Utilising bioeconomic modelling to examine the impact of lambing percentages and pre-weaning lamb growth rates on farm profitability

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Adam James Moloney

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Declaration

I (Adam Moloney), declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text and that this work has not been submitted for any other degree or professional qualification except as specified.

Parts of this work have been published in "Bio-economic system-dynamics modelling to investigate strategic management options in New Zealand sheep farming enterprises" (Farrell, 2020).

Abstract

Since 1980, the production and sale of sheep for meat has overtaken wool as the primary profit driver of Class 4 sheep enterprises in the Western North Island of New Zealand. While the sale of cull ewes and rams contributes to sheep enterprise production it's the production of lamb that contributes the greatest amount. Lambs born on farm can either be grown to heavier liveweights and sent direct to the works (termed prime for slaughter) or sold as store lambs for others to finish. Therefore, the production of lamb as a profit driver is dependent on the number of lambs along with the individual liveweight of each lamb. There is, however, no recent information that directly quantifies and compares the impacts of either increased lamb numbers, increased lamb liveweights, or a combination of both which maximises farmer profit.

Bio-economic modelling is a relatively recently adapted tool used in agricultural production systems such as New Zealand sheep enterprises. A bio-economic systems dynamics model has recently been created to compare changes in various sheep enterprises in New Zealand, with the model output production values found to be close to realised values. This bio-economic systems-dynamic model was identified as the most suitable model to use to complete this research. The specific objectives of this research were to update the current STELLA bio-economic system-dynamic model with more recent industry statistics before running eight scenarios with differing lambing percentage and pre-weaning growth rates to examine the impact on operating profitability.

The model has six key major modules within the sheep enterprise: the purebred flock, feed supply, feed demand, feed balance, wool production, and economics. These major modules all had sub-modules. Model inputs were driven by recently published industry standards, ensuring model outputs would replicate realised values as closely as possible.

Scenario 1 uses New Zealand average values for lambing percentage (133.5%) and lamb weaning weight. Scenarios 2, 3 and 4 use average lamb weaning weights but had lambing percentages of 140%, 150% and 160% respectively. Scenarios 5, 6 & 7 used average lambing percentage (133.5%) but has 10%, 20% & 30% greater pre-weaning lamb growth rates respectively. Scenario 8 had a lambing percentage of 140% and 10% increased pre-weaning lamb growth rates.

Increasing lambing percentage from 133.5% in scenario 1 to 160% in scenario 4 increased the proportion of lambs sold store due to a greater proportion of lambs being born as multiples. This scenario increased farm cash operating surplus from $291/ha to $368/ha. Gestational energy demand limited flock size, with the number of ewes decreasing from scenario 1 to 4. Increasing pre-weaning lamb growth rates to 30% (scenario 7) above average (scenario 1) while leaving lambing percentage as average also decreased flock size but increased the farm COS from $291/ha to $444/ha. Lactational demand to meet the increased lamb growth was the factor limiting flock size. In the scenario with 140% lambing and a 10% increase in pre-weaning lamb growth rates (scenario 8) farm COS increased to $365/ha, $74/ha above scenario 1. Overall, increasing pre-weaning lamb growth was more profitable than increasing lambing percentage. Therefore the results of this research indicates that if a farmer has a lambing percentage of 140% or above, it is recommended emphasis should be placed on improving pre-weaning lamb growth rates compared to lambing percentage.

There are several further considerations such as feed supply and lamb numbers, which must be considered before using these results. With the model relying solely on pasture for feed, any circumstances that leads to reduced feed supply may reduce the viability of these results.

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Callum Neil, thank you for providing me with the required industry statistics on behalf of Beef + Lamb New Zealand. Without access to the recent industry statistics, the results from this research would not have reflected a sheep enterprise in the modern day.

Nana and grandad. You two are the source of my passion for agriculture. Without you both, I wouldn't have achieved all that I have today. Your undivided support and passion for agriculture has driven me to be a better student and person, thank you both.

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Term	**Definition**
µm	Micron
b	Lamb Birthweight
BCS	Body Condition Score
C	Culling
c	Culling rate
COS	Cash Operating Surplus
CW	Carcass Weight
D	Deaths
d	Death rate
DM	Dry Matter
DO%	Dress Out Percentage
EBITR	Earnings Before Interest, Tax, and Rent
Eff. ha	Effective Hectares
EUR	Euro
F	Foetal Loss rate
FB	Feed Balance
FD	Feed Demand
FGM	Farm Gross Margin
FS	Feed Supply
G	Daily Fleece Growth
g	Grams
GFR	Gross Farm Revenue
GSL	Grazing System Limited
ha	Hectare
hd	Head
i	Age class
kg	Kilograms
L	Lamb liveweight at weaning
LB	Lambs Born
LS	Litter Size
LSU	Livestock Unit
LW	Liveweight
ME	Metabolisable Energy
ME_L	Metabolisable energy requirement for lactation
ME_M	Metabolisable energy requirement for maintenance
ME_p	Metabolisable energy requirement for pregnancy
ME_w	Metabolisable energy requirement for wool growth
MJ ME	Megajoules of Metabolisable Energy
MFM	Maternal Female Multiple
MFS	Maternal Female Single
mm	Millimetres
MMM	Maternal Male Multiple
MMS	Maternal Male Single
NZD	New Zealand Dollars
PD	Pregnancy Diagnosis
Q	Pasture Quality
R	Replacements
RR	Replacement Rate

SSU	Sheep Stock Units
USD	United States Dollars
W	Annual wool production per ewe
w	Wool production adjustment for each age group
WP	Wool Production
WNI	Western North Island
Y	Ewe Flock
Yr	Year
α	Lamb age at weaning

1.0 Introduction

New Zealand sheep enterprises are often run-in conjunction with an alternate enterprise such as cattle and/or deer. The majority of the breeding ewes currently in New Zealand are of Romney breed, with sheep enterprises utilising a maternal or terminal sire to produce lambs for use as replacements and for sale. The focus of this review and thesis is Class 4 sheep and beef farms in the western North Island of New Zealand. These farms account for approximately 21.3% of all sheep and beef farms in New Zealand, covering over 50% of all farms land in the North Island (Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021).

The two primary income earners for Class 4 sheep enterprises in New Zealand are coarse wool and meat. Lamb meat contributes the greatest proportion to meat production, with cull ewes and rams contributing the rest. While the value of wool has declined from the 1990-91 season, the value of lamb meat has increased dramatically. This change in value has seen many farmers transition their production goals from that of wool to lamb production. Lambing rates for Class 4 farms have increased from 100.6% in 1990-91 to 133.5% in 2021, highlighting the years of selective breeding and increased management techniques that farmers have used to improve lamb production. Lamb carcass weight has increased from 13.9 kg in 1990 to 19.0 kg in 2020 (Beef + Lamb New Zealand, 2021a). The combination of increased lambing performance and the increase in lamb carcass weight, has led to the carcass weight of lamb produced per ewe to increase to 21.5 kg in 2020 (Beef + Lamb New Zealand, 2021a).

Bio-economic modelling is a relatively recently adapted tool used to identify potential strategies to increase productivity or model the potential inclusion of any technological advancements. Farm system models are categorised as simulation or optimisation, with a few models utilising a combination of both optimisation and simulation, using both to overcome shortcomings of the other. Several models have been or are currently still utilised in New Zealand, including but not limited to Farmax and AgInform. Recently a research model has also been developed at Massey University, utilised to produce a wide range of literature with a focus on sheep and cattle enterprises in the North Island of New Zealand (Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c, 2021b, 2022; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e; Wangui et al., 2021).

Sheep enterprise operating profit can be defined as income less expenses and can be increased through increasing farm income and/or reducing farm expenses. Given the production of lamb has overtaken wool as the primary income earner for Class 4 sheep enterprises, increasing lamb output per hectare should increase total income for the enterprise. Farmers have two options if they want to increase lamb output per hectare, either increase lambing percentage or increase lamb weaning weights through increased pre-weaning lamb growth rates. There are few direct comparisons that have been completed, examining the impact of an increase in both lambing percentage and pre-weaning growth rate on farm operating profitability. A bio-economic system-dynamic model that utilises the most recent information collected from Class 4 farms could be used here to examine the impact on profitability using incremental changes to both lambing percentage and/or pre-weaning lamb growth.

Therefore, the specific objectives of this thesis were to:

1. Update the current STELLA bio-economic system-dynamic model (Farrell et al., 2022) with the most recent industry statistics
2. Using the updated STELLA model, run eight scenarios with differing lambing percentage and pre-weaning growth rates to examine the impact on operating profitability.

2.0 Literature review

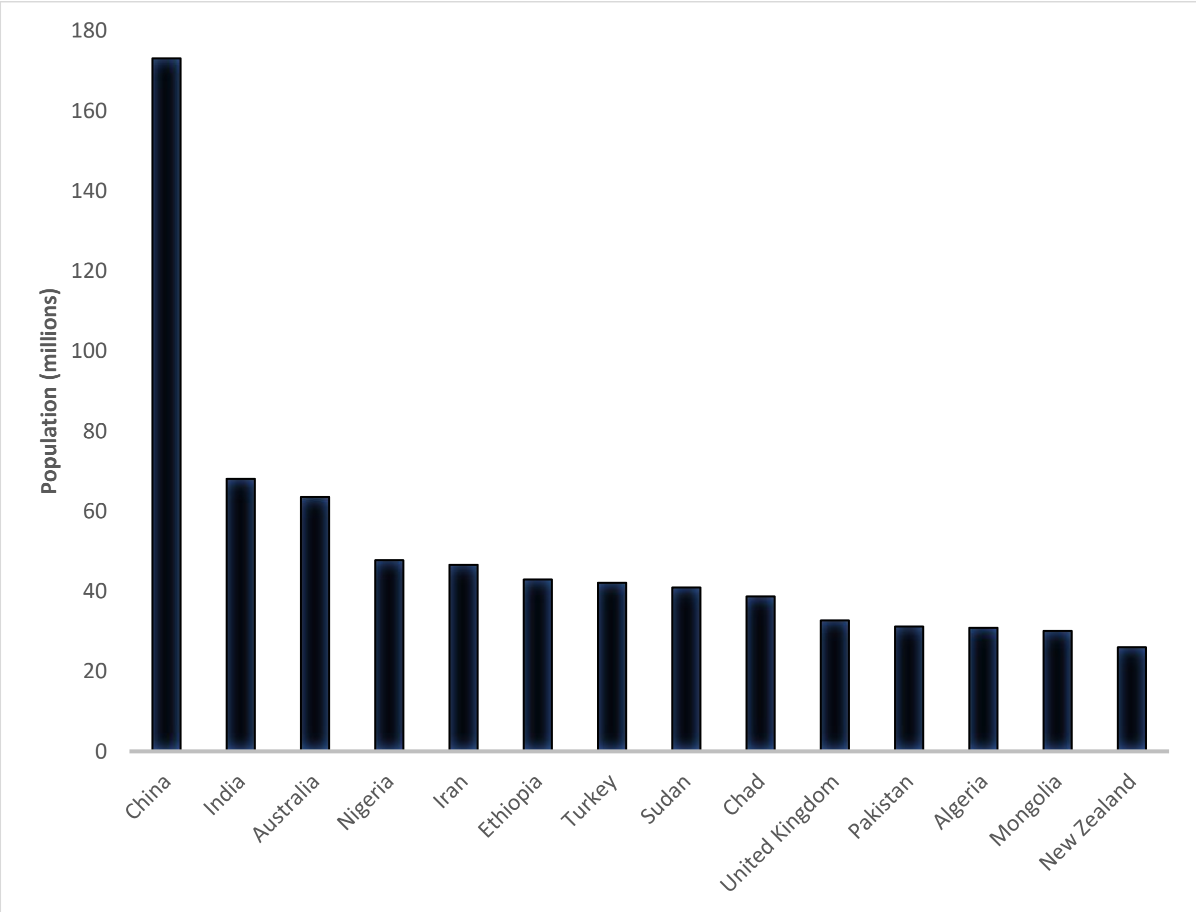
2.1 Introduction

The purpose of this literature review is to review sheep enterprises in New Zealand, their key profit drivers and the use of bio-economic models to investigate potential changes to sheep enterprises. The review describes the world sheep situation, outlining the key countries involved with sheep production along with their historic trends of production. Literature and data focussing on New Zealand sheep enterprises is reviewed, outlining the role sheep enterprises play in New Zealand agriculture along with historic production data. A basic calendar of events for a New Zealand sheep enterprise is outlined and defined before the primary profit drivers for a sheep enterprise are discussed. The review will then focus on national and international models that have been used before discussing the benefits and shortfalls of using models. Systems modelling will then be reviewed, outlining the types of models available along with the role modelling plays in agricultural enterprises. To conclude, the review will briefly outline gaps in the literature and the focus of the thesis that will help to address these gaps.

2.2 World Situation

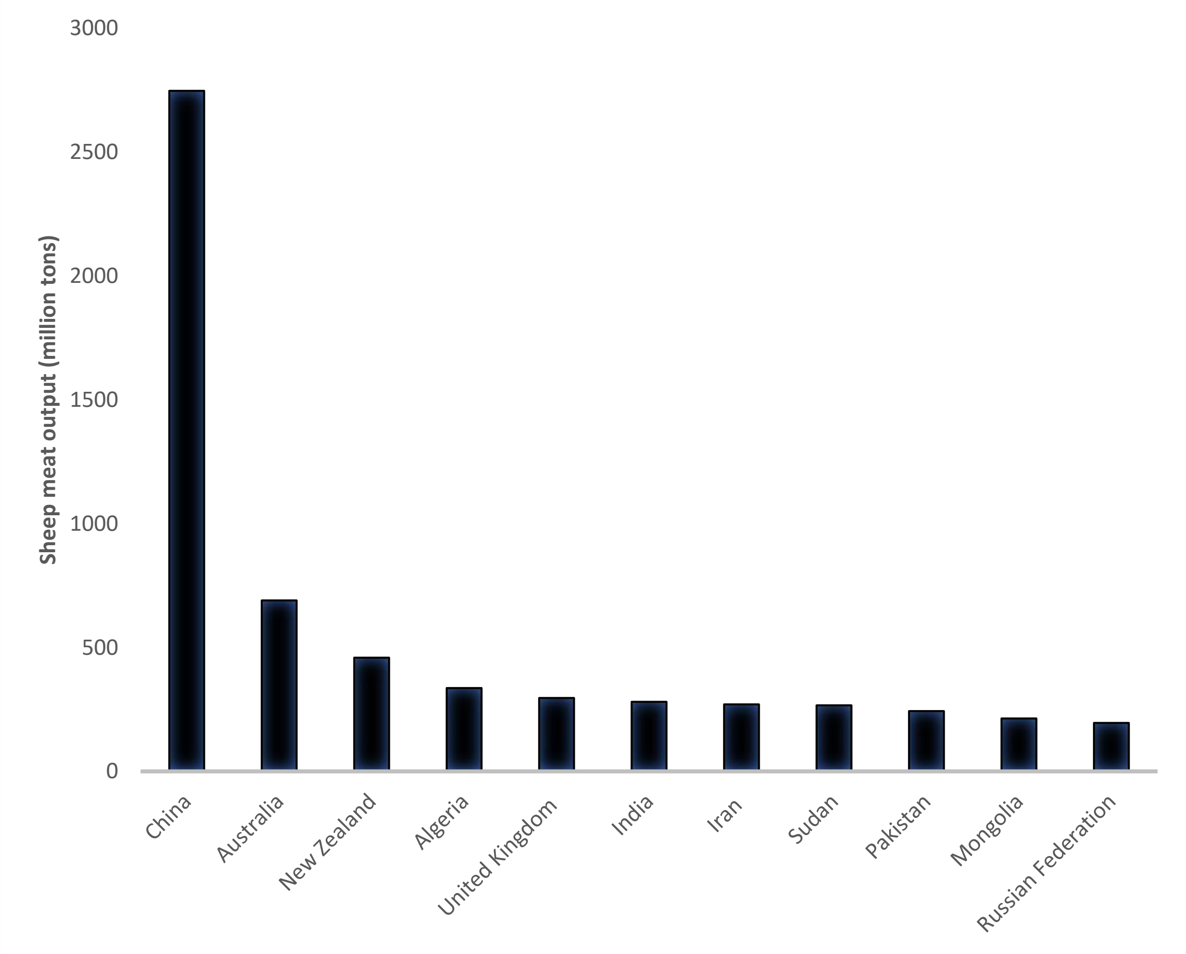
The world's sheep population in 2020 was approximately 1.26 billion, with China having the largest flock (13.7% of global sheep numbers) while New Zealand had approximately 2% of the worlds sheep population (Figure 2.1, FAOSTAT, 2020).

Figure 2.1 Sheep population of selected countries for 2020 (FAOSTAT, 2020)



In 2019, global sheep meat output was 15.3 million tonnes, with China responsible for 26% of global production, followed by Australia and New Zealand, at 8% and 5%, respectively (Figure 2.2, FAO, 2019; FAOSTAT, 2020). Approximately 1.79 million tonnes of greasy wool was produced worldwide in 2019, with production again led by China (19%), followed by Australia (18%) and New Zealand (8%) (FAOSTAT, 2020).

Figure 2.2 Sheep meat output of selected countries for 2020 (FAOSTAT, 2020)



Between 1990 and 2020, the global sheep population increased by approximately 5% , however, sheep meat production increased by approximately 41% (Table 2.1, FAOSTAT, 2020). However, global greasy wool production declined by approximately 48%, highlighting the transition from wool to meat-producing systems (Table 2.1, FAOSTAT, 2020). Since 1990, China has increased its sheep population and production to become the largest global producer of both meat and wool (Table 2.1, FAOSTAT, 2020). Meanwhile, since 1990, Australia has significantly reduced their sheep flock along with their production of greasy wool while slightly increasing their meat production (FAOSTAT, 2020).

Table 2.1 Change in sheep meat and greasy wool production and total sheep population for Australia, China, New Zealand and the overall world from 1990 to 2020 (FAOSTAT, 2020)

Country	Sheep meat	Wool production (greasy)	Sheep population
Australia	10%	-74%	-63%
China	401%	39%	56%
New Zealand	-13%	-51%	-55%
World	41%	-48%	5%

2.3 New Zealand situation

Since their introduction to New Zealand, sheep have been run in a mutually beneficial relationship with cattle, with the ratio of sheep to cattle differing by farm class (Beef + Lamb New Zealand, 2021a). The sheep population in New Zealand has declined from 57.9 million in the 1990-91 season to 27.3 million in the 2018-19 season (Beef + Lamb New Zealand, 2020a). The 2020 estimated sheep population in New Zealand was 26.03 million, a further 5% lower than the 2018-19 season (Beef + Lamb New Zealand, 2021a; FAOSTAT, 2020).

2.3.1 Land use

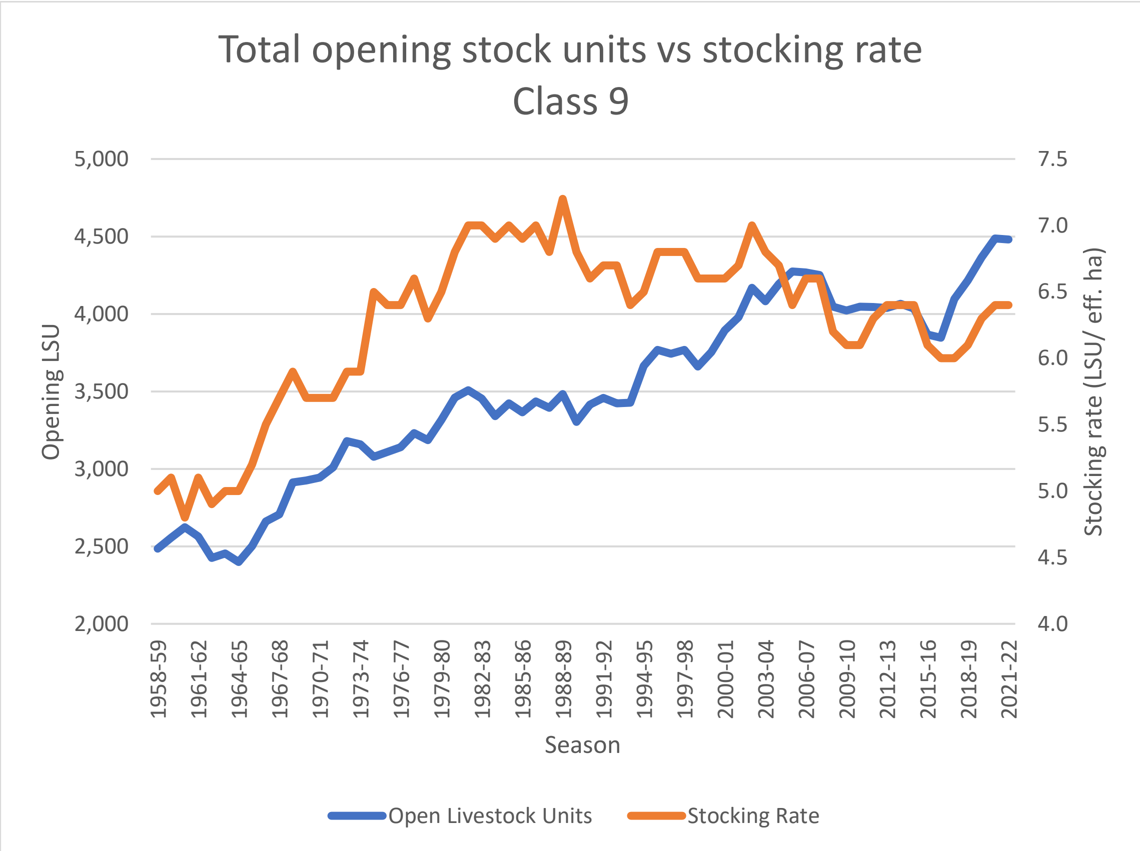
The area allocated for sheep and cattle farming in New Zealand has declined from 12.50 million hectares in 1990 to approximately 8.77 million hectares in 2017 (Beef + Lamb New Zealand, 2021a; Mackay et al., 2012). This decline is a result of changes to other production systems. For example, approximately 26% of sheep and cattle farming land lost has been converted to dairy farms, while the remainder was converted to forestry, conservation land, urban encroachment, viticulture and/or horticulture (Mackay et al., 2012). In 2017, there were 23,403 sheep and cattle farms registered, accounting for 45% of all farm types in New Zealand (Beef + Lamb New Zealand, 2020a, 2021a). Opening livestock numbers as of the 1st of July and livestock stocking rates (Livestock units per hectare; LSU/ha) have increased since the 1958-59 season as highlighted in Figure 2.3.

2.3.2 Breeds and primary products

Most New Zealand sheep flocks comprise dual-purpose sheep breeds to produce meat and coarse wool (>30 µm) with the Romney representing over 50% of the total national flock (Beef + Lamb New Zealand, 2020a). Texel, Suffolk, and South Suffolk are the primary terminal breeds used (Beef + Lamb New Zealand, 2020a). The use of terminal breeds as sires has increased in popularity in recent years to produce crossbred lambs that exhibit higher growth rates, improved meat quality, and increasing profitability (Beef + Lamb New Zealand, 2021a; Farrell et al., 2020a). Approximately 6% of the national sheep flock is Merino, which produces high quality fine wool (<24.5 µm) and is farmed on high country stations predominately in the South Island of New Zealand (Beef + Lamb New Zealand, 2021a). Up until the 1989-90 season, wool was the primary income earner for most sheep enterprises, with most breeds such as the Romney and Merino being selected based on their wool productivity traits rather than meat productivity traits (Tables 2.4 & 2.5, Beef + Lamb New Zealand, 2021a).

Although there has been a decrease in total meat production between 1990 & 2020, it is relatively small given the national flock has declined by 55% (Table 2.1, FAOSTAT, 2020). This smaller relative decline in meat production indicates lambing percentage, weaning weights, and carcass weights must have increased over time.

Figure 2.3 Time series of the opening number of livestock units and stocking rates (LSU/eff. ha) for all New Zealand sheep and cattle enterprises on 1st July (Beef + Lamb New Zealand Economic Service, 2021)



From 1990 to 2020, lamb carcass weight (kilograms per head; kg/hd) and lamb production (kg/ewe) has increased from 13.9 to 19.0 kg and 9.8 to 21.5 kg, respectively, highlighting lamb growth and weaning weights have increased (Beef + Lamb New Zealand, 2021a). Management practices that focussed on ewe reproduction such as pregnancy diagnosis and preferential treatment of multiple bearing ewes has allowed lambing percentage to increase from 102% in 1990-91 to 129% in 2019-20 (Beef + Lamb New Zealand, 2021a; Morris & Kenyon, 2014). Average lamb carcass weights have also changed, increasing from 13.0 kg in 1990 to 18.6 kg in the 2021-22 season (Beef + Lamb New Zealand, 2021a; Morris & Kenyon, 2014). Therefore, it can be concluded that the combination of improved lambing percentages and lamb performance is the key driver of the high meat output per sheep.

Given the significant decline in New Zealand sheep and cattle land area along with the decline in sheep numbers it is surprising that sheep meat production has only declined 13% from 1990, indicating improved productivity (Table 2.1, FAOSTAT, 2020). The ability to maintain high levels of sheep meat productivity arises from more efficient farming of sheep, with technological innovation, strict breeding regimes and improved pasture knowledge and management being the key drivers (Mackay et al., 2012; Morris & Kenyon, 2014).

2.3.3 New Zealand meat exports

New Zealand exports included 307,261 tonnes of lamb for the year ending 30th September 2020 (Beef + Lamb New Zealand, 2020b, 2021a). North Asia received the majority of this lamb (52%), followed by the European Union and North America (28% and 9%, respectively). The type of export has changed in recent decades, with a significant reduction in the number of frozen carcasses and an increase in chilled, frozen boneless, and frozen cuts (Table 2.2, Beef + Lamb New Zealand, 2021a).

