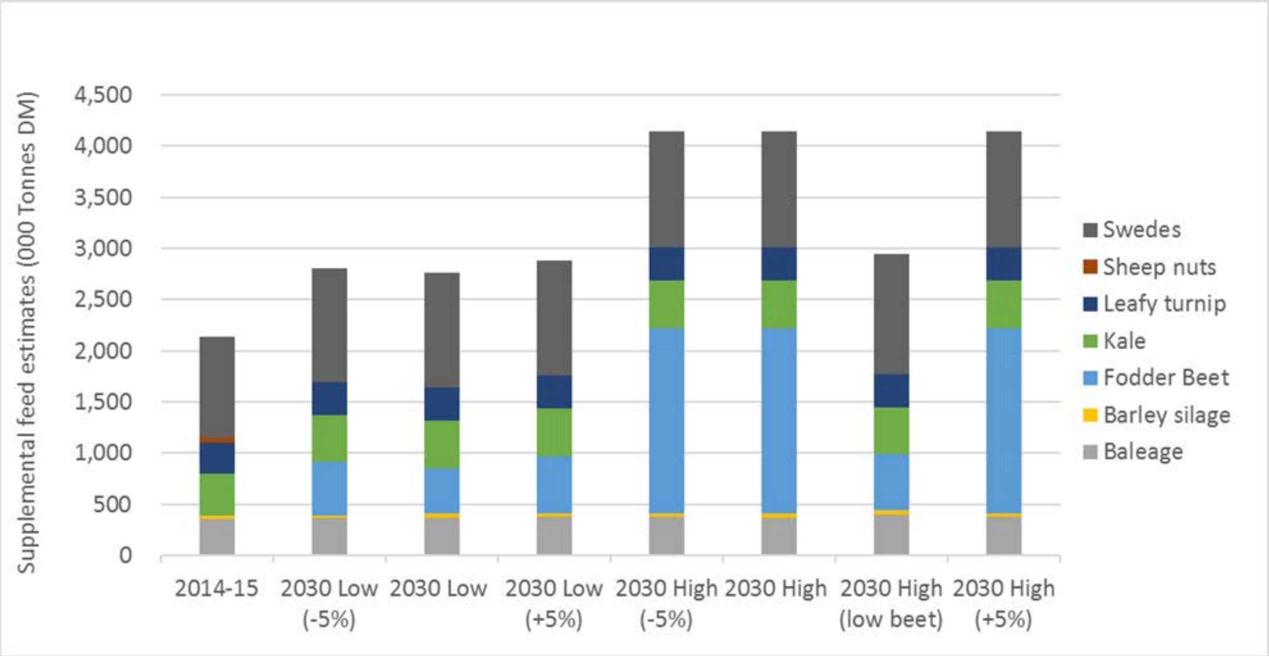


Figure 39. Estimated total national usage of supplements in historical Class 9 models and predicted demand in the 2030 scenarios (shown on the right-hand side of the dotted line), assuming no change in land area or farm numbers since the 2014-15 season.

Class 9 sheep

<u>Total feed demand:</u> Figure 40 shows historical national feed demand (as '000s tonnes DM) for sheep, with demand estimates for the future scenarios shown in Figure 41.

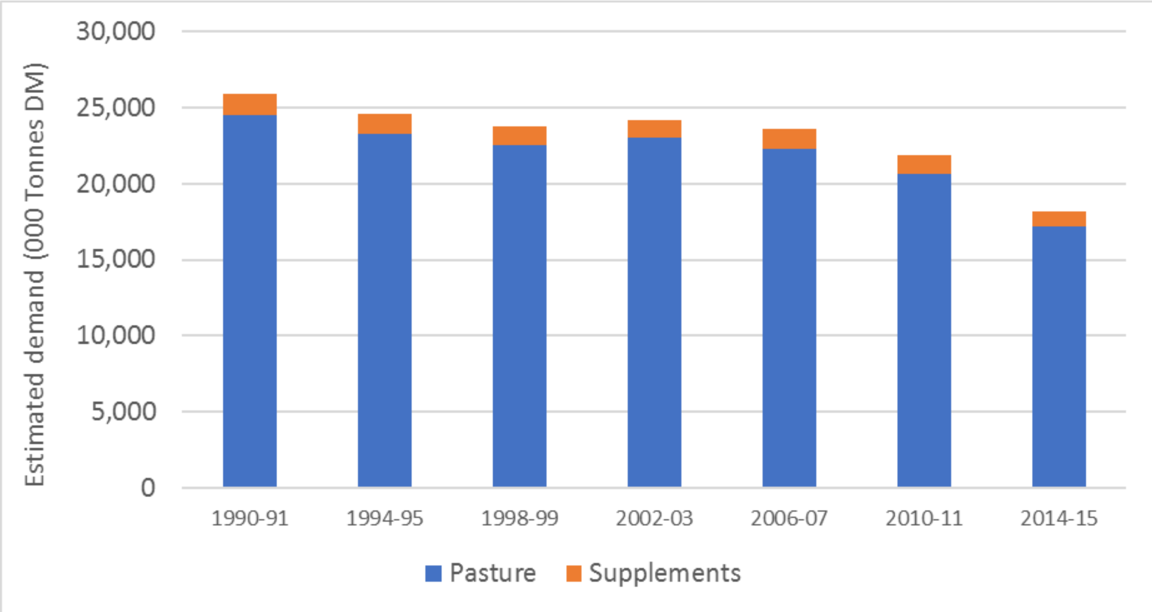


Figure 40. Estimated total national demand for historical Class 9 sheep models

Figure 41. Estimated total national demand for the 2030 sheep scenarios assuming no change in land area or farm numbers since the 2014-15 season.

Supplement usage: Figure 42 shows historical national supplemental feed estimates (as '000s tonnes DM) for sheep, with demand estimates for the future scenarios shown in Figure 43.

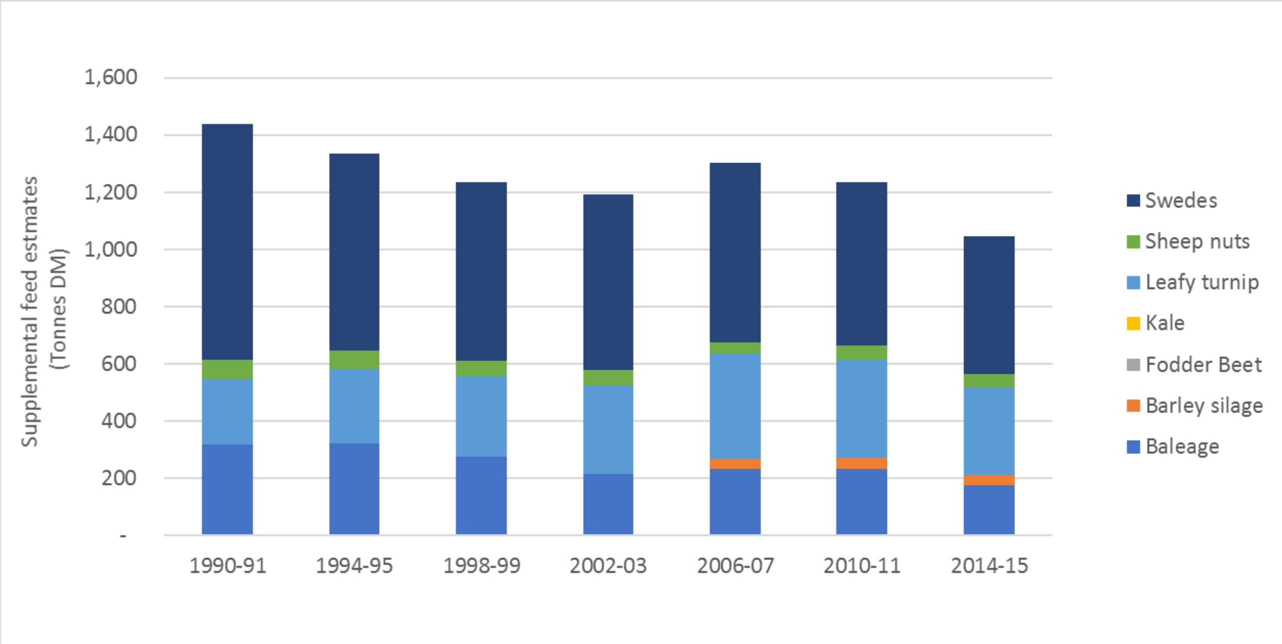


Figure 42. Estimated total national usage of supplements in the historical Class 9 sheep models

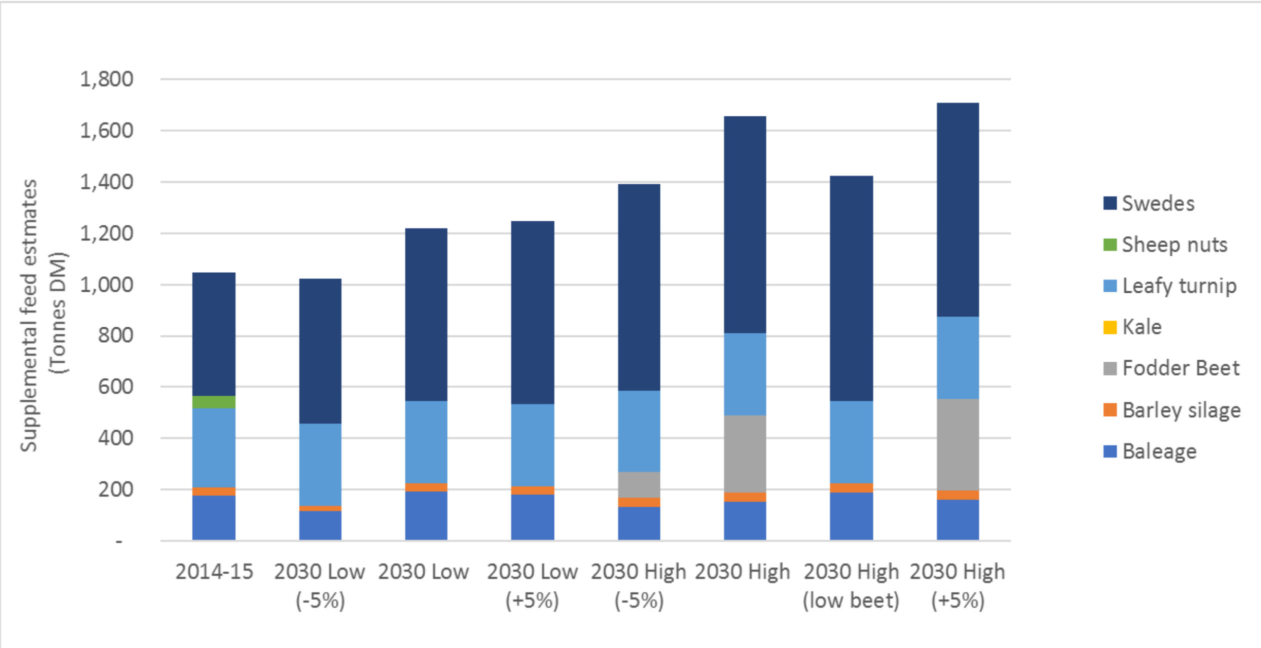


Figure 43. Estimated total national usage for the 2030 sheep scenarios assuming no change in land area or farm numbers since the 2014-15 season.

Methane emissions

Estimates of methane emissions for the Class 9 historical and future scenarios are shown in Table 7 and for the sheep stock classes in Table 8.

Table 7. National estimates of methane emissions (expressed as kilo tonnes of CO2e) for the historical Class 9 farm and 2030 scenarios.

	Class 9 farm estimates ('000 tonnes CO2e)			National estimates ('000 tonnes CO2e)			
	Sheep	**Other**	**Total**	**No of farms**	**Sheep**	**Other**	**Total**
1990-91	670,634	322,834	993,468	19,600	13,144	6,328	19,472
1994-95	703,571	454,654	1,158,225	17,700	12,453	8,047	20,501
1998-99	730,124	546,534	1,276,658	16,400	11,974	8,963	20,937
2002-03	798,255	585,563	1,383,818	15,290	12,205	8,953	21,159
2006-07	868,023	741,689	1,609,712	13,670	11,866	10,139	22,005
2010-11	873,906	612,543	1,486,449	12,610	11,020	7,724	18,744
2014-15	810,069	586,506	1,396,575	11,295	9,150	6,625	15,774
2030 Low (-5%)	840,791	737,964	1,578,755	11,295	9,497	8,335	17,832
2030 Low	913,582	645,341	1,558,923	11,295	10,319	7,289	17,608
2030 Low (+5%)	986,182	595,038	1,581,220	11,295	11,139	6,721	17,860
2030 High (-5%)	885,589	754,483	1,640,072	11,295	10,003	8,522	18,525
2030 High	961,849	661,285	1,623,134	11,295	10,864	7,469	18,333
2030 High (low fodder beet)	961,898	661,722	1,623,620	11,295	10,865	7,474	18,339
2030 High (+5%)	1,038,328	593,998	1,632,326	11,295	11,728	6,709	18,437

Table 8. National estimates of methane emissions (as kilo tonnes of CO2e) for the individual sheep classes within the historical Class 9 farm and 2030 scenarios.

	No of farms	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
1990-91	19,600	7,622	1,396	892	1,198	69	1,603	243	51	71	13,144
1994-95	17,700	7,199	1,384	936	1,229	42	1,425	162	37	40	12,453
1998-99	16,400	6,784	1,243	918	1,335	98	1,380	146	34	37	11,974
2002-03	15,290	6,985	1,311	921	1,320	105	1,355	137	34	36	12,205
2006-07	13,670	6,730	1,307	869	1,350	110	1,304	129	31	35	11,866
2010-11	12,610	6,214	1,212	807	1,283	139	1,193	113	29	31	11,020
2014-15	11,295	5,127	1,013	654	1,079	130	1,005	93	24	25	9,150
2030 Low (-5%)	11,295	4,936	997	603	1,485	102	1,229	89	27	28	9,497
2030 Low	11,295	5,363	1,085	656	1,615	111	1,334	96	29	30	10,319
2030 Low (+5%)	11,295	5,790	1,172	708	1,742	120	1,439	104	32	32	11,139
2030 High (-5%)	11,295	5,165	1,123	686	1,728	162	1,003	86	24	26	10,003
2030 High	11,295	5,612	1,221	746	1,873	173	1,091	93	26	28	10,864
2030High (low fodder beet)	11,295	5,612	1,222	746	1,873	173	1,091	93	26	28	10,865
2030 High (+5%)	11,295	6,057	1,319	806	2,022	186	1,178	100	29	30	11,728

Comparsion with previous results

The alignment between the Class 9 data and industry data used to develop the single enterprise models (as per project 17893) has resulted in minor differences in total feed demand and estimates of emissions.

Table 9 shows a comparison of the differences in estimates of total demand and land area between the Class 9 models used for this project and those reported within Project 17893.

- **1990-91:** Total demand estimates are 90% of that estimated under project 17893, whilst land area is only 81% of that reported for the total dry stock sector.
- **2014-15 and 2030:** Both total land area and demand estimates are more closely aligned, with the demand ratios ranging from 95 to 101%.

Table 9. Comparison of differences in total demand and land area between the Class 9 model estimates and that calculated under project 17893.

Model	Class 9		Project 17893		Class 9: Project 17893	
	Demand (million tonnes DM)	Area (000 hectares)	Demand[15] (million tonnes DM)	Area[16] (000 hectares)	Demand	Area
1990-91	36,283	10,094	40,469	12,465	90%	81%
2014-15	28,129	8,267	29,468	8,579	95%	96%
2030 Low	31,697		31,312		101%	
2030 High	33,253		33,224		100%	

Table 10 shows a comparison of demand estimates for the sheep, beef and deer enterprises, relative to those calculated under project 17893.

- **1990-91:** Demand estimates for sheep and deer are closely aligned, whilst beef is only 65% of that previously estimated. These results are closely aligned with estimates of total stock numbers on hand at 30 June[17], with the differences in beef likely due to the prevalence of beef cattle on small holdings, which are not captured within the B+LNZ economic survey Class 9 data sets.
- **2014:15**: The use of the 2014-15 Class 9 data results in an overestimation of total sheep demand. This is consistent with differences identified in the project 17893 report, where modelled production was 4 to 6 % lower than the observed production reported in the industry data sets.
  - Whilst opening beef stock numbers are more closely aligned, differences in demand are likely due to both the prevalence of cattle beef on small holdings, and anomalies around classification, with a considerable effort invested within project 17893 towards correctly splitting out maternal beef breed slaughter animals versus ex-dairy beef slaughter stock.
  - Differences in deer numbers are likely due to the scaling processes used to reconcile deer within the Class 9 data sets, versus total industry numbers.
- **2030 Low and High**: Results are consistent with those observed for the 2014-15 data sets.

[15] Total estimated demand for the sheep, beef and ex-Dairy beef sector from Table 16 of the project 17893 report.
[16] Includes land associated with the sheep, beef, ex-dairy and goat dry stock farming sectors.
[17] See Figure 45

Table 10. Comparison of demand estimates for the sheep, beef and deer enterprises, relative to calculated under project 17893.

Model	Enterprise	Demand estimates (million tonnes DM)		Class 9: Project 17893
		Class 9	Project 17893	
1990-91	Sheep	25,911	25,279	102%
	Beef[18]	9,037	13,900	65%
	Deer	1,335	1,289	104%
2014-15	Sheep	18,205	16,331	111%
	Beef	8,579	12,059	71%
	Deer	1,345	1,078	125%
2030 Low	Sheep	20,661	17,995	115%
	Beef	9,681	12,232	79%
	Deer	1,355	1,085	125%
2030 High	Sheep	21,884	19,632	111%
	Beef	9,967	12,494	80%
	Deer	1,403	1,099	128%

A comparison of estimates of gross national methane emissions for sheep, with minor variations due to the impact of difference in pasture quality between the Class 9 models and inventory (Table 11).

Table 11. Comparison of methane estimates calculated using the Class 9 model relative to those calculated under project 17893.

	Methane emissions (kilo tonnes of CO2e)			Class 9: Project 17893	
	Class 9	Inventory	Project 17893	Class 9	Inventory
1990-91	13,144	12,712	12,839	102%	99%
2014-15	9,150	9,149	8,195	112%	112%
2030 Low	10,319	10,358	9,017	114%	115%
2030 High	10,864	10,963	9,773	111%	112%

[18] Demand for ex-dairy beef included within both the class 9 and project 17893 comparisons.

Discussion

This project has quantified historical supplement usage, used fodder beet as model for future supplement usage, and raised a lot of questions around the average quality of pasture consumed, and the impact on methane emission estimates. Further discussion of some of the key points is provided below, including options for further research and application within the inventory methodologies.

1. **The rate of supplement feed usage is lower in sheep than it is in the other livestock enterprises**.

This is function of both total feed demand and practicality. Historical and ongoing increases in on-farm productivity have resulted in increases in total feed demand, and the ways that farmers may address this include: increased supplemental feed usage; changes in pasture management resulting in increases in the volume and/or quality of pasture produced; increasing the fertility of the soil through the use of conventional fertilizers; and accelerating seasonal growth through increased use of Nitrogen fertilizers.

- *Note that potential management changes are likely to include use of improved cultivars, increased rates of pasture replacement, irrigation and/or increased use of nitrogen fertiliser, with many of these changes likely to have an additional impact on nitrous oxide emissions (which have not been evaluated as part of this study).*

Practical issues, including the timing of seasonal events such as lambing and calving, and the ability of animals to effectively graze a range of feed types, influence the preferential use of both pasture and the various types of supplemental feed across a range of stock classes. Examples are cited below.

- During the lambing period (August-October), ewes cannot graze crops such as kale and fodder beet effectively; hence in this analysis, these crops are used almost exclusively in cattle. In the future models, additional feed is required through the main September-October lambing period; this feed can be provided through making all the pasture available to sheep by allocating all of the supplements to cattle; pasture growth rates can also be increased through use of nitrogen.
- Higher-yielding kale crops are more difficult to feed to sheep than to cattle. This is due to the height of the crop, very high wastage as sheep prefer to not eat the stems, and difficulties moving a multi-wire electric fence break needed to control sheep vs a single wire for cattle.
- Under summer-dry conditions, there is a seasonal shortage of quality pasture, so that farmers want to ensure that their lambs are slaughtered earlier at good weights (and prices), and may use supplemental feed to increase post-weaning growth rates in this period.
- Contract agreements for the grazing of dairy heifers and cows encourage preferential feeding of growing heifers and dairy cows over winter. In contrast, beef cows are a very low priority for supplements over winter. In fact, they are generally expected to lose weight and clean up low quality feed over the winter with some supplements provided in late winter/early spring. However, their progeny, other cattle destined for slaughter (finishing) which includes both beef cattle and cattle from the dairy industry (ex-dairy) are supplemented to ensure they continue to grow over winter.

<u>Options for consideration:</u> To more fully account for supplemental feed usage within the inventory, the feed tracking and scaling models could be extended to track supplement usage within individual stock classes for the beef, ex-dairy and dairy grazing enterprises. This would enable a more accurate evaluation

of supplemental feed usage within the individual stock classes, and the flow on effect into estimates of methane emissions. It may also provide a methodology for use within the inventory, where results are updated on an annual basis, and used to moderate the ME values applied within the inventory.

2. **The monthly estimates for the average ME content of food consumed differ from those used within the NZGHG inventory**

This is due to differences in assumptions around average pasture quality values, and supplement usage, with ME (MJME/kg DM) estimates for this project, calculated as a weighted average of monthly pasture and supplement estimates.

Pasture ME estimates: Within this project, we have used the Farmax default values for the ME content of high, medium and low-quality pasture, to calculate a weighted estimate of the average pasture ME for flat, rolling and steep hill terrain.

These default values are based on a simplified version of a pasture model originally designed in 1984, and may not accurately reflect the average ME of pasture currently used. Within the earlier productivity project (MPI project tender 17893)[19], the pasture ME values were calibrated as medium-quality pasture for the 1989-90 season and as high- quality pasture for the 2014-15 season, with only very small volumes of supplements required to meet total feed demand. A comparison of results showed minor differences between the two ME models, with the values from the productivity project used to calculate a weighted average estimate of both pasture and supplemental feed consumed.

Preferential feeding: In addition to differences in the average quality of pasture available for consumption, we have also made an allowance for preferential feeding of pasture to some livestock classes over others: for example, lambs get better feed than ewes, and dairy grazers are offered better feed than beef cows. These preferential pasture quality allocations have been accounted for when estimating both the quantity (kg DM) and quality (MJME) of feed consumed by individual stock classes in each month.

Inventory comparisons: Within the NZ greenhouse gas inventory, ME estimates are based on seasonal values for sheep, beef and deer. However, within this project, the pasture ME estimates are based on those used within the productivity project, and then further adjusted to account for preferential feeding, prior to the calculation of average ME as a weighted average of monthly pasture and supplement estimates. A comparison with inventory values showed that ME estimates for this project, are lower in winter and higher in summer than those used within the inventory. This results in differences in the total volume of feed consumed, and has a flow-on impact on the estimates of methane emissions.

Options for consideration: Currently, there is no "concrete" data for average pasture quality, and MPI is working with industry groups to evaluate the benefits of systems for improving estimates of pasture quality. When this work is completed, there is potential to re-optimise the Farmax models used within this project, and then re-evaluate the impacts on feed demand and emissions. Further work is also required on the preferential feed model, with the focus of this project being on supplemental feed usage,

[19] Analysis of the potential to increase emission intensity improvements through productivity gains. AbacusBio report (MPI tender 17893) by Jude Sise, Jason Archer, Tom Kirk, Brue McCorkindale, Tim Byrne, Peter Fennessy (June 2016).

as opposed to optimisation of the preferential feed model for individual stock classes. Optimisation of this model for individual stock classes, could also result in changes to the current inventory methodology.