Table 2.2 Lamb export products for 1990-91 and 2019-20 based on product type (Beef + Lamb New Zealand, 2021a)

Product type	1990-91	2019-20
Chilled	3%	16%
Frozen Boneless	2%	10%
Frozen Cuts	53%	71%
Frozen Carcasses	42%	3%

New Zealand accounts for approximately 47% of the world's trade in lamb (Beef + Lamb New Zealand, 2020b). In the 2021 season, New Zealand produced 92,000 tonnes of mutton, exporting 85,882 tonnes (93% of all mutton), worth $645.4 million (Beef + Lamb New Zealand, 2021a). Due to their export focus, New Zealand sheep enterprises are reliant on international markets, policies, and exchange rates to dictate price (Figure 2.4, Beef + Lamb New Zealand, 2020b; Morris, 2013). These everchanging variables result in significant price variability both within and between years (Figures 2.4 & 2.5, Table 2.3 (Figures 2.4 & 2.5, Table 2.3, ANZ, 2022; Beef + Lamb New Zealand, 2021a; Beef + Lamb New Zealand Economic Service, 2021). The general trend over time shows price per kg being highest toward the end of the year when few of the previous year's lambs are left for slaughter and a decline in the first quarter of the year as more lambs become available post-weaning. Since Covid-19 emerged in November 2019, the virus has impacted on individual countries economic activity, especially those relying on the export of goods for income (Beef + Lamb New Zealand, 2020b). For example, the value of high quality cuts such as the French rack in the USA and European Union plummeted from 2019 to 2021 due to the reduction in international restaurant trade, reducing the price to below that of moderate quality cuts (Figure 2.4, ANZ, 2022).

Figure 2.4 Trend in prices of lamb cuts, highlighting a reduction in French rack sales through a lack of trade in the USA and European Union (ANZ, 2022)

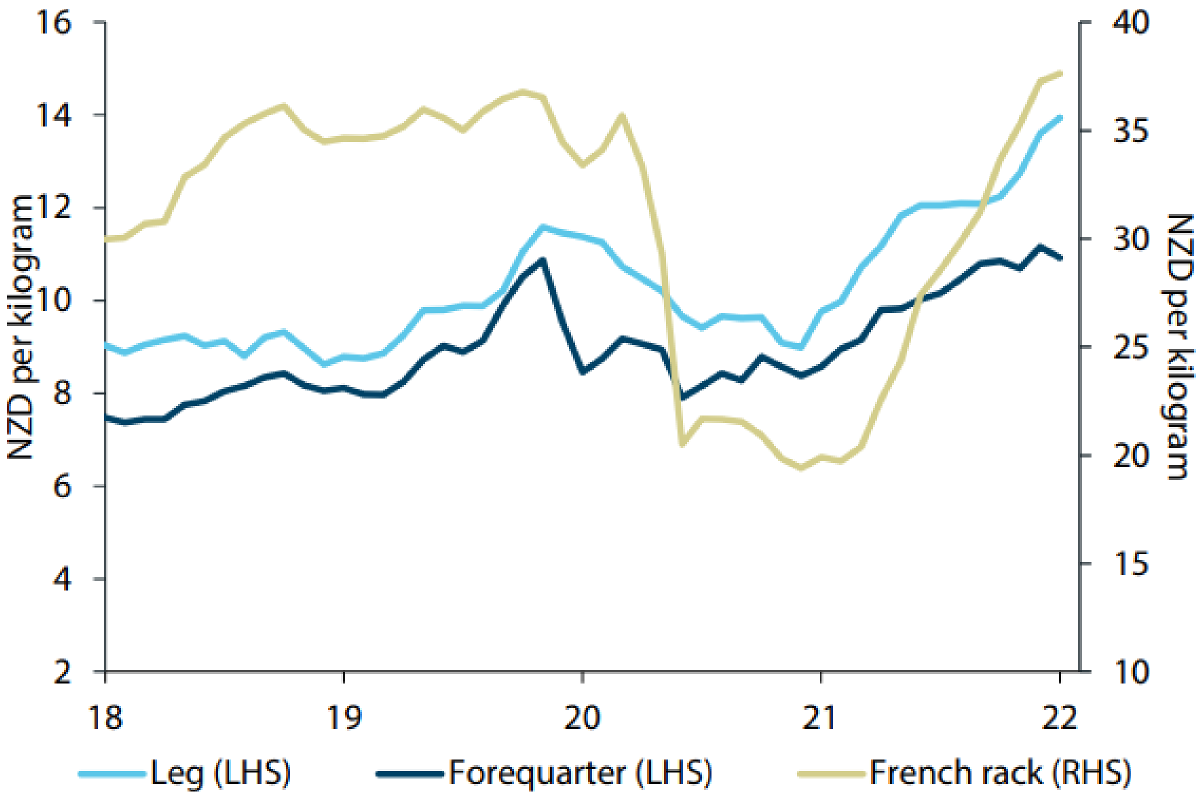
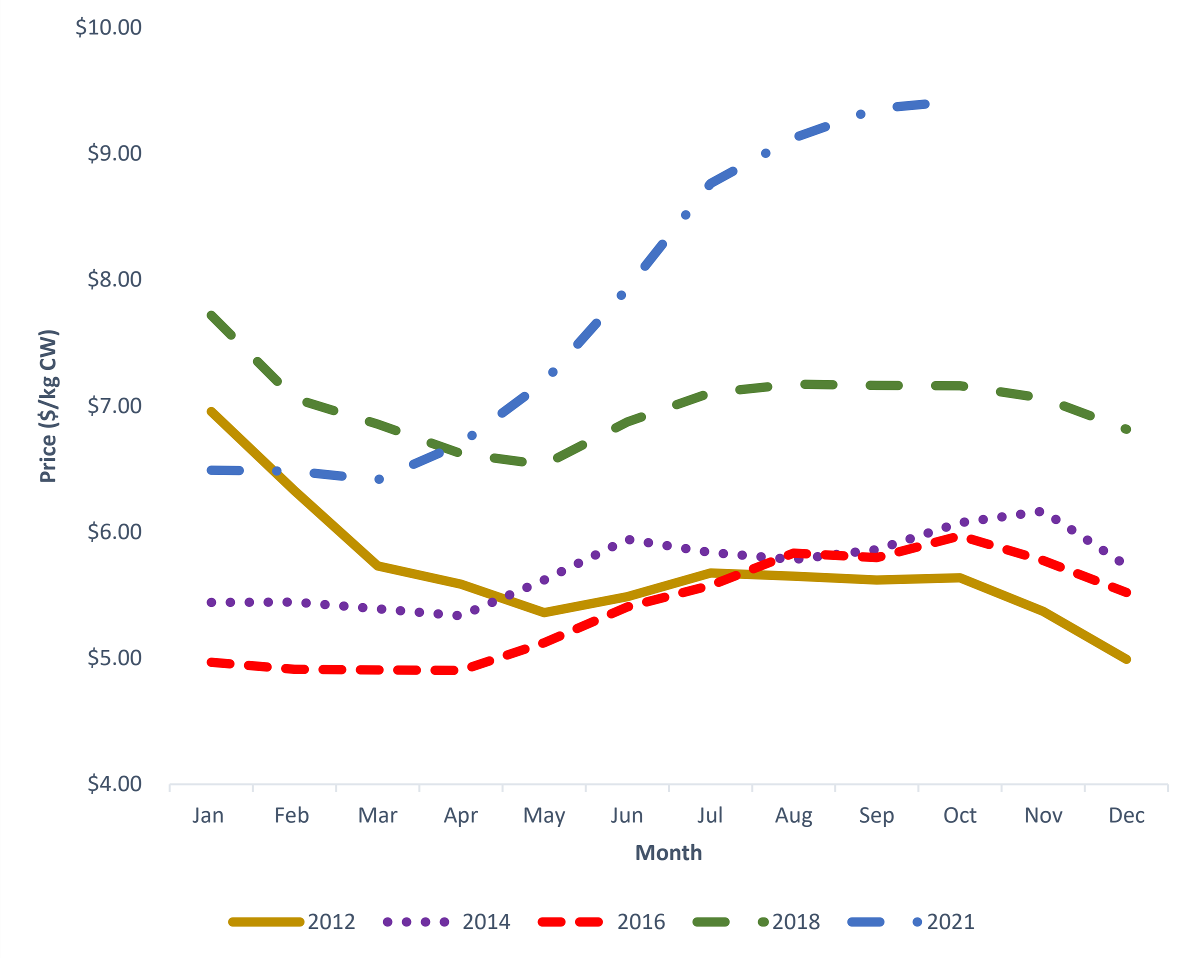


Table 2.3 Price variation of slaughter lamb (YM Grade) within the 2020 year (Beef + Lamb New Zealand, 2021b)

Month	Value (per head)	Value (per kg CW)
January	$121.41	$7.72
February	$111.60	$7.06
March	$108.18	$6.86
April	$104.22	$6.62
May	$103.20	$6.53
June	$108.34	$6.87
July	$112.22	$7.11
August	$113.35	$7.17
September	$113.45	$7.16
October	$113.03	$7.16
November	$110.33	$7.06
December	$106.40	$6.82

Figure 2.5 Average monthly values ($/kg carcass weight) of slaughter lamb (YM grade) from 2012 to 2021, highlighting an increasing trend in value (Beef + Lamb New Zealand, 2021b)



2.4 New Zealand farm classes

The topography in New Zealand varies greatly which influences enterprise type. To allow for comparison between similar farms, Beef and Lamb New Zealand has created eight farm classes. These farm classes include three in the North Island, ranging from hard hill (Class 3), hill country (Class 4) and intensive finishing (Class 5) (Beef + Lamb New Zealand, 2021c). The remaining five classes are found in the South Island and include high country (Class 1), hill country (Class 2), finishing breeding (Class 6), intensive finishing (Class 7) and mixed cropping and finishing (Class 8) (Beef + Lamb New Zealand, 2021c). Table 2.4 highlights the differences between the eight farm classes.

The sale of sheep which includes lambs and cull rams and ewes, provides a majority of gross farm income for all farm classes except for classes 5 and 8, which obtain the majority from the sale of beef and cash cropping, respectively (Table 2.4, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). The sale of wool only features as a primary source of gross farm income for Class 1 farms, with this high proportion of wool income driven from the use of the Merino breed (Beef + Lamb New Zealand, 2021a, 2021b). This is a change from 1990 (Table 2.5).

The sale of lamb was the key driver of sheep income in 2021 from farm classes that obtain a majority of their gross farm income from sheep (i.e., classes 1, 2, 3, 4, 6 & 7) (Table 2.4). Lambs were sold either as store lambs for farmers to finish to slaughter weights or sold directly to slaughter as slaughter lambs. The target grade within the New Zealand meat classification system for a slaughter lamb is YM, which indicates a carcass weight of between 13.3 and 17.1 kg, with a fat measurement of at least 7 mm but less than 12 mm over the 12th rib (GR measurement) (New Zealand Meat Classification Authority, 2004). Store lambs are valued per kilogram of liveweight ($/kg LW) while slaughter lambs (often termed 'Prime') are valued per kilogram of carcass weight ($/kg CW). The decision to sell lambs store or slaughter is often subjective, with seasonal variation in pasture production and quality of the lambs helping to dictate farmer's decisions. Long term trends, however, highlight those farm classes that predominately sell lambs as store or slaughter, with classes 4, 5, 6, 7 and 8 selling most lambs to slaughter (>70%), driving profit for these classes. There is however, a relatively even split of lambs sold for slaughter and store for classes 1, 2 & 3 (Table 2.4, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021).

Comparing Tables 2.4 and 2.5, there is a distinct change in primary income earners from 1990-91 to 2020-21 for sheep and cattle enterprises. For each farm class in 1990-91, wool provided a much higher proportion of gross farm income, with classes 1 and 2 obtaining 70.6 % and 40.4% of gross farm income from wool in 1990-91 with the two classes only obtaining 27% & 8% from the sale of wool in the 2020-21 season respectively (Tables 2.4 & 2.5). Classes 4 and 5 obtained the highest proportion of income from the sale of sheep in 1990-91, with sheep accounting for 41.5% & 53.7% of total income, respectively. While classes 1, 2, 3, 4, 5 & 7 had a similar proportion of lambs sold for slaughter and store in 1990-91 when compared to the 2020-21 season, Class 6 farms sold a greater proportion of lambs for slaughter while Class 8 farms sold a slightly greater proportion store in 1990-91 (Tables 2.4 & 2.5).

Class 4 farms are the most prevalent farm class in the North Island of New Zealand and includes the largest land area of the three farm classes in the North Island. The data from Table 2.4 highlights the sale of sheep is the primary income earner for Class 4 farms, with majority of lambs sold prime. Table 2.6 shows the quintile data from Beef + Lamb's economic survey for the 5 quintiles in Class 4 farms for the 2019-20 season. The data suggests that lambing percentage is a key driver of farm performance, with high performing farms (quintile 5) having the highest lambing percentage (Table 2.6, Beef + Lamb New Zealand, 2021d). Quintile 5 farms also have the highest stocking rate, suggesting that the combination of high lambing percentages and high stocking rates ensure high levels of income. Quintile 4 and 5 farms have higher than average expenditure per livestock unit, with higher-than-average fertiliser and repairs and maintenance expenditure (Table 2.6, Beef + Lamb New Zealand, 2021b). It can be assumed that the combination of higher stocking rates per hectare, higher lambing percentages and higher than average levels of expenses on fertiliser and repairs and maintenance allow for high sheep gross margins observed on quintile 5 Class 4 farms (Table 2.6, Beef + Lamb New Zealand, 2021b).

2.5 Summary of a basic North Island Hill country sheep system

As of the end of the 2021 season, there were a total of 5,020 sheep and beef farms in the North Island in classes 3, 4 and 5 (Table 2.7, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). Class 4 farms contributed 61% to the total number of farms, with a combined area of 1,362,530 ha, the largest area in the North Island (Table 2.4, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). Therefore, this research focussed on Class 4 North Island hill country sheep and beef farms with an emphasis on the western North Island of New Zealand. This farm type has previously been modelled for sheep and beef production systems (Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c; Farrell et al., 2021c; Farrell et al., 2019).

Table 2.4 Details of New Zealand sheep and beef farm classes for 2020-21 (Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021)

	Beef and Lamb NZ Farm Classes							
Class number	1	2	3	4	5	6	7	8
Class name	South Island High country	South Island Hill country	North Island Hard hill country	North Island Hill country	North Island finishing	South Island breeding	South Island finishing	South Island Mixed finishing
Number of farms in the survey	200	620	920	3,055	1,045	1,820	1,040	465
Effective area (ha)	8,374	1,497	836	446	283	509	258	367
Proportion of total area	26.19%	14.51%	12.03%	21.30%	4.62%	14.49%	4.20%	2.67%
Livestock units at opening[1]	12,260	6,743	6,767	4,077	2,925	4,186	2,773	2,423
Livestock units/ha	1.5	4.5	8.1	9.1	10.3	8.2	10.7	6.6
Total sheep livestock units	10,273	5,199	4,473	2,253	1,284	2,948	2,552	1,451
Total cattle livestock units	3,683	2,114	2,556	2,246	1,794	1,507	413	1,762
Sheep to cattle ratio	74:26	71:29	64:36	50:50	42:58	66:34	86:14	45:55
Labour units/farm	3.88	2.23	2.18	1.65	1.43	1.87	1.41	2.36
Ewe lambing %	109.7	123.8	127.1	130.6	133.3	136.5	136.2	134.1
% GFR from wool sales	27.0	8.9	4.3	3.2	1.5	3.5	4	0.8
% GFR from sheep sales	43.8	63.0	62.0	48.5	33.3	55.0	72	10.5
% GFR from beef sales	18.5	21.2	30.1	39.1	46.0	20.8	8	6.1
% GFR from other sales	10.7	6.9	3.6	9.2	19.2	20.8	15	82.7
Proportion of lambs sold prime (%)	53	52	52	73	96	74	91	95
Proportion of lambs sold store[2] (%)	47	48	48	27	4	26	9	5

[1] One livestock unit is equivalent to one breeding adult ewe rearing one lamb consuming 550 kg dry matter per year

[2]Store lambs can be sold slaughter but are often penalised due to light carcass weights. Slaughter lambs are often colloquially termed 'Prime' in New Zealand

GFR= Gross farm revenue

Table 2.5 Details of New Zealand Sheep and Beef Farm Classes for 1990-91 (Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021)

	Beef and Lamb NZ Farm Classes							
Class number	1	2	3	4	5	6	7	8
Class name	South Island High country	South Island Hill country	North Island Hard hill country	North Island Hill country	North Island finishing	South Island breeding	South Island finishing	South Island Mixed finishing
Number of farms in the survey	32	44	75	174	89	64	32	25
Effective area (ha)	10,389	1,604	607	376	215	381	183	251
Livestock units at opening[1]	9,283	5,707	4,933	4,040	2,584	3,182	2,363	1,773
Livestock units/ha	0.9	3.6	8.1	10.7	12.0	8.4	12.9	7.1
Total sheep livestock units	7,601	4,512	3,372	2,569	1,635	2,748	2,274	1,597
Total cattle livestock units	1,538	1,140	1,507	1,394	896	376	64	171
Sheep to cattle ratio	83:17	80:20	69:31	64:36	65:35	88:12	97:3	90:10
Labour units/farm	3.05	2.11	1.76	1.52	1.38	1.60	1.36	1.92
Ewe lambing %	84.1	94.6	91.9	100.6	98.3	103.2	120.2	113.7
% GFR from wool sales	70.6	40.4	31.8	27.6	21.7	32.2	32.2	11.5
% GFR from sheep sales	13.1	33.4	25.1	23.4	23.9	41.5	53.7	21.9
% GFR from beef sales	13.8	23.5	39.3	44.8	40.6	14.2	2.8	3.1
% GFR from other sales	1.2	1.7	1.9	2.3	4.0	4.7	1.5	2.1
Proportion of lambs sold prime (%)	49	75	47	75	93	89	95	89
Proportion of lambs sold store (%)	51	25	53	25	7	11	5	11

[1] One livestock unit is equivalent to one breeding adult ewe rearing one lamb consuming 550 kg dry matter per year

[2]Store lambs can be sold slaughter but are often penalised due to light carcass weights. Slaughter lambs are often colloquially termed ‘Prime’ in New Zealand

GFR= Gross farm revenue

Table 2.6 Quintile units for Class 4 farms in the western North Island of New Zealand for the 2019-2020 season ranked on EBITRm[1] per hectare (Beef + Lamb New Zealand, 2021d)

2019-2020	Units	Q1	Q2	Q3	Q4	Q5	Mean
Stocking rate	LSU/ha	8.9	8.4	8.5	8.9	9.9	8.9
Lambing percentage	%	116.9	121.9	137.3	142.0	147.5	133.5
Proportion of lambs sold prime	%	73	87	76	83	81	81
Proportion of lambs sold store	%	27	13	24	17	19	19
Lamb value	$/head (hd)	113.98	129.61	127.65	123.39	126.46	125.58
Total expenditure	$/LSU	84.76	84.76	97.93	117.14	100.99	97.60
Sheep gross margin	$/Sheep stock unit (SSU)	72.80	97.41	119.43	135.95	141.25	115.12

[1]EBITRm: Earnings before interest, tax, rent and wages paid to a manager

Class 4 farms rely primarily on pasture produced on farm for feed, having minimal cultivatable land for cropping, with the pasture production/supply varying throughout the year, with spring having the greatest levels of growth, highlighted in Figures 2.5.1 & 2.5.2 (Farrell, 2020; Radcliffe, 1976). Of the gross farm income for Class 4 hill country farms, only 3.2% is derived from the sale of wool, with nearly half of total income derived from sheep sales (Table 2.4). In comparison in 1990-91 the proportion of total farm income from wool and sheep was 27.6% and 23.4%, respectively (Table 2.5, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). Seventy two percent of all lambs sold from farm are sold for slaughter, with the remaining 28% sold store (Table 2.4, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). This significant reliance on the sale of lambs to drive gross farm income provides the opportunity for modelling-based research investigating efficient means to increase lamb production to help farmers improve income and profitability. The Class 4 sheep enterprise is based on dual-purpose coarse wool breeds such as the Romney with terminal sires used over a proportion of the flock to produce both wool and lamb as the primary outputs. Secondary meat-based outputs include cull ewes and rams. This clearly outlines the shift in income drivers and production systems to focus primarily on meat production.

2.5.1 Spring

The following section aims to briefly outline and discuss the annual events for a sheep enterprise, touching on key nutritional and animal health practices that must occur. The primary event occurring in spring is lambing, occurring predominately from the middle of August through to October. Lambing is closely aligned with the increase in pasture growth rates that come with the increase in soil temperatures and sunlight hours, commonly referred to as the spring flush (Figures 2.5 & 2.6, Kenyon & Webby, 2007; Litherland et al., 2002).

The final trimester of gestation and first part of lactation require high energy input to meet nutrition requirements and to maximise lamb growth and survival (Dalton et al., 1980; Kenyon et al., 2003; Kenyon & Webby, 2007). Ewe body condition score (BCS), which is a measure of stored energy reserves, may decline over spring due to the high lactation energy demand but should not decline more than one BCS (Figure 2.7, Kenyon et al., 2014).

Mixed-aged ewes often have minimal shepherding at lambing time and are stocked at a set rate of ewes per hectare, termed set stocking. The overall aim is to match feed demand with pasture growth rates on a hectare basis while keeping pasture cover above 1200 kg DM/ha to ensure animal intakes and subsequent performance is acceptable (Table 2.7, Kenyon & Webby, 2007) Multiple lamb bearing ewes should be a priority and receive the most sheltered paddocks and a greater quantity and quality of feed (Kenyon et al., 2009). If mated, hoggets will lamb approximately one to two months later than the ewe flock to ensure the majority of the hoggets have reached puberty (Kenyon et al., 2011c). The aim over the spring period is to maximise lamb survival and growth until weaning. While the average lambing percentage for Class 4 farms is 133.5% for the 2020-21 season, the reported range is from approximately 80% to 170%, highlighting the potential to increase the average (Figure 2.8, Beef + Lamb New Zealand, 2022). The quintile data for Class 4 farms in 2021 in the western North Island indicated quintile 4 and 5 farms had lambing percentages at 142.0% and 147.5%, respectively, and selling a majority (>80%) of their lambs as prime (Table 2.6, Beef + Lamb New Zealand, 2021d).

2.5.2 Summer

Lambs are weaned over the summer months at approximately 10 – 12 weeks of age (Kenyon & Webby, 2007). Single born lambs are weaned heavier than twin and triplets, with average weaning weights of 31.4, 26.0, and 22.7 kg respectively (Table 2.9). Lamb growth is heavily dependent on feed quantity and quality, with lambs exhibiting growth rates between 182 and 353 grams/day (Table 2.10). This shows there is the potential for high growth rates from birth to weaning for all birth ranks. Pasture covers should be between 900 – 1000 kg DM/ha during summer, with rainfall often dictating the pasture covers achieved (Table 2.7, Farrell, 2020; Kenyon & Webby, 2007). Average flock BCS will vary based on the quantity of summer feed and average pasture covers, with farmers aiming for a BCS of ≥3 (Figure 2.9).

Over the summer months, approximately 20 to 30% of the mature breeding flock is replaced, with ewe lambs from a maternal sire identified at summer and marked as replacements, with the heavier ewe lambs at weaning preferentially selected (Farrell et al., 2020b). Shearing typically occurs in summer months to help mitigate heat stress and reduce the risk of fly strike (Beef + Lamb New Zealand, 2021a; Denicolo et al., 2008a).

2.5.3 Autumn

Breeding generally starts between the middle of March and the start of April on most farms for mature ewes, with farmers controlling the time of ram introduction with the expected occurrence of the spring flush to ensure efficient production and minimise the chance of an adverse weather event during lambing. If hoggets are bred, breeding generally begins one to two months after the mature ewes, normally starting around early May.