3. **The use of specialist pasture is likely to further impact on the average ME content of pasture consumed**

Fundamental changes are developing in forage systems on NZ sheep and beef farms, with innovative producers beginning to develop "specialist high quality (high ME) pastures" through combinations of grazing herbs and new legume cultivars. These specialist non-grass pastures (which are being used for say 3 to 4 years), are typically being fitted between a supplementary feed crop and newly-sown pasture (a new conventional grass/legume pasture). In some cases, the herb and clover seeds are also being added to the supplementary crop seeds and therefore carry on producing after the supplementary crop has been used. With supplemental feed primarily used to "bridge" gaps in pasture production, use of specialist pastures may provide a cost-effective and practical opportunity to improve feed quality and enable further productivity gains whilst limiting increases in GHG emissions in the sheep sector.

Options for consideration: There is a good case to assess the impact of specialist pastures on the average ME content of feed consumed, along with the development of an adoption model to assess the likely impact within the 2030 production scenarios that have been modelled.

4. **Methane emission estimates for individual sheep stock classes are both higher and lower, than those estimated using inventory methodology**

Differences in assumptions around the average quality of feed consumed have resulted in estimates of the methane emission for the 1990-91 season being 3% higher than those estimated using the current inventory ME values. This is driven primarily by the feeding of ewes where the 1990-91 emissions were estimated as 6% higher than the inventory, whereas the emissions from lambs were 4-5% lower. In the 2014-15 season, there is no substantive difference in total sheep methane emissions between the two methods, with lower estimates for lambs offset by higher estimates in other sheep stock classes. Potential productivity gains modelled in the 2030 scenarios, result in a 1% reduction in overall methane estimates for sheep (relative to inventory).

Options for consideration: These results suggest that historical sheep methane estimates may be higher than previously thought. If the models used within this report are considered appropriate, then this could affect the baseline used to reference emission reductions required under the Paris accord. Further research that could be undertaken to examine this further include the following.

i. The emission models could be extended to include methane estimates for individual stock classes within the beef, ex-dairy beef, dairy grazing and deer enterprises. This would enable evaluation of the impact of changes in in farm composition (such as fewer sheep, and more dairy grazers).
ii. Actual production data could be used to more accurately estimate on-farm productivity for the 2005-06 season (as was previously done for the 1989-90, and 2014-15 seasons). This would enable further optimisation of the models used in this project.

Finally, no attempt has been made to consider the impact of variation in forage types, or of the impact of supplement usage on nitrous oxide emissions. Further research could be undertaken to assess these impacts as part of the wider greenhouse gas research objectives.

Appendix 1: Historical data

Stock numbers

Statistics New Zealand

Historical stock numbers were extracted from the Statistics New Zealand database (Table 12). Total stock numbers were not available for the 1997, 1998, 2000 or 2001 seasons, with results for these years estimated according to the average trend for the flanking years. Results are summarised in Figure 44 and show a 52% drop in total sheep numbers, whilst there was a 24% drop in beef cattle numbers; the number of deer ranged from 1.75 million to 0.853 million over the same period.

Table 12. Statistics New Zealand data showing changes in the total number of sheep, beef cattle and deer between 1990 and 2016 (June 30 financial year).

	Total Beef Cattle	**Total Sheep**	**Total Deer**
1990	4,593,160	57,852,192	976,290
1991	4,670,569	55,161,643	1,129,503
1992	4,676,497	52,568,393	1,135,242
1993	4,757,962	50,298,361	1,078,479
1994	5,047,848	49,466,054	1,231,109
1995	5,182,508	48,816,271	1,178,704
1996	4,852,179	47,393,907	1,192,138
1997*	4,782,688	46,822,568	1,353,688
1998*	4,696,260	46,251,230	1,515,238
1999	4,643,705	45,679,891	1,676,788
2000*	4,592,897	43,643,873	1,667,171
2001*	4,542,089	41,607,855	1,657,555
2002	4,491,281	39,571,837	1,647,938
2003	4,626,617	39,552,113	1,689,444
2004	4,447,400	39,271,137	1,756,888
2005	4,423,626	39,879,668	1,705,084
2006	4,439,136	40,081,594	1,586,918
2007	4,393,617	38,460,477	1,396,023
2008	4,136,872	34,087,864	1,223,324
2009	4,100,718	32,383,589	1,145,858
2010	3,948,520	32,562,612	1,122,695
2011	3,846,414	31,132,329	1,088,533
2012	3,734,412	31,262,715	1,060,694
2013	3,698,522	30,786,761	1,028,382
2014	3,669,862	29,803,402	958,219
2015	3,547,228	29,120,827	900,100
2016	3,473,491	27,576,247	852,919

* Estimated result

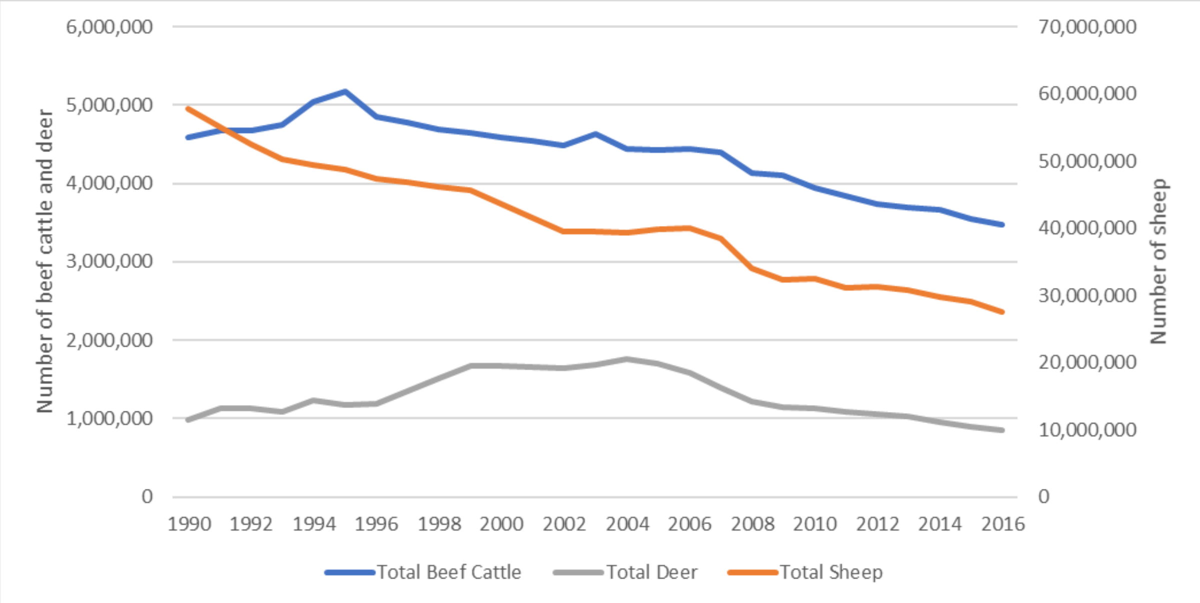


Figure 44. Statistics New Zealand data showing changes in the total numbers of sheep, beef cattle and deer reported over time.

Class 9 stock numbers

The B+LNZ Class 9 All farms data set was also used to estimate changes in total stock numbers over this period. Stock numbers for Class 9 are summarised in Table 13, and a comparison of the total numbers of stock on hand for each data set presented as a ratio in Figure 45.

Table 13. Opening (July 1) total estimated stock numbers for the B+LNZ Class 9 data sets.

	B+LNZ Eco service Class 9 data					**Estimated national stock numbers**		
	Number on hand at the 1st of July			**Average effective area**	**Number of farms**	**Sheep**	**Beef**	**Deer**
year end (30 June)	**Sheep**	**Beef**	**Deer**					
1990-91	2,804	166	20	514	19,600	54,958,400	3,253,600	392,000
1991-92	2,799	180	21	516	19,600	54,860,400	3,528,000	411,600
1992-93	2,684	192	26	514	19,600	52,606,400	3,763,200	509,600
1993-94	2,627	205	25	538	17,700	46,497,900	3,628,500	442,500
1994-95	2,807	220	27	560	17,700	49,683,900	3,894,000	477,900
1995-96	2,835	234	27	555	17,700	50,179,500	4,141,800	477,900
1996-97	2,829	230	29	549	16,820	47,583,780	3,868,600	487,780
1997-98	2,834	233	31	554	16,820	47,667,880	3,919,060	521,420

	B+LNZ Eco service Class 9 data					Estimated national stock numbers		
year end (30 June)	Number on hand at the 1st of July			Average effective area	Number of farms	Sheep	Beef	Deer
	Sheep	Beef	Deer					
1998-99	2,826	214	30	558	16,400	46,346,400	3,509,600	492,000
1999-00	2,909	217	33	569	16,260	47,300,340	3,528,420	536,580
2000-01	2,999	228	37	589	15,740	47,204,260	3,588,720	582,380
2001-02	3,001	243	37	593	15,740	47,235,740	3,824,820	582,380
2002-03	3,130	260	41	599	15,290	47,857,700	3,975,400	626,890
2003-04	3,013	261	45	600	15,290	46,068,770	3,990,690	688,050
2004-05	3,071	272	46	623	13,792	42,355,232	3,751,424	634,432
2005-06	3,165	276	43	664	13,757	43,540,905	3,796,932	591,551
2006-07	3,160	280	34	645	13,670	43,197,200	3,827,600	464,780
2007-08	3,106	286	33	649	13,600	42,241,600	3,889,600	448,800
2008-09	2,839	291	31	649	12,880	36,566,320	3,748,080	399,280
2009-10	2,763	302	26	658	12,700	35,090,100	3,835,400	330,200
2010-11	2,853	295	26	663	12,610	35,976,330	3,719,950	327,860
2011-12	2,813	300	33	640	12,490	35,134,370	3,747,000	412,170
2012-13	2,857	329	32	635	12,370	35,341,090	4,069,730	395,840
2013-14	2,838	336	35	634	12,290	34,879,020	4,129,440	430,150
2014-15	2,749	343	28	627	11,295	31,049,955	3,874,185	316,260

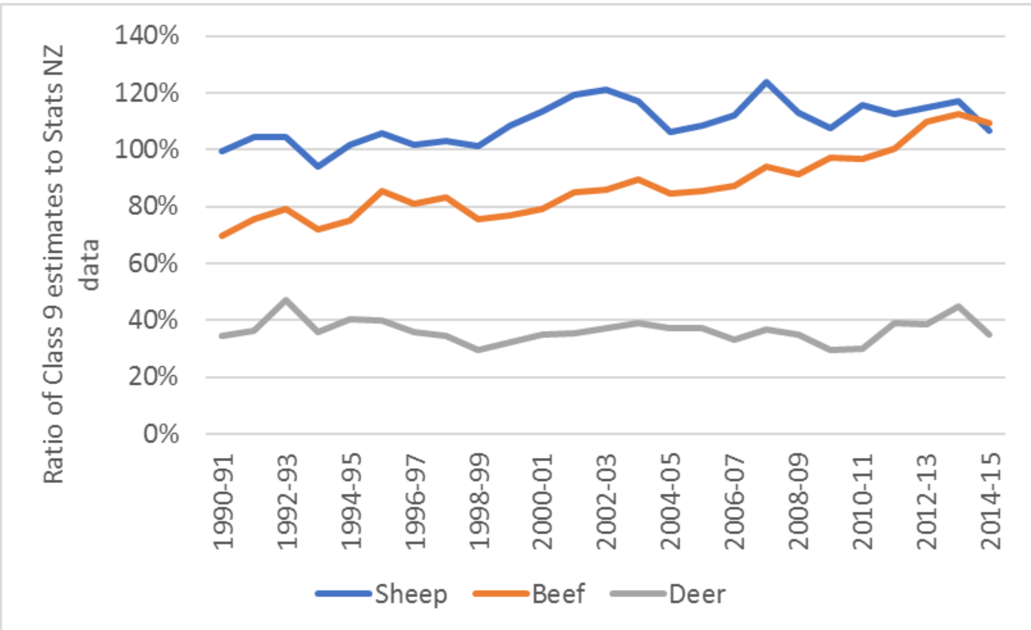


Figure 45. Relationship between estimates calculated using the B+LNZ Class 9 data sets, and the Statistic NZ data for total stock on hand at year end (30 June).

Stock number differences

- The differences in the 2014-15 sheep and beef data sets are consistent with differences identified in the project 17893 report, where modelled production was 4 to 6 % lower than the observed production reported in the industry data sets.
- The 1990 model for sheep is also closely aligned with the Statistics NZ and Class 9 data set estimates, whilst in beef, the Class 9 data estimates are initially considerably lower than that reported by Statistics NZ. This is likely due to the prevalence of cattle beef on small holdings, with the differences between the Stats NZ and Class 9 data reducing over time as the increase in dairy grazing has resulted in land use change.
- The differences in deer estimates, are likely caused by a bias in the selection of the B+LNZ Economic Service survey farms towards sheep and beef (as opposed to deer). To account for this, the Class 9 data have been scaled according to the total number of hinds and stags reported by Statistics NZ, divided by the number of Class 9 farms for each year of the analysis.

Class 9 farm size and composition

The changes identified in national stock numbers have been further examined according to changes in the average number of stock, relative to effective area on a typical Class 9 farm. Figure 46 shows that from 1990 to 2005, increases in the average number of sheep on farm at opening (1 July) mimicked the changes reported for average farm size, but that the numbers of sheep then dropped whilst average farm size remained relatively constant. This was offset by an increase in the number of both beef cattle (and dairy grazers) on hand at opening, whilst deer numbers remained relatively constant (see Figure 47).

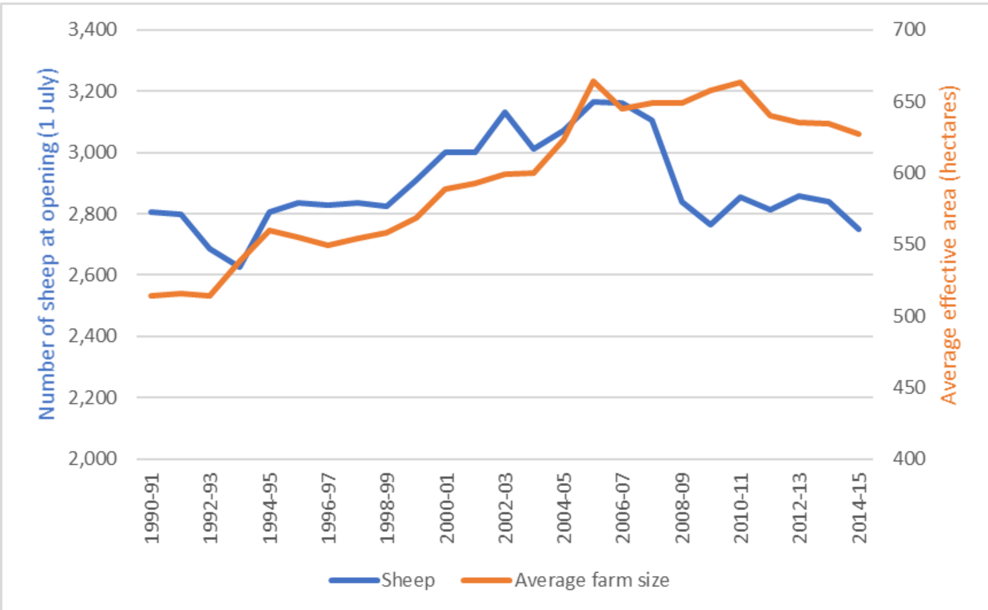


Figure 46. B+LNZ Class 9 data showing changes in the average number of sheep on hand at year end (30 June) relative to effective farm area.

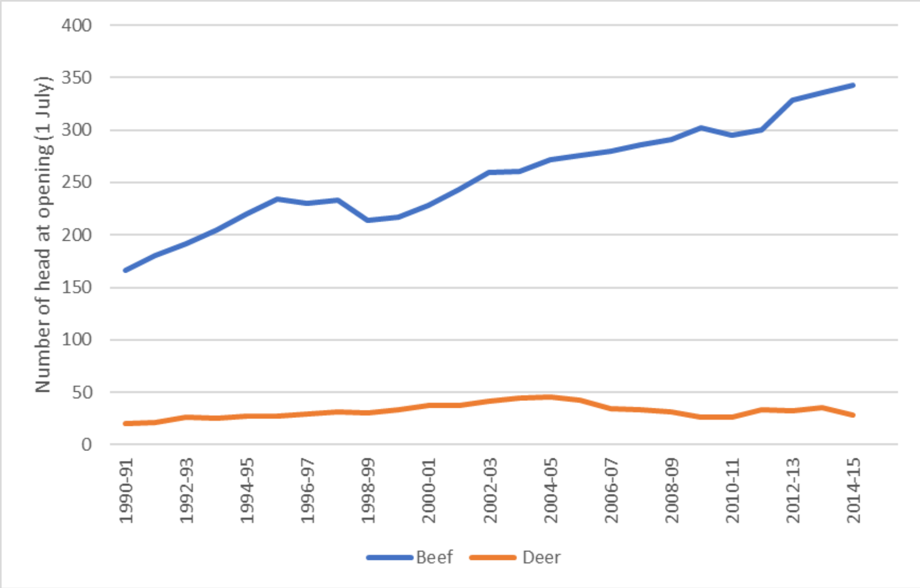


Figure 47. B+LNZ Class 9 data showing changes in the average number of beef cattle and deer at year end (30 June).

Land use change

Data from the Beef + Lamb NZ Economic Service were used to estimate changes in land use over time. Table 14 shows land use by area over time, where dry-stock land area reduced from 12.45 million hectares in 1990 to 8.59 million hectares in 2015, with 1 million hectares going to dairy production and 2.9 million hectares to alternate (non-grazing) land usage.

Table 14. B+LNZ land use data (000's of hectares), according to stock class and season.

Year	Land area (000 hectares)		
	Sheep, Beef, Deer and Goat	**Dairy (includes dairy support activities and dairy run-offs)**	**Total**
1990-91	12,465	1,349	13,814
1991-92	12,375	1,340	13,715
1992-93	12,481	1,360	13,841
1993-94	12,545	1,400	13,945
1994-95	12,014	1,521	13,536
1995-96	11,900	1,620	13,520
1996-97	11,631	1,635	13,265
1997-98	11,347	1,702	13,049
1998-99	11,091	1,742	12,833
1999-00	10,873	1,743	12,616
2000-01	10,583	1,816	12,400
2001-02	10,311	1,872	12,183
2002-03	10,060	1,907	11,967
2003-04	9,965	1,880	11,844
2004-05	9,825	1,896	11,722
2005-06	9,731	1,868	11,599
2006-07	9,587	1,890	11,477
2007-08	9,439	1,915	11,354
2008-09	9,335	2,019	11,354
2009-10	9,302	2,111	11,413
2010-11	9,180	2,122	11,302
2011-12	9,077	2,213	11,290
2012-13	8,842	2,255	11,097
2013-14	8,716	2,258	10,974
2014-15	8,594	2,331	10,925
Ha Change - 1990-91 to 2015-16f	-31%	73%	-21%
Ha Change - 1990-91 to 2015-16f	-3,871	982	-2,889

Changes in terrain

The Class 9 B+LNZ Economic service data were used to evaluate changes in both effective area, and the percentage of flat, rolling and steep land used for Class 9 farming systems. Table 15 shows these changes, with a 5% reduction in flat and 6% increase in rolling land type since 1990. Note that throughout the same period, effective area dropped by 15%. We have assumed that this is due to increased accuracy of recording non-effective area, with removal of this land (assumed to be steep) resulting in a 3% reduction in flat land usage, and an 11% increase in rolling land usage since 1990.

Table 15. B+LNZ Class 9 land area data.

	Land area			Terrain type				% of Effective terrain		
Season	**Effective**	**Total**	**% Effective**	**Flat**	**Rolling**	**Steep**	**Steep[1]**	**Flat**	**Rolling**	**Steep**
1990-91	514	515	100%	114	133	268	267	22%	26%	52%
1991-92	516	525	98%	114	138	273	264	22%	27%	51%
1992-93	514	548	94%	126	143	279	245	25%	28%	48%
1993-94	538	578	93%	125	150	303	263	23%	28%	49%
1994-95	560	605	93%	129	160	316	271	23%	29%	48%
1995-96	555	599	93%	131	162	306	262	24%	29%	47%
1996-97	549	596	92%	135	164	297	250	25%	30%	46%
1997-98	554	598	93%	132	166	300	256	24%	30%	46%
1998-99	558	604	92%	131	166	307	261	23%	30%	47%
1999-00	569	615	93%	131	184	300	254	23%	32%	45%
2000-01	589	636	93%	137	189	310	263	23%	32%	45%
2001-02	593	648	92%	147	194	307	252	25%	33%	42%
2002-03	599	650	92%	143	201	306	255	24%	34%	43%
2003-04	600	661	91%	143	200	318	257	24%	33%	43%
2004-05	623	690	90%	134	185	371	304	22%	30%	49%
2005-06	664	734	90%	136	205	393	323	20%	31%	49%
2006-07	645	716	90%	133	203	380	309	21%	31%	48%
2007-08	649	722	90%	131	206	385	312	20%	32%	48%
2008-09	649	724	90%	126	216	382	307	19%	33%	47%
2009-10	658	728	90%	132	226	370	300	20%	34%	46%
2010-11	663	754	88%	128	217	409	318	19%	33%	48%
2011-12	640	745	86%	126	224	395	290	20%	35%	45%
2012-13	635	741	86%	119	229	393	287	19%	36%	45%
2013-14	634	740	86%	120	233	387	281	19%	37%	44%
2014-15	627	732	86%	123	233	376	271	20%	37%	43%
Change relative to 1990-91								**-3%**	**+11%**	**-9%**

[1]Adjusted Steep

Figure 48 shows a comparison of the Class 9 total area estimates (calculated according to average farm area and total number of farms) relative to the total amount of dry stock area reported by the B+LNZ Economic Service. Land estimates for the 1990-91 season are approximately 80% of total area available, with the results becoming more closely aligned as the accuracy of reporting increases, with Class 9 land estimates within 5% of dry-stock area from the 2001-02 season onwards.

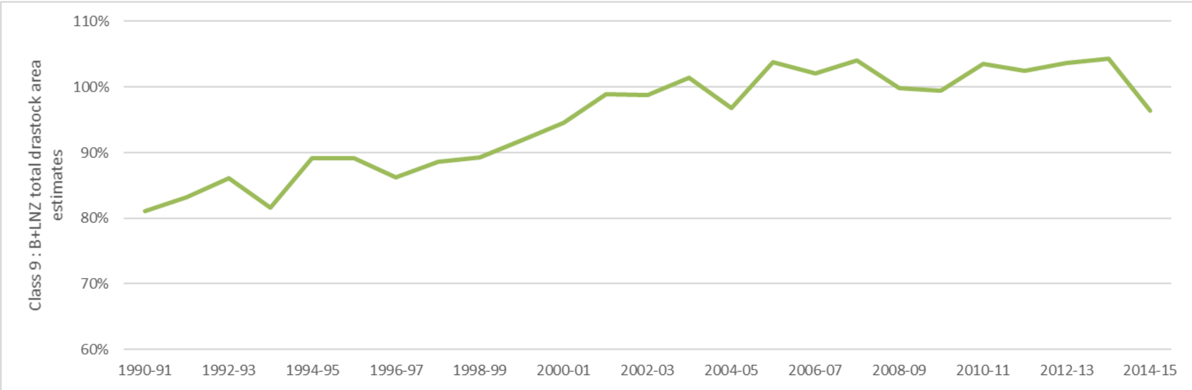


Figure 48. Comparison of total land area estimates calculated using the Class 9 data sets relative to total dry stock area reported by the B+LNZ Economic service.