Figure 2.6 Monthly pasture growth curve for western North Island sheep enterprises (Radcliffe, 1976)

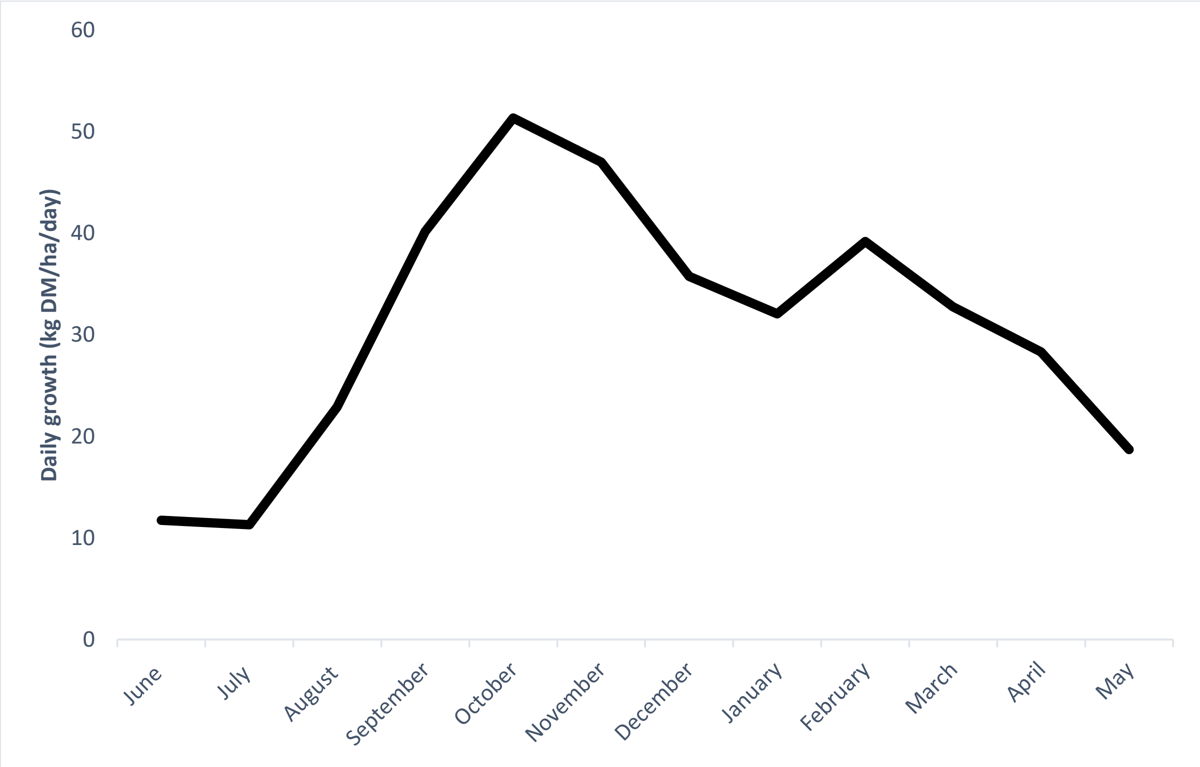


Figure 2.7 Monthly pasture growth rates for a sheep enterprise (Farrell, 2020)

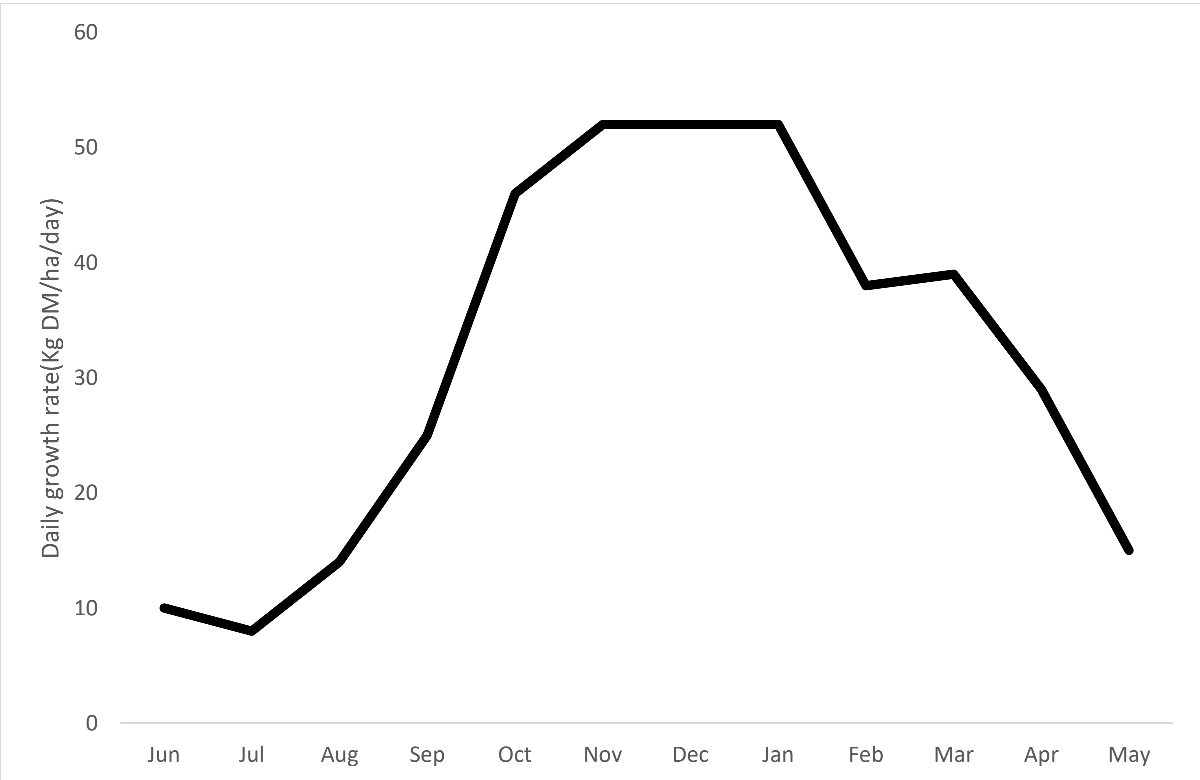


Figure 2.8 Lambing percentage distribution for Class 4 enterprises (Beef + Lamb New Zealand, 2022)

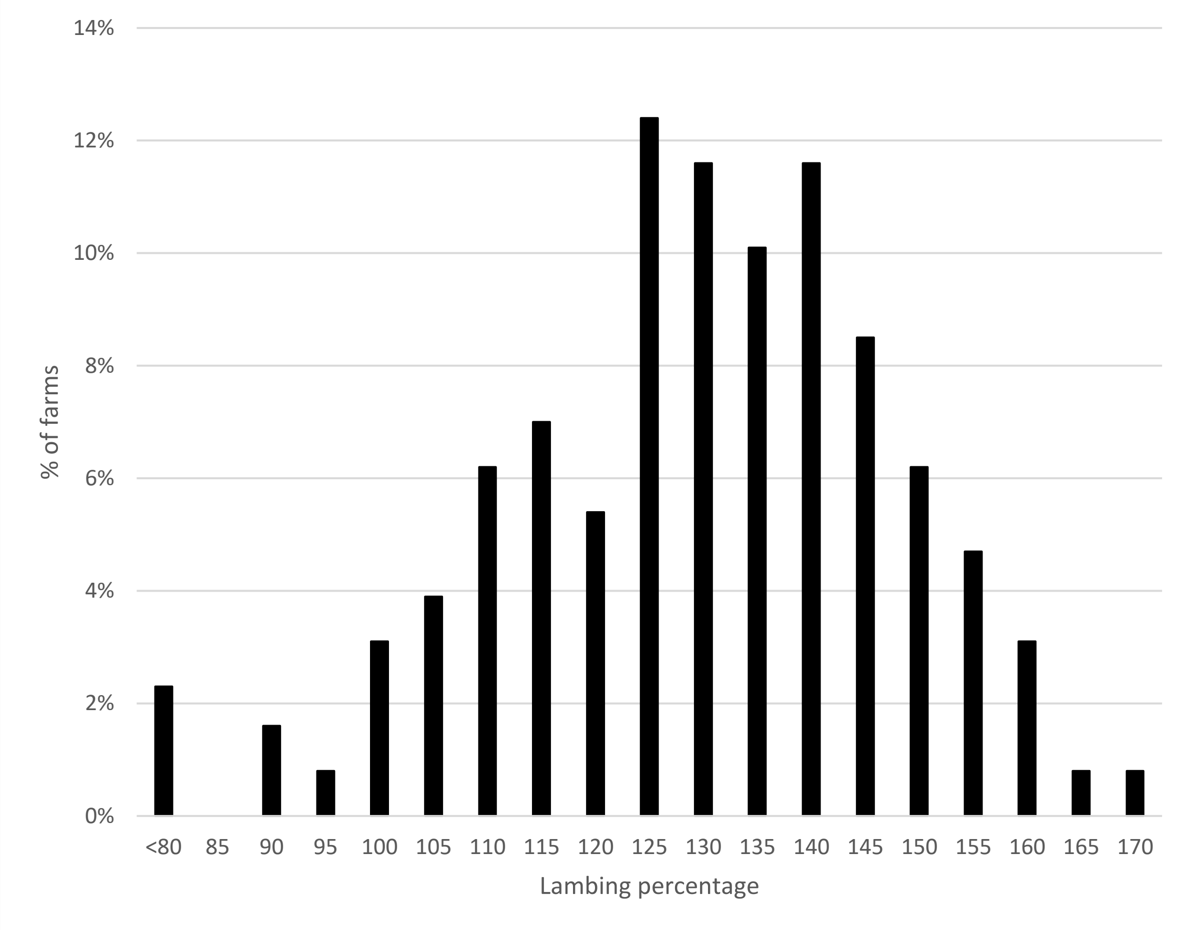
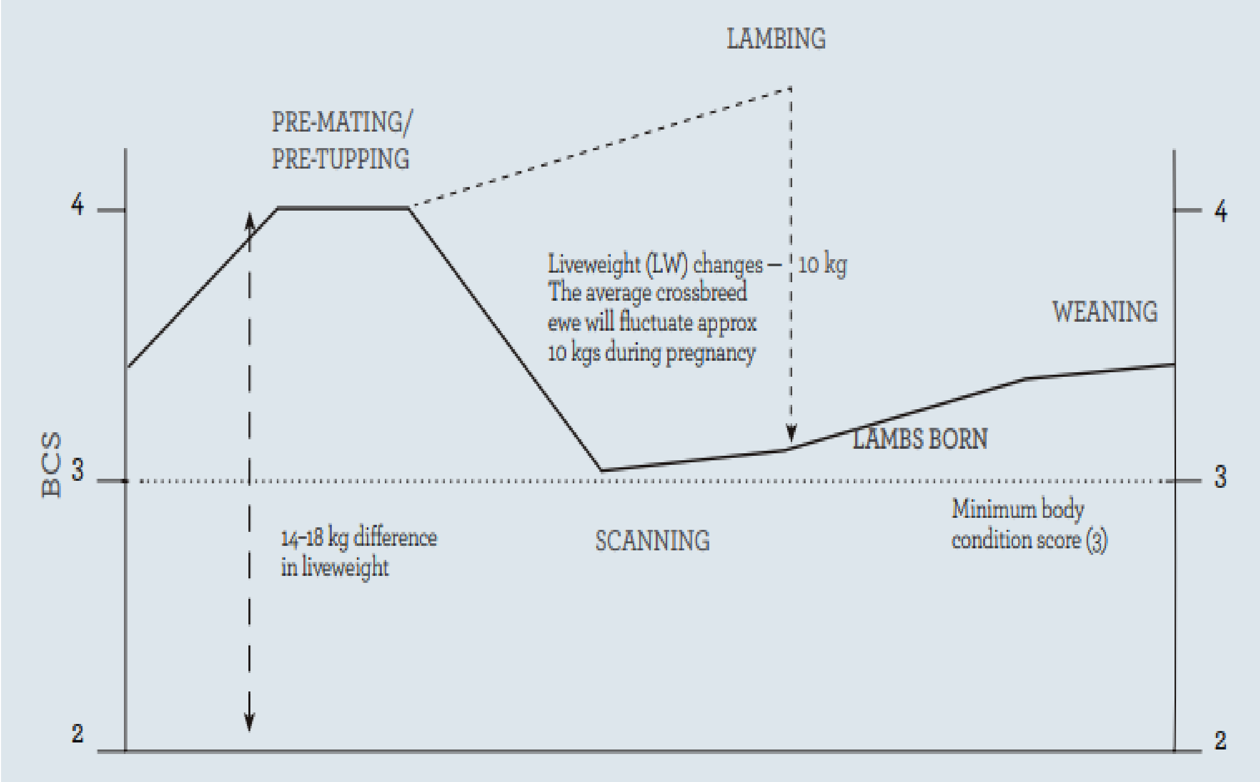


Table 2.7 Target pasture covers at varied times of the year and ewe and lamb production levels (Farrell, 2020)

Ewes	Target pasture cover Kg DM/ha	Target Liveweight gain Growth/day
Ewes and lambs	1200 - 1400	180 – 200g/day (lambs)
Summer	900 – 1000	Maintenance
Mating	1200 – 1400	120 – 150 g/day
Mid-pregnancy	900 – 1000	Maintenance
6-weeks pre lamb	1200	60 – 80 g/day

Figure 2.9 Body condition score targets at key production times of the year (Beef + Lamb New Zealand, 2019)



Prior to breeding, most farmers look to place their ewes on a rising plane of nutrition (Kenyon & Webby, 2007). Following lactation and often drier summer conditions with poor pasture availability and quality, ewe liveweight and BCS can be low (<2.5) (Kenyon et al., 2014; Kenyon & Webby, 2007). If bred at low liveweights/BCS, reproductive performance is negatively impacted (Kenyon & Webby, 2007). Providing ewes with high quality and quantity of feed four weeks prior (flushing) to mating, especially for low BCS ewes, utilises both the dynamic and static effects on reproduction, significantly improving ovulation and subsequent conception rates (Kenyon & Webby, 2007). Average pasture covers need to be greater than 1200 kg DM/ha if flushing is to be achieved, with the average pasture cover and autumn pasture growth rates dictating the practicality of flushing and how many ewes can be flushed successfully (Table 2.7, Kenyon & Webby, 2007). Ewes should have the highest BCS of the year during autumn, with targets of 3.0 often set for the tupping period (Figure 2.9, Kenyon et al., 2014; Kenyon & Webby, 2007).

2.5.4 Winter

During winter, pregnant ewe flocks are either rotationally grazed or set-stocked to ensure their desired nutrient intakes are met (Beef + Lamb New Zealand, 2018). Between 45 and 90 days of pregnancy, farmers utilise ultrasound pregnancy diagnosis to indicate pregnancy status (pregnant or dry) and number of foetuses carried (Beef + Lamb New Zealand, 2018; Kenyon & Webby, 2007; Nicoll et al., 1999). Pregnancy diagnosis (PD), often termed scanning, is the first stage at which the farmer can identify their potential lamb crop, providing the first piece of information to help determine rates of lamb mortality, also allowing farmers to focus nutritional need by ewe pregnancy rank (Anderson & Sewell, 2000).

Multiple bearing ewes should be preferentially fed throughout winter to ensure their increased pregnancy demand is met (Beef + Lamb New Zealand, 2018; Kenyon & Webby, 2007). If mated, hoggets also become a priority stock class to ensure they continue to grow while developing the foetuses, with the consequences of poor total hogget liveweight gain over winter often negating any benefit of mating hoggets (Kenyon et al., 2014). During the early to middle stages of pregnancy, rotationally grazed mature ewes need an average pasture cover of between 900 – 1000 kg DM/ha (Table 2.7, Kenyon & Webby, 2007). Required pasture covers increase to 1200 kg DM/ha in the final 6-weeks of pregnancy, as the foetus is rapidly developing in size. Maintaining an average flock BCS of 3 is the target for the winter period, with BCS's dropping from the peak around tupping (Figure 2.8, Kenyon et al., 2014; Kenyon & Webby, 2007). In lamb hoggets should not be fed covers below 1200 kg DM/ha throughout pregnancy if desired growth rates are to be obtained (Kenyon et al., 2014)

2.6 Profit drivers for sheep enterprises

The primary income driver of sheep enterprises on Class 4 hill country farms is the sale of sheep, primarily lamb, with the sale of sheep accounting for 48.5% of gross farm income (Table 2.4, Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021).

To increase income from a sheep enterprise, farms need to focus on maximising the number and weight of lambs weaned per ewe. These two variables combined can be used to calculate the total weight of lamb weaned per hectare: a key performance indicator (KPI) for sheep enterprises (R.M.P.P, 2018). Finally, income can be increased through a reduction in farm expenses.

2.6.1 Lamb weight

The first component of lamb performance is the weight of the lamb at sale, with prime lambs needing to produce a carcass within a target weight range of 14.1 to 23 kg depending on the abattoir's specifications (NZMA, 2004). Carcasses receive discounts on a per kilogram basis if they are too light or heavy and if the fat cover is above or below the standard (New Zealand Meat Classification Authority, 2004). Lamb birthweight differs by birth rank, with single born lambs heavier on average than their multiple born counterparts (Table 2.8). Lamb weaning weights not only vary by birth and rearing rank (Tables 2.9 & 2.10) but also by year, due to the annual variation in pasture production and lamb growth rates. The combination of birthweight and lamb growth rates to weaning determine lamb weaning weight (Tables 2.8, 2.9 & 2.10).

Sire type, (Carter & Kirton, 1975; Farrell et al., 2020b; McEwan et al., 1995), feed type and quality (Golding et al., 2011; Kemp et al., 2013; Kenyon et al., 2009; Marley et al., 2005) and ewe BCS (Kenyon et al., 2014) are the primary factors affecting lamb weight at weaning that have been previously investigated. The purpose of this research is not to investigate these key drivers of increased lamb weaning weight in detail, instead it focusses on the impact of increased lamb weight on productivity.

2.6.2 Lambing percent and lamb mortality

As tailing percentage increases above 100%, the proportion of twins, triplets and quadruplets increases respectively (Figure 2.9 & 2.10, Amer et al., 1999). These multiple born lambs are more prone to mortality than their single born counterparts, with dystocia and starvation/exposure the two primary causes (Tables 2.8 & 2.9). The combination of an increased proportion of multiple bearing ewes at higher lambing percentages and the increased mortality rate of multiple-born lambs poses significant risk if adverse conditions occur over lambing (Figure 2.10, Tables 2.11 & 2.12, Amer et al., 1999; Kenyon et al., 2019). There are well defined average lambing percentage values based on scanning percentages (Figure 2.9). Figure 2.9 shows that if a farmer has a lambing percentage of below the best fit, lamb losses are greater than expected.

Table 2.8 Birth weight of single, twin and triplet born lambs in New Zealand

Single	Twin	Triplet	Reference
4.43	3.53	2.90	(Hinch et al., 1985)
5.20	4.10	3.30	(Scales et al., 1986)
5.15	4.46	3.83	(Fogarty et al., 1992)
5.28	4.36	-	(Smeaton et al., 1999)
4.95	4.20	-	
-	4.60	3.70	(Morris et al., 2003)
-	4.60	3.70	(Morris & Kenyon, 2004)
5.83	4.70	3.91	(Thomson et al., 2004)
-	4.50	3.80	(Corner et al., 2008)
6.01	4.88	-	(Kenyon et al., 2009)
-	5.25	4.44	(Kenyon et al., 2010a)
4.60	3.60	-	(Young et al., 2010)
-	4.49	3.48	(Hutton et al., 2011)
5.60	4.2[1]	4.2[1]	(Loureiro et al., 2012)
5.00	4.40	-	(Corner et al., 2013)
6.00	5.10	-	(Blair, 2015)
-	3.53	-	
-	3.67	-	
5.65	5.16	4.25	(Pettigrew et al., 2021)
5.31	4.47	3.77	Average

[1]Twins and triplets were collectively recorded as multiples
– represents data that was not collected as part of that trial

Increasing mature ewe ovulation, conception, and scanning rates (Kenyon et al., 2014; Kenyon et al., 2004; Scaramuzzi & Radford, 1983; Smith & Stewart, 1990) and survival rates (Allworth et al., 2017; Dalton et al., 1980; DeNicolo et al., 2008b; Kenyon et al., 2019; Nicoll et al., 1999; Paganoni et al., 2014; Scales et al., 1986) are the three primary variables impacting the lambing percentage and number of lambs available for sale. In addition, breeding hoggets successfully can improve the overall number of lambs weaned per farm (Farrell et al., 2020a; Farrell et al., 2021a; Kenyon et al., 2011c). The purpose of this thesis is not to investigate these key drivers of increased lamb numbers available for sale, and instead focusses on the impacts of increased lamb numbers on productivity and profitability. The reviewed literature mentioned above is important as it outlines how lamb weaning percentages can be influenced and outlines the relationship between lambing percentages and lamb income and subsequent farm profit.

Table 2.9 Age at weaning and lamb weight of single, twin and triplets by birth and rearing rank in New Zealand

Single/ single	Twin/ Twin	Triplet/ triplet	Triplet/ twin	Triplet/ single	Age (days)	Reference
23.0	21.4	20.5	-	-	N.S.	(O'connor et al., 1985)
28.9	22.1	-	-	-	92[1]	(Smeaton et al., 1999)
26.4	20.9	-	-	-		
41.1	34.7	-	-	-	105	(Muir et al., 2000)
-	27.4	23.0	-	-	87	(Morris et al., 2003)
-	27.4	22.7	25.3	-	87	(Morris & Kenyon, 2004)
33.9	29.5	26.8	-	-	84	(Thomson et al., 2004)
-	25.2	21.7	-	-	90	(Corner et al., 2008)
34.4	29.4	-	-	-	100	(Kenyon et al., 2009)
-	23.1	22.5	23.7	-	75	(Kenyon et al., 2010a)
-	24.4	22.2	22.6	-	90	(Kenyon et al., 2010b)
30.6	29.1	-	-	-	100	(Young et al., 2010)
-	20.7	17.6	17.9	15.3	66	(Hutton et al., 2011)
28.0	26.1	24.2	26.1	28.0	92	(Kenyon et al., 2011b)
31.3	23.6[2]	23.6[2]	-	-	91	(Loureiro et al., 2012)
-	-	25.5	27.2	28.7	91	(Kenyon et al., 2012)
37.5	32.0	-	-	-	92	(Corner et al., 2013)
-	-	21.0	23.8	26.8	80	(Kenyon et al., 2013)
-	23.9	-	-	-	101	(Corner-Thomas et al., 2020b)
-	27.4	-	-	-		
30.0	26.2	23.8	-	-	82	(Pettigrew et al., 2021)
31.4	26.0	22.7	-	-	-	Average

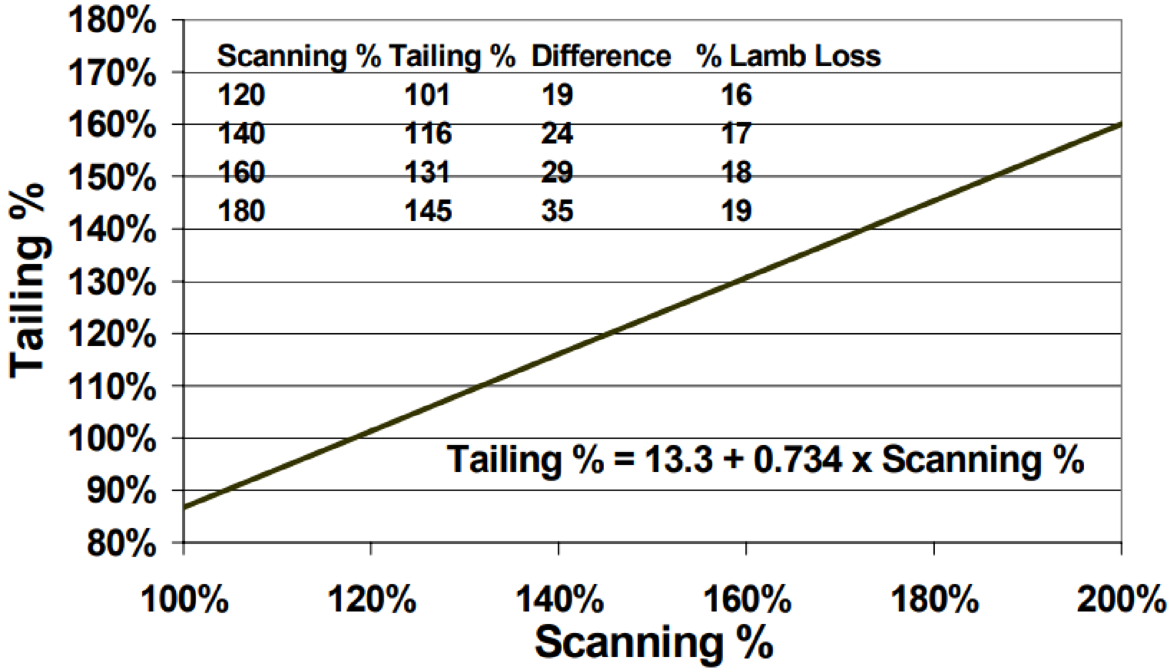
[1]Estimated using supplied materials/methods
[2]Twins and triplets were collectively recorded as multiples
– represents data that was not collected as part of that trial
N.S: Not stated

Table 2.10 Average birth weight, estimated growth and estimated 100-day weight for single, twin and triplet born lamb in New Zealand

Birth rank	Birth weight (kg)	Estimated Growth Rate (kg/d)[1]	Estimated 100-day weight (kg)	Reference
Single	5.20	0.248[2]	30.0	(Scales et al., 1986)
Twin	4.10	0.200[2]	24.1	
Single	5.28	0.256	31.0	(Smeaton et al., 1999)
Twin	4.36	0.193	23.7	
Single	4.95	0.233	28.3	
Twin	4.20	0.182	22.4	
Single	-	0.343[3]	39.4	(Muir et al., 2000)
Twin	-	0.292[3]	33.2	
Twin	4.60	0.262	30.8	(Morris et al., 2003)
Triplet	3.70	0.222	25.9	
Twin	4.60	0.262	30.8	(Morris & Kenyon, 2004)
Triplet	3.70	0.218	25.5	
Single	5.83	0.334	39.3	(Thomson et al., 2004)
Twin	4.70	0.295	34.2	
Triplet	3.91	0.273	31.2	
Twin	4.50	0.230	27.5	(Corner et al., 2008)
Triplet	3.80	0.199	23.7	
Single	6.01	0.284	34.4	(Kenyon et al., 2009)
Twin	4.88	0.245	29.4	
Single	4.60	0.260	30.6	(Young et al., 2010)
Twin	3.60	0.255	29.1	
Single	5.60	0.282	33.8	(Loureiro et al., 2012)
Multiples	4.20	0.213	25.5	
Single	5.00	0.353	40.3	(Corner et al., 2013)
Twin	4.40	0.300	34.4	
Twin	4.49	0.246	29.1	(Hutton et al., 2011)
Triplet	3.48	0.214	24.8	
Twin	3.53	0.236	27.1	(Corner-Thomas et al., 2020b)
Twin	3.67	0.263	30.0	
Twin	19.55[4]	0.341	34.9	(Corner-Thomas et al., 2020a)
Twin	19.0[4]	0.312	33.0	
Single	5.65	0.298	35.5	(Pettigrew et al., 2021)
Twin	5.16	0.256	30.8	
Triplet	4.25	0.238	28.1	
Single	5.35	0.289	34.25	Average
Twin	4.30	0.273	29.67	Average
Triplet	3.90	0.225	26.37	Average

[1]Calculated using Tables 2.8 and 2.9
[2]Only birthweights and growth from birth to weaning was supplied
[3]Used stated growth rates in the literature
[4] First available weight was at day 55
– represents data that was not collected as part of that trial

Figure 2.9 Predicted tailing percentage from scanning percentages for New Zealand sheep enterprises (Anderson & Sewell, 2000)



2.6.3 Expenses

Reducing expenses is another method to increase profit from sheep enterprises (Shadbolt & Martin, 2005). According to Beef and Lamb New Zealand (2020), fertiliser, repairs and maintenance, wages, and shearing accounted for approximately 64% of farm working costs in the 2020-21 season, contributing 23%, 17%, 14%, and 10%, respectively. With all four of the primary inputs being essential for farm productivity there is limited room to reduce them (Beef + Lamb New Zealand, 2020c). Given wool only contributes 3.2% to the gross farm income but accounts for 10% of the working costs, farmers are often struggling to cover the cost of shearing, with the practice focussing more on animal welfare rather than as an income source (Farrell, 2020).

Feed maintenance requirements contributes the most to any animal's daily feed demand, requiring around 60% of total annual feed demand (Nicol & Brookes, 2007). Selling lambs early in the season reduces the animals' total feed demand drastically, subsequently reducing feed costs, animal health costs while reducing the risk of injury and/or death. The rearing of replacement ewes not only affects the number of lambs available for sale but influences farm costs (Dawson & Carson, 2002; McHugh, 2012). Ewe lambs kept and marked as replacements are unable to be sold to generate income, while requiring a significant quantity of feed to both conceive and rear a lamb before they start to generate income for the farm. Reducing the replacement rate of the flock will help reduce the expenses associated with rearing replacements and potentially increase the farm's COS, but has impacts on factors such as average flock age (Farrell et al., 2020b).

2.7 Systems Modelling

Systems modelling has been adopted into agricultural enterprises, used to identify potential strategies to increase productivity or model the potential inclusion of any technological advancements. Farm system models are categorised as simulation or optimisation, with a few models utilising a combination of both optimisation and simulation, using one to overcome the limitations of the other. There are several benefits of systems modelling when utilised in agriculture.

Table 2.11 Lamb mortality rates for single, twin and triplet born lambs in New Zealand (Adapted from Kenyon et al, 2019)

Single	Twin	Triplet	Reference
17	27[1]	27.0[1]	(Dalton et al., 1980)
15.7	20.7	20.7	(Johnson et al., 1982)
9.9	19.1	44.7	(Hinch et al., 1985)
14.1	14.7	33.0	(Scales et al., 1986)
-	19.6	39.7	(Kenyon et al., 2006)
-	19.3	46.1	(Kenyon et al., 2006)
-	15.3	29.6	(Corner et al., 2008)
18.5	21.3	73.2	(DeNicolo et al., 2008b)
-	9.9	21.6	(Kenyon et al., 2010a)
-	16	35.0	(Kenyon et al., 2010a)
-	10	31.0	(Hutton et al., 2011)
-	-	30.5	(Kenyon et al., 2011a)
-	-	44.0	(Kenyon et al., 2011a)
-	-	38.3	(Kenyon et al., 2011a)
-	-	35.5	(Kenyon et al., 2011a)
-	-	29.7	(Kenyon et al., 2011a)
-	-	43.3	(Kenyon et al., 2011b)
-	-	37.3	(Kenyon et al., 2011b)
-	-	42.3	(Kenyon et al., 2011b)
-	-	33.2	(Kenyon et al., 2012)
-	-	27.1	(Kenyon et al., 2012)
-	-	28.9	(Kenyon et al., 2012)
-	-	24.9	(Kenyon et al., 2012)
-	-	34.9	(Kenyon et al., 2012)
-	-	32.5	(Kenyon et al., 2013)
-	-	38.1	(Kenyon et al., 2013)
-	-	23.9	(Kenyon et al., 2013)
-	-	28.0	(Kenyon et al., 2013)
-	-	34.6	(Kenyon et al., 2013)
5.4	16.3	23.8	(Kenyon & Blair, 2014)
15.25	21.3	34.6	(Paganoni et al., 2014)
-	15.1	25.9	(Juengel et al., 2018)
13.7	17.54	34.15	Average

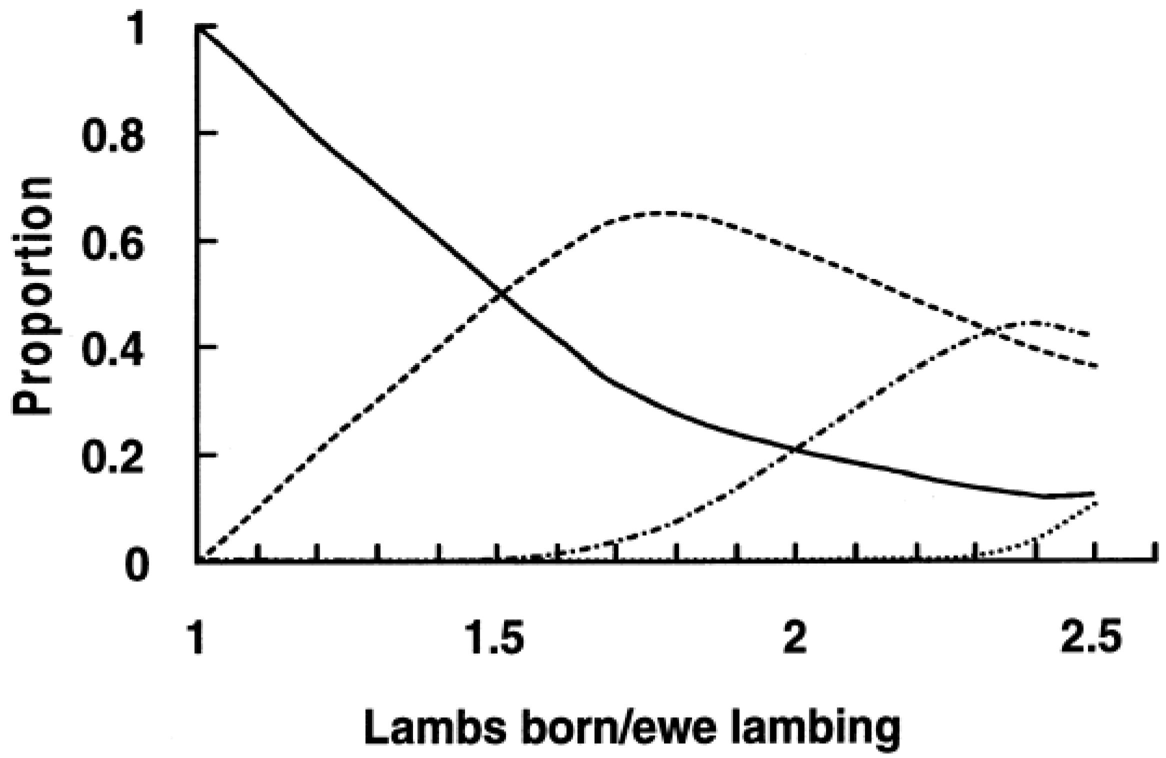
[1] Twins and triplets recorded as multiples
– represents data that was not collected as part of that trial

Table 2.12 Primary causes of Lamb Mortality[a] by birth rank (Kenyon et al., 2019)

	Pre-natal death			Dystocia[b]			Starvation exposure			Dystocia/starvation exposure			Other[f]		
	S[c]	Tw[d]	Tpl[e]	S	Tw	Tpl	S	Tw	Tpl	S	Tw	Tpl	S	Tw	Tpl
(Cloete et al., 1993)				25	25	30	50	19	30		13		25	43	40
(Cloete et al., 1993)				100	27	50		22	22		6	8		45	20
(Hinch et al., 1986)	17	10	31	33	40	38	0	10	13	17	17	14	33	23	9
(Hinch et al., 1986)	17	21	28	57	36	36	3	11	11	13	7	8	10	26	15
(Hinch et al., 1986)	0	3	0	68	36	33	13	12	17	7	30	33	13	18	17
Holmøy et al. 2017				48	30	29	5	5	7				48	65	64
Holst et al. 2002				33	14	24	10	23	22	49	49	44	8	14	10
Kerslake et al. 2005				61	49	50	20	29	27	7	9	9	11	13	14
Scales et al. 1986	3	12	7	75	39	7	13	33	50	1	29	29	6	13	7
Range	0-17	3-21	0-31	25-100	14-49	14-49	0-50	5-33	7-50	1-49	3-49	8-44	6-48	13-65	7-64

[a] As identified in an autopsy
[b] Dystocia includes prolonged birth, rupture or central nervous system damage
[c] S – Single
[d] Tw – Twin
[e] Tpl – Triplet
[f] Unknown cause of death or other cause

Figure 2.10 Proportion of ewes delivering singles (solid line), twins (dashed), triplets (chain) and quadruplets (dotted) (Amer et al., 1999)



2.7.1 Benefits of systems modelling

A system can be defined as several components that are interacting with purpose and respond to stimuli as a whole (Farrell, 2020; Spedding et al., 1988). Farm modelling allows modellers to identify issues that farmers are facing within their system and help produce solutions that may be integrated into the current farming operation to increase performance or correct the problems that have been identified (Anderson, 1985; Farrell, 2020; Norman & Collinson, 1985).

2.7.2 Types of models

All models rely on the assumption that one or more variables can be predicted by a set of predictor variables that are well known (Austin et al., 1998). Uncertainty regarding modelling can arise when the predictor variables are uncertain or based on uncertain information (Austin et al., 1998). At times data and information regarding specific predictor variables may be historic and/or fickle, thus assumptions must be made regarding what information to accept and use in the model (Austin et al., 1998).

2.7.2.1 Empirical or mechanistic

Empirical models rely on the relationships found within certain data and look to use known relationships to find new relationships and/or responses that may develop (Austin et al., 1998; Janssen & Van Ittersum, 2007). These empirical models rely on mathematical or statistical equations while placing low emphasis on the scientific content or scientific principles behind the equations (Thornley & France, 2007). The prediction of events primarily relies on the extrapolation of long-term historic trends of specific behaviours and a detailed description of agricultural technologies utilised (Janssen & Van Ittersum, 2007). Following the description of technologies used, one of the primary constraints of empirical models is the difficulty to modify these models to incorporate new or alternate agricultural technologies (Janssen & Van Ittersum, 2007).

Mechanistic models are formed on an image that the creator has of processes occurring within a system, what processes are important, and how these processes interrelate (Janssen & Van Ittersum, 2007; Thornley & France, 2007). Mechanistic models rely on the incorporation of predetermined knowledge and theory to form the backbone of the model (Janssen & Van Ittersum, 2007). Common examples are large-scale economic models, which rely on expert knowledge to succeed (Austin et al., 1998). Mechanistic models provide a level of understanding and/or explanation around the factors being modelled within the system (Thornley & France, 2007). Mechanistic models are required to have a minimum of two levels of organisation, with the plant and organ often being used as an example of the two levels required (Thornley, 2001; Thornley & France, 2007). Scientific reductionism is applied when forming a mechanistic model, breaking complex interactions to their respective parts. The term "understanding" is used, suggesting a causal relationship between the quantities and processes found on the "lower level" and the factors that are predicted/observed at the "upper level" (Thornley & France, 2007). For a sheep enterprise, lamb growth can be defined as an "upper-level factor" being explained by "lower-level" processes such as feed intake and lamb health among others.

While seemingly unrelated, empirical, and mechanistic models are interlinked. A mechanistic model consists of a structure of empirical components, with any empirical component able to be modelled mechanistically (Thornley & France, 2007). Lower levels in a mechanistic model are processes and can be empirical in nature, being described with moderate accuracy through the utilisation of equations (Thornley, 2001; Thornley & France, 2007). This trend can be used to evaluate the quality of a mechanistic model, however, high-quality mechanistic models should be transparent in nature and be readily modified or extended when new information or processes are made available (Thornley, 2001; Thornley & France, 2007).

Mechanistic models are more suited for research than empirical models, which are often application orientated (Thornley, 2001; Thornley & France, 2007). Mechanistic models are based on the scientific knowledge of the system and the individual components. Built from lower level assumptions, mechanistic models can provide an overview of system behaviour (Thornley, 2001; Thornley & France, 2007).

2.7.2.2 Deterministic or stochastic

Deterministic models revolve around the 'definite prediction' of factors and/or quantities with no associated probability distribution (Thornley, 2001; Thornley & France, 2007). Agricultural examples include daily animal intakes and/or the daily dry matter accumulation of crops and pastures. While the lack of an associated probability distribution may be suitable for some modelling systems, deterministic models are not suitable for any processes or quantities that are variable, such as annual rainfall or livestock death rates (Thornley, 2001; Thornley & France, 2007). To rectify these problems and ensure factors with significant variability such as climate are included, deterministic models can be constructed with an assumed set of data that can be modified (Thornley, 2001; Thornley & France, 2007).

Stochastic models differ from deterministic models through the inclusion of 'randomness' and probability distributions (Thornley, 2001; Thornley & France, 2007). Including stochasticity is important when determining how a system responds to uncertainty and risk (Farrell, 2020).

Stochastic models can be more difficult to create than deterministic models, with stochastic models being more difficult to 'test or falsify' (Székely Jr & Burrage, 2014). As a result, it is often recommended that a deterministic model is used when first exploring a system rather than using a stochastic model (Thornley, 2001; Thornley & France, 2007).

2.7.2.3 Dynamic or static

Dynamic models incorporate a time dimension, allowing for the inclusion of variables that fluctuate with time, an essential variable in pasture-based sheep enterprises (Janssen & Van Ittersum, 2007; Thornley, 2001; Thornley & France, 2007). Dynamic recursive models account for the annual variability through the use of the end values from the previous years as the starting values for the new year, with this trend commonly used when completing livestock reconciliations (Janssen & Van Ittersum, 2007).

Static models do not contain time within the model and are based on a fixed point in time. Common examples of static models include the total quantity of input into a sheep system such as feed and/or the total quantity of output from a system at the end of a set period, such as the quantity of lamb at weaning (Janssen & Van Ittersum, 2007; Thornley, 2001). Given the lack of time, static models are generally empirical (Thornley, 2001). While most agricultural models are dynamic, static models can be used when the agricultural system being described is assumed to be in equilibrium (Thornley, 2001; Thornley & France, 2007).

2.8 Bioeconomic systems modelling

Three broad categories of bioeconomic system model can be created: simulation models, optimisation models, and combined models. Simulation models attempt to model system behaviour while defining, describing, and elaborating on the range of farm responses (Pannell, 1996). Optimisation models attempt to predict the best utilisation, solutions, or alternatives for resource management and allocation (Janssen & Van Ittersum, 2007). Combined models utilise a mix of both simulation and optimisation models to help overcome the limitations each pose.

2.8.1 Simulation

Simulation models used for whole-farm modelling scenarios range from extremely simple models to extremely complex (Pannell, 1996). Many farm advisors and consultants build simple simulation models known as whole farm budgets, which have all the complex information simplified for ease of use by farmers who are less practiced in modelling. Complex models can include bio-physical dynamic simulation models that are integrated and flow directly into some form of economic model. These sub-unit bio-physical models include factors such as livestock classes and different plants.

The results produced can be adjusted to reflect what is observed and subsequently used to predict any advancements in technology and changes in short- and medium-term policy (Janssen & Van Ittersum, 2007). Simulation models can be used to represent bio-physical processes such as those outlined above and allow for seasonal variation. Accounting for any seasonal variation in bio-physical processes such as pasture production is essential for accuracy, as the effects of seasonal variation can be high. Simulation models are best suited for providing insights for farmers, students, and consultants about system changes (Farrell, 2020; McCall, 1994).

2.8.2 Optimisation

Optimisation models look to find the optimal management and utilisation of variables to ensure optimal production or profit. The viability of the predictions and/or results from optimisation models have been questioned depending on their optimisation goal. The rationale is that some farmers do not have the desire to manage their farms to the optimal level of production and/or profit for a variety of reasons such as lack of skill, work life balance and/or risk aversion (Janssen & Van Ittersum, 2007). Some farmers, however, target the modelled optimal level of production and/or profit but simply do not achieve it (Janssen & Van Ittersum, 2007).

Optimisation models can be mechanistic and static, using mathematical equations to create a model based on linear programming (LP) (Janssen & Van Ittersum, 2007). Linear programming relies on the farm activities being created as 'activities' (Janssen & Van Ittersum, 2007). The created activities are a set of operations that have corresponding inputs and outputs that deliver a set outcome (Janssen & Van Ittersum, 2007). An activity also has a set of coefficients that help express the contribution of the activity to the realisation of a defined goal or objective. Inputs are limited resources and activities must have their constraints defined, so the minimum and maximum amount of a resource that can be used is defined. The created system, activities, and associated constraints are then optimised for the purpose of reflecting an operator driven goal, such as profit or production maximisation (Janssen & Van Ittersum, 2007). Optimisation will usually occur when at least one constraint is limiting.

Linear optimisation models are not suitable when constraints and/or functions are non-linear, with non-linear modelling much more suited (Janssen & Van Ittersum, 2007). Non-linear optimisation models reflect functions that are non-linear in nature, which is often the case with agricultural variables (Benli & Kodal, 2003). These non-linear optimisation models more accurately predict output than linear optimisation models depending on input linearity. A dynamic optimisation model can be solved via dynamic programming, and as noted earlier these models include some form of recursive relationship (Kennedy, 2012).

2.8.3 Combined

A combined model utilises both dynamic simulation and static or dynamic optimisation, using each model to address and overcome the key limitations of the other (Robertson et al., 2012). The combination of both simulation and optimisation models may seem easy given the range of software available in the modern day, however, the combination model has only recently been created (Fu, 2002). These commercially available models use a reputed simulation model as the 'backbone', adding an optimisation model as a 'subroutine' (Fu, 2002).

The simulation model is often used to find the best scenario from the range available, the optimisation subroutine then analyses and perfects the chosen model, 'polishing' any found imperfections (Fu, 2002). The process of combining the two models comes with some faults and can be a drawn out process if the model is to be relied on for accurate estimation (Paul & Chanev, 1998).

2.9 Bio-economic sheep models

Bioeconomic models have been utilised in agriculture for many years and will likely continue to be used as technology and information accuracy increases. Bioeconomic models have been used for studying production systems both within New Zealand and internationally with differing levels of success. Models must account for the complex interaction between the biological factors such as pasture and livestock and their impact on the economic variables, with bio-economic models doing this well.

2.9.1 International models

The model of an integrated dryland agricultural system (MIDAS) produced in Australia is well known internationally (Table 2.13, Pannell, 1996). MIDAS focusses on Western Australian dryland crop and livestock farm and was created in the 1980s in response to a request by the Western Australian Dryland Research Institute (WADRI) for an improved mathematical programming model (MPM) (Morrison et al., 1986; Pannell, 1996). Since creation, MIDAS has been adapted to create versions that suit several regions and sheep enterprises within Western Australia, but all share the same components (Morrison et al., 1986; Pannell, 1996). MIDAS is best described as a linear optimisation model that utilises 290 activities along with 130 constraints which are primarily biological (Morrison et al., 1986; Pannell, 1996). MIDAS is designed to complement and improve the overall understanding of a system for farmers and researchers alike (Morrison et al., 1986; Pannell, 1996).

CSIRO have produced several decision support tools related to grazing that can be found under the GRAZPLAN umbrella (Table 2.13, Donnelly et al., 2002). The GRAZPLAN tools are suited for temperate Southern Australia and focusses on sheep enterprises relying on pasture production as the main feed source. The majority of the GRAZPLAN tools are simulation based models and look to reflect both seasonal and annual fluctuations for productivity and profitability while considering any business risks and environmental sustainability (Donnelly et al., 2002; Moore, 2001).

A model was completed in Ireland in 2016 which looked to complete a 'stochastic budgetary simulation' of an Irish sheep farm (Bohan et al., 2018; Bohan et al., 2016). Lambing dates, ewe productivity and lamb slaughter weights were changed to provide monthly comparison, with results compared to realised production from 20 Irish farms (Table 2.13, Bohan et al., 2018; Bohan et al., 2016).

Similar linear models have been used in Canada to optimise lamb production (Table 2.13, Fisher, 2001). Skonhoft (2008) utilised a bio-economic dynamic optimisation to determine the key ratio of stock classes (sheep) for profit optimisation. Researchers in other countries have created and/or utilised models, including the United Kingdom (Conington et al., 2004), Scandinavia (Skonhoft, 2008), Slovakia (Krupová et al., 2014) and the Czech Republic (Wolfová et al., 2009a; Wolfová et al., 2009b).

2.9.2 New Zealand models

The Grazing System Limited (GSL) model was a bio-economic whole farm optimisation model of sheep and beef but could be adapted for dairy systems (Table 2.14). GSL utilised linear programming and the concept of marginality to determine the best allocation of the farms limited resources (Farrell, 2020). As of October 2021, recent information regarding GSL could not be found in the literature or any search engine suggesting the model is now discontinued.

AgInform is a multi-year resource allocation and bio-economic optimisation model investigating profit maximisation in terms of earnings before interest, tax and rent (EBITR) on New Zealand sheep and cattle farms (Table 2.14) (Rendel et al., 2013; Rendel et al., 2020). AgInform models utilise LP along with user supplied information around their specific land management units to determine the optimal allocation of limited farm resources to maximise profit (Rendel et al., 2013; Rendel et al., 2020). Division of land into management units allows for accurate input for variable factors such as pasture mass and livestock requirements, and outputs such as animal performance (Rendel et al., 2013; Rendel et al., 2020).

The Farmax model is a bio-economic, whole-farm optimisation model focussed on New Zealand sheep and beef farms (Table 2.14) (Farrell, 2020). Farmax relies firstly on the modelling of animal energy and subsequent nutrient demand before calculating the minimum pasture cover required to meet the calculated animal demand. If the pasture cover is below the desired level or substantially above, Farmax enables the modeller to investigate alternate options to rectify (White et al., 2010). Farmax is commercially available across New Zealand and utilises the early 'Stockpol model' (Marshall et al., 1991). Farmax is widely used by farm consultants and farmers alike, but given the commercial nature of the model, the extent to which the model can be scrutinised is limited to protect commercial interest.

Beck and Dent (1987) developed a simulation model to examine the impact of government policy on extensive pastoral farming systems in New Zealand (Table 2.14). The model created was designed to be used long term, best suited to North Island hill country farms. The key inputs such as prices (stock and products) can be manipulated to simulate specific government policies that may be proposed or implemented (Beck & Dent, 1987).

Table 2.13 Some international optimisation and simulation models in sheep production (Adapted from Farrell, 2020)

International optimisation models	
Linear programming static model MIDAS for profit maximisation on a mixed sheep and cropping farm in Western Australia.	(Pannell, 1996)
Dynamic optimisation model of Canadian sheep production systems to maximise marginal profit.	(Fisher, 2001)
Deterministic, dynamic optimisation model of a Northern Scandinavian sheep farm to find a combination of animal categories for profit maximisation.	(Skonhoft, 2008)
International simulation models	
Grazplan is a set of dynamic simulation models as decision support tools for temperate southern Australia looking at profitability and environmental sustainability.	(Donnelly et al., 2002)
Dynamic simulation model of a UK sheep farm to analyse and compare genetic gain.	(Conington et al., 2004)
Model of UK sheep farm focussing on economic values for lamb growth.	(Jones et al., 2004)
Bio-economic simulation model of a Slovakian multi-purpose sheep farm investigating profitability using Ecoweight.	(Wolfová et al., 2009a)
Dynamic, stochastic simulation model of Irish sheep farm for profitability comparison.	(Bohan et al., 2016)

Morel and Kenyon (2006) designed a simulation model and subsequent sensitivity analysis to investigate the effects on farm gross margin (FGM) when changes are made to several sheep enterprise variables (Table 2.14). The model simulates the daily feed energy requirement over a one-year period, focussing on the Manawatu region of the North Island of New Zealand. Three levels of productivity were used in the simulation to produce FGM results that can be utilised by a wide range of farms within the region (Morel & Kenyon, 2006).

Several sheep production models have been produced from Lincoln University, New Zealand, termed 'Lincfarm' models (Table 2.14). The first is quantitative and focusses on the animal intake and subsequent growth (Finlayson et al., 1995). The second is a simulation based whole-farm model that has variables that can be predicted deterministically or stochastically (Cacho et al., 1995). The whole farm model includes several components such as those found in the first, along with farm management and looks to analyse the impacts on both productivity and subsequent profitability (Cacho et al., 1995). The whole-farm model has been used to analyse the impacts of specific alternate variables such as irrigation and stocking rate on the sheep production enterprise (Cacho et al., 1999; Gicheha et al., 2014).

Amer et al (1999) created a bio-economic model that focussed on the economic values of ewe prolificacy and lamb survival traits (Table 2.14). While this model is beneficial for sheep breeders within New Zealand, it focusses primarily on the biological side of sheep production and does not include any farm management practices thus is not suitable for a whole-farm plan.

Farrell (2020) created a bio-economic, systems dynamic simulation model based on a New Zealand hill country sheep and beef farm that relies on a limited supply of pasture. The model can be manipulated to meet the needs of the researcher, with more emphasis placed on productivity and profitability. The model has been utilised to study the implications of ewe wastage on farm productivity, the transition from a Romney flock to Wiltshire or Merino, and the impact of incorporating native shrubs into the farm system (Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e; Wangui et al., 2021).

Farrell (2020) utilised STELLA software (version 1.9.3) to produce these models, that can effectively model dynamic systems but remain user friendly to ensure the widest range of users can use the software (Lindfield, 1992). It is this model that will be utilised for the research component of this thesis.

2.10 Shortfalls of bioeconomic farm modelling

Farmers do not often adopt whole farm models as key decision-making tools, with the model produced more focussed on answering researcher's questions than practicality of use by farmers (Doyle, 1990; Keating & McCown, 2001). Farmers are unlikely to create their own model given the high labour requirement to create the model which often requires specialised technology or expensive software (Keating & McCown, 2001).

When created by researchers, it is reported that farmers and other key decision makers on farms have limited communication and input with the researcher regarding the information used in the model. This lack of communication often makes farmers suspicious of both the input data and the computer generated results (Keating & McCown, 2001). The utilisation of surveys and or regional data from corporations such as Beef and Lamb New Zealand is the best means to ensure farmers feel the input data is most relevant to their farm. These models are often discarded by the researcher post-completion of their research, often left in their complex state and not user friendly for any farmers that wish to pick the model up and utilise it (Keating & McCown, 2001; Pannell, 1996).

Models can also be complex, requiring a substantial amount of training if users such as students, teachers and or researchers are to utilise completed models for future research (Marshall et al., 1991; White et al., 2010). Through training and a small cost, farmers can utilise Farmax with high levels of success (Farrell, 2020). Farmax is, however, much more suited for farm advisors and consultants to ensure the production of reliable information.

2.11 Conclusion

Global sheep production continues to grow, with sheep populations and sheep meat output increasing in recent decades. China has increased productivity, responsible for 19% and 26% of the global wool and sheep meat production, respectively in 2019. Australia and New Zealand remain high producing countries for sheep meat, however, wool production for both has declined since 1990.

The production of sheep meat for sale has overtaken wool as the primary output and subsequently the primary income earner for the majority of the eight land classes in New Zealand. Lamb weaning weight along with the number of lambs for sale are the primary variables that can be manipulated in sheep enterprises across all land classes in New Zealand.