Changes in terrain relative to total dry stock land area

Figure 49 shows the impact of changes in land type (flat, rolling & steep) scaled to average farm size, and to total dry-stock land area. The proportion of steep land declined at a similar rate to total area, whilst rolling land area remained relatively constant but flat area dropped. Note that some of the reduction in steep will have been associated with large tracts of high country land being returned to the conservation estate as part of tenure review negotiations. This fits with anecdotal evidence of sheep and beef farmers moving onto “harder hill terrain”, with the sheep and beef productivity gains identified in project 17983 achieved through a combination of improved genetics and management, albeit the potential of which is unlikely to have been less easily realised on the harder hill country terrain.

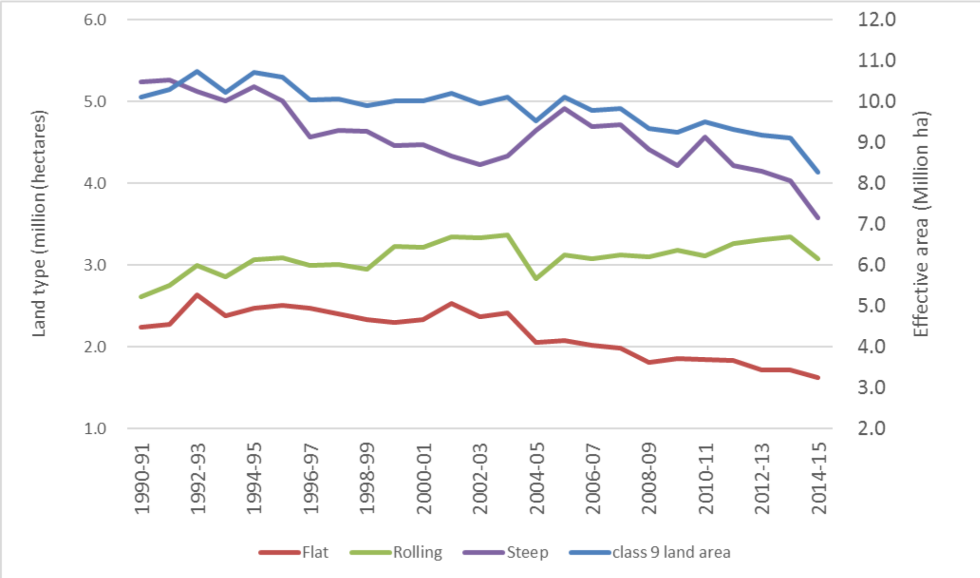


Figure 49. Changes in land type and effective dry stock land area.

Historical sheep data

Stock class changes

The B+LNZ Class 9 data were used to evaluate changes in the composition of the national sheep flock, with Figure 50 showing a 48% drop in the number of mixed age ewes mated, whilst reductions in the number of two-tooth ewes mated and lambs marked were more modest at 40% and 30% respectively. Changes observed reflect both the 2% increase in ewe replacement rate and 25% increase in reproductive rate of lambs born per ewe mated (see below).

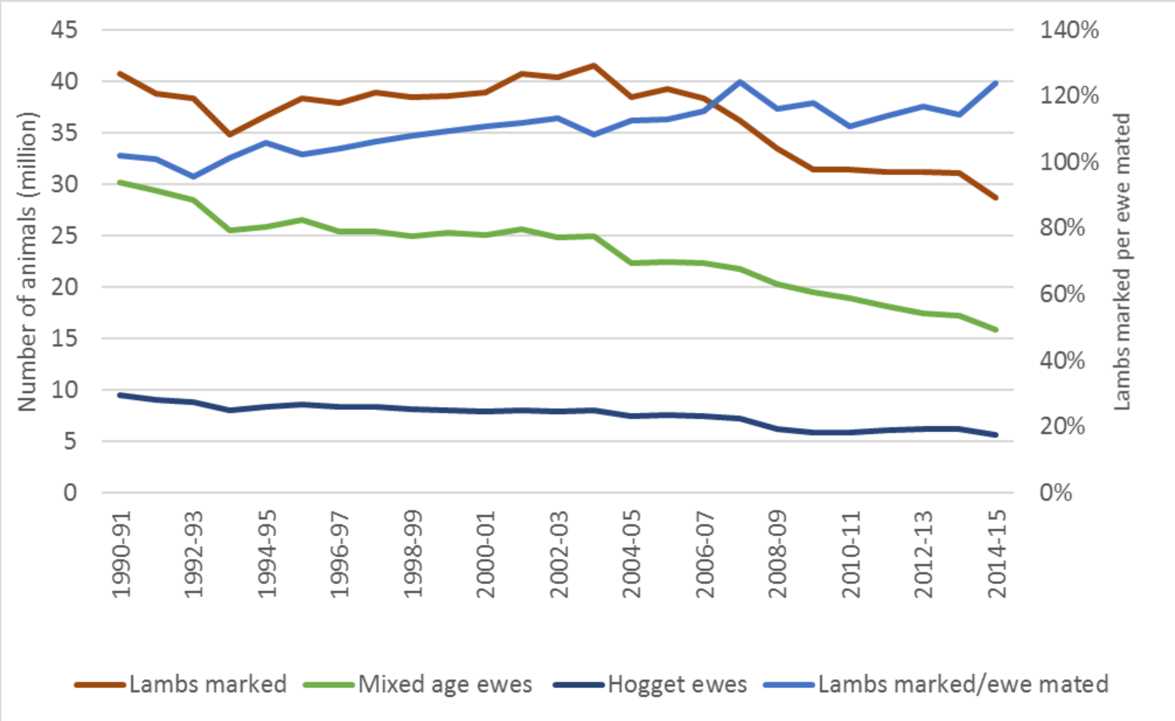


Figure 50. B+LNZ Class 9 data for sheep, scaled to account for the total number of mixed age and two tooth ewes mated relative to the number of lambs marked, and changes in lambing rate over time.

Reproduction data

Table 16 shows changes in the average number of lambs per ewe mated as reported by Statistics New Zealand, and B+LNZ for lambs marked per ewe (mixed age and two tooth ewes run with the ram).

Table 16. Statistics New Zealand data showing changes in the average number of lambs per ewe mated, and compared to project 17893 results when hogget lambs are included.

	Statistics New Zealand data			Class 9 data	Project 17893 data
	Average lambing date	Lambs marked per MA ewe mated	Lambs marked per hogget mated	Lambs marked or tailed per ewe mated[1]	Total lambs per ewe mated[2]
1990-91	25-08-90			103%	98%
1991-92	24-08-91			105%	99%
1992-93	25-08-92			96%	101%
1993-94	25-08-93			107%	102%
1994-95	25-08-94			109%	104%
1995-96	26-08-95			105%	105%
1996-97	26-08-96			112%	107%
1997-98	27-08-97			116%	108%
1998-99	27-08-98			114%	109%
1999-00	26-08-99			116%	111%
2000-01	26-08-00			116%	112%
2001-02	26-08-01	118%	48%	117%	114%
2002-03	26-08-02	119%	47%	122%	115%
2003-04	27-08-03	115%	40%	120%	116%
2004-05	27-08-04	121%	43%	126%	118%
2005-06	27-08-05	120%	52%	126%	119%
2006-07	26-08-06	121%	57%	126%	121%
2007-08	25-08-07	127%	74%	122%	122%
2008-09	26-08-08	123%	37%	118%	124%
2009-10	27-08-09	125%	40%	128%	125%
2010-11	26-08-10	118%	43%	117%	126%
2011-12	27-08-11	122%	45%	125%	128%
2012-13	26-08-12	122%	64%	130%	129%
2013-14	26-08-13	121%	47%	127%	131%
2014-15	25-08-14	130%	59%	129%	132%
Change relative to 1990-91				25%	35%

[1]Includes lambs from mixed age and two tooth ewes, relative to the number mated

[2]Based on the linear trend ex project 17893, and includes hogget lambs, relative to the number of mixed age and two tooth ewes mated.

Carcase weights

Results from project 17893, showed that average lamb carcase weight increased from 14.3 to 18.6 kg from 1989-90 to 2014-15 (0.17 kg per annum), which is consistent with the Class 9 data supplied by B+LNZ (Figure 51). Similar results were seen for ewe carcase weight, where the Class 9 data was consistent with the linear changes predicted from the project 17893 report (0.197 kg per annum, see Figure 52).

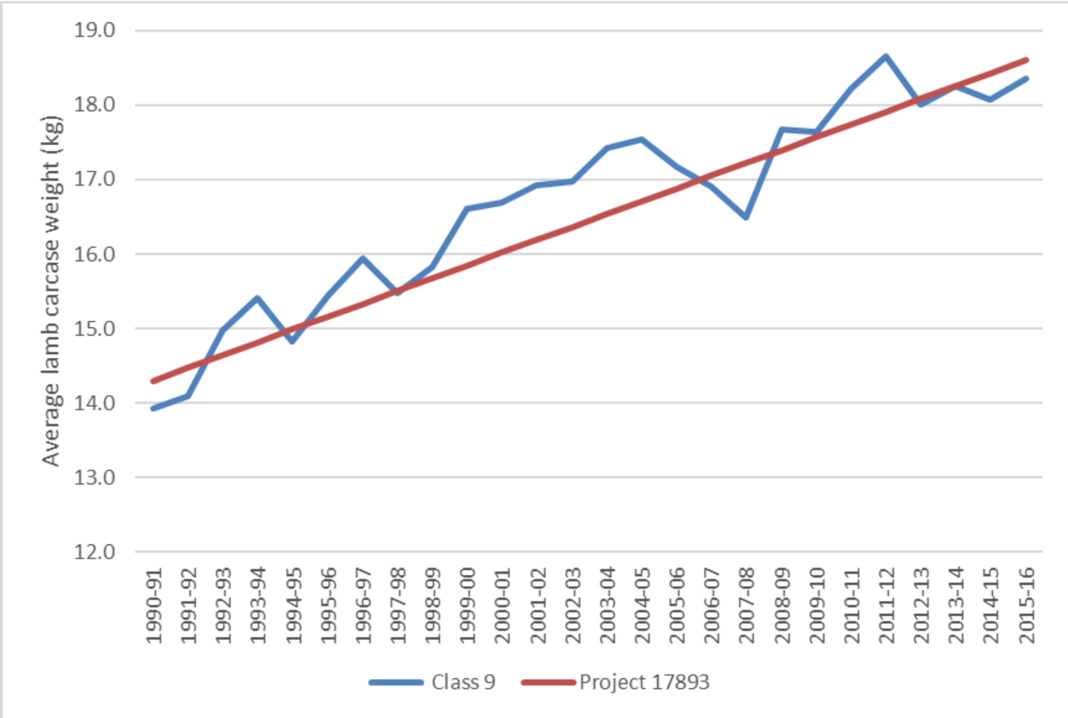


Figure 51. Comparison of the trend estimated for lamb carcase weight in project 17893, versus the Class 9 data supplied by the B+LNZ economic service.

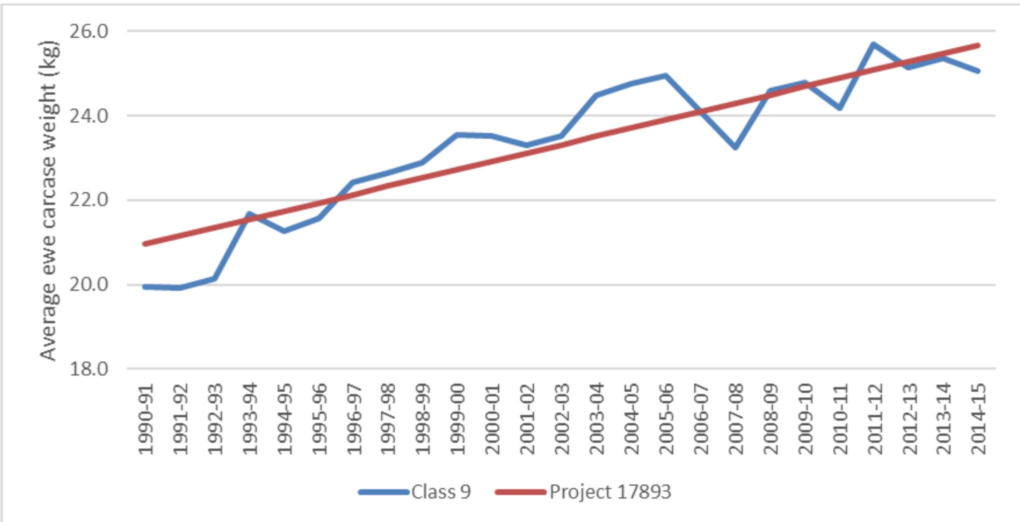


Figure 52. Comparison of the trend estimated for ewe carcase weight in project 17893, versus the Class 9 data supplied by the B+LNZ economic service.

Age at slaughter

The Class 9 data show there has been little change in the average age of lambs at slaughter, with results ranging from 191-206 days (Table 17). This is consistent with project 17893 results (see Table 18), where predicted age at slaughter for the main season kill dropped from 202 in the 1989/90 season to 188 days in 2014-15, but the average age of late season lambs increased from 307-329 days, and the proportion of total lambs slaughtered in the late season also increased.

Table 17. Class 9 data for average birth date, slaughter date and age at slaughter.

	Average birth date	Average slaughter date	Average age at slaughter (days)
1996-97	26-08-96	16-03-97	202
1997-98	27-08-97	11-03-98	196
1998-99	27-08-98	15-03-99	200
1999-00	26-08-99	19-03-00	206
2000-01	26-08-00	13-03-01	199
2001-02	26-08-01	18-03-02	204
2002-03	26-08-02	10-03-03	196
2003-04	27-08-03	09-03-04	195
2004-05	27-08-04	17-03-05	202
2005-06	27-08-05	19-03-06	204
2006-07	26-08-06	11-03-07	197
2007-08	25-08-07	09-03-08	197
2008-09	26-08-08	05-03-09	191
2009-10	27-08-09	09-03-10	194
2010-11	26-08-10	15-03-11	201
2011-12	27-08-11	16-03-12	202
2012-13	26-08-12	14-03-13	200
2013-14	26-08-13	12-03-14	198
2014-15	25-08-14	14-03-15	201

Table 18. Comparison of the age (days) and weight (kg) of lambs within the 2 kill periods (as reported in project 17893).

	1989/90	2014/15
Main period slaughtering (late November to June)		
Age	202	188
Weight	14.2	18.2
Secondary period slaughtering (July to early November)		
Age	307	329
Weight	14.8	19.9

Data for the annual pattern of slaughter are shown in Figure 53, with most lambs killed peak season over February and March. To account for seasonal variation, three-year rolling averages have been used within the Farmax models developed for this report. Figure 54 shows the kill profile for the 7 seasons modelled, with results for 1990-91 and 2014-15 based on actual data (as per the project 17893 report), and the 5 interim seasons based on the three-year rolling averages. Results for 1990-91 and 1994-95, reflect the higher age for the main slaughter period, with a secondary kill peak clearly identified in the Class 9 data for May.

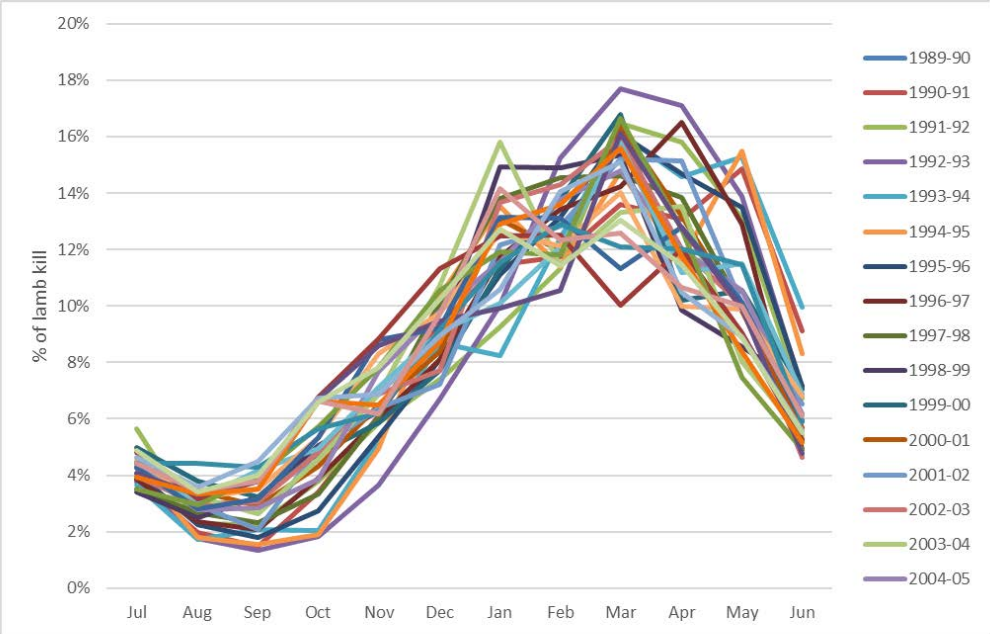


Figure 53. Class 9 data showing monthly slaughter patterns (percentage of lambs slaughtered relative to total lambs slaughtered).

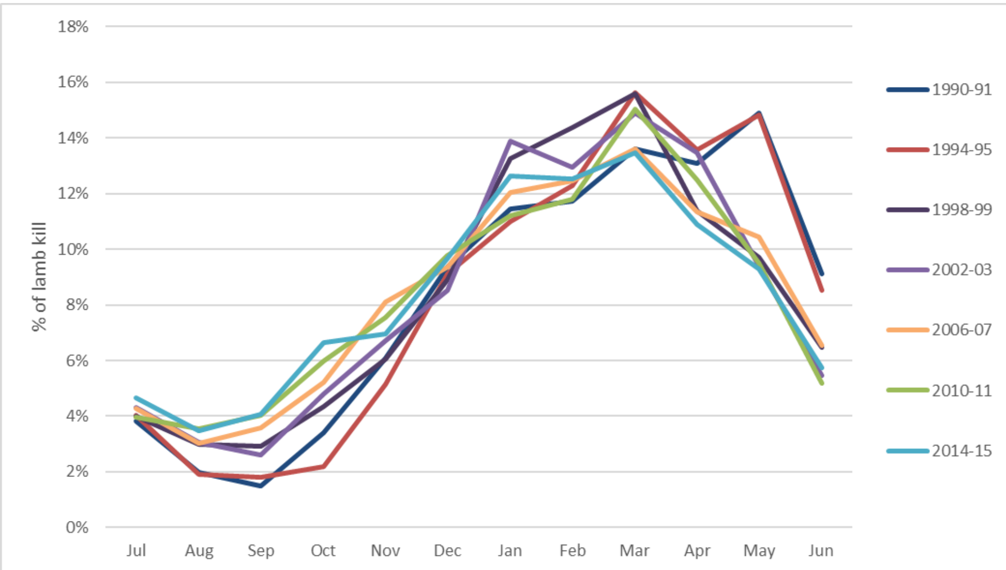


Figure 54. Farmax lamb slaughter profiles, based on 3 year rolling averages.

Ewe slaughter profile

The ewe slaughter profiles for the Class 9 data are shown in Figure 55, with the most notable differences seen in the 2007-08 season. Figure 56 shows the average number of ewes culled per farm and per hectare with the 2007-08 peak attributed to a combination of weather events, and the shift towards an increase in the average number of beef cattle and dairy grazers per farm. The minor change in the total number of ewes culled, relative to the number culled per hectare reflects both changes in replacement rate, and the shift towards more beef and dairy cattle grazing. Figure 57 shows slaughter profiles derived using the Farmax models.

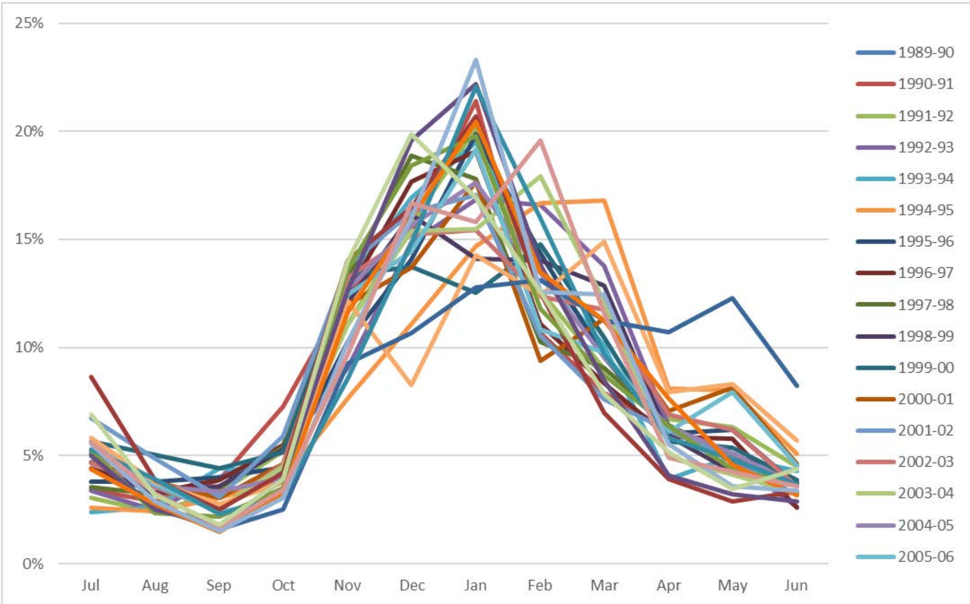


Figure 55. Class 9 data showing monthly changes in ewe slaughter patterns (percentage of ewes slaughtered relative to total ewes slaughtered).

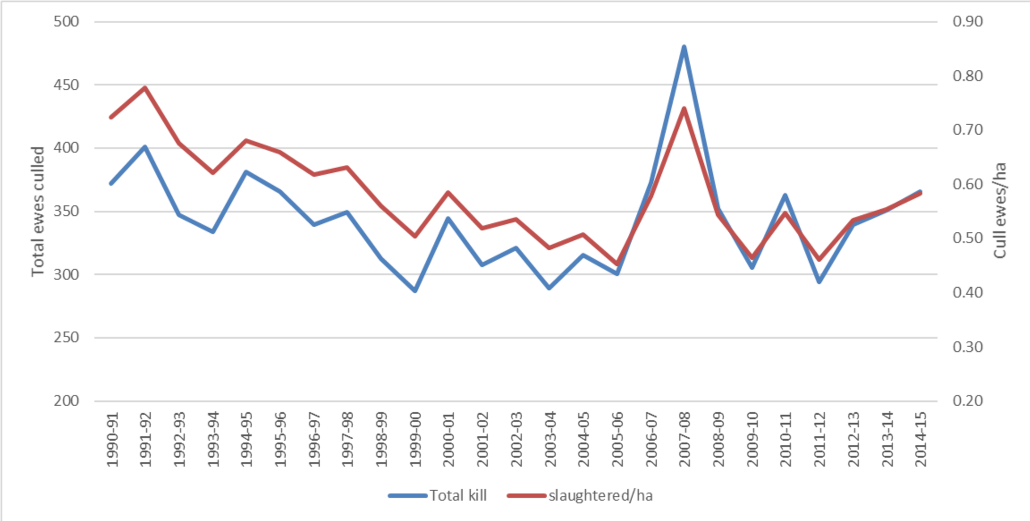


Figure 56. Total number of ewes culled on the Class 9 farms relative to the number of ewes culled per hectare.

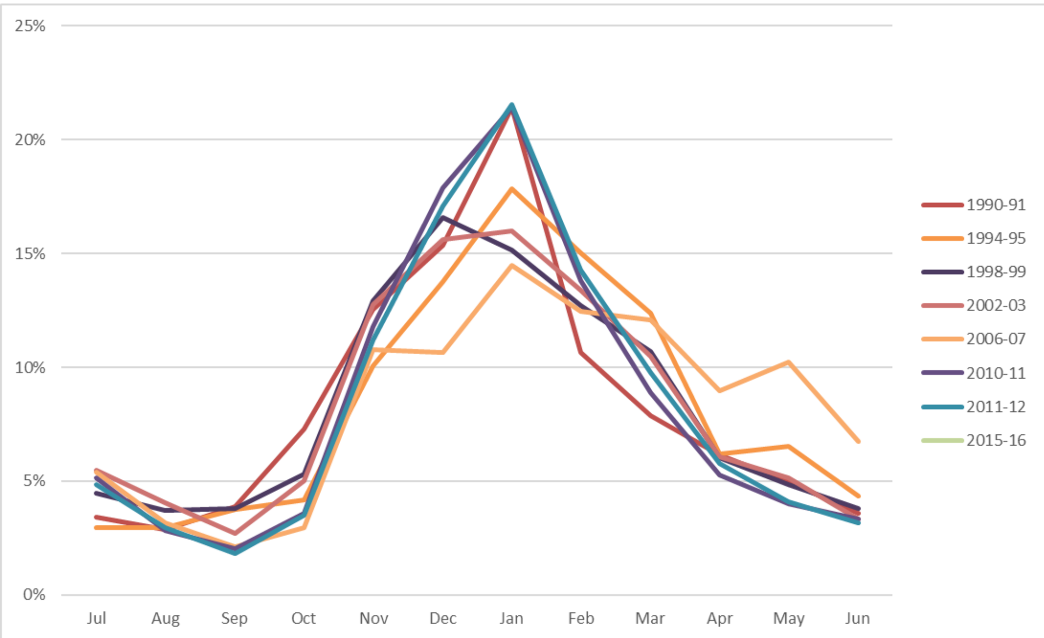


Figure 57. Farmax ewe slaughter profiles, based on 3 year rolling averages.

Ewe replacement rates

The Class 9 data have been used to evaluate changes in ewe replacement rates, where replacement rates have been calculated according to the number of two tooth ewes on hand at opening relative to the total number of ewes mated (mixed age + two tooth). Whilst results are relatively "noisy" there is an overall

lift of 2% in ewe replacement rates, with the low values obtained for 2009-10 likely an anomaly resulting from the reduction in the number of sheep per hectare (see Figure 58).

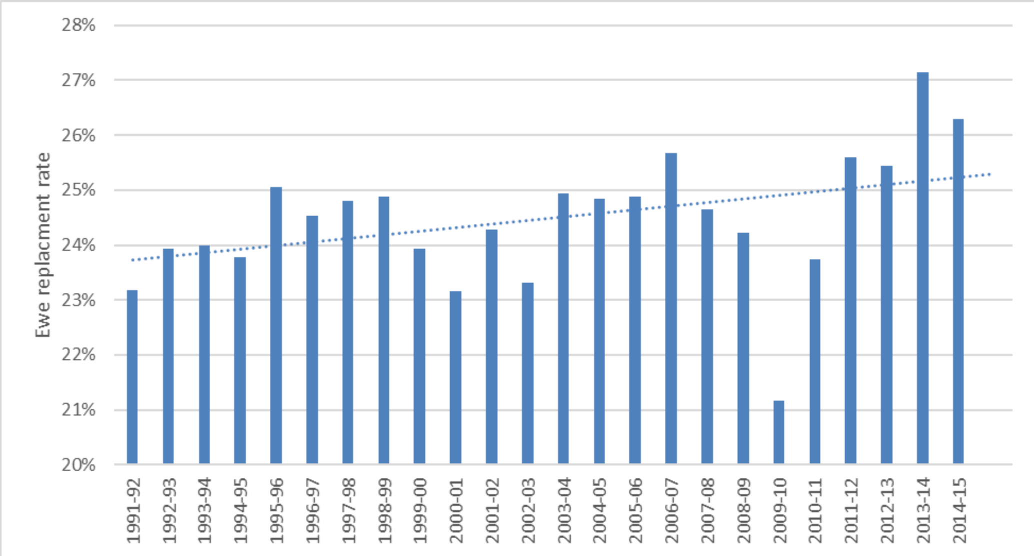


Figure 58. Variation in ewe replacement rates for Class 9 farms over time.

Appendix 2 – Historical feed data

Class 9 data

Class 9 data for feed type are shown in Table 19. Results for feed type were then scaled to 1,000 ha effective area to enable a comparison of changes in feed data. Results are summarised in Figure 59 and show that there have been:

- Small increases in the amount of new grass planted, as well as summer and winter feed plantings, whilst rates of over-sowing and hay and silage production have remained relatively static over time[20].
- There have only been small changes in the area used for supplemental feed usage (summer feed, winter feed, hay/silage) with land area per 1,000 hectares increasing from 5 to 6%.

Table 19. B+LNZ Class 9 feed data.

	Land area		Feed type				
	Effective area	Total area	Summer feed	Winter feed	New Grass	Over-sown grass	Hay & Silage
1990-91	514	515	2	10	7	4	13
1991-92	516	525	2	10	6	2	12
1992-93	514	548	1	10	6	3	17
1993-94	538	578	2	9	6	2	14
1994-95	560	605	2	10	7	3	13
1995-96	555	599	2	11	7	2	18
1996-97	549	596	2	11	7	1	15
1997-98	554	598	4	13	9	* 2	14
1998-99	558	604	2	12	10	2	15
1999-00	569	615	3	13	9	2	18
2000-01	589	636	3	13	10	3	15
2001-02	593	648	5	14	14	3	21
2002-03	599	650	4	15	14	1	16
2003-04	600	661	4	13	13	1	16
2004-05	623	690	4	13	13	5	17
2005-06	664	734	4	14	13	2	15
2006-07	645	716	4	14	11	2	17
2007-08	649	722	3	15	10	5	14
2008-09	649	724	4	17	11	1	17
2009-10	658	728	4	18	12	1	19
2010-11	663	754	4	18	12	3	18
2011-12	640	745	5	17	13	5	23
2012-13	635	741	5	17	13	3	15
2013-14	634	740	5	16	13	5	17
2014-15	627	732	5	16	11	3	15

* Estimated value (data not available)

[20] Note that there is no way to accurately determine if there has been any "double counting" where crops were planted prior to pasture renewal, but this is unlikely to have had a significant effect on the overall result outcomes.

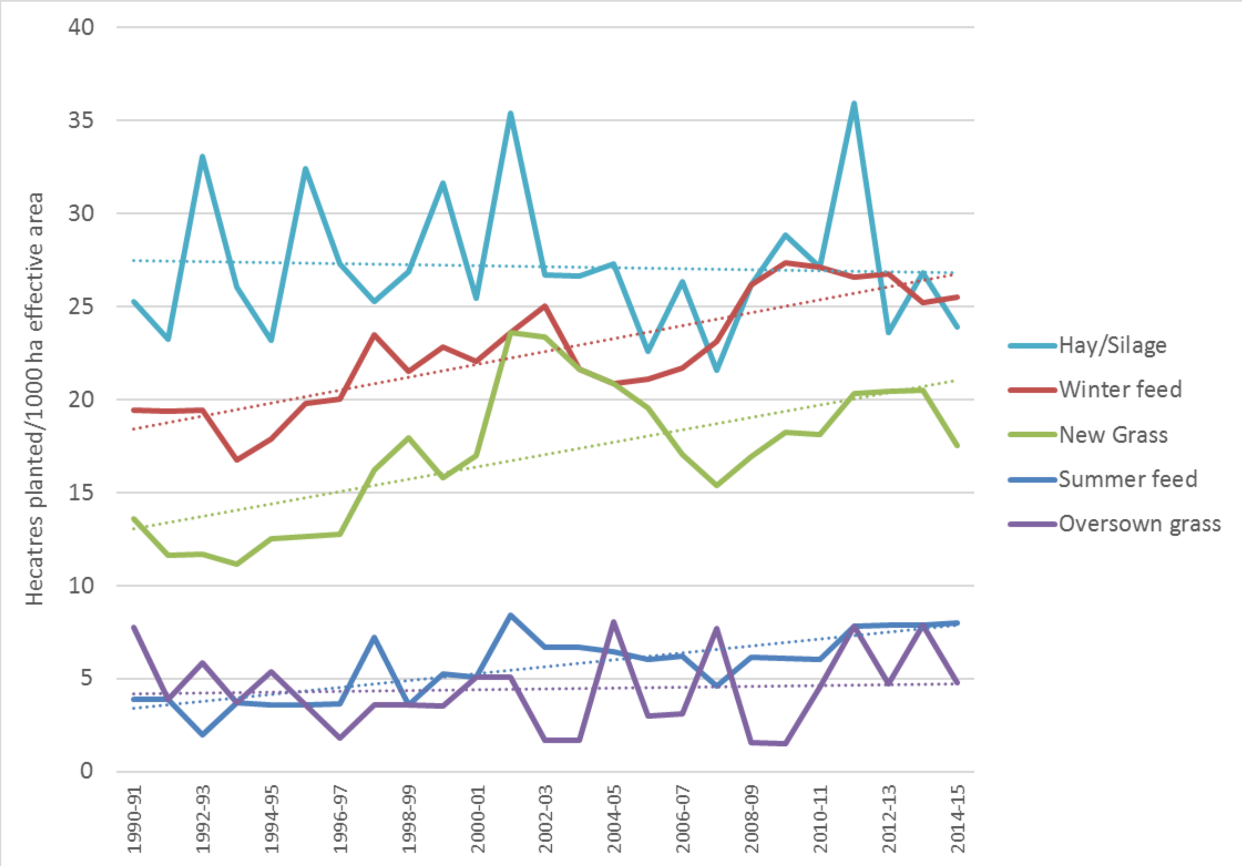


Figure 59. Estimated area of land (per 1,000 hectares) allocated to pasture renewal, over-sowing, hay & silage, winter and summer feed plantings.

Pasture renewal rates

Pasture renewal rates for new grass and over-sowing calculated according to the assumptions below with results ranging from 1.5 to 2.9 % (see Table 20). The average pasture replacement rate over the entire period was estimated at 2.1%, which is consistent with the 2% reported by BERL for 2006-07 sheep and beef farms[21].

- Pasture renewal was restricted to flat and rolling terrain, with a 50% higher renewal rate on flat than rolling land.
- Over-sowing was restricted to rolling and steep terrain, with the total over-sowing split in proportion to land type (i.e. average rate of re-sowing was independent of terrain type). Over sowing is assumed to exclude any crop establishment, but is focussed on pasture improvement though the introduction of new seed and fertiliser.

[21] http://www.pasturerenewal.org.nz/resources/research-articles-and-literature-reviews/report-unearths-nz-pasture-riches/

- The annual pasture renewal cycle which follows crops will include use of species such as chicory and plantain, which in this analysis are regarded as pasture components as distinct from supplementary feed through crops.

Table 20. Estimated area of pasture renewal and over-sowing per 1,000 ha of effective area (Includes land associated with sheep, beef, with renewal rates assumed to be 50% higher on flat versus rolling terrain).

	Pasture renewal (ha)		Over-sowing (ha)		Total pasture replacement (ha)			Average pasture replacement rate
	Flat[22]	Rolling	Rolling	Steep	Flat	Rolling	Steep	
1990-91	9.4	4.2	2.6	5.2	9.4	6.8	5.2	2.1%
1991-92	7.9	3.7	1.3	2.5	7.9	5.1	2.5	1.6%
1992-93	8.2	3.5	2.2	3.7	8.2	5.6	3.7	1.8%
1993-94	7.6	3.5	1.3	2.4	7.6	4.9	2.4	1.5%
1994-95	8.4	4.1	2.0	3.4	8.4	6.1	3.4	1.8%
1995-96	8.5	4.2	1.4	2.2	8.5	5.5	2.2	1.6%
1996-97	8.7	4.1	0.7	1.1	8.7	4.8	1.1	1.5%
1997-98	10.8	5.4	1.4	2.2	10.8	6.9	2.2	2.0%
1998-99	11.9	6.1	1.4	2.2	11.9	7.5	2.2	2.2%
1999-00	9.9	5.9	1.5	2.0	9.9	7.4	2.0	1.9%
2000-01	10.7	6.3	2.1	3.0	10.7	8.4	3.0	2.2%
2001-02	15.3	8.3	2.2	2.9	15.3	10.5	2.9	2.9%
2002-03	14.6	8.8	0.7	0.9	14.6	9.5	0.9	2.5%
2003-04	13.6	8.1	0.7	0.9	13.6	8.8	0.9	2.3%
2004-05	13.1	7.7	3.0	5.0	13.1	10.8	5.0	2.9%
2005-06	11.7	7.9	1.2	1.8	11.7	9.0	1.8	2.3%
2006-07	10.1	6.9	1.2	1.9	10.1	8.2	1.9	2.0%
2007-08	9.0	6.4	3.1	4.6	9.0	9.5	4.6	2.3%
2008-09	9.4	7.6	0.6	0.9	9.4	8.2	0.9	1.8%
2009-10	10.1	8.2	0.7	0.9	10.1	8.8	0.9	2.0%
2010-11	10.1	8.0	1.8	2.7	10.1	9.8	2.7	2.3%
2011-12	11.0	9.4	3.4	4.4	11.0	12.8	4.4	2.8%
2012-13	10.5	10.0	2.1	2.6	10.5	12.1	2.6	2.5%
2013-14	10.5	10.0	3.6	4.3	10.5	13.6	4.3	2.8%
2014-15	9.1	8.5	2.2	2.6	9.1	10.7	2.6	2.2%

Farmax data

Farmax Ltd was commissioned to extract an anonymised data set summarising the average rates of supplement usage by sheep and beef farms since 2001. Results are shown in Figure 60 where the total volume of supplement usage has increased from 6 to 10% over time, with fodder, conserved pasture, (hay and silage, baleage) winter forage and brassicas accounting for over 80% of total supplement used.

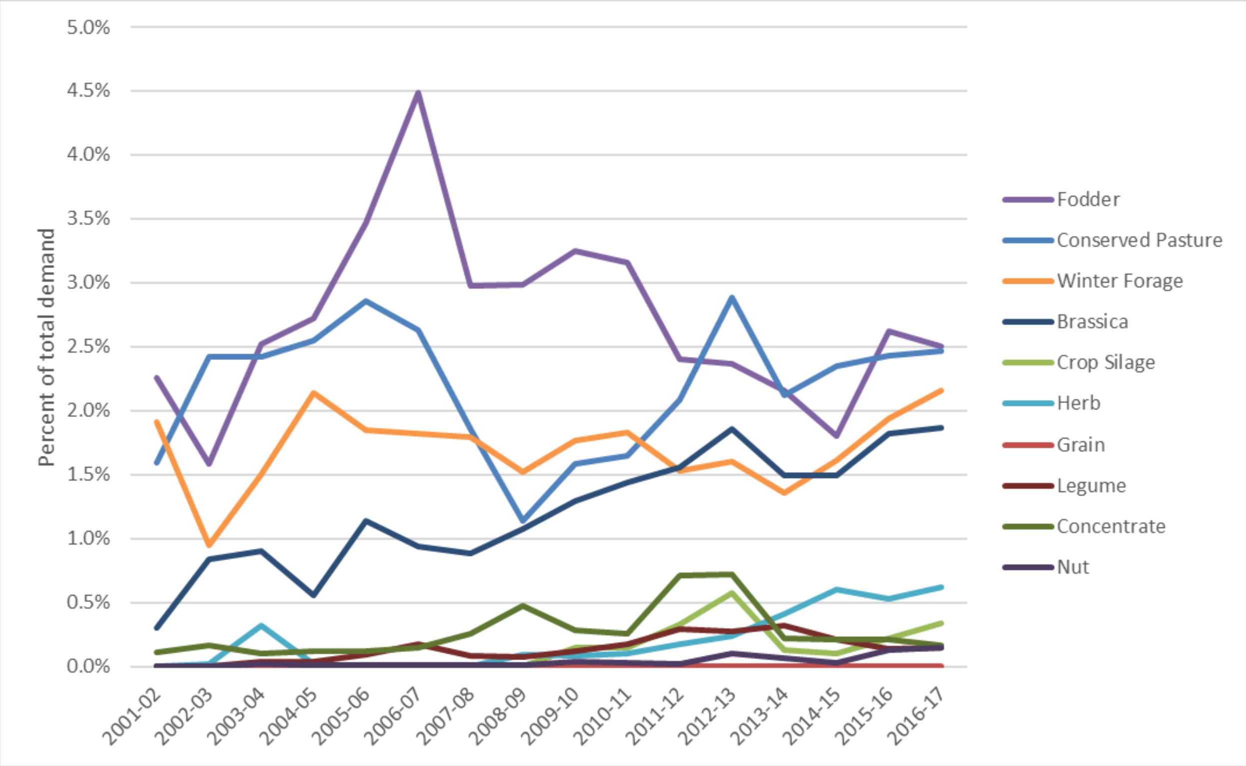


Figure 60. Farmax data for supplement usage (percentage of total feed) in sheep and beef farms since 2001.

Comparison of Class 9 and Farmax supplementary feed data

With crops such as brassicas being used as both summer and winter supplementary feed types, it is difficult to make a direct comparison of usage of individual supplement types.

Figure 61 shows a comparison of the total proportion of demand met by supplement as recorded in the B+LNZ Class 9 data sets, and as reported by Farmax. Results for 2002-03 are closely aligned, with Farmax showing higher rates of supplement usage in later seasons. This is consistent with the Farmax running files being dominated by North Island properties which have higher proportion of cattle stock units. It is also important to note that the Farmax users may not reflect “typical” sheep and beef data, with many Farmax users likely to be at the higher performing end of the spectrum.

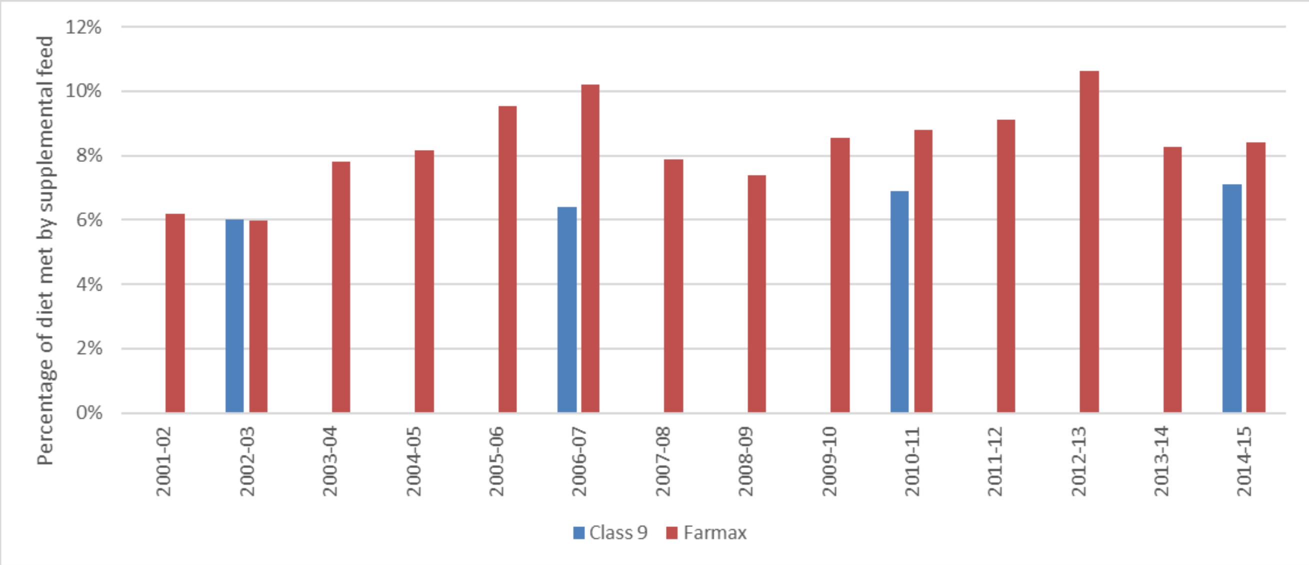


Figure 61. Comparison of rates of supplement usage reported within the B+LNZ Class 9 data sets and data supplied by the Farmax support group.

Appendix 3 – Farmax Modelling

Farmax was used to model a sequential set of historical Class 9 farms. The stock classes included for each livestock enterprise are outlined in Table 21.

Table 21. Class 9 livestock classes modelled.

Sheep	Beef cows	Dairy grazing	Ex dairy	Deer
Ewes	Cows	Wintered dairy cows	Ex-dairy bull calves	Hinds
Ewe hoggets	R2 heifers	Heifer calves	Ex-dairy R1 bulls	R2 replacement hinds
Ewe lambs	R1 heifers	R1 Heifers	Ex-dairy R2 bulls	R1 replacement hinds
Mixed lambs	Heifer calves		Ex-dairy heifer calves	Hind fawns
Wintered lambs	Steer calves		Ex-dairy R1 heifers	R1 finishing hinds
Terminal ewes	R1 steers			R2 finishing hinds
Rams	R2 steers			R2 venison Stags
Ram hoggets	Bull calves			R1 venison Stags
Ram lambs	R1 bulls			Stag fawns
	Bulls			R1 velvet stags
				R2 velvet stags
				MA velvet Stags

The production models developed for project 17893 were used as a starting point, with the 1990 and 2015 sheep, beef, ex-dairy beef and deer models imported into a new "whole farm" and then scaled to match the number of breeding stock in the B+L Class 9 data sets. The production characteristics remained the same with Table 22 showing the key production parameters, and Table 23 the feed demand per breeding female mated, for the sheep, beef, and deer enterprises modelled.

Table 22. Production estimates (kg product sold/breeding female) as reported in Table 1 of the project 17893 report.

		1989/90	2014/15	Change
Dry-stock systems: Sheep, beef, deer & goats				
Sheep	Meat	13.57	23.59	74%
	Wool	8.00	8.00	0%
	Total	21.57	31.59	46%
Beef		178.27	187.69	5%
ex Dairy beef	Bulls and steers	73.83	39.05	-47%
	Heifers	6.06	6.04	-0.3%
	Total	79.88	45.08	-44%
Deer	Venison	42.05	45.64	9%
	Velvet	0.51	1.06	111%
	Total	42.55	46.71	10%

Table 23. Feed demand per breeding female (kg DMI mated) as reported in Table 3 of the project 17893 report.

		1989/90	2014/15	Change
Dry-stock systems: Sheep, beef, deer, & goats				
Sheep		654	858	+31%
Beef		6,823	7,136	+5%
ex-Dairy beef	Bulls & steers	1,207	656	-46%
	Heifers	112	104	-7%
	Total	1,319	760	-42%
Deer:		2,185	2,396	+10%
Goat: meat			527	-
Dairy systems: Cows and goats				
Dairy cows		5,151	5,445	+6%
Dairy goats		-	1,256	-

Interim models were then developed (based on the Class 9 data) to span the period from 1990-91 to 2014-15, with these models then optimised to account for variations in in the Class 9 data versus expected levels of performance identified in project 17893.

Table 24 shows the key parameters used in the setup of the Class 9 models, along with a detailed description of the sheep mating and reproductive data, and slaughter data.

The Class 9 models for the historical beef ex-dairy, dairy grazing and deer models are shown in Table 25. Note that within project 17893, dairy grazing was not included within the dry-stock systems modelled, but allowance has been made for this within the Class 9 models developed for this report.

Table 24. Key parameters used in the setup for the historical Farmax models, and sheep enterprise.