Table 2.14 Some New Zealand sheep and beef optimisation and simulation models (Adapted from Farrell, 2020)

New Zealand optimisation models	
Farmax is a bio-economic, whole-farm optimisation model that is focussed on sheep and beef farms within New Zealand. Farmax relies on the calculation of animal energy requirements and desired pasture cover to investigate the viability of the current grazing regime and any proposed changes.	(Farrell, 2020; Marshall et al., 1991; White et al., 2010)
AgInform is a multi-year resource allocation and dynamic optimisation model investigating profit maximisation (EBITDA) on New Zealand sheep farms.	(Rendel et al., 2013; Rendel et al., 2020)
GSL is a linear programming model that utilises marginality to create a bio-economic whole farm plan.	(Farrell, 2020)
New Zealand simulation models	
A simulation model used to examine the impact of government policy on extensive pastoral farming systems in New Zealand	(Beck & Dent, 1987)
A bio-economic, commercially available whole-farm simulation model that relies on animal energy requirements and desired pasture cover to function.	(Farrell, 2020; Marshall et al., 1991; White et al., 2010)
Quantitative and simulation based whole farm model that can be run deterministically or stochastically depending on the modellers needs	(Cacho et al., 1995; Finlayson et al., 1995)
Bio-economic simulation model that focusses on the economic value of ewe prolificacy and lamb survival traits.	(Amer et al., 1999)
A simulation model and sensitivity analysis produced to analyse the effect on gross farm margin when changes are made to several sheep production variables.	(Morel & Kenyon, 2006)
A bio-economic simulation model of a North Island sheep and beef farm with limited pastural feed that places an emphasis on productivity and profitability.	(Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e)
A bio-economic simulation model of a North Island sheep and beef farm with limited pastural feed, investigating the impact of cow liveweight on feed supply.	(Farrell et al., 2021b)

Modelling has been utilised to model changes in agricultural systems around the world. Modelling helps reduce the uncertainty and variability that comes with systems through the utilisation of long-term trends. Models aren't without fault however, often being technical and requiring validation with annual production statistics to ensure output reflects observed production.

For a Class 4 sheep enterprise in the Western North Island (WNI) of New Zealand improved income can be achieved through weaning and selling heavier lambs and/or having a greater number of lambs for sale. Research that investigates the impacts of variable lamb weights and numbers are hard to control due to the significant variability associated with New Zealand pastural based systems. A bioeconomic model could be utilised to accurately predict the economic impacts of improved lamb weaning weights and/or increased lamb numbers on a Class 4 WNI sheep enterprise in New Zealand.

The overall objective of this research was to utilise bio-economic modelling to examine the impact of improved lamb performance (lamb numbers and lamb weaning weight) on the profitability of a Class 4 sheep and beef farm in the WNI of New Zealand. A status quo scenario will be run to provide the base line results, comparing the results from each of the scenarios run to this status quo scenario to allow for quantification of the changes. The model created by Farrell (2020) using STELLA will be the model utilised for the purpose of this research. This model has only recently been created, but has been used to produce a wide array of literature in recent years (Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c, 2021b; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e; Wangui et al., 2021).

It was hypothesised that increasing both lambing percentage and lamb weaning weight will increase profitability compared to the status quo model, with lambing percentage having the greatest impact on profitability than lamb weaning weight.

3.0 Bioeconomic model and data

3.1 Introduction

This model will be utilised to quantify the effect of changes to both lambing percentage and lamb growth rates on overall farm profitability on a Class 4 WNI hill country farm in New Zealand.

Bio-economic modelling has successfully been utilised to investigate potential changes to sheep enterprises in recent years (Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e; Wangui et al., 2021). This STELLA Architect model can be utilised to successfully achieve the objective of quantifying the impacts of lambing percentage and pre-weaning lamb growth on Class 4 sheep enterprise profitability (STELLA Architect, 2019).

3.2 Materials and methods

3.2.1 Introduction

System dynamics modelling was utilised to examine the flock dynamics and the feed energy demand for the total flock and the distribution of the demand by sheep ages on a Class 4 farm. Modelling was then utilised to examine the impact of the proposed changes on flock productivity and lamb production and to examine the financial performance of the eight scenarios produced.

This bio-economic systems-dynamic model contains six key modules, each focussing on an individual section of the sheep enterprise (Figure 3.1): flock dynamics (purebred flock) (Section 3.2.2), feed supply (Section 3.2.3), feed demand (Section 3.2.4), feed balance (Section 3.2.5), wool production (Section 3.2.6), and economics (Section 3.2.7). The purebred flock module covers the ewe breeding flock and the flow of ewes between age brackets, along with the rams required for breeding and the distribution of lambs born between birth and weaning ranks. It has been labelled as purebred flock rather than simply flock to allow for the addition of a terminal sire module in future research. The feed supply module is a key driving module, utilising average pasture growth rates by month and land type to produce the total energy to be supplied to the flock. The feed demand, wool, and economic modules were all driven by the flock module, with the feed balance module utilising both feed supply and feed demand modules.

There were eight scenarios studied. Scenario one is the status quo scenario, using current industry averages for lambing percentage and lamb weaning weight (Table 3.1, Beef + Lamb New Zealand, 2020c). Scenarios 2, 3 and 4 have used the status quo lamb weaning weights but have lambing percentages of 140%, 150%, and 160%, respectively. Scenarios 5, 6 and 7 use the status quo lambing percentage but have increased weaning weights of 10%, 20%, and 30%, respectively. Scenario 8 utilises a lambing percentage of 140% along with a 10% increase in lamb weaning weight (Morel & Kenyon, 2006). The model was constructed and modified using STELLA version 1.9.3 (Farrell, 2020). The model was run for thirty-five consecutive years for each scenario to provide sufficient time for model stabilisation, with the output from the final year utilised for the discussion and production of graphs.

3.2.2 Purebred flock

An average Class 4 sheep and cattle hill country farm in the WNI of New Zealand has been modelled, using the provisional data for the 2020-21 season provided by the Beef + Lamb New Zealand farm survey analysis (Beef + Lamb New Zealand Economic Service, 2021). The farm is 478 hectares (ha) effective and has a self-replacing flock of 2037 autumn mated ewes that are grazed on pasture throughout the year, with only the sheep enterprise analysed. The sheep to cattle proportion used is 60:40 (Farrell, 2020). All ewes produce coarse wool (>30 µm), with maternal rams used at a ratio of

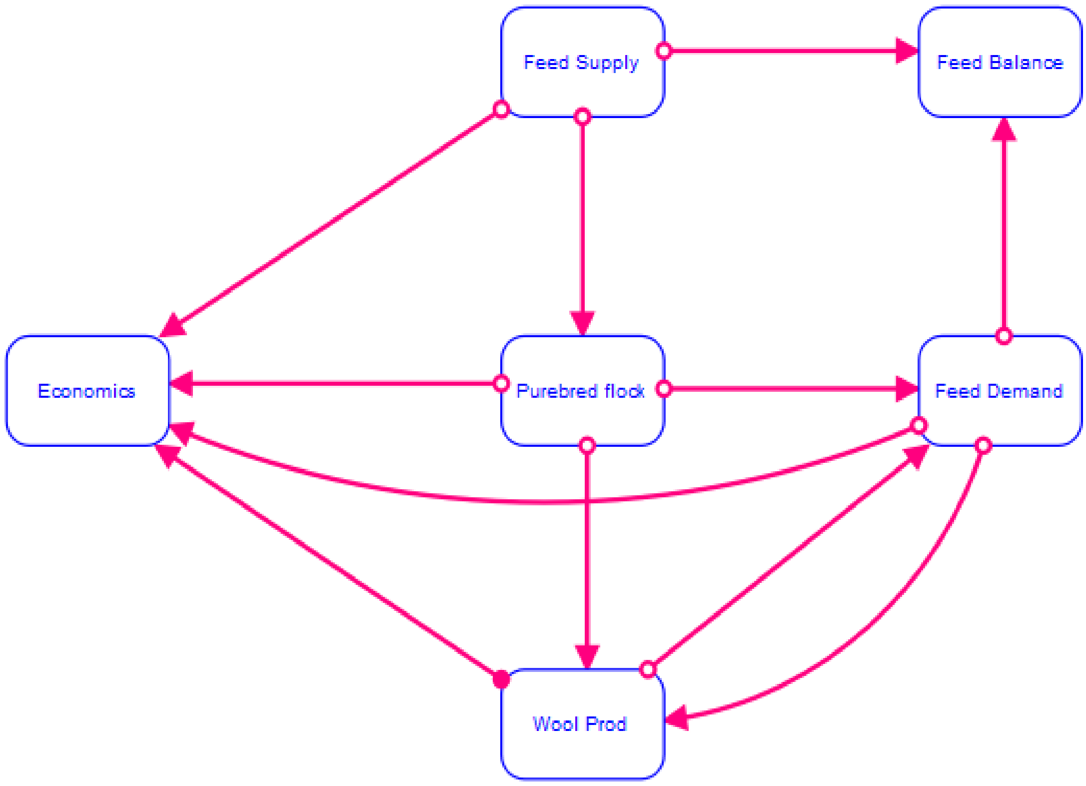
1:100 mixed age (MA) ewes with all lambs excluding those required for replacements being sold either store or for slaughter as prime lambs. For this research, no ewes were presented to a terminal ram and hoggets (Y_1) were not mated.

Table 3.1 Parameters for the 8 scenarios

Scenario	Lambing percentage[1]	Lamb weaning weight (Single/multiple)
1	133.5%	30.0 kg 25.0 kg
2	140.0%	30.0 kg 25.0 kg
3	150.0%	30.0 kg 25.0 kg
4	160.0%	30.0 kg 25.0 kg
5	133.5%	33.0 kg 27.5 kg
6	133.5%	36.0 kg 30.0 kg
7	133.5%	39.0 kg 32.5 kg
8	140.0%	33.0 kg 27.5 kg

[1]Lambs weaned per ewe mated

Figure 3.1 Overview of the six key modules within the bio-economic model used and the flow of information within



Sheep enterprises in New Zealand are typically run in conjunction with cattle and/or deer, with sheep contributing the greatest proportion to the total farm stock units (≥60%) (Beef + Lamb New Zealand Economic Service, 2021). For this research, it was assumed that the sheep enterprise accounted for 60% of the total livestock units (LSU) for the farm. One LSU can be defined as a 55 kg ewe that is rearing a single lamb to 28 kg liveweight, consuming 550 kg DM/year (Trafford & Trafford, 2011).

The ewe flock (Y) had six key age groups ($Y_{1\text{-}6}$) ranging from maiden ewes (one year old) (Y_1) to six-year-old ewes (Y_6) (Equation 3.1, Figure 3.2). All ewes from $Y_{2\text{-}6}$ were presented for breeding at a ratio of 1 ram to 100 ewes. Each year, the ewes from the previous age group (Y_{i-1}) aside from the culls (C_i) and deaths (D_i) aged up to the next age bracket (Equation 3.2). The number of culls (C_i) and deaths (D_i) is a product of the number of ewes in that age group (Y_i) and the age specific cull rate (c_i) and death rate (d_i) (Equations 3.3 and 3.4). *i* can be defined as the age class/es applicable.

$$Y = \sum_{i=1}^{6} Y_i \qquad [3.1]$$

$$Y_i = Y_{i-1} - D_{i-1} - C_{i-1} \qquad [3.2]$$

$$D_i = Y_i * d_i \qquad [3.3]$$

$$C_i = Y_i * c_i \qquad [3.4]$$

A c_i of 20% was used for all $Y_{2\text{-}6}$ ewes along with a $d_{2\text{-}6}$ of 5.2% (Griffiths, 2016). All Y_6 ewes remaining at the end of their sixth year were culled for age and removed from the farm. All ewe deaths were assumed to occur at lambing due to the greatest proportion of ewe deaths occurring during dystocia births or other lambing difficulties (Farrell et al., 2019). A preweaning death rate of 15% was assumed for lambs (Y_0) of all birth ranks (Farrell, 2020). $Y_{0.5}$ represents lambs on farm post weaning, from which replacements are kept and aged into Y_1 ewes, with all others sold. A 3.2% death rate (d_1) was assumed for all hoggets (Y_1) with a 0% culling rate (c_1) as no hoggets were presented for mating.

Lambs born (*LB*) was a function of the ewe flock ($Y_{2\text{-}6}$), the reproductive rate (RR_i) and the litter size (LS_i) (Equation 3.5). *LS* ranged from 1 (single) to 4 (quadruplets). Based on the values from Amer et al (1999) and the lambing percentage used in the model, no quadruplets were born, with only a small number of triplets born at the lambing percentage of 160%. Relative reproductive rates varied with age, where RR_2=0.85 , RR_3=0.97, RR_4=1.04, RR_5=1.09 and RR_6=1.06 (Farrell et al., 2019; Thomson et al., 2004).

$$LB = \sum_{i=2}^{6} \sum_{j=1}^{4} (Y_i * RR_i * LS_{ij}) \qquad [3.5]$$

The proportion of lambs born in each birth rank depends on the flock lambing percentage, with a higher proportion of multiples born at higher lambing percentages (Figure 2.10, Table 3.2, Amer et al., 1999). The number of replacements (R) required was a sum of the culls from the breeding flock ($C_{1\text{-}6}$) and all deaths from weaned lambs to 6-year-old ewes ($D_{0.5\text{-}6}$) (Equation 3.6). Replacements were taken from ewe lambs born as multiples, with ewe lambs born as singles used to fill any deficits.

$$R = \sum_{i=1}^{6} (D_{0.5-6} + C_{1-6}) \qquad [3.6]$$

3.2.3 Feed Supply

Pasture was the only source of feed for the sheep enterprise. The pasture growth rates were derived from Trafford and Trafford (2011) while the quality values were derived from Bown et al (2012) (Figure 3.3). Land area was segregated into three land classes based on topography: low slope, medium slope, and high slope, with each class accounting for 8.7%, 45.9%, and 45.4% of the effective land area, respectively (Beef + Lamb New Zealand, 2021a). It was assumed that each of the slopes had the same pasture growth rates and same fluctuation in pasture quality highlighted in Figure 3.3. However, each land class had differing slope effects on the total amount of energy available through varied utilisation rates with low slope, medium slope and steep slopes having 100%, 52.1% and 38.1% of the total energy available, respectively. It has been assumed that the sheep flock have a pasture utilisation value of 70% across the three slope classes. The sheep enterprise contributes 60% of the total stock units on the farm and subsequently, only 60% of total feed will be supplied to the sheep enterprise (Beef + Lamb New Zealand, 2020c, 2021a). A total of 11.815 million MJ ME of energy was supplied to the sheep in each of the eight scenarios.

Figure 3.2 Simplified structure of the purebred flock module. Each age class (Y_i) is subject to culls (C_i) and deaths (D_i) because of age specific cull rates (c_i) and death rates (d_i). Lambs born is a product of the reproductive rate (RR) and Litter size (LS) of breeding ewes ($Y_{2\text{-}6}$). Replacements (R) is a product of all ewe deaths ($D_{1\text{-}6}$) and culls ($C_{1\text{-}6}$), with the product flowing into lambs being kept.

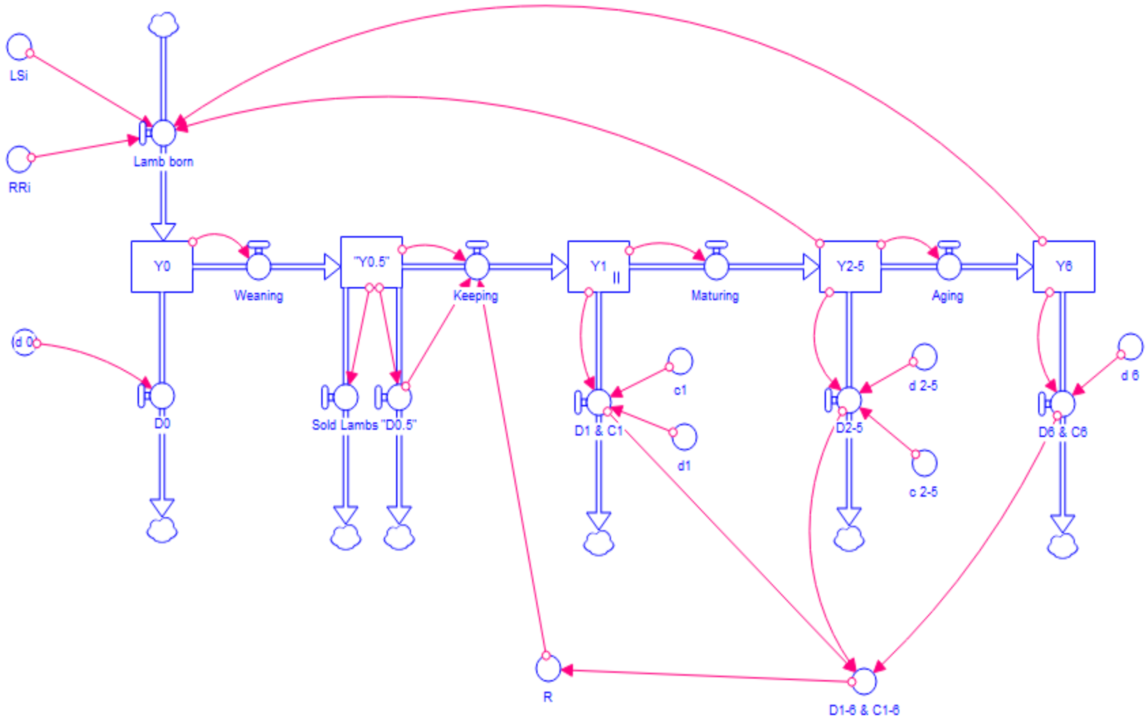
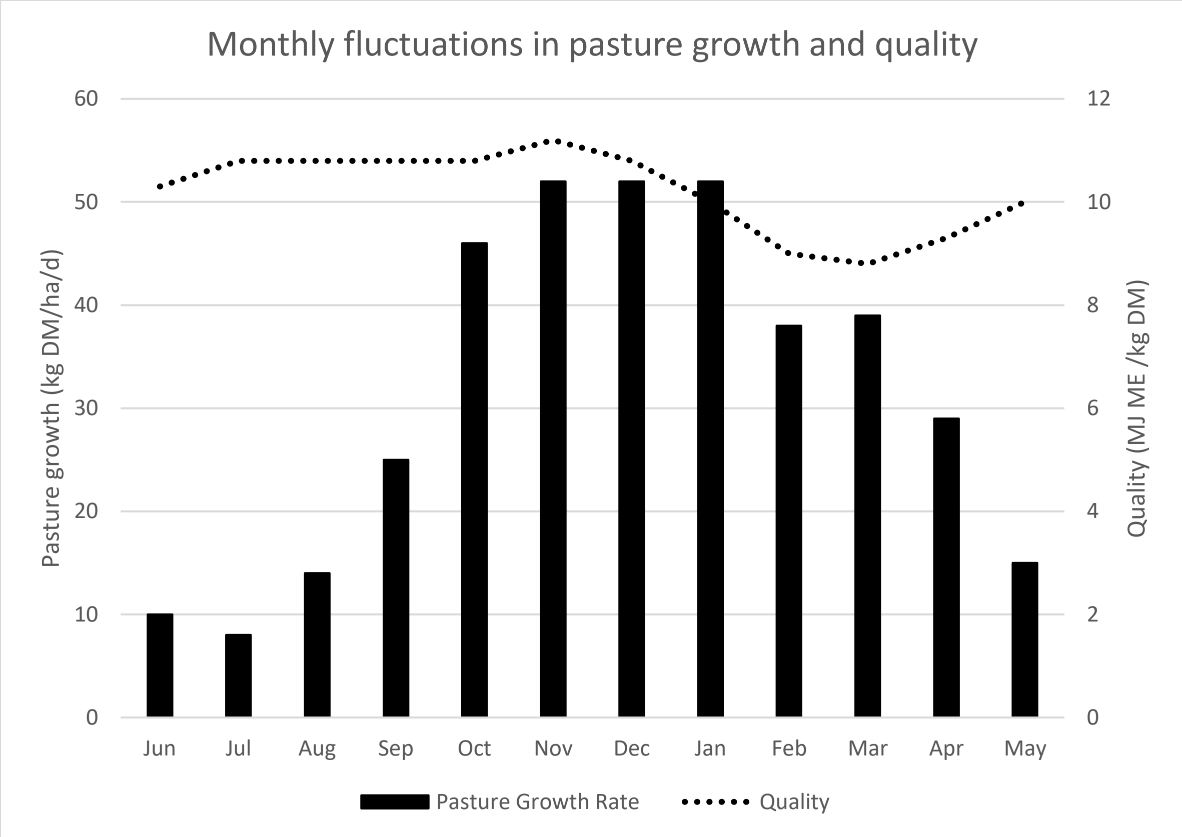


Table 3.2 Proportion of lambs at each birth rank based on flock lambing percentage

Scenario	Lambing percentage	Single	Twin	Triplet	Quadruplet
1	133.5%	0.665	0.335	0.00	0.00
2	140.0%	0.600	0.400	0.00	0.00
3	150.0%	0.500	0.500	0.00	0.00
4	160.0%	0.406	0.588	0.06	0.00

Figure 3.3 Monthly pasture growth rates and changes in pasture quality, highlighting a spike in pasture growth over spring and a decline in pasture quality over summer (Bown et al., 2012; Trafford & Trafford, 2011)



3.2.4 Feed Demand

Feed demand was calculated monthly and was dictated by the number of animals in each class along with the four key demand requirements: maintenance, pregnancy, lactation, and animal growth. All demand was converted into megajoules of metabolisable energy (MJ ME) to compare with that of feed supply to ensure model validation.

Daily animal feed maintenance requirements were calculated using equation 3.7, derived from Nicol and Brookes (2007), where *LW* is the animal's liveweight in kilograms and *Q* is the pasture quality measured as MJ ME/kg DM, and was assumed to be an annual average of 10 MJ ME/kg DM (Bown et al., 2012; Litherland et al., 2002). *i* represents flock age which only exhibits slight fluctuation between the eight scenarios (3.45 to 3.49 years old) (Nicol & Brookes, 2007). *A* represents activity, which is assumed to be 1.0.

$$ME_m = \left[0 \cdot 28 \frac{LW_i^{0.75} * e^{-0.03*i}}{0.02*Q+0.5}\right] * A \quad [3.7]$$

Ewes were assumed to have a mature liveweight of 65 kg, with rams having a mature liveweight of 70 kg (Thomson et al., 2004). The liveweight of 1yo ewes was assumed to be 80% of the mature ewe liveweight, weighing 52 kg. All males are assumed to have an extra 10% maintenance requirements compared to females (CSIRO, 2007; Nicol & Brookes, 2007).

All lamb maintenance requirements from birth until weaning is met through the ewe lactational demand, with lamb maintenance requirements calculated post-weaning. Lambs' post-weaning maintenance requirements reflect the weight of the lamb at the end of the week, accounting for the respective week's liveweight gain. Energy demand for lactation (ME_l) was calculated based on the liveweight of the lamb at weaning (L), the age of the lamb at weaning (α), along with values estimated in equation 8 from Nicol and Brookes (2007) (Equation 3.8, Table 3.3).

$$ME_l = -1808 + 51.4 * L + 134.7 * \alpha \quad [3.8]$$

Table 3.3 Single and multiple lamb weaning weights for each of the 8 scenarios

Scenario	Single (kg)	Multiple (kg)
1	30	25
2	30	25
3	30	25
4	30	25
5	33	27.5
6	36	30
7	39	32.5
8	33	27.5

The energy demand for pregnancy (ME_P) is calculated based on the number of foetuses and lamb birth weight, with the values estimated from Nicol and Brookes (2007). It has been assumed that all singles have a birth weight of 5.5 kg while multiples have a birth weight of 4.5 kg, accounting for gestational demand of 277.5 and 227.5 MJ ME for each lamb, respectively (Nicol & Brookes, 2007).

The energy demand for every kilogram of liveweight increase was assumed to be 55 MJ ME while every kilogram of liveweight loss was assumed to conserve 35 MJ ME (Nicol & Brookes, 2007). Ewes were assumed to gain 2 kilograms of liveweight for 6 weeks over flushing in autumn at a rate of approximately 50 grams per head per day. Ewes were also assumed to lose 2 kilograms during the early lactation period. Single born lambs were assumed to have a post-weaning growth rate of 0.2 kg/day while multiples were assumed to grow at 0.1 kg/day. Based on the varied pre-weaning growth rates of lambs and difference in sale date, the weight of lamb when sold varied between scenarios (Table 3.4). All single born lambs were assumed to be sold 28 days post-weaning as prime lambs for slaughter, with multiple born males and multiple born females sold 77 days and 91 days post weaning, respectively, as store lambs regardless of liveweight (Table 3.4).

It is important to note that both male and female singles and multiples are referred to as maternal lambs to allow for the introduction of terminal sires and subsequently terminal lambs in future research.

3.2.5 Feed Balance

The feed balance (*FB*) module was run using the feed supply (*FS*) and feed demand (*FD*) modules (Figure 3.9). The feed balance module was used to ensure the scenarios that were run are viable, highlighting any significant energy surplus or deficits (Equation 3.9).

$$FB = FS - FD \quad [3.9]$$

Table 3.4 Differences in weaning weight, sale weight and date sold for male singles (MS), female singles (FS), male multiples (MM) and female multiples (FM)

	Weaning weight				Sale weight				Days after weaning sold			
Scenario	MS	FS	MM	FM	MS	FS	MM	FM	MS	FS	MM	FM
1	30.0	30.0	25.0	25.0	35.6	35.6	32.7	34.1	28.0	28.0	77.0	91.0
2	30.0	30.0	25.0	25.0	35.6	35.6	32.7	34.1	28.0	28.0	77.0	91.0
3	30.0	30.0	25.0	25.0	35.6	35.6	32.7	34.1	28.0	28.0	77.0	91.0
4	30.	30.0	25.0	25.0	35.6	35.6	32.7	34.1	28.0	28.0	77.0	91.0
5	33.0	33.0	27.5	27.5	38.6	38.6	35.2	36.6	28.0	28.0	77.0	91.0
6	36.0	36.0	30.0	30.0	41.6	41.6	37.7	39.1	28.0	28.0	77.0	91.0
7	39.0	39.0	32.5	32.5	44.6	44.6	40.2	41.6	28.0	28.0	77.0	91.0
8	33.0	33.0	27.5	27.5	38.6	38.6	35.2	36.6	28.0	28.0	77.0	91.0

3.2.6 Wool Production

It was assumed that all ewes and rams produced a 4.8 kg fleece (greasy weight) annually, having a daily fleece growth (*G*) of 13.15 g/animal/day (CSIRO, 2007). Total flock wool production (*WP*) was estimated using growth (*G*), average annual wool production per ewe (*W*) and adjusted for the wool production of each age bracket (w_i) (Equation 3.10). The energy demand for wool growth (ME_w) was calculated using the equation provided by CSIRO (2007) along with daily fleece growth calculated above (Equation 3.11). It is assumed that shearing takes place once a year during summer. It is also assumed that the single born lambs that are sold at 16 weeks of age are sold prior to shearing, while multiple born lambs and those kept as replacements for the ewe flock are present for shearing. It is assumed that lambs produce 41% of the fleece of a mature ewe.

$$WP = \sum_{i=1}^{6} Y_i * (W + w_i) \quad [3.10]$$

$$ME_W = 0.13 * (G - 6) \quad [3.11]$$

3.2.7 Economics

The economic analysis was completed in New Zealand dollars, NZD$ 1 = EUR€ 0.62 = USD$ 0.68 as of 12th April 2022 (xe.com). All scenarios are driven by values provided by Beef +Lamb New Zealand for the 2020-21 season. Lamb values are an average of the last two seasons to ensure the increasing value of lamb in the last 5 years is captured and more closely reflects the expected prices for the 2021-22 season. It was assumed that lambs sold less than 17 weeks old (119 days) have a dressing out (DO) percentage of 50%, while those sold older than 17 weeks are assumed to have a dressing out percentage of 43% (Muir et al., 2008). It has also been assumed that the cut off carcass weight for a lamb to be sold as prime to slaughter is 17.8 kg. Given the above DO percentage rules, a lamb sold before 17 weeks of age must have a liveweight of 35.6 kg while a lamb sold after 17 weeks of age must have a liveweight of 41.4 kg. Sale type is based on birth rank, with all singles sold as prime and multiples being sold store. Male multiples are sold at a liveweight of 32.7 kg while all female multiples are retained for replacements. Female multiples are retained as replacements, with any surplus to requirements being sold store at 25 weeks post-weaning at a liveweight of 31.3 kg. Lambs sold as store are sold based on carcass weight for ease of comparison between scenarios.