	1990-91	1994-95	1998-99	2002-03	2006-07	2010-11	2014-15
Land and terrain data							
Land area	514	560	558	599	645	663	627
% Flat	22%	23%	23%	24%	21%	19%	20%
% Rolling	26%	29%	30%	34%	31%	33%	37%
% Steep	52%	48%	47%	43%	48%	48%	43%
Plantings[23]							
Summer feed (ha)	2.0	2.6	2.9	3.6	4.3	4.8	5.0
Winter feed (ha)	10.0	11.5	12.0	13.5	15.2	16.2	16.0
New Grass (ha)	7.0	8.0	8.3	9.3	10.5	11.2	11.0
Over-sown grass (ha)	4.0	4.1	3.8	3.8	3.7	3.5	3.0
Hay/Silage (ha)	13.0	14.0	13.9	14.7	15.7	16.0	15.0
Mating and reproductive data							
MA and 2 tooth ewes mated[24],[25]	2020	2117	2026	2086	2149	2110	1902
Ewes mated/ha	3.93	3.78	3.63	3.48	3.33	3.18	3.03
Ewe mate weight[26]	52	54	56	58	60	62	64
Average mate date[27]	21 Mar	22 Mar	24 Mar	23 Mar	23 Mar	23 Mar	22 Mar
Average lambing date	24 Aug	25 Aug	27 Aug	26 Aug	26 Aug	26 Aug	25 Aug
Lambs tailed per ewe mated[28]	103%	107%	115%	119%	125%	123%	129%
Lambs from ewes[29]	2041	2069	2334	2569	2711	2423	2439
Lambs from hoggets[30]	0	4	25	94	121	99	114
Ewe replacement rate[31]	24%	24%	24%	24%	24%	24%	24%
Slaughter data							
Lambs slaughtered[32]	1,448	1,648	1,766	2,024	2,164	1,959	1,928
Average lamb carcase weight[33]	14.5	15.2	15.8	16.5	17.2	17.9	18.6

[23] Based on linear trends for the class 9 data for summer and winter feed, and baleage & silage usage
[24] Total ewes mated includes maternal and terminal mated mixed age ewes, and maternal mated two tooth ewes. The maternal mixed age and two tooth ewes have been modelled as a single livestock class, with 20% of the total ewes assumed to be terminally sire mated.
[25] The total number of ewes mated has been calculated by scaling the Class 9 land area to 1,000 hectares, and then applying a linear trend to estimate the number of ewes mated in the selected seasons
[26] Based on linear trends established within the project 17893 data
[27] Based on class 9 data
[28] Based on a 3-year rolling average for the class 9 data (hogget mating excluded)
[29] Based on a 3-year rolling average for the class 9 data
[30] Based on a 3-year rolling average for the class 9 data
[31] Whilst Figure 58 does show a small lift in ewe replacement rates over time, this has been modelled as remaining constant at 24% (to eliminate variation due the major swings observed between years).
[32] Calculated by Farmax after allowance for replacement ewes and expected losses.
[33] Based on linear trends established within the project 17893 data.

Table 25. Key parameters used in the setup of the historical Class 9 beef, ex-dairy, dairy grazing and deer livestock enterprises.

	1990-91	1994-95	1998-99	2002-03	2006-07	2010-11	2014-15
Beef							
Number of cows[34]	47	66	62	63	72	75	74
Average cow weight (kg)[35]	455	461	466	472	477	483	490
Average cow carcase weight (kg)	228	230	233	236	239	242	245
Average heifer carcase weight (kg)	213	218	222	227	232	237	242
Ex dairy slaughter stock (B+LNZ)							
Estimated number of bulls[36]	19	23	22	42	43	29	37
Estimated number of steers[37]	2	3	2	5	5	3	4
Estimated number of heifers	3	4	4	9	10	7	10
Average heifer carcase weight (kg)	184	189	194	199	204	209	214
Dairy Grazing							
Estimated number of dairy cows	10	16	24	29	30	31	32
Estimated number of dairy heifers	15	25	36	46	47	48	49
Average dairy cow weight (kg)	465	469	472	476	479	483	485
Average heifer carcase weight (kg)	184	189	194	199	204	209	214
Deer							
Number of hinds mated[38]	28	32	53	59	63	48	43
Number of stags on hand at 30 June	23	27	31	31	34	26	26
Average hind weight (kg)	103	105	107	109	111	113	115
Average stag weight (kg)	195	199	203	207	211	215	219

Pasture quality assumptions

The average quality of pasture is described as megajoules of metabolizable energy (MJME) per kg of dry matter offered. Within Farmax, this is based on the default values applied to low, medium and high-quality pasture[39]. These are dependent on the relative amounts of green, dead and stem components of the pasture with a breakdown of this for high quality pasture shown in Table 26.

[34] Beef cow, dairy origin and dairy grazing stock numbers based on the 3-year rolling averages for the class 9 data
[35] All weights based on linear trends established within the project 17893 data
[36] Based on B+LNZ class 9 data
[37] The number of heifers and steers is based on a linear regression of the project 17893 data for the ratio of ex dairy heifers to bulls, with 90% of males sold assumed to be bulls and 10% steers, and the number of heifers based on the relative proportions of heifers to bulls identified within the project 17893 report.
[38] The number of hinds and stags mated have been calculated based on Stats NZ data for the total number of hinds and stags on hand at 30 June, divided by the number of class 9 farms reported by B+LNZ.
[39] Note that the values for low, medium and high-quality pasture are based on a simplified version of an initial pasture model designed my David McCall, and subsequently implemented within Stockpol, from which the current version of Farmax was derived. http://mro.massey.ac.nz/bitstream/handle/10179/3556/02_whole.pdf?sequence=1&isAllowed=y

Table 26.High quality pasture component assumptions.

	High quality pasture - kg DM/ha				MJME/kgDM
	Green	Dead	Stem	Total	
Jul	1,308	69		1,377	10.1
Aug	1,318	69		1,388	10.5
Sep	1,515	121		1,637	11.1
Oct	1,455	171	83	1,708	11
Nov	1,301	168	208	1,678	10.9
Dec	1,338	273	232	1,843	10.4
Jan	1,448	464	157	2,069	10.2
Feb	1,463	506	52	2,021	10.1
Mar	1,472	430		1,902	9.6
Apr	1,693	362		2,055	9.8
May	1,573	227		1,800	10
Jun	1,455	120		1,575	9.9

Table 27 shows the quality assumptions for pasture on offer for the different terrains, with total demand for each stock class calculated from average demand per head multiplied by the number of animals. The dry matter supplied through pasture consumption is then calculated according to average terrain type.

Table 27. Farmax estimates for the average quality of pasture offered (MJME per kg DM), where flat terrain is assumed to have high quality pasture, whilst rolling and steep terrain are assumed to have medium and low-quality pasture on offer.

Pasture & terrain type	High quality/ Flat	Medium quality/ Rolling	Low quality/ Steep
Jul	10.1	9.6	9.1
Aug	10.5	9.6	9.4
Sep	11.1	10.0	10.5
Oct	11.0	10.8	10.5
Nov	10.9	10.8	10.5
Dec	10.4	10.7	9.9
Jan	10.2	10.0	9.8
Feb	10.1	9.9	9.8
Mar	9.6	9.8	8.7
Apr	9.8	9.2	8.9
May	10.0	9.4	9.2
Jun	9.9	9.6	9.1

Average quality of pasture consumed (MJME per kg DM)

The average ME (MJME) content of pasture consumed for the 1990-91 and 2014-15 seasons was determined according to the feed quality required to generate the production performance identified for sheep within project 17893. Linear increases have been used to account for pasture quality improvements between 1990-91 and 2014-15, with the base pasture quality values used within the Class 9 models, relative to the NZGHG inventory[40] shown in Table 28 below[41].

Table 28. Assumed average MJME pasture values consumed by sheep.

Month	Inventory	1990-91	1994-95	1998-99	2002-03	2006-07	2010-11	2014-15
July	10.8	9.6	9.7	9.8	9.9	9.9	10.0	10.1
August	10.8	10.0	10.1	10.2	10.3	10.3	10.4	10.5
September	11.4	10.8	10.9	10.9	11.0	11.0	11.1	11.1
October	11.4	10.8	10.8	10.9	10.9	10.9	11.0	11.0
November	11.4	10.7	10.7	10.8	10.8	10.8	10.9	10.9
December	9.9	10.0	10.1	10.1	10.2	10.3	10.3	10.4
January	9.9	9.9	10.0	10.0	10.1	10.1	10.2	10.2
February	9.9	9.8	9.9	9.9	10.0	10.0	10.1	10.1
March	9.6	9.2	9.3	9.3	9.4	9.5	9.5	9.6
April	9.6	9.4	9.5	9.5	9.6	9.7	9.7	9.8
May	9.6	9.6	9.7	9.7	9.8	9.9	9.9	10
June	10.8	9.4	9.5	9.6	9.7	9.7	9.8	9.9

Impact of changes in terrain and pasture management

Figure 62 shows differences in the average quality of pasture offered versus consumed for the 1990-91, 2002-03, and 2014-15 seasons. Changes in Class 9 terrain type show that the average quality of pasture on offer increased between 1990 and 2002 (where changes in effective land area relative to total resulted in a loss of steep terrain), but then dropped again as flat land was lost due to dairy expansion. The models developed for project 17893 required a significant lift in the average quality of feed consumed to achieve the productivity gains identified through analysis of industry data, with these gains achieved through improved animal and pasture management.

[40] Detailed methodologies for agricultural greenhouse gas emission calculation. Version 2: MPI technical paper No: 2013/27

[41] Note that no allowance was made for the use of supplements within the original analysis, and this may lead to a slight overestimation of the winter pasture ME values used for emission estimates within this analysis, but are expected to have had no substantial impact on result outcomes.

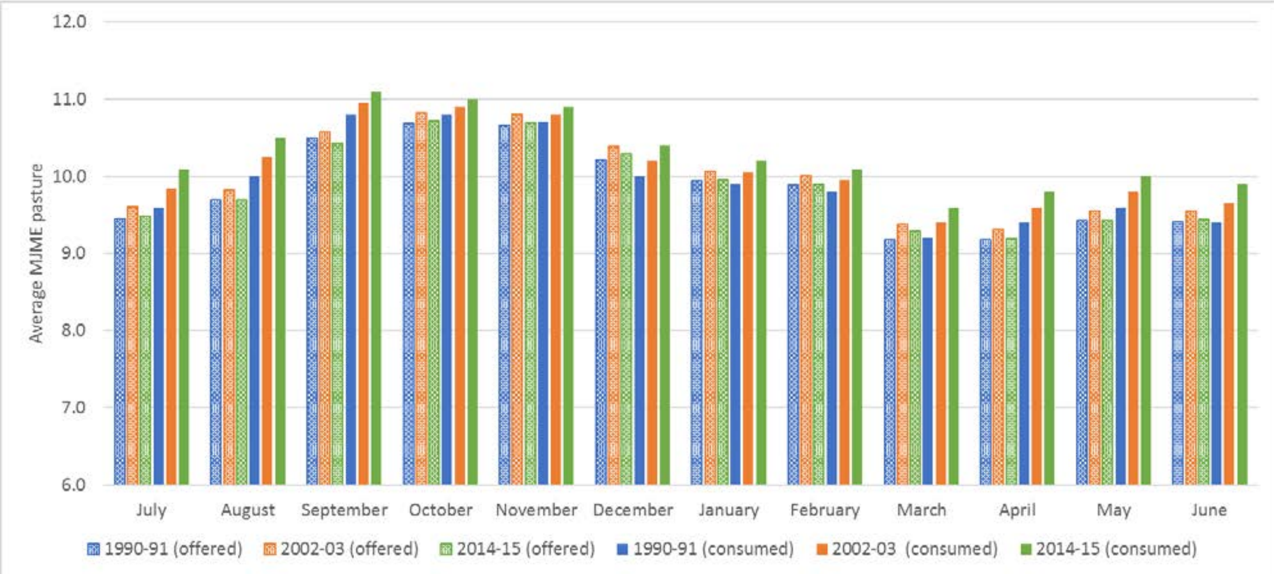


Figure 62. Differences between the average MJME content of feed consumed (solid bars), versus MJME content of feed offered (patterned bars) and used in the total feed demand calculations.

Future pasture quality estimates

Within project 17893, the Farmax model estimates of feed intake were adjusted to meet the increased production demands, with the models optimised according to expected pasture availability and supplemental feed requirements. Fertiliser usage within the project 17893 future scenarios (conservative and high) was calculated according to the 2014/15 base load, with 33% of the additional feed required to meet the 2030 production scenarios came from increased N fertiliser usage[42] and the remaining 67% of additional feed is assumed to come from improvements in pasture management and cultivars.

The future models required for this project require an evaluation of potential future supplement usage. To enable this, we have assumed that the average quality of pasture offered will continue to improve. This is likely to be achieved through ongoing improvements in both cultivars available to farmers, and in pasture management. Whilst the absolute scale of these improvements is unknown, we have modelled these via improvements in the quality of pasture offered on the rolling and steep hill country terrain. This is demonstrated in Figure 63 where, with no changes in terrain, the average quality of feed available on rolling and steep terrain increases to match the high and medium quality pasture estimates currently applied to the flat and rolling terrain types[43].

[42] Nitrogen fertiliser response rate equals 10 kg of dry matter per kg of N applied

[43] Note that to ensure consistency with project 17893, no changes were made to the average feed quality of pasture consumed within the 2030 scenarios.

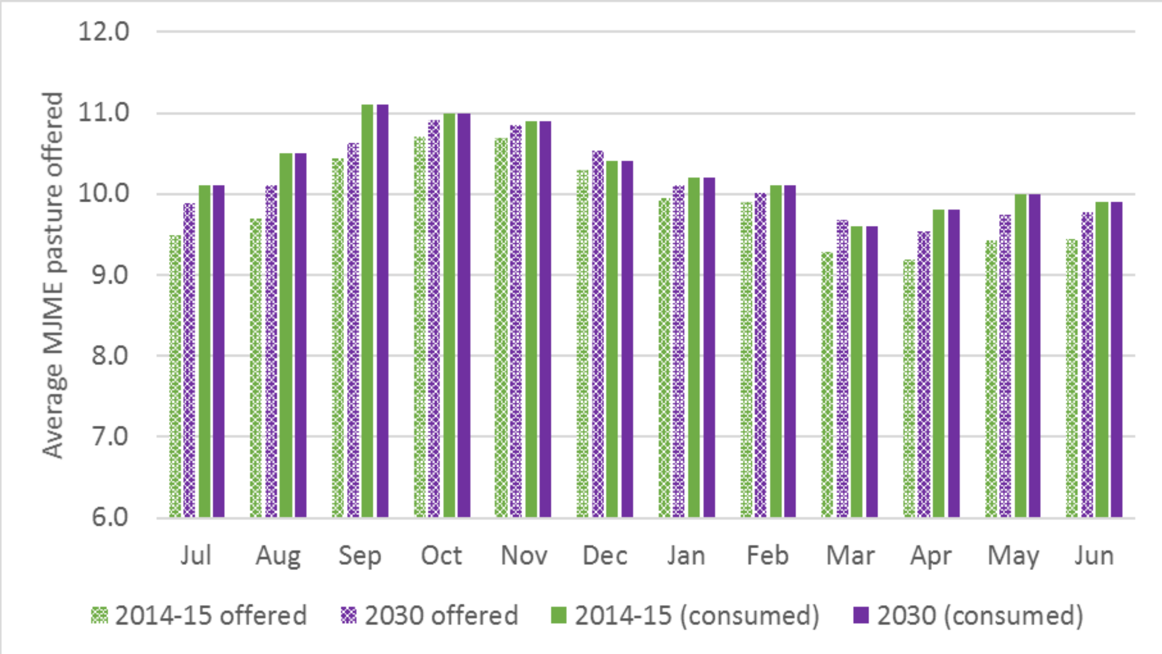


Figure 63. Differences between average quality (MJME/kg DM) of feed consumed (solid bars), versus quality (MJME/kg DM) of feed offered (patterned bars).

Stock class adjustments

A range of adjustments have been made to account for preferential feeding of some stock classes over others. The rationale for these changes is that lambs will be fed preferentially compared to ewes, whilst the average quality of feed consumed by cattle is expected to be lower than that consumed by sheep, with the biggest impacts in the cows and R2 heifer stock classes. Conversely, ex-dairy beef and dairy grazing calves are likely to be treated like lambs throughout the December – February period, and as such consume higher quality feed than the other stock classes. Table 29 shows a summary of the preferential feed allocation values, where:

- Pasture ME values are multiplied by 1 + the adjustment value to calculate average quality for feed consumed by each stock class each month. For example, in December 1995, the average quality (MJME/kg DM) of feed consumed by the following stock classes is calculated as:
    - Ewes (post-weaning) and Rams: 9.9 * 0.98 = 9.7
    - Lambs (weaned), ex dairy and dairy grazing calves: 9.9 *1.05 = 10.4
    - Cows, R2 heifers & Bulls 9.9 * 0.95 = 9.4
- Values for missing stock classes or months, are taken as the average quality of pasture as shown in Table 28 above.

Table 29. Preferential allocation of feed relative to average feed quality made available for sheep.

	Sheep			Beef	Ex dairy	Dairy grazing
Month	**Ewes**	**Rams**	**Lambs**	**Cows, R2 heifers & Bulls**	**Ex dairy calves**	**Calves**
July	-2%		0	-8%		
August				-8%		
September				-4%		
October				-4%		
November				-4%		
December	-2%	-2%	+5%	-5%	+5%	+5%
January	-2%	-2%	+5%	-5%	+5%	+5%
February	-2%	-2%	+5%	-5%	+5%	+5%
March	-2%	-2%	+5%	-5%		
April			+2%	-2%		
May			+2%	-2%		
June	-2%	-2%		-8%		

Supplement usage

Supplements have been incorporated into the Farmax models as specified by the Class 9 data requirements. The supplements used include the following:

Summer feed: Modelled as leafy turnips, but which could also include other commonly used supplements such as rape crops.

Winter feed: Modelled as swedes, kale and fodder beet, but which would also include other commonly used supplements such as winter turnips and cereal green-feeds.

Hay and silage: Modelled as baleage and barley silage

Data supplied by the Farmax support group, show a small volume of concentrates such as sheep nuts or barley grain have also been used. To account for this data (which has not been available within the crop information provided by the Class 9 data set, a small volume of sheep nuts were included in some farm system models. The quality (MJ ME/kg DM) and utilisation rates for these supplements are shown in Table 30 with all supplemental feed usage calculations based on kg of dry matter consumed.

Table 30. Supplement Dry Matter (DM) percentage, utilisation rates and kg of DM intake per kg of supplement consumed.

	Unit size (kg)	DM%	MJME/kgDM	Utilization	Kg DM consumed/unit
Baleage (big bales)	525	38%	10.0	100%	200
Barley silage	1000	100%	10.0	75%	750
Fodder Beet	1000	100%	12.8	100%	1000
Kale	1000	100%	11.0	75%	750
Leafy turnip	1000	100%	12.5	82%	820
Sheep nuts	1002	100%	13.0	90%	902
Swedes	1000	100%	12.8	80%	800

Appendix 4 - Feed tracking model

Total demand

Excel models have been developed to track historical and potential feed demand according to feed type (pasture or supplement), stock class, and month.

For each enterprise, feed is tracked for individual stock classes with key inputs including:

- Total demand (kg DM per head per day) for the month
- Average number of animals for the month

These values are then combined to estimate total feed demand for each livestock enterprise. Table 31 shows an example of this for the sheep enterprise, which clearly demonstrates the annual changes in feed demand for ewes[44] throughout pregnancy and lactation, and lambs, as they are weaned and then slaughtered according to the 2014-15 Class 9 slaughter patterns.

[44] Note that within the Farmax models, the terminal ewes are mobbed up with the main ewe group from December to February, with all feed demand for this group included within the main ewe mob.

Table 31. Total estimated demand for sheep in the 2014-15 season, broken down by stock class and month (kg DM).

2014-2015	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
July	68,674	14,373	0	0	8,898	16,963	1,455	887	0	111,250
August	79,158	17,041	0	0	8,052	19,985	1,349	929	0	126,514
September	99,015	19,766	0	0	7,232	24,570	1,341	804	0	152,728
October	114,271	25,425	0	0	2,827	29,765	1,423	421	0	174,132
November	104,242	26,113	3,116	8,333	0	27,428	1,413	437	0	171,082
December	60,016	22,056	26,524	48,813	0	2,085	1,469	368	0	161,331
January	55,978	17,330	27,617	41,029	0	0	1,693	164	404	144,215
February	48,582	16,946	20,188	34,194	0	0	1,671	0	688	122,269
March	58,545	11,050	17,034	38,169	0	5,514	836	0	1,071	132,219
April	56,986	0	13,997	26,065	0	13,716	217	0	1,191	112,172
May	56,847	0	14,701	15,636	0	14,136	1,343	0	1,055	103,718
June	57,796	0	13,077	12,640	0	14,478	1,307	0	883	100,181
Total	**860,110**	**170,100**	**136,254**	**224,879**	**27,009**	**168,640**	**15,517**	**4,010**	**5,292**	**1,611,811**

Supplement allocation

Within Farmax, supplements are applied to the whole farm, and usage is tracked according to the total percent of monthly demand met by supplements. The feed tracking model uses this data to “allocate” supplements to individual stock classes. The total volume of each supplement is calculated as a percentage of total feed demand (over all stock classes) for the month, and then allocated to individual stock classes according to the percentage of diet expecting to be met by each supplement, with “fine balancing” used to ensure supplement allocation equals supplements used.

Table 32 shows an example of the allocation model for July in the 2014-15 Farmax system model. In this model, there was a total volume of 42.7 tonnes of DM supplied through non-pasture supplements, including baleage (7.9 tonnes), kale (10.8 tonnes), sheep nuts (0.7 tonnes), and swedes (23.2 tonnes). Within this model, being mid-winter, the ewes were allocated 5% of their diet supplied by swedes, with top-ups supplied through baleage and sheep nuts. In contrast, 55% of the hogget’s diet was comprised of swedes, with an additional 10% supplied through baleage, leaving just 35% of the diet met through pasture grazing. The rationale for this is that ewes are predominantly rotated around paddocks grazing pasture, whilst hoggets are more frequently confined to a single crop paddock over winter, to ensure adequate winter growth rate. It is important to note that the allocations reflect a whole of NZ farm approach, with regional variation expected across the underlying B+LNZ farm types.

Table 32. Supplement allocation model for July 2014.

Livestock enterprise	Feed demand and supplement usage (by stock class)				Supplements allocation	
	Stock class	Demand (kg DM)	Supplement type	% of diet	kg DM	%
Sheep	Ewe Hoggets	15,153	Baleage	10%	1,485	19%
	Ewe Hoggets	15,153	Swedes	55%	8,334	36%
	Ewes	67,988	Baleage	2%	1,469	19%
	Ewes	67,988	Sheep nuts	0%	773	100%
	Ewes	67,988	Swedes	5%	3,399	15%
	Wintered lambs	6,078	Swedes	20%	1,216	5%
Beef	R1 heifers	4,235	Baleage	8%	339	4%
	R1 heifers	4,235	Kale	25%	1,059	10%
	R1 steers	4,821	Baleage	8%	386	5%
	R1 steers	4,821	Swedes	35%	1,687	7%
	R2 heifers	4,612	Baleage	3%	138	2%
	R2 heifers	4,612	Kale	12%	553	5%
	R2 steers	3,451	Swedes	35%	1,208	5%
Dairy grazing	R1 Heifer grazing	6,246	Baleage	10%	625	8%
	R1 Heifer grazing	6,246	Kale	52%	3,248	30%
	Wintered dairy cows	10,410	Baleage	30%	3,123	39%
	Wintered dairy cows	10,410	Kale	35%	3,644	34%
	Wintered dairy cows	10,410	Swedes	35%	3,644	16%
ex-Dairy	ex-Dairy bull R1	6,469	Baleage	6%	356	4%
	ex-Dairy bull R1	6,469	Swedes	58%	3,720	16%
	ex-Dairy bull R2	6,904	Kale	34%	2,323	21%

The volume of total supplement is then tracked on a monthly basis for the complete farm system model, with results for annual usage also tracked within the individual sheep stock classes. Examples are shown in Table 33 and Table 34 below.

Table 33 tracks supplement usage for the 2014-15 year according to the total voume of each supplement consumed within the 2014-15 farm system model.

- The winter crops including baleage, barley silage, kale and swedes are used extensively through the May-September period, with leafy turnips providing an additional boost through the summer months (January-April), and sheep nuts used as a boost both prior to lambing, and again prior to mating.

Table 34 tracks supplement usage within the individual sheep stock classes for the 2014-15 model.

- As a proprotion of total demand, ewe hoggets are the biggest user of supplements (16%) whilst use in lamb classes is moderate at 10% and overall use in the maternal ewe flock was just 3%[45].
- Sheep account for 58% of total supplement usage, but 68% of total feed demand, with higher relative rates of usage within the beef cattle and ex-dairy/dairy grazing enterprises[46]

[45] Note that in reality, it is likely that both the maternal and terminal-mated ewes are likely to receive similar amounts of supplemental feed usage through the winter months, but for the purpose of this analysis all of the supplemental feed was allocated to the main ewe flock.

[46] Whilst all livestock classes have been included in the supplement allocation model, the functionality to extract supplement usage by stock class for the beef, ex-dairy and dairy grazing enterprises has not yet been developed. No supplements have been allocated to the deer enterprises within the models developed.

Table 33. Supplement usage (kg of DM consumed per month) for the 2014-15 farm system model.

2014-15	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
Baleage	7,926	9,806	4,597	1,853	0	0	0	0	0	0	2,307	5,286	31,776
Barley silage	0	1,839	1,149	0	0	0	0	0	0	0	0	0	2,988
Fodder Beet													
Kale	10,826	10,011	2,988	0	0	0	0	0	0	0	1,731	10,044	35,600
Leafy turnip	0	0	0	0	0	0	4,637	11,077	7,297	4,544	0	0	27,554
Sheep nuts	773	1,226	460	0	0	0	0	426	941	413	0	0	4,239
Swedes	23,199	25,128	16,781	4,234	0	0	0	0	0	0	2,884	14,801	87,028
Total (kg DM)	42,724	48,010	25,975	6,087	-	-	4,637	11,503	8,238	4,957	6,922	30,131	189,184

Table 34. Supplement usage (kg of DM consumed) for the individual sheep stock classes within the 2014-15 farm system model.

2014-15							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,989	0	0	0	0	22,418	26,407
Ewe Lambs	1,881	0	0	6,647	0	5,275	13,803
Ewes	9,691	2,988	0	0	4,239	9,909	26,827
Mixed Lambs	0	0	0	20,689	0	2,786	23,475
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	**15,561**	**2,988**	**0**	**27,336**	**4,239**	**42,494**	**92,618**
Other Enterprises	16,214	0	35,600	219	0	44,533	96,566
Total	**31,775**	**2,988**	**35,600**	**27,555**	**4,239**	**87,027**	**189,184**
Percentage for sheep	**52%**	**100%**	**0%**	**99%**	**100%**	**51%**	**51%**

Estimation of ME intake

The average quality of feed consumed is tracked on a monthly basis for each livestock class, with the quality estimated as a weighted average (of the MJME content) of the pasture and different supplement types used. Table 35 shows an example of the feed quality estimates for feed consumed by the different stock classes in the June 2014-15 model. The average quality of pasture ME ranges from 9.7 to 9.9 after the preferential feed adjustments, with the average quality over all stock classes estimated at 9.75 MJME. When supplement usage is taken into account the average quality of feed consumed by ewes increases from 9.70 to 9.77 with the average over all stock classes for the month estimated at 9.99 MJME.

Table 35. Feed quality estimates for feed consumed by sheep in June of the 2014-15 farm system model.

	Total	Ewes	Ewe Lambs	Mixed Lambs	Terminal ewes	Rams	Ram Lambs
Supplements (kg DM)	9,626	1,761	5,392	2,473	0	0	0
Pasture (kg DM)	90,555	56,035	7,685	10,167	14,478	1,307	883
Total demand (kg DM)	100,181	57,796	13,077	12,640	14,478	1,307	883
Average pasture quality (consumed)	9.75	9.70	9.90	9.90	9.70	9.90	9.90
Average MJME consumed	9.99	9.77	10.86	10	9.70	9.90	9.90
Total ME consumed (000)	1,001	564.5	142	132.3	140.5	12.9	8.7

Estimates of methane emissions

The impact of changes in supplemental feed usage, and the resulting changes in ME have been used to model the impact on emissions from the sheep enterprise, and from the Class 9 farm system. Because the models have not specifically allowed for the tracking of both products (carcase and wool) and N fertiliser usage, emissions have been tracked according to methane (enteric fermentation and pasture manure) emissions only.

Total dry matter intake was tracked by month and stock class and used to estimate methane using three different sets of ME values.

1. Average estimated ME of feed consumed, including pasture and supplemental feed
2. Average estimated pasture ME, where pasture values have been adjusted to allow for preferential feeding of some stock classes over others.
3. Average ME estimated according to the New Zealand Greenhouse Gas inventory values.

To ensure an appropriate comparison was made, demand values for the second and third estimates were scaled according to the modelled Farmax demand and ME, resulting in the pasture demand estimates always exceeding the pasture + supplemental feed estimates, and the inventory estimates coming in higher or lower depending on the average ME value used within the inventory, relative to those calculated by the Farmax models.

The estimated total demand, feed (ME) and methane for the 2014-15 farm system model are presented in Table 36 where pasture demand for the ewes has been recalculated according to:

- Pasture only demand = $860{,}110_{kgDM} * 10.40_{MJME(Farmax\ feed)} / 10.37_{MJME\ (Farmax\ pasture)} = 862{,}896_{kgDM}$
- Inventory demand = $860{,}110_{kgDM} * 10.40_{MJME(Farmax\ feed)} / 10.64_{MJME\ (Inventory)} = 840{,}915_{kgDM}$

Table 36. Feed intake and methane estimates for the 2014-15 farm system model.

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	26,827	26,407	13,803	23,475	2,106	0	0	0	0	92,618
Total demand (kgDM)	860,110	170,100	136,254	224,879	27,009	168,640	15,517	4,010	5,292	1,611,811
% supplements	3.1%	15.5%	10.1%	10.4%	7.8%	0.0%	0.0%	0.0%	0.0%	5.7%
Average ME Farmax (MJME/kgDM)	10.40	10.86	10.68	10.71	10.78	10.50	10.31	10.62	10.18	10.53
Average ME Farmax pasture (MJME/kgDM)	10.37	10.53	10.49	10.56	10.59	10.50	10.31	10.62	10.18	10.44
Average ME Inventory (MJME/kgDM)	10.64	10.71	9.93	9.90	11.03	10.87	10.52	10.94	9.86	10.51
Pasture only demand (kgDM)	862,896	175,445	138,668	228,109	27,503	168,640	15,517	4,010	5,292	1,626,080
Inventory demand (kgDM)	840,915	172,503	146,547	243,290	26,409	162,921	15,200	3,892	5,463	1,617,140
Methane kg CO_2e (Farmax)	453,926	89,680	57,898	95,550	11,474	88,981	8,191	2,117	2,252	810,069
Methane kg CO_2e (Pasture)	455,426	92,565	58,955	96,922	11,690	88,981	8,191	2,117	2,252	817,099
Methane kg CO_2e (Inventory)	443,562	90,977	62,399	103,600	11,211	85,894	8,020	2,055	2,327	810,045

Enteric and dung methane has been estimated according to the NZGHG methodology as outlined below.

Enteric methane (CH4): This was estimated according to DM intake, and species-specific conversion factors used to estimate methane emitted per kg of DM intake[47]. Table 37 shows the factors applied for both the sheep and other enterprises, with a factor of 21.6 used for all Class 9 non-sheep stock classes. Note that no allowance has been made for variation in forage types, with the recent Australian publication (Charmley et al 2016[48]) indicating that a single methane value is appropriate for cattle fed forage diets above 70% forage.

Table 37. Factors used to estimate enteric methane output, for 1 kg of DM intake.

Conversion factors (g CH4/kg of DMI) used	
Sheep (< 1 year of age)	16.8
Sheep (> 1 year of age)	20.9
Other	21.6
Inventory conversion factors required for the individual Class 9 enterprises	
Beef cattle	21.6
Deer	21.25
Dairy cattle	21.6

Dung methane: this has been estimated according to the inventory methodology where:

1. Faecal dry matter (FDM) has been calculated according to DM intake and digestibility (D):

   FDM = DM intake * (1-D)

2. Methane yields have then been used to estimate output assuming 100% of the dung is deposited on pasture with methane yield factors (Ym) used to account for differences in output between different species.

   CH4 (pasture) = FDM * Y_m (pasture)

Where

Y_m = 0.000691 for sheep, and 0.00098198 for all other sheep stock classes.

[47] Species specific factors sourced from the detailed methodologies for agricultural greenhouse gas emission calculation, Version 2: MPI technical paper 2013/27

[48] Charmley E., Williams S. R. O., Moate P. J., Hegarty R. S., Herd R. M., Oddy V. H., Reyenga P., Staunton K. M.,Anderson A., Hannah M. C. (2016) A universal equation to predict methane total industry production of forage-fed cattle in Australia. **Animal Production Science 56**, 169–180. http://dx.doi.org/10.1071/AN15365)

Scaling process used to enable year on year comparisons

Total pasture and supplement usage has been scaled according to farm size to enable comparisons of feed intake and supplement usage relative to other years.

In the total farm model, results are simply scaled according to effective area with all results presented as demand per 1000 hectares of effective area.

For sheep, results are also scaled according to the percentage of feed required by sheep relative to the total voume consumed by all of the livestock enterprises. This enables a comparsion of changes in feed demand per 1,000 hectares of sheep effective area, as opposed to 1,000 hectares of total effective area.

Appendix 5 – Feed demand and allocation summaries

This appendix summarises key data presented in this report, with a description of tables provided summarised below.

Class 9 pasture and supplemental feed demand estimates

Table 38: Summarizes total pasture and feed demand used within the historical and 2030 models

Table 39: Summarizes total feed demand by enterprise type (sheep, beef, dairy grazing, ex-dairy and deer)

Table 40: Summary of supplemental feed estimates by type (baleage, barley silage, fodder beet, kale, leafy turnip, sheep nuts and swedes)

Class 9 – scaled to 1,000 hectares

Table 41: Summarizes total Class 9 pasture and feed demand scaled to 1000 hectares to enable across year comparisons

Table 42: Summarizes Class 9 supplements scaled to 1000 hectares

Class 9 sheep - pasture and supplemental feed demand estimates

Table 43: Summarizes total pasture and feed demand estimates for sheep

Table 44: Contains a breakdown of pasture demand estimates for sheep by stock class

Table 45: Contains a breakdown of supplemental feed demand estimates for sheep by stock class

Table 46: Contains a breakdown of total demand estimates for sheep by stock class

Table 47: Summary of supplemental feed estimates used in sheep by type

Table 48: Summarises sheep supplement usage by stock class and supplement type

Class 9 sheep - scaled to 1,000 hectares

Table 49: Summarizes total pasture and feed demand estimates for sheep (by stock class) scaled to 1000 hectares

Table 50: Summarizes Class 9 supplements used in sheep scaled to 1000 hectares

Other Class 9 pasture and supplemental feed demand estimates

Table 51: Summarizes total pasture and feed demand estimates for the beef, dairy grazing, ex-dairy and deer enterprises

Sheep ME and methane estimates

National estimates

Class 9 pasture and supplemental feed demand tables

Table 38. Summary of total pasture and supplemental feed Class 9 demand estimates (Tonnes DM).

	Pasture	Supplements	Total	% Supplements
1990-91	1,789	122	1,910	6.4%
1994-95	2,072	139	2,210	6.3%
1998-99	2,296	150	2,446	6.1%
2002-03	2,491	160	2,651	6.0%
2006-07	2,724	186	2,911	6.4%
2010-11	2,656	196	2,852	6.9%
2014-15	2,492	189	2,681	7.0%
2030 Low (-5%)	2,776	249	3,025	8.2%
2030 Low	2,763	245	3,008	8.1%
2030 Low (+5%)	2,805	255	3,061	8.3%
2030 High (-5%)	2,795	367	3,162	11.6%
2030 High	2,779	367	3,146	11.7%
2031 High (low beet)	2,779	261	3,039	8.6%
2030 High (+5%)	2,809	367	3,177	11.6%

Table 39. Total Class 9 demand (tonnes DM) by enterprise type.

	Sheep	Beef	Dairy grazing	ex-Dairy	Deer	Total	% Sheep
1990-91	1,322	361	59	100	68	1,910	69%
1994-95	1,391	500	96	136	87	2,210	63%
1998-99	1,450	489	141	222	144	2,446	59%
2002-03	1,584	503	178	227	160	2,651	60%
2006-07	1,724	599	182	226	180	2,911	59%
2010-11	1,738	603	191	186	134	2,852	61%
2014-15	1,612	604	191	156	119	2,681	60%
2030 - Low (-5)	1,683	619	201	409	119	3,031	56%
2030 - Low	1,829	619	201	238	120	3,008	61%
2030 - Low (+5)	1,974	441	201	325	119	3,061	64%
2030 - High (-5)	1,784	637	201	417	123	3,162	56%
2030 - High	1,937	637	201	245	124	3,146	62%
2030 - High (+5)	2,091	428	201	333	123	3,177	66%

Table 40. Summary of supplemental Class 9 feed estimates by type (Tonnes DM).

	Baleage	Barley silage	Fodder Beet	Kale	Leafy turnip	Sheep nuts	Swedes	Total
1990-91	28.0	0.0	0.0	21.9	11.5	3.6	56.7	122
1994-95	30.4	0.0	0.0	25.3	14.8	3.6	64.4	139
1998-99	31.3	0.0	0.0	27.9	17.7	3.3	69.7	150
2002-03	31.7	0.0	0.0	30.3	20.4	3.4	74.2	160
2006-07	34.1	3.1	0.0	34.0	27.3	3.0	84.6	186
2010-11	34.8	3.2	0.0	36.4	27.5	3.8	90.7	196
2014-15	31.8	3.0	0.0	35.6	27.6	4.2	87.0	189
2030 Low (-5%)	33.0	1.8	46.4	40.2	28.4	0.0	99.0	249
2030 Low	33.0	3.0	39.7	41.0	28.4	0.0	99.8	245
2030 Low (+5%)	33.1	3.0	49.6	41.3	28.5	0.0	99.8	255
2030 High (-5%)	33.1	3.2	160.8	41.0	28.4	0.0	100.1	367
2030 High	32.8	3.2	161.0	41.1	28.4	0.0	100.3	367
2030 High (low beet)	35.9	3.1	48.9	40.3	28.5	0.0	104.3	261
2030 High (+5%)	33.1	3.2	161.0	41.2	28.5	0.0	100.5	367

Class 9 - scaled to 1,000 hectares

Table 41. Class 9 pasture and supplements scaled to 1000 ha (Tonnes/ha).

1990-91: 514 hectares	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Tonnes per ha per annum
Total Supplements (Tonnes DM)	0.12	0.02	0.01	0.02	0.05	0.24
Pasture demand (Tonnes DM)	0.43	1.03	0.97	0.86	0.20	3.48
Total demand (Tonnes DM)	0.55	1.05	0.99	0.88	0.25	3.72
% supplements	22%	2%	2%	3%	21%	6.4%
1994-95: 560 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per ha per annum**
Total Supplements (Tonnes DM)	0.12	0.03	0.02	0.02	0.05	0.25
Pasture demand (Tonnes DM)	0.45	1.07	1.05	0.92	0.21	3.70
Total demand (Tonnes DM)	0.57	1.11	1.06	0.94	0.26	3.95
% supplements	22%	3%	1%	3%	19%	6%
1998-99: 558 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per ha per annum**
Total Supplements (Tonnes DM)	0.14	0.03	0.02	0.02	0.06	0.27
Pasture demand (Tonnes DM)	0.50	1.18	1.18	1.02	0.24	4.11
Total demand (Tonnes DM)	0.64	1.21	1.20	1.05	0.29	4.38
% supplements	22%	2%	2%	2%	20%	6%
2002-03: 599 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per ha per annum**
Total Supplements (Tonnes DM)	0.12	0.04	0.02	0.04	0.05	0.27
Pasture demand (Tonnes DM)	0.53	1.21	1.18	1.01	0.24	4.16
Total demand (Tonnes DM)	0.65	1.24	1.20	1.05	0.29	4.43
% supplements	19%	3%	2%	3%	18%	6%

2006-07: 645 hectares	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Tonnes per ha per annum
Total Supplements (Tonnes DM)	0.14	0.04	0.03	0.03	0.05	0.29
Pasture demand (Tonnes DM)	0.52	1.23	1.19	1.04	0.24	4.22
Total demand (Tonnes DM)	0.66	1.27	1.22	1.07	0.30	4.51
% supplements	21%	3%	2%	3%	18%	6%
2010-11: 663 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per ha per annum**
Total Supplements (Tonnes DM)	0.14	0.03	0.03	0.04	0.06	0.30
Pasture demand (Tonnes DM)	0.50	1.18	1.13	0.98	0.22	4.01
Total demand (Tonnes DM)	0.64	1.21	1.15	1.01	0.28	4.30
% supplements	22%	3%	2%	4%	21%	7%
2014-15: 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per ha per annum**
Total Supplements (Tonnes DM)	0.14	0.05	0.03	0.03	0.05	0.30
Pasture demand (Tonnes DM)	0.49	1.15	1.12	0.98	0.23	3.97
Total demand (Tonnes DM)	0.63	1.21	1.14	1.01	0.28	4.28
% supplements	23%	4%	2%	3%	17%	7%
2030 Low (-5%): 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.18	0.08	0.03	0.03	0.07	0.40
Pasture demand (Tonnes DM)	0.53	1.19	1.34	1.09	0.26	4.43
Total demand (Tonnes DM)	0.72	1.28	1.37	1.13	0.33	4.82
% supplements	25%	7%	2%	3%	20%	8%
2030 Low: 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.16	0.10	0.03	0.04	0.06	0.39
Pasture demand (Tonnes DM)	0.53	1.20	1.34	1.08	0.26	4.41
Total demand (Tonnes DM)	0.68	1.30	1.37	1.12	0.32	4.80
% supplements	23%	8%	2%	3%	20%	8%

2030 Low (+5): 627 hectares	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Tonnes per 1000 ha per annum
Total Supplements (Tonnes DM)	0.16	0.12	0.03	0.04	0.07	0.41
Pasture demand (Tonnes DM)	0.54	1.22	1.37	1.09	0.26	4.47
Total demand (Tonnes DM)	0.69	1.34	1.40	1.12	0.33	4.88
% supplements	23%	9%	2%	3%	20%	8%
2030 High (-5): 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.23	0.22	0.03	0.04	0.06	0.59
Pasture demand (Tonnes DM)	0.50	1.13	1.37	1.18	0.28	4.46
Total demand (Tonnes DM)	0.73	1.35	1.40	1.22	0.34	5.04
% supplements	32%	17%	2%	3%	19%	12%
2030 High: 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.23	0.22	0.03	0.04	0.06	0.59
Pasture demand (Tonnes DM)	0.49	1.13	1.36	1.17	0.27	4.43
Total demand (Tonnes DM)	0.72	1.36	1.39	1.21	0.34	5.02
% supplements	32%	17%	2%	3%	19%	12%
2030 High (low beet): 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.19	0.09	0.03	0.04	0.07	0.42
Pasture demand (Tonnes DM)	0.49	1.13	1.36	1.17	0.27	4.43
Total demand (Tonnes DM)	0.68	1.22	1.39	1.21	0.34	4.85
% supplements	28%	7%	2%	3%	20%	9%
2030 High (+5): 627 hectares	**Winter (Jul-Aug)**	**Spring (Sept-Nov)**	**Summer (Dec-Feb)**	**Autumn (Mar-May)**	**Winter (Jun)**	**Tonnes per 1000 ha per annum**
Total Supplements (Tonnes DM)	0.23	0.22	0.03	0.04	0.06	0.59
Pasture demand (Tonnes DM)	0.50	1.15	1.38	1.18	0.27	4.48
Total demand (Tonnes DM)	0.73	1.37	1.41	1.21	0.34	5.07
% supplements	32%	16%	2%	3%	19%	12%

Table 42. Class 9 supplements scaled to 1000 ha (kg/ha).

	Baleage	Barley silage	Fodder Beet	Kale	Leafy turnip	Sheep nuts	Swedes	Total
1990-91	54.5	0.0	0.0	42.6	22.4	7.0	110.3	237
1994-95	54.3	0.0	0.0	45.2	26.4	6.4	115.0	248
1998-99	56.1	0.0	0.0	50.0	31.7	5.9	124.9	269
2002-03	52.9	0.0	0.0	50.6	34.1	5.7	123.9	267
2006-07	52.9	4.8	0.0	52.7	42.3	4.7	131.2	288
2010-11	52.5	4.8	0.0	54.9	41.5	5.7	136.8	296
2014-15	50.7	4.8	0.0	56.8	44.0	6.7	138.8	301
2030 Low (-5%)	52.6	2.9	74.0	64.1	45.3	0.0	157.9	397
2030 Low	52.6	4.8	63.3	65.4	45.3	0.0	159.2	391
2030 Low (+5%)	52.8	4.8	79.1	65.9	45.5	0.0	159.2	407
2030 High (-5%)	52.8	5.1	256.5	65.4	45.3	0.0	159.6	585
2030 High	52.3	5.1	256.8	65.6	45.3	0.0	160.0	585
2031 High (low beet)	57.3	4.9	78.0	64.3	45.5	0.0	166.3	416
2030 High (+5%)	52.8	5.1	256.8	65.7	45.5	0.0	160.3	585

Class 9 sheep - pasture and supplement feed tables

Table 43. Summary of total pasture and supplement feed Class 9 demand estimates for sheep (Tonnes DM).

	Pasture	Supplements	Total	% Supplements
1990-91	1,249	73.4	1,322	5.6%
1994-95	1,315	75.4	1,390	5.4%
1998-99	1,374	75.4	1,449	5.2%
2002-03	1,506	77.9	1,584	4.9%
2006-07	1,629	95.2	1,724	5.5%
2010-11	1,640	98.0	1,738	5.6%
2014-15	1,519	92.6	1,612	5.7%
2030 Low (-5%)	1,589	94.3	1,683	5.6%
2030 Low	1,723	106.3	1,829	5.8%
2030 Low (+5%)	1,864	110.6	1,975	5.6%
2030 High (-5%)	1,661	123.4	1,784	6.9%
2030 High	1,791	146.6	1,938	7.6%
2031 High (low beet)	1,811	126.1	1,937	6.5%
2030 High (+5%)	1,940	151.2	2,091	7.2%

Table 44. Pasture demand estimates (Tonnes DM) for the individual sheep stock classes within the historical Class 9 and 2030 scenarios modelled.

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
1990-91	717	109	90	134	7.1	155	23.5	4.9	8.5	1,249
1994-95	750	122	108	152	4.5	153	17.3	4.0	5.2	1,315
1998-99	763	121	116	178	11.2	159	16.8	3.9	5.3	1,374
2002-03	848	139	126	184	14.1	168	17.0	4.2	5.5	1,506
2006-07	907	155	132	209	16.8	181	17.8	4.3	6.0	1,629
2010-11	905	157	132	216	23.8	179	17.0	4.3	5.8	1,640
2014-15	833	144	122	201	24.9	169	15.5	4.0	5.3	1,519
2030 Low (-5%)	810	141	110	280	17.0	206	15.0	4.5	5.8	1,589
2030 Low	875	151	120	308	18.5	224	16.1	4.9	6.3	1,723
2030 Low (+5%)	947	162	131	332	21.1	241	17.3	5.3	6.7	1,864
2030 High (-5%)	834	148	128	331	27.2	168	14.5	4.0	5.4	1,661
2030 High	893	161	139	361	29.1	183	15.6	4.4	5.8	1,791
2030 High (low beet)	903	172	135	364	28.9	183	15.6	4.4	5.8	1,811
2030 High (+5%)	967	174	151	391	31.3	198	16.8	4.8	6.2	1,940

Table 45. Supplemental feed demand (Tonnes DM) estimates for the individual sheep stock classes within the historical Class 9 and 2030 scenarios modelled.