Table 3.5 Values of commodities used

Income	Unit	Value
Lambs ≤13 weeks old	$/kg CW	$6.82
Lambs <18 weeks old	$/kg CW	$7.10
Lambs <23 weeks old	$/kg CW	$6.77
Lambs <27 weeks old	$/kg CW	$6.64
Cull hoggets & 2-ths	$/hd	$143.52
Cull mixed age ewes	$/hd	$125.94
Lamb wool	$/kg (Greasy)	$2.94
Ewe & ram wool	$/kg (Greasy	$2.42

Cull hoggets and Y_2 are assumed to be worth $143.52 each while cull ewes are assumed to be worth $125.94 each (Table 3.5, Beef + Lamb New Zealand, 2021c). All rams no longer required are assumed to be killed for use on farm. The value of coarse wool from lambs and ewes and rams was assumed to be $2.94/kg and $2.42/kg greasy, respectively (Table 3.5, PGG Wrightson, 2022).

The productivity of the sheep enterprise, prices and expenses were used to calculate the cash operating surplus of the sheep enterprise (COS) on a per sheep stock unit (SSU) basis. The farms COS is often utilised to indicate profitability and relies on the cash income of the sheep enterprise with the cash operating expenses deducted (Shadbolt & Martin, 2005). The expenses per SSU were used to calculate the COS included the variable costs along with the sheep enterprise portion of fixed costs which costs such as repairs and maintenance, vehicles, and administration. Expenses per SSU were $66.34 (Beef + Lamb New Zealand, 2021b). The COS excludes tax, interest, depreciation, rent and drawings (Shadbolt & Martin, 2005). All animals that die on farm are disposed of on farm and do not incur any extra cost.

4.0 Results and discussion

4.1 Introduction

The impacts of different lambing percentages and pre-weaning lamb growth rates on the ewe flock, energy demand, productivity, profitability, and the implications for each scenario will be discussed separately in the following sections. The sections follow those previously used in published literature using the bioeconomic model (Farrell, 2020; Farrell et al., 2020a; Farrell et al., 2021a; Farrell et al., 2020b; Farrell et al., 2020c, 2021b, 2022; Farrell et al., 2021c; Farrell et al., 2019; Farrell et al., 2020d; Farrell et al., 2020e).

4.2 Sheep numbers

Feed demand on a per ewe basis varied between the 8 scenarios, impacting the total number of ewes within each scenario. As lambing percentage increased from 133.5% in scenario 1 to 160% in scenario 4, the amount of energy required for gestation became a factor limiting flock size (Nicol & Brookes, 2007). As a result, the flock size was progressively decreased from 2203 ewes in scenario 1 to 2172 ewes in scenario 7, aligning with the results from several articles which show decreasing ewe numbers due to increasing gestational requirements (Table 4.1, Earle et al., 2017a; Earle et al., 2016, 2017b).

As pre-weaning lamb growth rates progressively increased from scenario 5 to 7, individual ewe lactational demand also progressively increased (Nicol & Brookes, 2007). Given the increase in lactational energy and individual lamb herbage demand from scenario 5 to 7, the ewe flock decreased from 2184 to 2146 ewes respectively, again aligning with research results (Table 4.1, Earle et al., 2017a; Earle et al., 2016, 2017b). The distribution of ewes between age groups is similar within all scenarios, with approximately 25% as one-year-olds reducing to approximately 7% as six-year-olds (Table 4.1). The average age of the flock did not vary greatly between the eight scenarios, remaining relatively constant at 3.43 years old due to the consistency in ewe numbers within each age class.

Table 4.1 Ewe flock dynamics and distribution of ewes between age class

Scenario	Total ewe numbers[1]	1yo	2yo	3yo	4yo	5yo	6yo
1	2203	561	543	406	304	227	161
2	2195	559	541	405	303	226	161
3	2182	556	538	403	301	225	160
4	2172	553	535	401	300	224	159
5	2184	556	538	403	301	225	160
6	2166	552	534	400	299	224	159
7	2146	547	529	396	296	221	157
8	2178	555	537	402	300	225	160

[1]Difference in total number and the sum of age groups is attributed to rounding each age bracket

4.3 Lamb production

The production of lamb for sale as prime or store lambs varies greatly between the 8 scenarios (Table 4.2). There were 2192 lambs weaned in scenario 1, with a total of 1612 lambs sold, and 580 ewe lambs kept as replacements. Most of the lambs sold were singles and were subsequently sold prime (67%) with the remainder sold store, for a total of 93 kilograms of lamb sold per hectare (Table 4.2).

As lambing percentage increased from scenario 2 to 4, a greater number of lambs were weaned and sold, respectively, aligning with the results from Beef + Lamb New Zealand (2022) (Table 4.2). The proportion of lambs sold prime progressively decreased from scenario 2 to 4, due to the increasing proportion of multiples in the total lamb flock, with only 33% of lambs sold direct for slaughter in scenario 4 (Table 4.2). At these higher lambing percentages, the replacement requirement is met by the multiple born ewe lambs, with all remaining female multiples being sold at a liveweight of 34.1 kg. The weight of lamb sold per hectare (carcass weight, with store lambs liveweight adjusted to carcass weight) increases from 97 kg/ha to 107 kg/ha as lambing percentage increases from 140% to 160% (Table 4.2).

As pre-weaning lamb growth rates increase in scenarios 5, 6 and 7, the total number of lambs weaned and sold decreased as less ewes were carried on farm (Table 4.2). All three scenarios had the same proportion of lambs sold prime vs store as scenario 1, such that all singles and multiples were sold prime and store respectively, regardless of weight. The weight of lamb sold per hectare (carcass weight) increased as pre-weaning growth rates increased to a peak of 113 kg/ha (Table 4.2).

The number of lambs weaned and sold in scenario 8 ranked as the fourth highest number of lambs of the eight scenarios and also the fourth highest amount of lamb per hectare at 104 kg/ha (Table 4.2). The proportion of lambs sold prime decreased by 10% to 57% when compared to scenario 1, with the remaining 43% of lambs being sold store.

While the proportion of lambs sold prime vs store was highest in scenarios 1, 5, 6 & 7, the ratio was much lower than what has been reported for Class 4 sheep enterprises in the WNI (Beef + Lamb New Zealand, 2021d). The ratio sold in the model is dictated by birth rank rather than lamb liveweight, with the model able to be changed to reflect the expected ratios more accurately. This could be considered in future research.

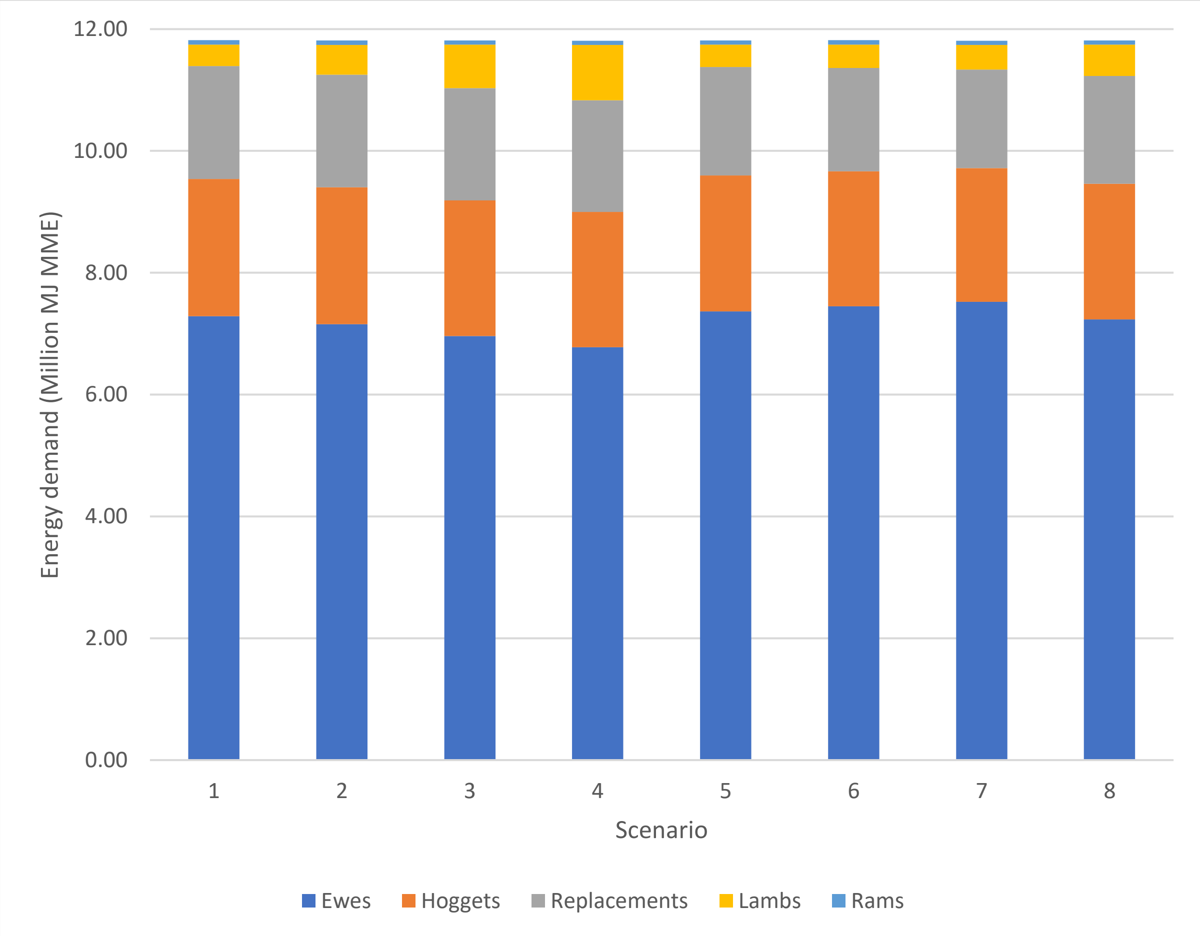
4.4 Feed demand

The total energy demand was calculated in terms of million megajoules of metabolisable energy per year (million MJ ME/yr), with the potential energy demand limited to annual quantity of energy supplied which was fixed at 11.815 million MJ ME/yr. The demand for all eight scenarios was 11.815 million MJ ME/yr ± 0.05%, with the difference due to rounding errors within the modules (Nicol & Brookes, 2007). The distribution of energy demanded between the sheep classes differed however (Figure 4.1, Table 4.3).

4.4.1 Ewe energy demand

Ewe feed demand accounted for most of the annual energy requirement within each of the 8 scenarios, which aligns with Nicol and Brookes (2007) (Figure 4.1 & Table 4.3). Ewe demand in scenario 1 is 7.29 million MJ ME/year, accounting for 61.7% of total annual demand (Table 4.3). Annual ewe demand (MJ ME/yr) and the proportion of total demand (%) decreased progressively from scenario 1 to 4, with demand in scenario 4 being 6.78 million MJ ME/yr (57.4% total annual demand). Ewe demand in scenario 5 is 7.37 million MJ ME/yr, with ewe demand increasing progressively to scenario 7, which had the peak ewe demand of 7.52 million MJ ME/yr (63.7% of total demand). Ewe demand in scenario 8 is slightly lower than scenario 1, accounting for 61.2% of total annual demand (Figure 4.1, Table 4.3).

Figure 4.1 Distribution of energy demand by stock class



While the flock size for scenarios 2 to 7 was smaller than that of scenario 1, ewe feed demand differed (Tables 4.1 & 4.3). Lambing percentage increased in scenario 2, 3 and 4 and subsequently having an increased gestational requirement because of multiple born lambs requiring greater energy during gestation (Nicol & Brookes, 2007). Although the number of lambs weaned progressively increased from scenario 1 to 4, lactational demand gradually proportionally decreased. This is a result of lambs born as multiples requiring less energy supplied via lactation, and the proportion of multiples within the total lamb flock increased from scenarios 2 to 4 (Nicol & Brookes, 2007). If the lambing percentage is expected to increase beyond 160% the size of the ewe flock will have to decrease to account for the greater gestational demand which is the limiting factor in scenarios 2, 3 and 4 (Nicol & Brookes, 2007).

Ewe numbers in scenarios 5, 6 and 7 were reduced compared to scenario 1, progressively decreased by approximately 20 ewes in each scenario, respectively (Table 4.1). Gestational energy demand for scenarios 5 to 7 decreased progressively, with the decline attributable to the combination of reduced gestational demand for single born lambs compared to multiples (277.5 and 227.5 MJ ME/lamb respectively) and less total lambs as a result of a smaller flock (Nicol & Brookes, 2007). Lactational demand is the factor limiting flock size however, as milk demand increased due to heavier lamb weaning weights. To allow for the increased pre-weaning lamb growth rates and pre-weaning lamb demand being predominately derived from the ewe, individual ewe lactational requirements increased drastically (Nicol & Brookes, 2007). If pre-weaning lamb growth is expected to increase beyond 30% greater than the status quo, the size of the ewe flock would have to decrease to take into account for greater lactational feed demand during both spring and early summer.

Table 4.2 Lamb productivity across the eight scenarios

	Lambs weaned					Lambs sold					Sale type		Carcass weight of lamb sold
Scenario	MS[1]	FS[2]	MM[3]	FM[4]	Total	MS	FS	MM	FM	Total	% Sold Prime	% Sold Store	Kg /ha[4]
1	546	546	550	550	2192	546	535	531	0	1612	67%	33%	93
2	491	491	654	654	2290	491	491	634	96	1712	57%	43%	97
3	407	407	813	813	2440	407	407	792	258	1864	44%	56%	102
4	329	329	952	952	2562	329	329	932	399	1989	33%	67%	107
5	541	541	545	545	2172	541	531	526	0	1598	67%	33%	100
6	537	537	541	541	2156	537	526	521	0	1584	67%	33%	107
7	532	532	536	536	2136	532	521	516	0	1569	67%	33%	113
8	487	487	649	649	2272	487	487	628	95	1697	57%	43%	104

[1]Male singles
[2]Female singles
[3]Male multiples
[4]Store lambs liveweight have been adjusted to carcass weights

Table 4.3 Distribution of annual energy feed demand by stock class (Million MJ ME/yr) and proportion of total annual demand (% in brackets)

Scenario	Ewes	Hoggets	Replacements	Lambs	Rams	Total
1	7.29 (61.7%)	2.25 (19.1%)	1.86 (15.7%)	0.35 (3.0%)	0.07 (0.6%)	11.82 (100%)
2	7.16 (60.6%)	2.24 (19.0%)	1.85 (15.7%)	0.49 (4.1%)	0.07 (0.6%)	11.81 (100%)
3	6.96 (58.9%)	2.23 (18.9%)	1.84 (15.6%)	0.71 (6.0%)	0.07 (0.6%)	11.82 (100%)
4	6.78 (57.4%)	2.22 (18.8%)	1.83 (15.5%)	0.91 (7.7%)	0.07 (0.6%)	11.81 (100%)
5	7.37 (62.4%)	2.23 (18.9%)	1.78 (15.0%)	0.37 (3.1%)	0.07 (0.6%)	11.82 (100%)
6	7.45 (63.1%)	2.21 (18.7%)	1.70 (14.4%)	0.39 (3.3%)	0.07 (0.6%)	11.82 (100%)
7	7.52 (63.7%)	2.19 (18.6%)	1.62 (13.7%)	0.41 (3.4%)	0.07 (0.6%)	11.81 (100%)
8	7.23 (61.2%)	2.23 (18.8%)	1.77 (15.0%)	0.51 (4.4%)	0.07 (0.6%)	11.82 (100%)

The ewe flock in scenario 8 had 25 animals fewer than the ewe flock in scenario 1 and therefore a slightly lower total ewe demand, requiring 60,000 MJ ME/year less. While individual ewe lactational demand increased because of the improved pre-weaning lamb growth rates, the decline in ewe numbers reduced the total lactational demand below that of the total lactational demand in scenario 1 (Nicol & Brookes, 2007). Given the increase in lambing percentage from 133.5% to 140% for scenarios 1 and 8, respectively, gestational demand was greater in scenario 8 to account for the greater number of total lambs.

4.4.2 Hogget & replacements energy demand

Hogget and replacement ewe demand follows the same trend as the total ewe demand (Figure 4.1, Table 4.3). As lambing percentages increased from scenario 2 to 4, the energy required for replacements and hoggets decreased because of fewer animals of each stock class.

As pre-weaning lamb growth rates increase from scenario 5 to 7, replacements were heavier at weaning in summer and had subsequently less weight to gain to reach their target hogget weight. Energy required for pre-weaning growth of the replacements has been attributed to the ewes lactational demand. While weaning heavier replacements reduced their energy demand for growth to a set hogget weight (Nicol & Brookes, 2007), it also increased hogget reproductive performance if put to the ram (Corner-Thomas et al., 2020b; Kenyon et al., 2011c). The combination of fewer replacements and hoggets required along with heavier replacements at weaning ensured that the total energy demand for hoggets and replacements decreased from scenario 5 to 7.

The total demand from both hoggets and replacements in scenario 8 was less than that of scenario 1. This was due to a smaller ewe flock, less replacements and hoggets required, while the replacements that were drafted off from the sale lambs at weaning were at a desired liveweight, requiring less energy for growth of the hogget to the desired hogget (Nicol & Brookes, 2007)

4.4.3 Rams energy demand

Ram demand is identical within each of the eight scenarios as ram numbers were not altered, requiring 0.07 million MJ ME/year, accounting for approximately 0.6% of the total annual demand (Figure 4.1, Table 4.3) (Nicol & Brookes, 2007).

4.5 Economics

The income for scenario 1 was $280,000, with total expenses of $196,500 giving a cash operating surplus of $83,500, or $291/ha (Figure 4.2 & Table 4.5). Single born lambs were sold prime 16 weeks post-weaning when the market price was $7.10/kg CW, earning $126.38 each from a carcass weight of 17.8 kg. All multiples were sold store and had their liveweights converted to carcass weights and multiplied by the estimated market price. Male multiples were sold 23 weeks post-weaning when the market price was $6.64/kg CW, earning $93.37 each given a carcass weight of 14.1 kg. Female multiples were sold 25 weeks post-weaning when the schedule was also $6.64/kg CW, earning $95.4 each from a given carcass weight of 14.4 kg.

As lambing percentage increased from scenario 1 to 4, total income increased from $280,000 to $305,400, with all lambs sold for the same value as those in scenario 1 (Table 4.5). Expenses also increased due to the greater number of lambs at the higher lambing percentages, increasing total animal health expenses due to activities such as drenching and shearing. Given the relatively larger increase in income compared to expenses, overall profit increased from scenario 1 to 4. Total COS increased to $105,400 in scenario 4, earning $77/ha more than scenario 1, or $368/ha (Figure 4.2 & Table 4.5). Using the results outlined in Table 4.5, a 1% increase in lambing percentage increased COS by 1.16% from scenario 1 to 2, with the marginal return decreasing to 0.67% from scenario 3 to 4. This indicates that lambing percentage follows the law of diminishing returns as lambing percentage increased above 140%. These findings in terms of economic response from increased lambing percentage are supported by the findings in Morel and Kenyon (2006), with farms that have higher modelled ewe prolificacy values achieving a greater level of profit. The extent of the profit response to increased lambing percentage is dependant on the starting lambing percentage. The farms that have lower starting ewe prolificacy values achieving the best results economically from increased lambing performance compared to ewes with high starting values (Morel & Kenyon, 2006). Another trial in Canterbury highlighted farmers already achieving the mean lambing percentage receive greater financial benefit from focussing instead on pre-weaning growth rather than increasing lambing percentage to achieve the greatest gain in profit (Ludemann & Trafford, 2009).

As pre-weaning lamb growth rates increase from scenario 4 to 7, income increased from $293,000 to $318,700. The value of lambs sold prime increased to a peak of $158/hd in scenario 7, with the value of male multiples and female multiples increasing to a peak of $116/hd & $118/hd respectively (Table 4.6). Expenses progressively declined from scenario 5 to 7 when compared to scenario 1, largely because of the smaller flock and fewer lambs present. As pre-weaning lamb performance increased from scenario 5 to 7, total COS increased from $98,200 to $127,200. Scenario 7 had the greatest COS of all scenarios, with a COS equating to $444/ha, $153/ha more than scenario 1. Scenario 8 had the fourth highest total COS at $104,800, or $365/ha. Using the results in Table 4.5, a 1% increase in pre-weaning lamb growth increased COS by 1.7% from scenario 1 to scenario 5. While this marginal benefit decreased to 1.3% between scenario 6 to 7, the overall return from increased pre-weaning growth remains higher than the returns from improved lambing percentages.

While these pre-weaning lamb growth results are supported by some literature, they contradict with others. Thompson et al (2016) concluded that there was not a linear relationship between heavier weaning weights and profitability, when examining three geoclimatic areas in New Zealand. The results suggest that the response of farm profitability to lamb growth relies heavily on several inter-related factors such as feed supply and the timing of lambing, with each varying between the three scenarios examined (Thompson et al., 2016). Given the model used in this research has a fixed feed supply along with a set lambing date for each of the eight scenarios, the results around pre-weaning growth rates in the model can be compared with each other but should be considered carefully if compared with other studies.

Morel and Kenyon's (2006) findings around lamb growth rate support the findings of this research, with a 10% increase in lamb growth simultaneously increasing income and decreasing farm expenses for farms with 'low', 'medium' and 'high' levels of productivity, increasing each farm type's gross margin (FGM). The marginal impact of changes to both ewe prolificacy and lamb growth rate differed based on the starting values of the farms. A 1% increase in lamb growth increased FGM by the same amount as a 1% increase in ewe prolificacy for low performing farms, while the gain from a 1% increase in lamb growth rate for farms with a high starting value required a 3% increase in ewe prolificacy (Morel & Kenyon, 2006).

4.6 Implications of these scenarios

This model produces results which are directly applicable to Class 4 farmers in the Western North Island of New Zealand but, must be considered carefully if recommendations are to be drawn from the results.

If a farm's productivity is at the levels utilised in scenario 1, any increase to lambing percentage or pre-weaning growth rates will increase the farm's profitability (Table 4.5). Increasing pre-weaning lamb growth rates will return greater profit than increasing the farm's lambing percentage as highlighted in Table 4.5, for lambing percentages similar to those examined.

If the farm's current lambing percentage is below the baseline of 133.5%, or below the median seen in Figure 2.8, it is recommended that the farmer look to increase their lambing percentage to at least 133.5%, with 140% being preferable. It is likely that the median lambing percentage will increase beyond 133.5% in seasons to come, with farms below the median now at risk of getting further behind the average lambing percentage (Beef + Lamb New Zealand, 2022).

If the farm is already achieving a lambing percentage of 140% or greater, it is more efficient to increase pre-weaning lamb growth rate rather than lambing percentage. This recommendation is supported by the results from Morel and Kenyon (2006), with 1% increase in lamb growth for a high producing farm returning the same profit as a 3% change to ewe prolificacy. Increasing lambing percentage above 150% also has potential consequences on lamb mortality risk which is outlined below.

If lambing percentage is slightly below 140%, as scenario 8 highlights, simultaneously increasing both lambing percentage by 6.5% and pre-weaning growth rates by 10% can significantly increase profit (Table 4.5).

4.7 Further considerations

There are several aspects of the model that must be considered further when looking to implement changes to either the farms lambing percentage or pre-weaning lamb growth rate.

4.7.1 Feed supply

Pasture growth rates were supplied by Trafford and Trafford (2011) while pasture quality was set by Bown et al (2012), outlining the total quantity of feed available for the year. The realised values for any given year can be higher or lower depending on several factors such as soil moisture levels, rainfall and sunshine hours. Both feed deficits and surplus scenarios can have implications on the outcomes of this model.

A feed surplus must be managed to ensure pasture quality during spring and summer remains adequate. Regardless of the time of year, a feed surplus can be effectively managed by increasing the level of performance of any sheep enterprise or alternate enterprise such as beef or alternatively increasing the numbers of animals consuming herbage. If the surplus occurs during spring and summer, and animal performance is already at the desired level across all enterprises, feed could be conserved or more stock purchased in such as trade lambs. If this surplus continues over several years the famer could consider mating their hoggets as a means to increase feed demand, which has the additional benefit of increasing the number of lambs available at weaning (Farrell et al., 2020a; Kenyon et al., 2011c).