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
1990-91	19.5	26.3	16.9	9.6	1.1	0.0	0.0	0.0	0.0	73.4
1994-95	20.1	26.4	16.2	11.6	1.1	0.0	0.0	0.0	0.0	75.4
1998-99	20.9	22.5	15.6	13.5	2.8	0.0	0.0	0.0	0.0	75.4
2002-03	17.6	23.8	15.6	18.8	2.1	0.0	0.0	0.0	0.0	77.9
2006-07	25.5	26.5	18.0	23.1	2.1	0.0	0.0	0.0	0.0	95.2
2010-11	28.2	25.1	19.1	23.5	2.1	0.0	0.0	0.0	0.0	98.0
2014-15	26.8	26.4	13.8	23.5	2.1	0.0	0.0	0.0	0.0	92.6
2030 Low (-5%)	18.3	26.9	15.4	29.4	4.3	0.0	0.0	0.0	0.0	94.3
2030 Low	24.5	31.7	16.6	28.9	4.6	0.0	0.0	0.0	0.0	106.3
2030 Low (+5%)	24.4	35.0	16.2	31.2	3.9	0.0	0.0	0.0	0.0	110.6
2030 High (-5%)	32.1	40.5	15.4	28.9	6.5	0.0	0.0	0.0	0.0	123.4
2030 High	49.0	44.0	17.0	29.6	7.0	0.0	0.0	0.0	0.0	146.6
2030 High (low beet)	38.6	33.6	20.2	26.5	7.2	0.0	0.0	0.0	0.0	126.1
2030 High (+5%)	49.1	47.4	16.9	30.3	7.6	0.0	0.0	0.0	0.0	151.2

Table 46. Total feed demand (Tonnes DM) estimates for the individual sheep stock classes within the historical Class 9 and 2030 scenarios modelled.

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
1990-91	737	135	107	144	8.2	155	24	4.9	8.5	1,322
1994-95	770	148	124	164	5.6	153	17	4.0	5.2	1,390
1998-99	784	144	132	192	14.0	159	17	3.9	5.3	1,449
2002-03	866	163	142	203	16.2	168	17	4.2	5.5	1,584
2006-07	933	182	150	232	18.9	181	18	4.3	6.0	1,724
2010-11	933	182	151	240	25.9	179	17	4.3	5.8	1,738
2014-15	860	170	136	225	27.0	169	16	4.0	5.3	1,612
2030 Low (-5%)	828	168	125	309	21.3	206	15	4.5	5.8	1,683
2030 Low	900	183	137	337	23.1	224	16	4.9	6.3	1,829
2030 Low (+5%)	971	197	147	363	25.0	241	17	5.3	6.7	1,975
2030 High (-5%)	866	189	143	360	33.7	168	15	4.0	5.4	1,784
2030 High	942	205	156	391	36.1	183	16	4.4	5.8	1,938
2030 High (low beet)	942	206	155	391	36.1	183	16	4.4	5.8	1,937
2030 High (+5%)	1,016	221	168	421	38.9	198	17	4.8	6.2	2,091

Table 47. Summary of supplemental feed estimates used within the sheep enterprise by type (kg DM).

	Baleage	Barley silage	Fodder Beet	Leafy turnip	Sheep nuts	Swedes	Total
1990-91	16,264	0	0	11,545	3,565	42,043	73,417
1994-95	18,111	0	0	14,780	3,624	38,928	75,443
1998-99	16,732	0	0	17,201	3,296	38,129	75,358
2002-03	14,015	0	0	20,426	3,358	40,137	77,936
2006-07	16,963	2,554	0	26,964	2,955	45,737	95,173
2010-11	18,463	3,188	0	27,133	3,806	45,379	97,968
2014-15	15,561	2,988	0	27,336	4,239	42,494	92,618
2030 Low (-5%)	11,902	3,012	0	28,481	0	50,878	94,273
2030 Low	16,866	2,964	0	26,864	0	59,634	106,328
2030 Low (+5%)	15,870	3,049	0	28,465	0	63,251	110,635
2030 High (-5%)	11,866	3,194	8,586	28,377	0	71,367	123,390
2030 High	13,436	3,185	26,745	28,417	0	74,813	146,596
2034 High (low beet)	16,795	3,098	0	28,496	0	77,712	126,101
2030 High (+5%)	14,263	3,234	31,476	28,453	0	73,735	151,161

Table 48. Quantities (kg dry matter) of supplements allocated to the sheep stock classes and other enterprises for the historical Class 9 scenarios modelled.

1990-91							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	5,917	0	0	0	0	20,419	26,336
Ewe Lambs	3,389	0	0	3,965	0	9,584	16,938
Ewes	6,584	0	0	0	3,565	9,320	19,455
Mixed Lambs	374	0	0	7,594	0	1,597	9,565
Wintered lambs	0	0	0	0	0	1,123	0
Total sheep	16,264	0	0	11,545	3,565	42,043	1,123
Other Enterprises	11,777	0	18,586	0	0	14,653	73,417
Total	28,041	0	21,863	11,559	3,565	56,696	121,710
Percentage for sheep	**58%**	**-**	**0%**	**100%**	**100%**	**74%**	**60%**
1994-95							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	5,194	0	0	0	0	21,254	26,448
Ewe Lambs	2,556	0	0	4,558	0	9,109	16,223
Ewes	9,694	0	0	0	3,624	6,823	20,141
Mixed Lambs	384	0	0	10,222	0	961	11,567
Wintered lambs	283	0	0	0	0	781	1,064
Total sheep	18,111	0	0	14,780	3,624	38,928	75,443
Other Enterprises	12,285	0	25,315	0	0	25,490	63,090
Total	30,396	0	25,315	14,780	3,624	64,418	138,533

Percentage for sheep	60%	-	0%	100%	100%	60%	54%
1998-99							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	4,090	0	0	0	0	18,389	22,479
Ewe Lambs	2,112	0	0	4,096	0	9,411	15,619
Ewes	9,997	0	0	0	3,296	7,642	20,935
Mixed Lambs	0	0	0	13,105	0	437	13,542
Wintered lambs	533	0	0	0	0	2,250	2,783
Total sheep	16,732	0	0	17,201	3,296	38,129	75,358
Other Enterprises	14,616	0	27,928	454	0	31,606	74,604
Total	31,348	0	27,928	17,655	3,296	69,735	149,963
Percentage for sheep	**53%**	**-**	**0%**	**97%**	**100%**	**55%**	**50%**
2002-03							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,590	0	0	0	0	20,246	23,836
Ewe Lambs	1,851	0	0	4,624	0	9,114	15,589
Ewes	8,574	0	0	0	3,358	5,624	17,556
Mixed Lambs	0	0	0	15,802	0	3,047	18,849
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	0	0	0	20,426	3,358	40,137	77,936
Other Enterprises	14,015	0	30,327	0	0	34,105	82,113
Total	31,696	0	30,327	20,426	3,358	74,242	160,049
Percentage for sheep	**44%**	**-**	**0%**	**100%**	**100%**	**54%**	**49%**
2006-07							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,640	0	0	0	0	22,833	26,473
Ewe Lambs	3,016	0	0	6,123	0	8,845	17,984
Ewes	10,307	2,554	0	0	2,955	9,647	25,463
Mixed Lambs	0	0	0	20,841	0	2,306	23,147
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	16,963	2,554	0	26,964	2,955	45,737	95,173
Other Enterprises	17,127	572	34,003	329	0	38,898	90,929
Total	34,090	3,126	34,003	27,293	2,955	84,635	186,102
Percentage for sheep	**50%**	**82%**	**0%**	**99%**	**100%**	**54%**	**51%**
2010-11							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,677	0	0	0	0	21,411	25,088
Ewe Lambs	3,016	0	0	5,521	0	10,561	19,098
Ewes	11,770	3,188	0	0	3,806	9,446	28,210
Mixed Lambs	0	0	0	21,611	0	1,855	23,466
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	18,463	3,188	0	27,133	3,806	45,379	97,968
Other Enterprises	16,336	0	36,403	320	0	45,329	98,388

Total	34,799	3,188	36,403	27,453	3,806	90,708	196,356
Percentage for sheep	**53%**	**100%**	**0%**	**99%**	**100%**	**50%**	**50%**
2014-15							
	Baleage	**Barley silage**	**Kale**	**Leafy turnip**	**Sheep nuts**	**Swedes**	**Total**
Ewe Hoggets	3,989	0	0	0	0	22,418	26,407
Ewe Lambs	1,881	0	0	6,647	0	5,275	13,803
Ewes	9,691	2,988	0	0	4,239	9,909	26,827
Mixed Lambs	0	0	0	20,689	0	2,786	23,475
Wintered lambs	0	0	0	0	0	2,106	2,106
Total sheep	15,561	2,988	0	27,336	4,239	42,494	92,618
Other Enterprises	16,214	0	35,600	219	0	44,533	96,566
Total	31,775	2,988	35,600	27,555	4,239	87,027	189,184
Percentage for sheep	**52%**	**100%**	**0%**	**99%**	**100%**	**51%**	**51%**

Class 9 Sheep - scaled to 1,000 hectares

Table 49. Sheep Class 9 pasture and supplements scaled to 1000 ha (Tonnes/ha).

1990-91	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements	0.04	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.14
Total pasture	1.39	0.21	0.17	0.26	0.01	0.30	0.05	0.01	0.02	2.43
Total demand	1.43	0.26	0.21	0.28	0.02	0.30	0.05	0.01	0.02	2.57
% supplements	2.6%	19.5%	15.8%	6.7%	13.6%	0.0%	0.0%	0.0%	0.0%	5.6%
1994-95	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.04	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.13
Total pasture	1.34	0.22	0.19	0.27	0.01	0.27	0.03	0.01	0.01	2.35
Total demand (kgDM)	1.38	0.26	0.22	0.29	0.01	0.27	0.03	0.01	0.01	2.48
% supplements	2.6%	17.8%	13.0%	7.1%	19.3%	0.0%	0.0%	0.0%	0.0%	5.4%
1998-99	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.04	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.14
Total pasture	1.37	0.22	0.21	0.32	0.02	0.29	0.03	0.01	0.01	2.46
Total demand (kgDM)	1.40	0.26	0.24	0.34	0.03	0.29	0.03	0.01	0.01	2.60
% supplements	2.7%	15.6%	11.9%	7.1%	19.9%	0.0%	0.0%	0.0%	0.0%	5.2%
2002-03	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.03	0.04	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.13
Total pasture	1.42	0.23	0.21	0.31	0.02	0.28	0.03	0.01	0.01	2.51
Total demand (kgDM)	1.44	0.27	0.24	0.34	0.03	0.28	0.03	0.01	0.01	2.64
% supplements	2.0%	14.7%	11.0%	9.3%	13.0%	0.0%	0.0%	0.0%	0.0%	4.9%

2002-03	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	0.04	0.04	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.15
Total pasture	1.41	0.24	0.20	0.32	0.03	0.28	0.03	0.01	0.01	2.53
Total demand (kgDM)	1.45	0.28	0.23	0.36	0.03	0.28	0.03	0.01	0.01	2.67
% supplements	2.7%	14.6%	12.0%	10.0%	11.1%	0.0%	0.0%	0.0%	0.0%	5.5%
2002-03	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.04	0.04	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.15
Total pasture	1.37	0.24	0.20	0.33	0.04	0.27	0.03	0.01	0.01	2.47
Total demand (kgDM)	1.41	0.27	0.23	0.36	0.04	0.27	0.03	0.01	0.01	2.62
% supplements	3.0%	13.8%	12.7%	9.8%	8.1%	0.0%	0.0%	0.0%	0.0%	5.6%
2014-15	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.04	0.04	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.15
Total pasture	1.33	0.23	0.20	0.32	0.04	0.27	0.02	0.01	0.01	2.42
Total demand (kgDM)	1.37	0.27	0.22	0.36	0.04	0.27	0.02	0.01	0.01	2.57
% supplements	3.1%	15.5%	10.1%	10.4%	7.8%	0.0%	0.0%	0.0%	0.0%	5.7%
2030 Low (-5%)	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.03	0.04	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.14
Total pasture	1.29	0.23	0.18	0.45	0.03	0.33	0.02	0.01	0.01	2.54
Total demand (kgDM)	1.32	0.27	0.20	0.49	0.03	0.33	0.02	0.01	0.01	2.68
% supplements	2.2%	14.8%	11.3%	9.3%	20.0%	0.0%	0.0%	0.0%	0.0%	5.4%
2030 Low	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.04	0.05	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.17
Total pasture	1.40	0.24	0.19	0.49	0.03	0.36	0.03	0.01	0.01	2.75
Total demand (kgDM)	1.44	0.29	0.22	0.54	0.04	0.36	0.03	0.01	0.01	2.92
% supplements	2.7%	17.4%	13.3%	8.6%	20.0%	0.0%	0.0%	0.0%	0.0%	5.9%

2030 Low (+5%)	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	0.04	0.06	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.18
Total pasture	1.51	0.26	0.21	0.53	0.03	0.39	0.03	0.01	0.01	2.97
Total demand (kgDM)	1.55	0.31	0.24	0.58	0.04	0.39	0.03	0.01	0.01	3.15
% supplements	2.5%	17.8%	11.0%	8.6%	15.5%	0.0%	0.0%	0.0%	0.0%	5.6%
2030 High (-5%)	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.05	0.06	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.20
Total pasture	1.33	0.24	0.20	0.53	0.04	0.27	0.02	0.01	0.01	2.65
Total demand (kgDM)	1.38	0.30	0.23	0.57	0.05	0.27	0.02	0.01	0.01	2.85
% supplements	3.7%	21.5%	10.8%	8.0%	19.3%	0.0%	0.0%	0.0%	0.0%	6.9%
2030 High	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.08	0.07	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.23
Total pasture	1.42	0.26	0.22	0.58	0.05	0.29	0.02	0.01	0.01	2.86
Total demand (kgDM)	1.50	0.33	0.25	0.62	0.06	0.29	0.02	0.01	0.01	3.09
% supplements	5.2%	21.4%	10.9%	7.6%	19.4%	0.0%	0.0%	0.0%	0.0%	7.6%
2030 High (low beet)	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.06	0.05	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.20
Total pasture	1.44	0.27	0.22	0.58	0.05	0.29	0.02	0.01	0.01	2.89
Total demand (kgDM)	1.50	0.33	0.25	0.62	0.06	0.29	0.02	0.01	0.01	3.09
% supplements	4.1%	16.4%	13.0%	6.8%	19.9%	0.0%	0.0%	0.0%	0.0%	6.5%
2030 High (+5%)	**Ewes**	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	0.08	0.08	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.24
Total pasture	1.54	0.28	0.24	0.62	0.05	0.32	0.03	0.01	0.01	3.09
Total demand (kgDM)	1.62	0.35	0.27	0.67	0.06	0.32	0.03	0.01	0.01	3.34
% supplements	4.8%	21.4%	10.0%	7.2%	19.5%	0.0%	0.0%	0.0%	0.0%	7.2%

Table 50. Sheep Class 9 pasture and supplements scaled to 1000 ha (kg/ha).

	Baleage	Barley silage	Fodder Beet	Leafy turnip	Sheep nuts	Swedes	Total
1990-91	31.6	0.0	0.0	22.5	6.9	81.8	143
1994-95	32.3	0.0	0.0	26.4	6.5	69.5	135
1998-99	30.0	0.0	0.0	30.8	5.9	68.3	135
2002-03	23.4	0.0	0.0	34.1	5.6	67.0	130
2006-07	26.3	4.0	0.0	41.8	4.6	70.9	148
2010-11	27.8	4.8	0.0	40.9	5.7	68.4	148
2014-15	24.8	4.8	0.0	43.6	6.8	67.8	148
2030 Low (-5%)	19.0	4.8	0.0	45.4	0.0	81.1	150
2030 Low	26.9	4.7	0.0	42.8	0.0	95.1	170
2030 Low (+5%)	25.3	4.9	0.0	45.4	0.0	100.9	176
2030 High (-5%)	18.9	5.1	13.7	45.3	0.0	113.8	197
2030 High	21.4	5.1	42.7	45.3	0.0	119.3	234
2034 High (low beet)	26.8	4.9	0.0	45.4	0.0	123.9	201
2030 High (+5%)	22.7	5.2	50.2	45.4	0.0	117.6	241

Other Class 9 pasture and supplements

Table 51. Summary of total pasture and supplement feed Class 9 demand estimates for the beef, ex-dairy, dairy grazing and deer enterprises (Tonnes DM).

	Pasture	Supplements	Total	% Supplements
1990-91	540	49	588	8.3%
1994-95	757	64	820	7.8%
1998-99	922	75	997	7.5%
2002-03	985	82	1,067	7.7%
2006-07	1,095	91	1,187	7.6%
2010-11	1,016	98	1,114	8.8%
2014-15	973	96	1,069	9.0%
2030 Low (-5%)	1,187	155	1,342	11.5%
2030 Low	1,040	139	1,179	11.8%
2030 Low (+5%)	941	144	1,086	13.3%
2030 High (-5%)	1,134	244	1,378	17.7%
2030 High	988	220	1,208	18.2%
2031 High (low beet)	968	135	1,102	12.2%
2030 High (+5%)	869	216	1,086	19.9%

Sheep ME and methane estimates

Table 52. Feed intake (kgDM), feed quality (MJME) and methane (kgCO_2e) estimates for sheep by stock class.

1990-91										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	19,455	26,336	16,938	9,565	1,123	0	0	0	0	73,417
Total demand (kgDM)	736,331	134,997	106,883	143,562	8,240	155,116	23,495	4,889	8,470	1,321,983
% supplements	2.6%	19.5%	15.8%	6.7%	13.6%	0.0%	0.0%	0.0%	0.0%	5.6%
Average MJME Farmax	10.07	10.66	10.43	10.27	10.52	10.07	9.85	10.29	9.82	10.18
Average MJME Pasture	10.02	10.18	10.02	10.14	10.11	10.07	9.85	10.29	9.82	10.05
Average MJME Inventory	10.63	10.70	9.90	9.84	11.00	10.77	10.40	11.03	9.86	10.50
Pasture demand (kgDM)	740,538	141,386	111,185	145,311	8,572	155,116	23,495	4,889	8,470	1,339,036
Inventory demand (kgDM)	697,930	134,548	112,590	149,736	7,881	145,088	22,265	4,559	8,434	1,283,030
Methane CO_2e Farmax (kg)	388,882	71,209	45,519	61,133	3,509	81,809	12,385	2,580	3,608	670,634
Methane CO_2e Pasture(kg)	391,147	74,574	47,278	61,816	3,644	81,809	12,385	2,580	3,608	678,841
Methane CO_2e Inventory(kg)	368,149	71,042	47,929	63,721	3,354	76,626	11,765	2,407	3,592	648,585

1994-95										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	20,141	26,448	16,223	11,567	1,064	0	0	0	0	75,443
Total demand (kgDM)	770,183	148,264	124,390	163,216	5,516	152,506	17,304	3,981	5,248	1,390,608
% supplements	2.6%	17.8%	13.0%	7.1%	19.3%	0.0%	0.0%	0.0%	0.0%	5.4%
Average MJME Farmax	10.11	10.67	10.46	10.36	10.55	10.21	10.02	10.30	9.84	10.24
Average MJME Pasture	10.06	10.23	10.14	10.26	10.14	10.21	10.02	10.30	9.84	10.13
Average MJME Inventory	10.62	10.69	9.93	9.89	10.98	10.86	10.53	10.93	9.86	10.50
Pasture demand (kgDM)	773,594	154,677	128,375	164,784	5,740	152,506	17,304	3,981	5,248	1,406,210
Inventory demand (kgDM)	733,255	148,049	131,049	170,927	5,298	143,374	16,472	3,752	5,237	1,357,413
Methane CO_2e Farmax (kg)	406,725	78,201	52,889	69,416	2,345	80,519	9,140	2,101	2,235	703,571
Methane CO_2e Pasture(kg)	408,571	81,662	54,630	70,102	2,443	80,519	9,140	2,101	2,235	711,403
Methane CO_2e Inventory(kg)	386,791	78,084	55,800	72,788	2,249	75,590	8,691	1,978	2,230	684,201
1998-99										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	20,935	22,479	15,619	13,542	2,783	0	0	0	0	75,358
Total demand (kgDM)	783,466	143,726	131,629	191,420	14,013	159,358	16,833	3,913	5,270	1,449,628
% supplements	2.7%	15.6%	11.9%	7.1%	19.9%	0.0%	0.0%	0.0%	0.0%	5.2%
Average MJME Farmax	10.17	10.66	10.51	10.42	10.71	10.27	10.08	10.36	9.91	10.30
Average MJME Pasture	10.13	10.26	10.23	10.33	10.27	10.27	10.08	10.36	9.91	10.20
Average MJME Inventory	10.63	10.66	9.93	9.90	11.01	10.87	10.53	10.94	9.86	10.50
Pasture demand (kgDM)	786,576	149,318	135,272	193,176	14,619	159,358	16,833	3,913	5,270	1,464,336
Inventory demand (kgDM)	749,626	143,736	139,293	201,504	13,639	150,650	16,115	3,707	5,296	1,423,567
Methane CO_2e Farmax (kg)	413,685	75,809	55,959	81,398	5,954	84,126	8,884	2,065	2,244	730,124
Methane CO_2e Pasture(kg)	415,363	78,827	57,551	82,164	6,219	84,126	8,884	2,065	2,244	737,443
Methane CO_2e Inventory(kg)	395,418	75,814	59,310	85,807	5,790	79,524	8,502	1,954	2,255	714,374

2002-03										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	17,556	23,836	15,589	18,849	2,106	0	0	0	0	77,936
Total demand (kgDM)	865,351	162,590	141,755	203,114	16,182	167,916	17,025	4,190	5,472	1,583,595
% supplements	2.0%	14.7%	11.0%	9.3%	13.0%	0.0%	0.0%	0.0%	0.0%	4.9%
Average MJME Farmax	10.23	10.69	10.54	10.54	10.70	10.33	10.13	10.43	9.98	10.36
Average MJME Pasture	10.20	10.34	10.29	10.39	10.35	10.33	10.13	10.43	9.98	10.26
Average MJME Inventory	10.64	10.67	9.93	9.90	11.01	10.87	10.52	10.93	9.86	10.51
Pasture demand (kgDM)	867,700	168,100	145,201	206,055	16,741	167,916	17,025	4,190	5,472	1,598,400
Inventory demand (kgDM)	831,732	162,766	150,513	216,184	15,728	159,616	16,391	3,997	5,537	1,562,464
Methane CO_2e Farmax (kg)	456,862	85,753	60,259	86,342	6,876	88,632	8,990	2,211	2,330	798,255
Methane CO_2e Pasture(kg)	458,132	88,727	61,274	87,628	7,120	88,632	8,990	2,211	2,330	805,044
Methane CO_2e Inventory(kg)	438,718	85,849	64,088	92,058	6,677	84,151	8,648	2,107	2,358	784,654
2006-07										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	25,463	26,473	17,984	23,147	2,106	0	0	0	0	95,173
Total demand (kgDM)	932,696	181,362	149,558	232,364	18,940	180,842	17,847	4,286	5,956	1,723,851
% supplements	2.7%	14.6%	12.0%	10.0%	11.1%	0.0%	0.0%	0.0%	0.0%	5.5%
Average MJME Farmax	10.29	10.74	10.60	10.60	10.71	10.39	10.20	10.49	10.04	10.42
Average MJME Pasture	10.25	10.39	10.37	10.44	10.42	10.39	10.20	10.49	10.04	10.32
Average MJME Inventory	10.64	10.67	9.93	9.90	11.01	10.87	10.53	10.94	9.86	10.51
Pasture demand (kgDM)	935,868	187,457	152,952	235,839	19,477	180,842	17,847	4,286	5,956	1,740,525
Inventory demand (kgDM)	902,090	182,546	159,689	248,757	18,423	172,836	17,282	4,107	6,067	1,711,796
Methane CO_2e Farmax (kg)	492,352	95,643	63,578	98,760	8,048	95,422	9,423	2,262	2,535	868,023
Methane CO_2e Pasture(kg)	494,598	98,933	65,049	100,280	8,282	95,422	9,423	2,262	2,535	876,784
Methane CO_2e Inventory(kg)	475,831	96,282	67,995	105,928	7,821	91,121	9,118	2,165	2,584	858,845

2010-11										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	28,210	25,088	19,098	23,466	2,106	0	0	0	0	97,968
Total demand (kgDM)	933,690	182,229	150,603	239,336	25,939	179,231	16,950	4,288	5,840	1,738,106
% supplements	3.0%	13.8%	12.7%	9.8%	8.1%	0.0%	0.0%	0.0%	0.0%	5.6%
Average MJME Farmax	10.35	10.77	10.68	10.65	10.73	10.45	10.25	10.55	10.11	10.48
Average MJME Pasture	10.32	10.46	10.43	10.51	10.52	10.45	10.25	10.55	10.11	10.38
Average MJME Inventory	10.65	10.68	9.93	9.90	11.03	10.87	10.53	10.95	9.86	10.51
Pasture demand (kgDM)	936,758	187,766	154,284	242,341	26,453	179,231	16,950	4,288	5,840	1,753,911
Inventory demand (kgDM)	907,717	183,841	161,990	257,344	25,230	172,209	16,505	4,134	5,989	1,734,960
Methane CO_2e Farmax (kg)	492,812	96,094	63,996	101,709	11,021	94,579	8,948	2,262	2,485	873,906
Methane CO_2e Pasture(kg)	494,464	99,081	65,604	103,025	11,239	94,579	8,948	2,262	2,485	881,687
Methane CO_2e Inventory(kg)	478,788	96,963	68,975	109,585	10,711	90,790	8,708	2,179	2,551	869,250
2014-15										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	26,827	26,407	13,803	23,475	2,106	0	0	0	0	92,618
Total demand (kgDM)	860,110	170,100	136,254	224,879	27,009	168,640	15,517	4,010	5,292	1,611,811
% supplements	3.1%	15.5%	10.1%	10.4%	7.8%	0.0%	0.0%	0.0%	0.0%	5.7%
Average MJME Farmax	10.40	10.86	10.68	10.71	10.78	10.50	10.31	10.62	10.18	10.53
Average MJME Pasture	10.37	10.53	10.49	10.56	10.59	10.50	10.31	10.62	10.18	10.44
Average MJME Inventory	10.64	10.71	9.93	9.90	11.03	10.87	10.52	10.94	9.86	10.51
Pasture demand (kgDM)	862,896	175,445	138,668	228,109	27,503	168,640	15,517	4,010	5,292	1,626,080
Inventory demand (kgDM)	840,915	172,503	146,547	243,290	26,409	162,921	15,200	3,892	5,463	1,617,140
Methane CO_2e Farmax (kg)	453,926	89,680	57,898	95,550	11,474	88,981	8,191	2,117	2,252	810,069
Methane CO_2e Pasture(kg)	455,426	92,565	58,955	96,922	11,690	88,981	8,191	2,117	2,252	817,099
Methane CO_2e Inventory(kg)	443,562	90,977	62,399	103,600	11,211	85,894	8,020	2,055	2,327	810,045

2030 Low (-5%)										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	18,607	24,855	14,154	28,728	4,254	0	0	0	0	90,597
Total demand (kgDM)	828,180	167,478	125,632	309,449	21,274	206,131	14,996	4,471	5,815	1,683,426
% supplements	2.2%	14.8%	11.3%	9.3%	20.0%	0.0%	0.0%	0.0%	0.0%	5.4%
Average MJME Farmax	10.43	10.89	10.70	10.66	10.68	10.40	10.31	10.63	10.16	10.54
Average MJME Pasture	10.40	10.54	10.44	10.46	10.14	10.40	10.31	10.63	10.16	10.43
Average MJME Inventory	10.68	10.72	9.89	9.85	10.80	10.68	10.52	10.94	9.86	10.47
Pasture demand (kgDM)	830,166	172,945	128,807	315,454	22,387	206,131	14,996	4,471	5,815	1,701,172
Inventory demand (kgDM)	808,448	170,050	135,861	334,820	21,029	200,744	14,696	4,341	5,991	1,695,981
Methane CO_2e Farmax (kg)	437,046	88,296	53,376	131,501	9,040	108,786	7,916	2,358	2,472	840,791
Methane CO_2e Pasture(kg)	437,977	91,140	54,990	134,173	9,527	108,786	7,916	2,358	2,472	849,339
Methane CO_2e Inventory(kg)	426,253	89,580	58,051	142,649	8,933	105,878	7,749	2,288	2,551	843,932

2030 Low										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	24,475	31,696	18,171	28,921	4,623	0	0	0	0	107,886
Total demand (kgDM)	899,769	182,222	136,567	336,435	23,115	223,747	16,121	4,927	6,278	1,829,181
% supplements	2.7%	17.4%	13.3%	8.6%	20.0%	0.0%	0.0%	0.0%	0.0%	5.9%
Average MJME Farmax	10.43	10.90	10.76	10.65	10.68	10.40	10.30	10.63	10.16	10.54
Average MJME Pasture	10.40	10.54	10.43	10.46	10.14	10.40	10.30	10.63	10.16	10.43
Average MJME Inventory	10.68	10.72	9.90	9.85	10.80	10.68	10.52	10.94	9.86	10.47
Pasture demand (kgDM)	901,947	188,427	140,851	342,514	24,325	223,747	16,121	4,927	6,278	901,947
Inventory demand (kgDM)	878,316	185,268	148,476	363,535	22,848	217,899	15,796	4,786	6,468	878,316
Methane CO_2e Farmax (kg)	474,825	96,063	58,036	142,973	9,822	118,083	8,510	2,599	2,671	913,582
Methane CO_2e Pasture(kg)	476,005	99,412	59,766	145,631	10,352	118,083	8,510	2,599	2,671	923,029
Methane CO_2e Inventory(kg)	463,250	97,707	63,101	154,826	9,706	114,884	8,334	2,523	2,755	917,086

2030 Low (+5%)										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	24,376	34,999	16,163	31,206	3,891	0	0	0	0	110,635
Total demand (kgDM)	971,337	196,817	147,593	362,902	25,035	241,401	17,336	5,289	6,742	1,974,452
% supplements	2.5%	17.8%	11.0%	8.6%	15.5%	0.0%	0.0%	0.0%	0.0%	5.6%
Average MJME Farmax	10.43	10.92	10.71	10.65	10.56	10.40	10.30	10.63	10.16	10.54
Average MJME Pasture	10.40	10.54	10.43	10.46	10.14	10.40	10.30	10.63	10.16	10.43
Average MJME Inventory	10.68	10.72	9.90	9.85	10.80	10.68	10.51	10.94	9.86	10.47
Pasture demand (kgDM)	973,763	203,877	151,469	369,445	26,050	241,401	17,336	5,289	6,742	1,995,371
Inventory demand (kgDM)	948,267	200,420	159,688	392,109	24,470	235,092	16,985	5,137	6,946	1,989,114
Methane CO_2e Farmax (kg)	512,593	103,762	62,713	154,225	10,663	127,400	9,167	2,790	2,869	986,182
Methane CO_2e Pasture(kg)	513,907	107,564	64,407	157,048	11,086	127,400	9,167	2,790	2,869	996,238
Methane CO_2e Inventory(kg)	500,144	105,698	68,000	166,958	10,395	123,994	8,962	2,708	2,958	989,817

2030 High (-5%)										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	32,073	40,543	15,385	28,868	6,520	0	0	0	0	123,390
Total demand (kgDM)	866,535	188,581	142,982	359,934	33,700	168,355	14,490	4,030	5,361	1,783,968
% supplements	3.7%	21.5%	10.8%	8.0%	19.3%	0.0%	0.0%	0.0%	0.0%	6.9%
Average MJME Farmax	10.43	11.00	10.75	10.63	11.00	10.50	10.31	10.61	10.16	10.57
Average MJME Pasture	10.37	10.56	10.48	10.46	10.51	10.50	10.31	10.61	10.16	10.43
Average MJME Inventory	10.65	10.72	9.95	9.89	10.99	10.87	10.52	10.93	9.86	10.47
Pasture demand (kgDM)	871,629	196,507	146,602	365,950	35,279	168,355	14,490	4,030	5,361	1,808,203
Inventory demand (kgDM)	848,991	193,460	154,478	386,914	33,730	162,628	14,198	3,913	5,523	1,803,835
Methane CO_2e Farmax (kg)	457,287	99,393	60,746	152,967	14,308	88,830	7,649	2,126	2,283	885,589
Methane CO_2e Pasture(kg)	460,035	103,671	62,329	155,596	14,998	88,830	7,649	2,126	2,283	897,517
Methane CO_2e Inventory(kg)	447,812	102,028	65,773	164,765	14,321	85,739	7,491	2,063	2,352	892,344

2030 High										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	48,985	43,982	16,996	29,626	7,007	0	0	0	0	146,596
Total demand (kgDM)	941,600	205,172	155,515	390,232	36,097	183,064	15,583	4,411	5,789	1,937,463
% supplements	5.2%	21.4%	10.9%	7.6%	19.4%	0.0%	0.0%	0.0%	0.0%	7.6%
Average MJME Farmax	10.46	11.01	10.75	10.63	11.00	10.50	10.31	10.61	10.16	10.59
Average MJME Pasture	10.37	10.56	10.48	10.46	10.50	10.50	10.31	10.61	10.16	10.43
Average MJME Inventory	10.65	10.72	9.95	9.89	10.99	10.87	10.52	10.92	9.86	10.47
Pasture demand (kgDM)	949,431	213,898	159,477	396,460	37,795	183,064	15,583	4,411	5,789	1,965,909
Inventory demand (kgDM)	924,788	210,567	168,041	419,189	36,132	176,837	15,265	4,285	5,964	1,961,070
Methane CO_2e Farmax (kg)	496,867	108,136	66,070	165,844	15,325	96,591	8,226	2,327	2,463	961,849
Methane CO_2e Pasture(kg)	501,098	112,846	67,803	168,568	16,068	96,591	8,226	2,327	2,463	975,990
Methane CO_2e Inventory(kg)	487,793	111,050	71,547	178,777	15,341	93,230	8,054	2,259	2,540	970,591
2030 High (low beet)										
	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Total
Total supplements (kgDM)	38,645	33,577	20,154	26,547	7,178	0	0	0	0	126,101
Total demand (kgDM)	941,600	205,172	155,515	390,232	36,097	183,064	15,583	4,411	5,789	1,937,463
% supplements	4.1%	16.4%	13.0%	6.8%	19.9%	0.0%	0.0%	0.0%	0.0%	6.5%
Average MJME Farmax	10.43	10.95	10.79	10.61	11.01	10.50	10.31	10.61	10.16	10.56
Average MJME Pasture	10.37	10.55	10.48	10.46	10.50	10.50	10.31	10.61	10.16	10.43
Average MJME Inventory	10.65	10.72	9.95	9.89	10.99	10.87	10.52	10.92	9.86	10.47
Pasture demand (kgDM)	946,534	212,785	160,056	395,904	37,834	183,064	15,583	4,411	5,789	1,961,959
Inventory demand (kgDM)	921,984	209,481	168,660	418,589	36,169	176,837	15,265	4,285	5,964	1,957,236
Methane CO_2e Farmax (kg)	496,900	108,150	66,063	165,853	15,325	96,591	8,226	2,327	2,463	961,898
Methane CO_2e Pasture(kg)	499,569	112,261	68,050	168,332	16,085	96,591	8,226	2,327	2,463	973,904
Methane CO_2e Inventory(kg)	486,314	110,477	71,811	178,253	15,356	93,230	8,054	2,264	2,540	968,299

2030 High (+5%)										
	Ewes	**Ewe Hoggets**	**Ewe Lambs**	**Mixed Lambs**	**Wintered lambs**	**Terminal ewes**	**Rams**	**Ram Hoggets**	**Ram Lambs**	**Total**
Total supplements (kgDM)	49,111	47,370	16,858	30,255	7,567	0	0	0	0	151,161
Total demand (kgDM)	1,016,247	221,602	167,987	421,314	38,881	197,628	16,812	4,791	6,217	2,091,479
% supplements	4.8%	21.4%	10.0%	7.2%	19.5%	0.0%	0.0%	0.0%	0.0%	7.2%
Average MJME Farmax	10.45	11.00	10.73	10.62	11.00	10.50	10.30	10.61	10.16	10.58
Average MJME Pasture	10.37	10.56	10.48	10.46	10.50	10.50	10.30	10.61	10.16	10.43
Average MJME Inventory	10.65	10.72	9.95	9.89	10.99	10.87	10.52	10.93	9.86	10.47
Pasture demand (kgDM)	1,023,651	231,003	171,875	427,685	40,715	197,628	16,812	4,791	6,217	2,120,376
Inventory demand (kgDM)	997,132	227,403	181,131	452,201	38,921	190,906	16,470	4,654	6,405	2,115,223
Methane CO_2e Farmax (kg)	536,269	116,797	71,373	179,058	16,507	104,276	8,875	2,527	2,646	1,038,328
Methane CO_2e Pasture(kg)	540,271	121,870	73,074	181,845	17,309	104,276	8,875	2,527	2,646	1,052,693
Methane CO_2e Inventory(kg)	525,951	119,929	77,121	192,567	16,525	100,648	8,870	2,453	2,728	1,046,792

National estimates

Table 53. National estimates of Class 9 pasture demand (000 Tonnes of dry matter).

	n farms	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Total
1990-91	19,600	4,312	10,327	9,808	8,628	1,980	35,055
1994-95	17,700	4,455	10,643	10,387	9,095	2,086	36,667
1998-99	16,400	4,568	10,828	10,761	9,341	2,158	37,657
2002-03	15,290	4,817	11,056	10,773	9,258	2,178	38,083
2006-07	13,670	4,583	10,838	10,516	9,152	2,154	37,243
2010-11	12,610	4,158	9,874	9,425	8,162	1,873	33,491
2014-15	11,295	3,466	8,177	7,916	6,936	1,650	28,145
2030 Low (-5%)	11,295	3,781	8,448	9,515	7,748	1,859	31,353
2030 Low	11,295	3,725	8,480	9,512	7,645	1,843	31,205
2030 Low (+5%)	11,295	3,794	8,621	9,690	7,714	1,866	31,686
2030 High (-5%)	11,295	3,540	8,001	9,701	8,369	1,963	31,575
2030 High	11,295	3,489	8,017	9,653	8,287	1,939	31,386
2030 High (low beet)	11,295	3,489	8,017	9,653	8,287	1,939	31,386
2030 High (+5%)	11,295	3,521	8,148	9,788	8,329	1,947	31,733

Table 54 . National estimates of supplement feed demand (000 Tonnes of dry matter).

	n farms	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Total
1990-91	19,600	1,241	242	150	240	514	2,387
1994-95	17,700	1,237	327	153	241	496	2,454
1998-99	16,400	1,268	246	186	223	536	2,460
2002-03	15,290	1,124	340	186	329	468	2,448
2006-07	13,670	1,247	317	225	294	460	2,544
2010-11	12,610	1,187	262	229	306	492	2,476
2014-15	11,295	1,025	362	182	227	340	2,137
2030 Low (-5%)	11,295	1,292	595	218	236	468	2,810
2030 Low	11,295	1,109	737	212	251	458	2,768
2030 Low (+5%)	11,295	1,114	851	216	250	461	2,892
2030 High (-5%)	11,295	1,633	1,588	214	251	458	4,144
2030 High	11,295	1,632	1,589	212	252	458	4,143
2030 High (low beet)	11,295	1,356	639	214	251	484	2,944
2030 High (+5%)	11,295	1,636	1,589	215	250	460	4,150

Table 55. National estimates of total feed demand (000 Tonnes of dry matter).

	n farms	Winter (Jul-Aug)	Spring (Sept-Nov)	Summer (Dec-Feb)	Autumn (Mar-May)	Winter (Jun)	Total
1990-91	19,600	5,552	10,570	9,958	8,868	2,494	37,442
1994-95	17,700	5,692	10,970	10,540	9,336	2,582	39,121
1998-99	16,400	5,837	11,074	10,948	9,564	2,695	40,117
2002-03	15,290	5,941	11,397	10,959	9,588	2,646	40,530
2006-07	13,670	5,830	11,155	10,741	9,446	2,614	39,787
2010-11	12,610	5,344	10,136	9,654	8,468	2,365	35,967
2014-15	11,295	4,491	8,539	8,099	7,163	1,990	30,282
2030 Low (-5%)	11,295	5,074	9,044	9,733	7,984	2,328	34,163
2030 Low	11,295	4,834	9,217	9,724	7,897	2,301	33,973
2030 Low (+5%)	11,295	4,908	9,472	9,906	7,964	2,327	34,577
2030 High (-5%)	11,295	5,174	9,589	9,915	8,621	2,421	35,719
2030 High	11,295	5,121	9,606	9,865	8,539	2,397	35,529
2030 High (low beet)	11,295	4,845	8,656	9,867	8,538	2,423	34,330
2030 High (+5%)	11,295	5,157	9,737	10,003	8,579	2,407	35,883

Class 9 supplement type

Table 56. National estimates of supplement usage by type (000 Tonnes).

	No of farms	Baleage	Barley silage	Fodder Beet	Kale	Leafy turnip	Sheep nuts	Swedes	Total supplements	Total feed
1990-91	19600	550	0	0	429	226	70	1,111	2,386	37,442
1994-95	17700	538	0	0	448	262	64	1,140	2,452	39,121
1998-99	16400	514	0	0	458	290	54	1,144	2,459	40,117
2002-03	15290	474	0	0	464	312	51	1,135	2,436	40,530
2006-07	13670	466	43	0	465	373	40	1,157	2,544	39,787
2010-11	12610	439	40	0	459	346	48	1,144	2,476	35,967
2014-15	11295	359	34	0	402	311	48	983	2,137	30,282
2030 Low (-5%)	11295	373	21	524	454	320	0	1,118	2,809	34,236
2030 Low	11295	372	33	448	463	321	0	1,127	2,764	33,972
2030 Low (+5%)	11295	374	34	560	467	322	0	1,127	2,884	34,577
2030 High (-5%)	11295	374	36	1,816	463	321	0	1,130	4,140	35,719
2030 High	11295	371	36	1,818	464	321	0	1,133	4,142	35,529
2030 High (low beet)	11295	405	35	553	455	322	0	1,178	2,948	35,529
2030 High (+5%)	11295	373	37	1,818	465	321	0	1,135	4,149	35,883

Sheep pasture and supplement feed demand

Table 57. National estimates of sheep pasture demand (000 Tonnes of dry matter).

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Sheep Total
1990-91	14,051	2,130	1,763	2,626	139	3,040	461	96	166	24,472
1994-95	13,276	2,156	1,915	2,684	79	2,699	306	70	93	23,278
1998-99	12,506	1,988	1,903	2,917	184	2,613	276	64	86	22,538
2002-03	12,963	2,122	1,929	2,817	215	2,567	260	64	84	23,022
2006-07	12,402	2,117	1,799	2,860	230	2,472	244	59	81	22,264
2010-11	11,418	1,982	1,658	2,722	301	2,260	214	54	74	20,682
2014-15	9,412	1,623	1,383	2,275	281	1,905	175	45	60	17,159
2030 Low (-5%)	9,144	1,611	1,259	3,171	192	2,328	169	50	66	17,991
2030 Low	9,886	1,700	1,337	3,473	209	2,527	182	56	71	19,442
2030 Low (+5%)	10,696	1,828	1,485	3,747	239	2,727	196	60	76	21,052
2030 High (-5%)	9,425	1,672	1,441	3,739	307	1,902	164	46	61	18,756
2030 High	10,082	1,821	1,565	4,073	329	2,068	176	50	65	20,228
2030 High (low beet)	10,199	1,938	1,529	4,108	327	2,068	176	50	65	20,459
2030 High (+5%)	10,924	1,968	1,707	4,417	354	2,232	190	54	70	21,916

Table 58. National estimates of sheep supplement feed demand (000 Tonnes of dry matter).

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Sheep Total
1990-91	381	516	332	187	22	0	0	0	0	1,439
1994-95	356	468	287	205	19	0	0	0	0	1,335
1998-99	343	369	256	222	46	0	0	0	0	1,236
2002-03	268	364	238	288	32	0	0	0	0	1,192
2006-07	348	362	246	316	29	0	0	0	0	1,301
2010-11	356	316	241	296	27	0	0	0	0	1,235
2014-15	303	298	156	265	24	0	0	0	0	1,046
2030 Low (-5%)	210	281	160	324	48	0	0	0	0	1,023
2030 Low	276	358	205	327	52	0	0	0	0	1,219
2030 Low (+5%)	275	395	183	352	44	0	0	0	0	1,250
2030 High (-5%)	362	458	174	326	74	0	0	0	0	1,394
2030 High	553	497	192	335	79	0	0	0	0	1,656
2030 High (low beet)	436	379	228	300	81	0	0	0	0	1,424
2030 High (+5%)	555	535	190	342	85	0	0	0	0	1,707

Table 59. National estimates of total sheep feed demand (000 Tonnes of dry matter).

	Ewes	Ewe Hoggets	Ewe Lambs	Mixed Lambs	Wintered lambs	Terminal ewes	Rams	Ram Hoggets	Ram Lambs	Sheep Total
1990-91	14,432	2,646	2,095	2,814	162	3,040	461	96	166	25,911
1994-95	13,632	2,624	2,202	2,889	98	2,699	306	70	93	24,614
1998-99	12,849	2,357	2,159	3,139	230	2,613	276	64	86	23,774
2002-03	13,231	2,486	2,167	3,106	247	2,567	260	64	84	24,213
2006-07	12,750	2,479	2,044	3,176	259	2,472	244	59	81	23,565
2010-11	11,774	2,298	1,899	3,018	327	2,260	214	54	74	21,918
2014-15	9,715	1,921	1,539	2,540	305	1,905	175	45	60	18,205
2030 Low (-5%)	9,354	1,892	1,419	3,495	240	2,328	169	50	66	19,014
2030 Low	10,163	2,058	1,543	3,800	261	2,527	182	56	71	20,661
2030 Low (+5%)	10,971	2,223	1,667	4,099	283	2,727	196	60	76	22,301
2030 High (-5%)	9,788	2,130	1,615	4,065	381	1,902	164	46	61	20,150
2030 High	10,635	2,317	1,757	4,408	408	2,068	176	50	65	21,884
2030 High (low beet)	10,635	2,317	1,757	4,408	408	2,068	176	50	65	21,884
2030 High (+5%)	11,479	2,503	1,897	4,759	439	2,232	190	54	70	23,623

Sheep supplement type

Table 60. National estimates of sheep supplement usage by type (000 Tonnes).

	Baleage	Barley silage	Fodder Beet	Kale	Leafy turnip	Sheep nuts	Swedes	Total supplements (sheep)
1990-91	319	0.0	0.0	0.0	226	69.9	824	1,439
1994-95	321	0.0	0.0	0.0	262	64.1	689	1,335
1998-99	274	0.0	0.0	0.0	282	54.1	625	1,236
2002-03	214	0.0	0.0	0.0	312	51.3	614	1,192
2006-07	232	34.9	0.0	0.0	369	40.4	625	1,301
2010-11	233	40.2	0.0	0.0	342	48.0	572	1,235
2014-15	176	33.7	0.0	0.0	309	47.9	480	1,046
2030 Low (-5%)	115	20.7	0.0	0.0	320	0.0	568	1,023
2030 Low	191	33.5	0.0	0.0	321	0.0	674	1,219
2030 Low (+5%)	179	34.4	0.0	0.0	322	0.0	714	1,250
2030 High (-5%)	134	36.1	97.0	0.0	321	0.0	806	1,394
2030 High	152	36.0	302.1	0.0	321	0.0	845	1,656
2030 High (low beet)	190	35.0	0.0	0.0	322	0.0	878	1,424
2030 High (+5%)	161	36.5	355.5	0.0	321	0.0	833	1,707