Table 4.5 Total income, expenses, and COS along with income, expenses and COS by effective hectare

Scenario	Income ($ ‘000)	Income ($/ eff. ha)	Expenses ($ ‘000)	Expenses ($/ eff. ha)	Total COS ($ ‘000)	COS ($/ eff. Ha)
1	280.0	976	196.5	685	83.5	291
2	287.1	1001	197.4	688	89.7	313
3	297.5	1037	198.5	692	99.0	345
4	305.4	1065	200.0	697	105.4	368
5	293.0	1022	194.8	679	98.2	342
6	305.7	1066	193.2	674	112.5	392
7	318.7	1111	191.5	668	127.2	444
8	300.6	1048	195.8	683	104.8	365

Figure 4.2 Income, expenses, and cash operating surplus by effective hectare

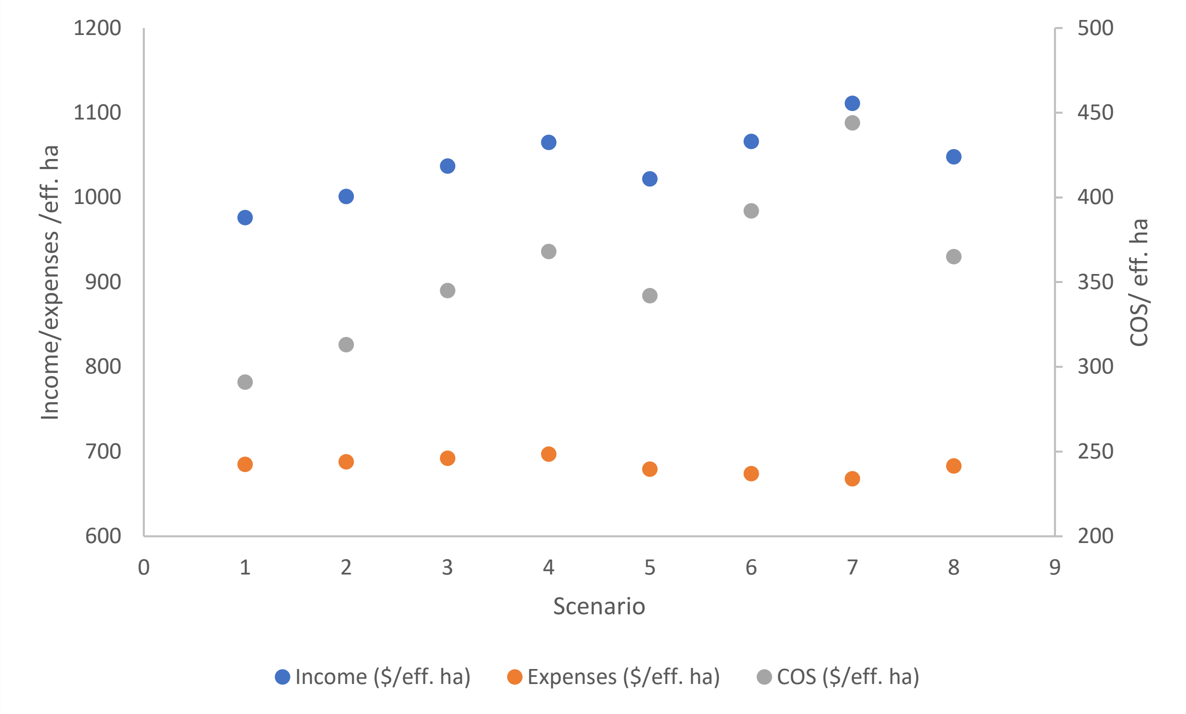


Table 4.6 Lamb value for scenarios five to eight by sex and birth rank

	Male singles		Female singles		Male multiples		Female multiples	
Scenario	CW (kg)	Value ($)	CW (kg)	Value ($)	CW (kg)	Value ($)	CW (kg)	Value ($)
5	19.3	$137.0	19.3	$137.0	15.14	$100.5	14.36	$95.4
6	20.8	$147.7	20.8	$147.7	16.21	$107.6	16.51	$109.6
7	22.3	$158.3	22.3	$158.3	17.50	$116.2	17.80	$118.2
8	19.3	$137.0	19.3	$137.0	15.14	$100.5	15.44	$102

If animal performance is to be maintained in a period of feed deficit, supplementary feed will need to be purchased or sheep numbers reduced. Depending on the timing of the deficit, cull ewes could be sold earlier, or replacement stock sent off farm for grazing. These deficits will need to be monitored, if it becomes a long-term trend, the farmer will need to adjust their stock numbers and expected performance to suit. Droughts can be common across New Zealand, with several severe summer droughts such as the one occurring in the Manawatu during the 2012-13 season virtually stopping pasture production and halting animal performance (NIWA, 2012, 2013). Scenarios 2, 3 & 4 had lambs on property for a longer period given the higher proportion of multiple born lambs in the flock. If a summer drought and/or a severe feed deficit were to occur, farmers in these scenarios could be stuck with a large proportion of stock that are too light to slaughter with limited potential store buyers.

4.7.2 Lamb numbers

The total number of lambs in scenarios 2, 3 & 4 were greater than the number in scenario 1, with a greater proportion of these lambs being born as multiples (Table 4.2). These multiple born lambs are more prone to mortality than their single born counterparts, especially during the perinatal period (Kenyon et al., 2019). If conditions are unfavourable during lambing, a large portion of these multiple born lambs may perish, reducing the number of lambs available at weaning and mitigating some or all of the potential benefits of achieving a higher scanning percentage.

These multiple born lambs also remain on farm due to lighter weights at weaning for a longer period than their single born counterparts, with a much higher total maintenance requirement, resulting in more feed going to maintenance requirements rather than production (Nicol & Brookes, 2007). These multiple born lambs have more risk associated with them due to the length of time on farm and are therefore more likely to have animal health issues such as fly strike than their single born counterparts as a result. Single born lambs in all scenarios have less risk as they are sold earlier.

4.7.3 Lamb weight

Only pre-weaning lamb growth rates have been modified in this model, with post-weaning growth for singles and multiples remaining at 0.2 & 0.1 kg/hd/day respectively. These growth rates are relatively low compared to the pre-weaning growth rates, but if increased, would have significant impacts on flock dynamics, ewe numbers and sale date It is important to note that multiple born lambs in scenarios 6 & 7 reach liveweights when sold, which closely reflect the liveweight of single born lambs in scenario 1 that are sold prime (Table 4.6). These heavier multiple born lambs could then be sold direct for slaughter, increasing the proportion of lambs sold prime vs store and increasing income further.

4.7.4 Scanning percentages

If farmers in scenarios 2, 3 & 4 are to achieve lambing percentages of 140%, 150%, or 160% scanning percentages must be high (Anderson & Sewell, 2000). While the average mortality rate of lambs from scanning to weaning varies, a mortality rate of 19% would require scanning rates of 166.6%, 178.5% and 190.4% in scenarios 2, 3 & 4, respectively (Anderson & Sewell, 2000). These scanning percentages are high, with farmers needing to have their ewes in prime condition, flush well and have high genetic potential for reproduction if they are to be achieved (Kenyon & Webby, 2007). If coming out of a summer drought, ewes are not likely to be at an ideal weight and the farmer is unlikely to have adequate feed to flush well, making these scanning rates unlikely to be attained. Anderson and Sewell (2000) estimated that tailing (docking) rates of 140%, 150% and 160% require scanning rates of approximately 173%, 186% & 200%. Given a lambing percentage of 133.5% requires a scanning rate of approximately 160%, increasing the scanning rate to 200% will require a substantially greater quantity of feed during flushing and mating to occur and high genetic potential for reproductive performance.

4.7.5 Sale type (i.e., store vs prime)

This model utilises birth rank and sex to dictate the timing of sale and sale type (prime or store) ignoring individual liveweights of the lambs. If this model were to be re-run, I would recommend using lamb liveweight and the estimated dressing out percentage at the time of sale to drive sale type. This would ensure that store lambs grown to heavy weights would be classified as prime and sold for slaughter.

This change would reflect farmers decision on sale type and increase the proportion sold prime to store closes towards the ratio outlined in industry standards, increasing income through the sale of a greater proportion of valuable prime lambs (Table 2.6, Beef + Lamb New Zealand, 2021d).

5.0 Conclusion

Sheep enterprises in New Zealand derive nearly all annual feed from pasture grown on farm, with stocking rates, animal performance and output per hectare reliant on the limited seasonal pasture growth rates (Litherland et al., 2002). Pasture growth exhibits significant seasonality in favour of spring, with farmers looking to align lambing with the timing of the spring flush, to ensure lamb performance is maximised (Litherland et al., 2002).

Class 4 sheep enterprises in the Western North Island of New Zealand derive majority of their income from the sale of sheep (Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021). The production of lambs from a traditional Romney flock and sale as either prime for slaughter or as store for others to finish contributes the greatest to sheep enterprise income, with the sale of cull ewes and ram contributing the remainder (Beef + Lamb New Zealand, 2021b; Beef + Lamb New Zealand Economic Service, 2021).

The productivity of Class 4 sheep enterprises in terms of lamb output per hectare has increased drastically since the 1990's, largely driven by farmers lifting their lambing percentage from an average of 100.6% in 1990-91 to 133.5% in the 2020-21 season (Beef + Lamb New Zealand, 2021b, 2022; Beef + Lamb New Zealand Economic Service, 2021). The distribution of lambing for Class 4 farms indicates that there is room for farms at the average of 133.5% to increase their lambing percentage and improve productivity further., as many farmers achieve greater than 140% (Beef + Lamb New Zealand, 2021c)

While improved lambing percentages have ensured there are a greater number of lambs available to sell, individual lamb performance has also increased since 1990 to present. Lamb carcass weight (kg/hd) has increased from 13.9 to 19.0 kg respectively (Beef + Lamb New Zealand, 2021a). While this improvement in lamb weight can partly be attributed animal selection and crossbreeding, farmers have improved pasture production and management to ensure improved efficiency.

The problem that arises when looking to improve lamb production and overall profit is whether the farmer should focus on improving lambing percentages or pre-weaning lamb growth. Given feed supply is limited to the rate of pasture growth, farmers aren't often able to increase both simultaneously without supplementary feed. This bio-economic systems dynamic sheep enterprise model looked to investigate the means to improve profit, running three scenarios with improved lambing percentages, three scenarios with improved pre-weaning lamb growth and one with slight improvements to both.

Improving pre-weaning lamb growth rates improved COS by a greater margin than improved lambing percentages, with a 30% improvement to pre-weaning lamb growth generating 52.35% higher COS than the status quo scenario (Figure 4.2 & Table 4.5). These results suggest that if a Class 4 sheep enterprise is already achieving a lambing percentage of 133.5% or above, they are better off spending their limited feed focussing on pre-weaning lamb growth, rather than lambing percentage, matching previous findings (Morel & Kenyon, 2006). If farms are below the average lambing percentage, they are better off increasing their lambing percentage, to the average, before focussing on improving pre-weaning lamb growth rates.

This model can be updated with more recent data and statistics as they become available from sources such as Beef and Lamb New Zealand. The model has been set using a range of industry standard inputs such as stocking rate and ewe numbers, with each of these inputs able to be examined in depth to see their impact on overall farm performance and profitability.

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7.0 Appendices

7.1 Appendix 1: Glossary of equations

Term	Units	Definition
% culled at weaning	%	Proportion of ewes culled at weaning
% DM slope H	%	Proportion of dry matter from highly sloped land
% DM slope L	%	Proportion of dry matter from lowly sloped land
% DM slope M	%	Proportion of dry matter from medium sloped land
% lambs from 1yo	%	Proportion of lambs from 1-year-old ewes
% MAE to M/W	%	Proportion of mixed age ewes bred to maternal sires
% MAE to terminal	%	Proportion of mixed age ewes bred to maternal sires
% prime	%	Proportion of lambs sold prime
% sheep overall	%	Proportion of sheep from overall total stock units
% sheep slope H	%	Proportion of highly sloped land with sheep
% sheep slope L	%	Proportion of lowly sloped land with sheep
% sheep slope M	%	Proportion of medium sloped land with sheep
% shrub land	%	Proportion of farmland as shrubs
% store	%	Proportion of lambs sold store
1&2yo cull price	$/head	Price per head for 1 and 2-year-old cull ewes
>1yo ewe flock	Head	Number of ewes within the flock older than 1-year-old
1yo	Head	1-year-old ewes
1yo culls	Head	1-year-old ewes that are culled for that year
1yo deaths	Head	1-year-old ewes that die within that year
1yo lambing rate	%	Lambs weaned per 1-year-old ewe presented for mating
1yo SU	Number	Number of stock units from 1-year-old ewes
2yo	Head	2-year-old ewes

3yo	Head	3-year-old ewes
4yo	Head	4-year-old ewes
5yo	Head	5-year-old ewes
6yo	Head	6-year-old ewes
Activity		Activity of the animal based on land class (1 for hill country)
Age	years	Age of the animal in years
Age MAE	years	Average age of the mixed aged ewe flock (1 to 7 years old)
April conserve	kg	Feed conserved in April
April feed out	kg	Supplementary feed supplied to stock in April
April ME	MJ/month	Metabolisable energy available for sheep to consume during the month of April
April ME req	MJ month	Sheep energy demand during the month of April
April PGR	Kg dry matter (DM)/ha/day	Pasture growth rate for the month of April
April quality	MJ ME/kg DM	Pasture quality in terms of energy content for the month of April
Ave FW MAE	kg	Average fleece weight of mixed aged ewes
Bal April	MJ	Balance of metabolisable energy at the end of April
Barren rate	%	Ewes marked as dry (not pregnant) at scanning
Become 2yo	head	The INFLOW of ewes from the previous age class to the current age class
Birth Weight	kg	Lamb birth weight
Breeding ram ratio	Ratio	Ratio of rams to breeding ewes
Carcass Weight	kg	Weight of carcass once empty
Coarse wool price	$/kg	Price per kg of coarse wool
Cold		Temperature value (0 if sheep aren't under cold stress)
COS per ha	$/ha	Cash operating surplus per hectare

Conception	Head	INFLOW of foetuses
Conserved feed	Kg	Feed that has been conserved in form of supplement (Hay and/or baleage)
Cull rate	%	Proportion of stock that is culled within that year
Cull rate excluding barren	%	Culling rate of the ewe flock excluding barren ewes
Death rate	%	Proportion of stock that die within that year
Delay 1yo lambing 1mo	Months	If mating 1-year-olds, a delay in lambing in one-month increments
Dressing out (DO) %	%	Dressing out percentage for carcasses
Effective area	ha	Total effective area from pasture, forage and crops on farm
Effective farmland	ha	Total effective farmland area
F1	MJ/fortnight	Energy requirements of the entire sheep flock for that fortnight
FB 1		Fortnightly feed balance
FWE	$/SU	Farm working expenses
GFW	kg	Greasy fleece weight
GR		Choice of the pasture growth rate curve used
Growth rate	kg/day	Daily liveweight growth rates of stock
INFLOW		Flow of a unit into another category
INIT		Initial value of a variable
Lambs from 1yo price	$	Value of lambs from 1 year old ewes
Lamb income	$	Income from the sale of all lambs (both prime and store)
Lambing date		Date lambing occurs
Lambing rate	%	Number of lambs weaned divided by the number of ewes presented for breeding
Leave	Weeks	Weeks post weaning those lambs are sold
Length of cold	days	Time in days the flock is under cold stress if applicable
Loss rate	%	Mortality rate of lambs from birth to weaning
LW	kg	Liveweight of the animal

LW flushing	kg	Liveweight of ewes aged two to seven during the flushing period
LWC	kg	Liveweight change of livestock
LWC flushing	kg	Liveweight change over the flushing period
LWC gestation	kg	Liveweight change over gestation
LWC lactation	kg	Liveweight change over the lactation period
LWC summer	kg	Liveweight change over the summer period
M/D	MJ ME/kg DM	Pasture quality
M barren rate	%	Barren rate of the maternal ewe flock
M multiple loss rate	%	Maternal multiple lamb loss rate
M single loss rate	%	Maternal single lamb loss rate
MAE	head	Mixed aged ewes
MAE cull rate	%	Cull rate of the mixed-aged-ewes
MAE weaning age	Weeks	Weaning age of lambs from MAE in weeks from lambing
MAE weaning wt multiple	kg	Weaning weight of lambs born as multiples
MAE weaning wt single	kg	Weaning weight of lambs born as singles
Maternal		Stock that is maternal breed (Romney)
Maternal multiple birth weight	kg	Birth weight of lambs born as multiples
Maternal single birth weight	kg	Birth weight of lambs born as singles
ME	MJ	Metabolisable energy
MFM[1]		Maternal female lamb born as a multiple
MFS[1]		Maternal female lamb born as a single
MMM[1]		Maternal male lamb born as a multiple
MMS[1]		Maternal male lamb born as a single
Minimum flock size	Head	Minimum flock size that can be used
Micron		The average micron of the fleece
Multiple		Lamb born as a multiple (Twins, triplets and quadruplets)

Mutton price	$/hd	Value of culled ewes aged three years and older
NON-NEGATIVE		Value cannot be negative
OUTFLOW		Flow of a unit out of a category
Price lambs' wool		Price paid for lambs' wool
Prime	%	Lambs sold direct to slaughter
Prolificacy	%	Lamb weaning rate from the ewe breeding flock
Quad loss rate	%	Loss rate for lambs born as quadruplets
Rams	Head	Number of rams used based on the mating ratio
Ram age	years	Ram age in years
Ram GFW		
Ram LW	Kg	Liveweight of rams used
Ram price	$	Cost of per ram to purchase
Ram wool price	$/kg	Value received for rams wool
Replacements	Head	Ewe lambs retained to replace ewes leaving the breeding flock
Shearing date	Week	Shearing date (weeks after lambing)
Shedding score	%	Sheep wool shedding score (0 for Romney)
Single		Lambs born as a single
Singles kept	Head	Single lambs kept on farm for use in the ewe flock
Singles finished	Head	Single lambs finished for sale
Slope H	%	Proportion of land with high slope
Slope L	%	Proportion of land with low slope
Slope M	%	Proportion of land with medium slope
T		Indicates terminal stock
UNIFLOW		Outlining INFLOW/OUTFLOW can only flow one way
Weaning age	Weeks	Lamb age in weeks from the start of lambing when they are weaned
Weaning weight	kg	Weight of lambs at weaning

[1]The M before the FM denotes the female multiple is a maternal lamb

7.2 Appendix 2: Model equations

Sheep_Economics:
"1&2yo_cull_price" = $143.52
"1yo_SU" = 0.12679+0.011357*purebred_ME_calc."1yo_LW"+0.002179*(purebred_flock."1yo_lambing_rate"*100)
Costs_per_SU = FWE
Discounted_Net_Cash_Flow = "Shrub_n_Sheep_COS_(NCF)"*(1/(1+PV_Discount_Rate)^TIME)
"Exp/ha" = Total_expenses/Feed_Supply.NS_Total_area
FWE = $66.34
Lamb_income = (Lambs_from_1yo_price*purebred_flock.Lambs_from_1yo)+MAE_Lamb_Income.MAE_Lamb_Income
Lambs_from_1yo_price = $67
MAE_SU = 0.12679+0.011357*purebred_ME_req.MAE_LW_Summer+0.002179*(Prolificacy*100)
Mutton_price = $125.94
Prolificacy = (purebred_flock.Maternal_lambs_born+purebred_flock.Lambs_from_1yo)/(purebred_flock.Ewe_flock+0.00001)
Purebred_expenses = (Costs_per_SU*Sheep_stock_units)+Shearing_costs+(Ram_price*purebred_flock.Rams_for_1yo)/3
Purebred_Income = Wool_purebred.Total_wool_income+purebred_Stock_income
purebred_Stock_income = (purebred_flock.Ewe_culls-purebred_flock."1yo_culls"-purebred_flock."2yo_culls")*Mutton_price+(purebred_flock."2yo_culls"+purebred_flock."1yo_culls")*"1&2yo_cull_price"+Lamb_income
PV_Discount_Rate = 0.1
Ram_price = 800
Shearing_cost = GRAPH(Shedding_score)
(0.000, 10.98), (0.9999, 10.98), (1.000, 8.98), (1.9999, 8.98), (2.000, 4.89), (2.9999, 4.89), (3.000, 2.0), (3.999, 2.0), (4.000, 0.0)
DOCUMENT: $ per head
Shearing_costs = Shearing_cost*purebred_flock.Ewe_flock+purebred_flock.Maternal_lambs_born*3.71
Shedding_score = 0
Sheep_COS = Total_income-Total_expenses
"Sheep_n_Shrub_COS/ha/y" = "Shrub_n_Sheep_COS_(NCF)"/((Feed_Supply.NS_Total_area*Feed_Supply.Sheep_Land_Use)+Shrub.Steep_Slope)
"Sheep_n_Shrub_COS/ha/y-_NPV" = NPV("Shrub_n_Sheep_COS_(NCF)", PV_Discount_Rate)
Sheep_stock_units = (purebred_flock.Ewe_flock-purebred_flock."1yo")*MAE_SU+purebred_flock.Rams+purebred_flock.Keeping*0.5+"1yo_SU"*purebred_flock."1yo"
"Shrub_n_Sheep_COS_(NCF)" = Shrub_Area_Economics.Profit_n_Loss+Sheep_COS
Total_expenses = Purebred_expenses
Total_income = Purebred_Income
"Total_income_/_stock_units" = Total_income/Sheep_stock_units

MAE_Lamb_Income:
Lamb_MFM_Income = MFM_Lamb_CWt_Selling*MFM_lambs_price*purebred_flock.MF_twins_finished
Lamb_MFS_Income = MFS_Lamb_CWt_Selling*MFS_lamb_price*purebred_flock.MF_singles_finished
Lamb_MMM_Income = MMM_Lamb_CWt_Selling*MMM_lambs_price*purebred_flock.MM_Multis_finished
Lamb_MMS_Income = MMS_Lamb_price*purebred_flock.MM_singles_finished*MMS_Lamb_CWt_Selling
MAE_Lamb_Income = Lamb_MMS_Income+Lamb_MFS_Income+Lamb_MMM_Income+Lamb_MFM_Income
MFM_Lamb_CWt_Selling = IF purebred_ME_calc.Leave_MFTW<17 THEN (purebred_ME_calc.MAE_Weaning_wt_multiple+(Lamb_ME.LWt_G_MFM*(purebred_ME_calc.Leave_MFTW-(purebred_ME_calc.MAE_weaning_age+1))*7))*0.5 ELSE (purebred_ME_calc.MAE_Weaning_wt_multiple+(Lamb_ME.LWt_G_MFM*(purebred_ME_calc.Leave_MFTW-(purebred_ME_calc.MAE_weaning_age+1))*7))*0.43
MFM_lambs_price = IF purebred_ME_calc.Leave_MFTW=13 THEN 6.82 ELSE IF purebred_ME_calc.Leave_MFTW<18 THEN 7.10 ELSE IF purebred_ME_calc.Leave_MFTW<23 THEN 6.77 ELSE IF purebred_ME_calc.Leave_MFTW<27 THEN 6.64 ELSE IF purebred_ME_calc.Leave_MFTW<31 THEN 6.66 ELSE IF purebred_ME_calc.Leave_MFTW<35 THEN 6.86 ELSE IF purebred_ME_calc.Leave_MFTW<40 THEN 7.4 ELSE IF purebred_ME_calc.Leave_MFTW<44 THEN 7.93 ELSE IF purebred_ME_calc.Leave_MFTW<49 THEN 8.15 ELSE IF purebred_ME_calc.Leave_MFTW<53 THEN 8.26 ELSE IF purebred_ME_calc.Leave_MFTW<57 THEN 8.29 ELSE 117.045
MFS_Lamb_CWt_Selling = IF purebred_ME_calc.Leave_MFS<17 THEN (purebred_ME_calc.MAE_Weaning_wt_Single+(Lamb_ME.LWt_G_MFS*(purebred_ME_calc.Leave_MFS-(purebred_ME_calc.MAE_weaning_age))*7))*0.5 ELSE (purebred_ME_calc.MAE_Weaning_wt_Single+(Lamb_ME.LWt_G_MFS*(purebred_ME_calc.Leave_MFS-(purebred_ME_calc.MAE_weaning_age))*7))*0.43
MFS_lamb_price = IF purebred_ME_calc.Leave_MFS=13 THEN 6.82 ELSE IF purebred_ME_calc.Leave_MFS<18 THEN 7.10 ELSE IF purebred_ME_calc.Leave_MFS<23 THEN 6.77 ELSE IF purebred_ME_calc.Leave_MFS<27 THEN 6.64 ELSE IF purebred_ME_calc.Leave_MFS<31 THEN 6.66 ELSE IF purebred_ME_calc.Leave_MFS<35 THEN 6.86 ELSE IF

purebred_ME_calc.Leave_MFS<40 THEN 7.40 ELSE IF purebred_ME_calc.Leave_MFS<44 THEN 7.93 ELSE IF purebred_ME_calc.Leave_MFS<49 THEN 8.15 ELSE IF purebred_ME_calc.Leave_MFS<53 THEN 8.26 ELSE IF purebred_ME_calc.Leave_MFS<57 THEN 8.29 ELSE 117.045

DOCUMENT: Monthly long term average Lamb price per head and per kg CW

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
07/08 $107.70 $109.07 $102.00 $108.87 $103.64 $103.56 $96.11 $106.05 $111.26 $106.93 $111.59 $122.02
08/09 $130.80 $125.65 $117.40 $121.17 $125.00 $129.56 $135.34 $140.36 $146.98 $152.42 $151.59 $147.69
09/10 $146.20 $131.36 $118.83 $110.16 $113.76 $115.75 $106.26 $115.41 $124.72 $120.57 $125.83 $133.26
10/11 $134.00 $132.96 $129.61 $120.54 $129.18 $131.72 $130.59 $135.79 $145.13 $148.93 $147.41 $148.25
11/12 $141.39 $145.57 $139.54 $136.07 $120.92 $110.95 $111.72 $107.17 $107.82 $110.18 $106.44 $108.15
12/13 $112.96 $109.71 $99.17 $103.35 $98.16 $93.66 $94.83 $100.90 $105.12 $100.36 $106.81 $112.25
13/14 $111.19 $118.08 $109.82 $104.08 $105.36 $103.79 $98.56 $103.36 $108.29 $103.54 $103.31 $103.24
14/15 $101.71 $103.86 $94.43 $98.14 $93.51 $91.57 $96.14 $96.14 $95.81 $89.64 $90.76 $94.53
15/16 $107.80 $102.65 $91.02 $95.09 $93.05 $94.12 $90.94 $93.03 $100.37 $99.30 $102.13 $102.04
16/17 $106.93 $105.57 $98.85 $96.21 $97.16 $101.85 $98.35 $103.76 $109.88 $105.73 $107.24 $111.15
17/18 $111.36 $113.53 $112.37 $107.89 $107.62 $110.43 $109.22 $110.00 $117.09 $112.38 $116.78 $118.94
18/19 $118.83 $118.77 $115.23 $113.90 $110.50 $107.38 $107.95 $113.40 $117.55 $111.54 $115.56 $119.72
19/20 $118.08 $122.33 $119.24 $118.67 $109.26 $104.94 $107.62 $105.90 $112.11 $111.06 $111.84 $111.71
Average $119.15 $118.39 $111.35 $110.32 $108.24 $107.64 $106.43 $110.10 $115.55 $113.27 $115.18 $117.92
$6.62 $6.58 $6.19 $6.13 $6.01 $5.98 $5.91 $6.12 $6.42 $6.29 $6.40 $6.55

Monthly time in weeks 1 5 10 14 18 22 27 31 36 40 44
Weeks after weaning + 1 week 14 18 23 27 31 35 40 44 49 53 57
Source: Peter Tozer

MMM_Lamb_CWt_Selling = IF purebred_ME_calc.Leave_MMTW<17 THEN (purebred_ME_calc.MAE_Weaning_wt_multiple+(Lamb_ME.LWt_G_MMM*(purebred_ME_calc.Leave_MMTW-(purebred_ME_calc.MAE_weaning_age))*7))*0.5 ELSE (purebred_ME_calc.MAE_Weaning_wt_multiple+(Lamb_ME.LWt_G_MMM*(purebred_ME_calc.Leave_MMTW-(purebred_ME_calc.MAE_weaning_age))*7))*0.43

MMM_lambs_price = IF purebred_ME_calc.Leave_MMTW=13 THEN 6.82 ELSE IF purebred_ME_calc.Leave_MMTW<18 THEN 7.10 ELSE IF purebred_ME_calc.Leave_MMTW<23 THEN 6.77 ELSE IF purebred_ME_calc.Leave_MMTW<27 THEN 6.64 ELSE IF purebred_ME_calc.Leave_MMTW<31 THEN 6.66 ELSE IF purebred_ME_calc.Leave_MMTW<35 THEN 6.86 ELSE IF purebred_ME_calc.Leave_MMTW<40 THEN 7.40 ELSE IF purebred_ME_calc.Leave_MMTW<44 THEN 7.93 ELSE IF purebred_ME_calc.Leave_MMTW<49 THEN 8.15 ELSE IF purebred_ME_calc.Leave_MMTW<53 THEN 8.26 ELSE IF purebred_ME_calc.Leave_MMTW<57 THEN 8.29 ELSE 117.045

MMS_Lamb_CWt_Selling = IF purebred_ME_calc.Leave_MMS<17 THEN (purebred_ME_calc.MAE_Weaning_wt_Single+(Lamb_ME.LWt_G_MMS*(purebred_ME_calc.Leave_MMS-(purebred_ME_calc.MAE_weaning_age))*7))*0.5 ELSE (purebred_ME_calc.MAE_Weaning_wt_Single+(Lamb_ME.LWt_G_MMS*(purebred_ME_calc.Leave_MMS-(purebred_ME_calc.MAE_weaning_age))*7))*0.43

MMS_Lamb_price = IF purebred_ME_calc.Leave_MMS=13 THEN 6.82 ELSE IF purebred_ME_calc.Leave_MMS<18 THEN 7.10 ELSE IF purebred_ME_calc.Leave_MMS<23 THEN 6.77 ELSE IF purebred_ME_calc.Leave_MMS<27 THEN 6.64 ELSE IF purebred_ME_calc.Leave_MMS<31 THEN 6.86 ELSE IF purebred_ME_calc.Leave_MMS<35 THEN 7.40 ELSE IF purebred_ME_calc.Leave_MMS<40 THEN 7.93 ELSE IF purebred_ME_calc.Leave_MMS<44 THEN 8.15 ELSE IF purebred_ME_calc.Leave_MMS<49 THEN 8.26 ELSE IF purebred_ME_calc.Leave_MMS<53 THEN 8.29 ELSE IF purebred_ME_calc.Leave_MMS<57 THEN 7.06 ELSE 117.045

DOCUMENT: Monthly long term average Lamb price per head and per kg CW

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
07/08 $107.70 $109.07 $102.00 $108.87 $103.64 $103.56 $96.11 $106.05 $111.26 $106.93 $111.59 $122.02
08/09 $130.80 $125.65 $117.40 $121.17 $125.00 $129.56 $135.34 $140.36 $146.98 $152.42 $151.59 $147.69
09/10 $146.20 $131.36 $118.83 $110.16 $113.76 $115.75 $106.26 $115.41 $124.72 $120.57 $125.83 $133.26
10/11 $134.00 $132.96 $129.61 $120.54 $129.18 $131.72 $130.59 $135.79 $145.13 $148.93 $147.41 $148.25
11/12 $141.39 $145.57 $139.54 $136.07 $120.92 $110.95 $111.72 $107.17 $107.82 $110.18 $106.44 $108.15
12/13 $112.96 $109.71 $99.17 $103.35 $98.16 $93.66 $94.83 $100.90 $105.12 $100.36 $106.81 $112.25
13/14 $111.19 $118.08 $109.82 $104.08 $105.36 $103.79 $98.56 $103.36 $108.29 $103.54 $103.31 $103.24
14/15 $101.71 $103.86 $94.43 $98.14 $93.51 $91.57 $96.14 $96.14 $95.81 $89.64 $90.76 $94.53
15/16 $107.80 $102.65 $91.02 $95.09 $93.05 $94.12 $90.94 $93.03 $100.37 $99.30 $102.13 $102.04
16/17 $106.93 $105.57 $98.85 $96.21 $97.16 $101.85 $98.35 $103.76 $109.88 $105.73 $107.24 $111.15
17/18 $111.36 $113.53 $112.37 $107.89 $107.62 $110.43 $109.22 $110.00 $117.09 $112.38 $116.78 $118.94

18/19 $118.83 $118.77 $115.23 $113.90 $110.50 $107.38 $107.95 $113.40 $117.55 $111.54 $115.56 $119.72
19/20 $118.08 $122.33 $119.24 $118.67 $109.26 $104.94 $107.62 $105.90 $112.11 $111.06 $111.84 $111.71
Average $119.15 $118.39 $111.35 $110.32 $108.24 $107.64 $106.43 $110.10 $115.55 $113.27 $115.18 $117.92
$6.62 $6.58 $6.19 $6.13 $6.01 $5.98 $5.91 $6.12 $6.42 $6.29 $6.40 $6.55

Monthly time in weeks 1 5 10 14 18 22 27 31 36 40 44
Weeks after weaning + 1 week 14 18 23 27 31 35 40 44 49 53 57
Source: Peter Tozer

Economics:
Total_Farm_COS = Beef_Economics.Beef_COS+Sheep_Economics."Shrub_n_Sheep_COS_(NCF)"
"Total_Farm_COS/ha/y" = Total_Farm_COS/Land_Module.Effective_Farm_Land

Land_Module:
"L.Slope_H" = "\"Slope_H\""*Effective_Farm_Land
"L.Slope_L" = Effective_Farm_Land*"\"Slope_L\""
"L.Slope_M" = "\"Slope_M\""*Effective_Farm_Land
"\"Slope_H\"" = 1-("\"Slope_L\""+"\"Slope_M\"")
"\"Slope_L\"" = 0.087
DOCUMENT: Values are proportions
Saggar et al, 2015
"\"Slope_M\"" = 0.459
"%_H_slope_Shrub" = H_slope_Shrub/"L.Slope_H"*100
"%_Shrub_land" = 0
Effective_Farm_Land = 478
DOCUMENT: Estimates for 2020-21
https://beeflambnz.com/sites/default/files/data/files/eni%20class%204%20hill%20country.xlsx
H_slope_Shrub = IF Total_Shrub_land>"L.Slope_H" THEN "L.Slope_H" ELSE Total_Shrub_land
Total_Shrub_land = Effective_Farm_Land*"%_Shrub_land"/100

Feed_Supply:
Conserved_feed(t) = Conserved_feed(t - dt) + (Conserving - Feeding_out - Leftover) * dt {NON-NEGATIVE}
INIT Conserved_feed = 0
INFLOWS:
Conserving = Jun_conserve+Jul_conserve+Aug_conserve+Sep_conserve+Oct_conserve+Nov_conserve+Dec_conserve+Jan_conserve+Feb_conserve+Mar_conserve+Apr_conserve+May_conserve {UNIFLOW}
OUTFLOWS:
Feeding_out = Jun_feedout+Jul_feedout+Aug_feedout+Sep_feedout+Oct_feedout+Nov_feedout+Dec_feedout+Jan_feedout+Feb_feedout+Mar_feedout+Apr_feedout+May_feedout {UNIFLOW}
Leftover = Conserving-Feeding_out {UNIFLOW}
"%_DM_slope_M" = 0.521
DOCUMENT: Based on (Kemp& Lopez, 2016) slope effect on pasture production where medium and steep slopes yields 46.2% and 31.9% of the flat land respectively. For purposes of calibration of the model using Beef and Lamb sheep survey data (564ha effective land and 2167 ewe flock), the yields for the medium and steep slopes were adjusted up with 6.5% to result to 52.7% and 38.4% respectively.
"%_sheep_Free_steep" = 1
DOCUMENT: % SU as sheep
"%_sheep_overall" = 0.6
DOCUMENT: % SU as sheep
"%_sheep_Slope_L" = 1
"%_Sheep_Slope_M" = 1
DOCUMENT: % SU as sheep
Apr_conserve = 0
Apr_conserve_1 = 0
Apr_feedout = 0
Apr_feedout_1 = 0
Apr_GR_0 = GRAPH(GR_Slope_L)

(1.00, 10.000), (2.00, 41.000), (3.00, 29.000), (4.00, 29.000), (5.00, 28.000), (6.00, 25.000), (7.00, 26.000), (8.00, 21.000), (9.00, 14.000), (10.00, 20.000), (11.00, 13.000), (12.00, 5.000), (13.00, 0.000), (14.00, 16.000), (15.00, 21.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Apr_GR_1 = GRAPH(GR_1)
(1.00, 10.000), (2.00, 41.000), (3.00, 29.000), (4.00, 29.000), (5.00, 28.000), (6.00, 25.000), (7.00, 26.000), (8.00, 21.000), (9.00, 14.000), (10.00, 20.000), (11.00, 13.000), (12.00, 5.000), (13.00, 0.000), (14.00, 16.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
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Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Apr_GR_2 = GRAPH(GR_Free_steep)
(1.00, 10.000), (2.00, 41.000), (3.00, 29.000), (4.00, 29.000), (5.00, 28.000), (6.00, 25.000), (7.00, 26.000), (8.00, 21.000), (9.00, 14.000), (10.00, 20.000), (11.00, 13.000), (12.00, 5.000), (13.00, 0.000), (14.00, 16.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)

9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Apr_ME_0 = 30*Apr_GR_0*Apr_qual_0*"%_sheep_Slope_L"*Area_Slope_L*Utilisation_Slope_L*Slope_effect_Slope_L
Apr_ME_1 = 30*Apr_GR_1*Apr_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Apr_ME_10 = Apr_ME_0*Beef_land_use_Convertor
Apr_ME_11 = Apr_ME_1*Beef_land_use_Convertor
Apr_ME_12 = Apr_ME_2*Beef_land_use_Convertor
Apr_ME_2 =
30*Apr_GR_2*Apr_qual_2*"%_sheep_Free_steep"*Area_Free_steep*Utilisation_Free_steep*Slope_effect_Free_steep
Apr_ME_9 = Apr_ME_12+Apr_ME_11+Apr_ME_10+Apr_feedout_1-Apr_conserve_1
Apr_ME_sheep = Apr_ME_0+Apr_ME_1+Apr_ME_2-Apr_conserve+Apr_feedout
Apr_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 8.300), (2.00, 9.600), (3.00, 11.300), (4.00, 10.900), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 7.000), (10.00, 9.300), (11.00, 8.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Apr_qual_1 = GRAPH(Qual_1)
(1.00, 8.300), (2.00, 9.600), (3.00, 11.300), (4.00, 10.900), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 7.000), (10.00, 9.300), (11.00, 8.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Apr_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 8.300), (2.00, 9.600), (3.00, 11.300), (4.00, 10.900), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 7.000), (10.00, 9.300), (11.00, 8.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Area_1 = Land_Module."L.Slope_M"*Sheep_Land_Use
Area_Free_steep = Sheep_Land_Use*Shrub.Free_Steep_slope
Area_Slope_L = Land_Module."L.Slope_L"*Sheep_Land_Use
Aug_conserve = 0
Aug_conserve_1 = 0
Aug_feedout = 0
Aug_feedout_1 = 0
Aug_GR_0 = GRAPH(GR_Slope_L)
(1.00, 20.000), (2.00, 0.000), (3.00, 33.000), (4.00, 14.000), (5.00, 18.000), (6.00, 15.000), (7.00, 32.000), (8.00, 7.000), (9.00, 9.000), (10.00, 11.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 9.000), (15.00, 16.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Aug_GR_1 = GRAPH(GR_1)

(1.00, 20.000), (2.00, 0.000), (3.00, 33.000), (4.00, 14.000), (5.00, 18.000), (6.00, 15.000), (7.00, 32.000), (8.00, 7.000), (9.00, 9.000), (10.00, 11.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 9.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Aug_GR_2 = GRAPH(GR_Free_steep)
(1.00, 20.000), (2.00, 0.000), (3.00, 33.000), (4.00, 14.000), (5.00, 18.000), (6.00, 15.000), (7.00, 32.000), (8.00, 7.000), (9.00, 9.000), (10.00, 11.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 9.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Aug_ME_0 = 31*Aug_GR_0*Aug_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Aug_ME_1 = 31*Aug_GR_1*Aug_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Aug_ME_10 = Aug_ME_0*Beef_land_use_Convertor
Aug_ME_11 = Aug_ME_1*Beef_land_use_Convertor
Aug_ME_12 = Aug_ME_2*Beef_land_use_Convertor
Aug_ME_2 = 31*Aug_GR_2*Aug_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Aug_ME_9 = Aug_ME_12+Aug_ME_11+Aug_ME_10+Aug_feedout_1-Aug_conserve_1
Aug_ME_sheep = Aug_ME_1+Aug_ME_0+Aug_ME_2-Aug_conserve+Aug_feedout
Aug_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 11.500), (2.00, 10.800), (3.00, 11.500), (4.00, 11.200), (5.00, 11.500), (6.00, 11.400), (7.00, 10.600), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Aug_qual_1 = GRAPH(Qual_1)

(1.00, 11.500), (2.00, 10.800), (3.00, 11.500), (4.00, 11.200), (5.00, 11.500), (6.00, 11.400), (7.00, 10.600), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Aug_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 11.500), (2.00, 10.800), (3.00, 11.500), (4.00, 11.200), (5.00, 11.500), (6.00, 11.400), (7.00, 10.600), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Beef_Land_Use = 0.4
Beef_land_use_Convertor = (Beef_Land_Use/Sheep_Land_Use)
Dec_conserve = 0
Dec_conserve_1 = 0
Dec_feedout = 0
Dec_feedout_1 = 0
Dec_GR_0 = GRAPH(GR_Slope_L)
(1.00, 35.000), (2.00, 73.000), (3.00, 37.000), (4.00, 52.000), (5.00, 44.000), (6.00, 60.000), (7.00, 30.000), (8.00, 34.000), (9.00, 19.000), (10.00, 48.000), (11.00, 52.000), (12.00, 12.000), (13.00, 16.000), (14.00, 44.000), (15.00, 29.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 pasture growth data unless stated otherwise

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2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18
16 -
17 -
18 -
19 -
20 -
Dec_GR_1 = GRAPH(GR_1)
(1.00, 35.000), (2.00, 73.000), (3.00, 37.000), (4.00, 52.000), (5.00, 44.000), (6.00, 60.000), (7.00, 30.000), (8.00, 34.000), (9.00, 19.000), (10.00, 48.000), (11.00, 52.000), (12.00, 12.000), (13.00, 16.000), (14.00, 44.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

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4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)

14 - Taieri Hill (C-82)
15
Dec_GR_2 = GRAPH(GR_Free_steep)
(1.00, 35.000), (2.00, 73.000), (3.00, 37.000), (4.00, 52.000), (5.00, 44.000), (6.00, 60.000), (7.00, 30.000), (8.00, 34.000), (9.00, 19.000), (10.00, 48.000), (11.00, 52.000), (12.00, 12.000), (13.00, 16.000), (14.00, 44.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

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4 - Gisborne hill (C-78)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Dec_ME_0 = 31*Dec_GR_0*Dec_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Dec_ME_1 = 31*Dec_GR_1*Dec_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Dec_ME_10 = Dec_ME_0*Beef_land_use_Convertor
Dec_ME_11 = Dec_ME_1*Beef_land_use_Convertor
Dec_ME_12 = Dec_ME_2*Beef_land_use_Convertor
Dec_ME_2 =
31*Dec_GR_2*Dec_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Dec_ME_9 = Dec_ME_12+Dec_ME_11+Dec_ME_10+Dec_feedout_1-Dec_conserve_1
Dec_ME_sheep = Dec_ME_0+Dec_ME_1+Dec_ME_2+Dec_feedout-Dec_conserve
Dec_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 8.500), (2.00, 9.900), (3.00, 10.800), (4.00, 11.300), (5.00, 10.800), (6.00, 10.300), (7.00, 10.700), (8.00, 10.000), (9.00, 9.500), (10.00, 10.800), (11.00, 9.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Dec_qual_1 = GRAPH(Qual_1)
(1.00, 8.500), (2.00, 9.900), (3.00, 10.800), (4.00, 11.300), (5.00, 10.800), (6.00, 10.300), (7.00, 10.700), (8.00, 10.000), (9.00, 9.500), (10.00, 10.800), (11.00, 9.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Dec_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 8.500), (2.00, 9.900), (3.00, 10.800), (4.00, 11.300), (5.00, 10.800), (6.00, 10.300), (7.00, 10.700), (8.00, 10.000), (9.00, 9.500), (10.00, 10.800), (11.00, 9.500), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
"DM_kg/ha_H" = (ME_total_Free_Slope_Sheep/10)/Area_Free_steep
"DM_kg/ha_L" = (ME_total_Slope_L_Sheep/10)/Area_Slope_L
"DM_kg/ha_M" = (ME_total_Slope_M_sheep/10)/Area_1
Feb_conserve = 0
Feb_conserve_1 = 0
Feb_feedout = 0
Feb_feedout_1 = 0
Feb_GR_0 = GRAPH(GR_Slope_L)
(1.00, 15.000), (2.00, 61.000), (3.00, 30.000), (4.00, 38.000), (5.00, 26.000), (6.00, 35.000), (7.00, 12.000), (8.00, 35.000), (9.00, 14.000), (10.00, 43.000), (11.00, 35.000), (12.00, 7.000), (13.00, 8.000), (14.00, 28.000), (15.00, 32.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Feb_GR_1 = GRAPH(GR_1)
(1.00, 15.000), (2.00, 61.000), (3.00, 30.000), (4.00, 38.000), (5.00, 26.000), (6.00, 35.000), (7.00, 12.000), (8.00, 35.000), (9.00, 14.000), (10.00, 43.000), (11.00, 35.000), (12.00, 7.000), (13.00, 8.000), (14.00, 28.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Feb_GR_2 = GRAPH(GR_Free_steep)
(1.00, 15.000), (2.00, 61.000), (3.00, 30.000), (4.00, 38.000), (5.00, 26.000), (6.00, 35.000), (7.00, 12.000), (8.00, 35.000), (9.00, 14.000), (10.00, 43.000), (11.00, 35.000), (12.00, 7.000), (13.00, 8.000), (14.00, 28.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)

15
Feb_ME_0 = 28*Feb_GR_0*Feb_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Feb_ME_1 = 28*Feb_GR_1*Feb_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Feb_ME_10 = Feb_ME_0*Beef_land_use_Convertor
Feb_ME_11 = Feb_ME_1*Beef_land_use_Convertor
Feb_ME_12 = Feb_ME_2*Beef_land_use_Convertor
Feb_ME_2 =
28*Feb_GR_2*Feb_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Feb_ME_9 = Feb_ME_12+Feb_ME_11+Feb_ME_10+Feb_feedout_1-Feb_conserve_1
Feb_ME_sheep = Feb_ME_0+Feb_ME_2+Feb_ME_1-Feb_conserve+Feb_feedout
Feb_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 0.000), (2.00, 9.900), (3.00, 10.600), (4.00, 10.500), (5.00, 10.500), (6.00, 10.400), (7.00, 10.600), (8.00, 10.200), (9.00, 9.000), (10.00, 9.000), (11.00, 8.200), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Feb_qual_1 = GRAPH(Qual_1)
(1.00, 7.200), (2.00, 9.900), (3.00, 10.600), (4.00, 10.500), (5.00, 10.500), (6.00, 10.400), (7.00, 10.600), (8.00, 10.200), (9.00, 9.000), (10.00, 9.000), (11.00, 8.200), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Feb_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 7.200), (2.00, 9.900), (3.00, 10.600), (4.00, 10.500), (5.00, 10.500), (6.00, 10.400), (7.00, 10.600), (8.00, 10.200), (9.00, 9.000), (10.00, 9.000), (11.00, 8.200), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
GR_1 = 4
DOCUMENT: which pasture growth curve/values
GR_Free_steep = 4
DOCUMENT: which pasture growth curve/values
GR_Slope_L = 4
DOCUMENT: which pasture growth curve/values

Average growth rate (kg DM/ha/day)
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Pasture unless stated otherwise

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10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18
16 -
17 -
18 -
19 -
20 -
Jan_conserve = 0
Jan_conserve_1 = 0
Jan_feedout = 0
Jan_feedout_1 = 0
Jan_GR_0 = GRAPH(GR_Slope_L)
(1.00, 25.000), (2.00, 59.000), (3.00, 29.000), (4.00, 52.000), (5.00, 38.000), (6.00, 45.000), (7.00, 15.000), (8.00, 36.000), (9.00, 13.000), (10.00, 48.000), (11.00, 42.000), (12.00, 12.000), (13.00, 14.000), (14.00, 36.000), (15.00, 28.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Jan_GR_1 = GRAPH(GR_1)
(1.00, 25.000), (2.00, 59.000), (3.00, 29.000), (4.00, 52.000), (5.00, 38.000), (6.00, 45.000), (7.00, 15.000), (8.00, 36.000), (9.00, 13.000), (10.00, 48.000), (11.00, 42.000), (12.00, 12.000), (13.00, 14.000), (14.00, 36.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Jan_GR_2 = GRAPH(GR_Free_steep)
(1.00, 25.000), (2.00, 59.000), (3.00, 29.000), (4.00, 52.000), (5.00, 38.000), (6.00, 45.000), (7.00, 15.000), (8.00, 36.000), (9.00, 13.000), (10.00, 48.000), (11.00, 42.000), (12.00, 12.000), (13.00, 14.000), (14.00, 36.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
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Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)

11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Jan_ME_0 = 31*Jan_GR_0*Jan_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Jan_ME_1 = 31*Jan_GR_1*Jan_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Jan_ME_10 = Jan_ME_0*Beef_land_use_Convertor
Jan_ME_11 = Jan_ME_1*Beef_land_use_Convertor
Jan_ME_12 = Jan_ME_2*Beef_land_use_Convertor
Jan_ME_2 = 31*Jan_GR_2*Jan_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Jan_ME_9 = Jan_ME_12+Jan_ME_11+Jan_ME_10+Jan_feedout_1-Jan_conserve_1
Jan_ME_sheep = Jan_ME_0+Jan_ME_1+Jan_ME_2-Jan_conserve+Jan_feedout
Jan_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 8.200), (2.00, 9.900), (3.00, 11.100), (4.00, 10.700), (5.00, 10.900), (6.00, 10.400), (7.00, 10.700), (8.00, 10.300), (9.00, 9.000), (10.00, 10.000), (11.00, 9.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jan_qual_1 = GRAPH(Qual_1)
(1.00, 8.200), (2.00, 9.900), (3.00, 11.100), (4.00, 10.700), (5.00, 10.900), (6.00, 10.400), (7.00, 10.700), (8.00, 10.300), (9.00, 9.000), (10.00, 10.000), (11.00, 9.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jan_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 8.200), (2.00, 9.900), (3.00, 11.100), (4.00, 10.700), (5.00, 10.900), (6.00, 10.400), (7.00, 10.700), (8.00, 10.300), (9.00, 9.000), (10.00, 10.000), (11.00, 9.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jul_conserve = 0
Jul_conserve_1 = 0
Jul_feedout = 0
Jul_feedout_1 = 0
Jul_GR_0 = GRAPH(GR_Slope_L)
(1.00, 10.000), (2.00, 24.000), (3.00, 19.000), (4.00, 8.000), (5.00, 12.000), (6.00, 5.000), (7.00, 16.000), (8.00, 3.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 12.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Jul_GR_1 = GRAPH(GR_1)
(1.00, 10.000), (2.00, 24.000), (3.00, 19.000), (4.00, 8.000), (5.00, 12.000), (6.00, 5.000), (7.00, 16.000), (8.00, 3.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Jul_GR_2 = GRAPH(GR_Free_steep)
(1.00, 10.000), (2.00, 24.000), (3.00, 19.000), (4.00, 8.000), (5.00, 12.000), (6.00, 5.000), (7.00, 16.000), (8.00, 3.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Jul_ME_0 = 31*Jul_GR_0*Jul_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Jul_ME_1 = 31*Jul_GR_1*Jul_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Jul_ME_10 = Jul_ME_0*Beef_land_use_Convertor
Jul_ME_11 = Jul_ME_1*Beef_land_use_Convertor
Jul_ME_12 = Jul_ME_2*Beef_land_use_Convertor
Jul_ME_2 = 31*Jul_GR_2*Jul_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Jul_ME_9 = Jul_ME_12+Jul_ME_11+Jul_ME_10+Jul_feedout_1-Jul_conserve_1
Jul_ME_sheep = Jul_ME_0+Jul_ME_1+Jul_ME_2+Jul_feedout-Jul_conserve
Jul_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 9.700), (2.00, 10.800), (3.00, 12.600), (4.00, 11.000), (5.00, 11.200), (6.00, 11.000), (7.00, 10.700), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jul_qual_1 = GRAPH(Qual_1)
(1.00, 9.700), (2.00, 10.800), (3.00, 12.600), (4.00, 11.000), (5.00, 11.200), (6.00, 11.000), (7.00, 10.700), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jul_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 9.700), (2.00, 10.800), (3.00, 12.600), (4.00, 11.000), (5.00, 11.200), (6.00, 11.000), (7.00, 10.700), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jun_conserve = 0
Jun_conserve_1 = 0
Jun_feedout = 0

Jun_feedout_1 = 0
Jun_GR_0 = GRAPH(GR_Slope_L)
(1.00, 10.000), (2.00, 25.000), (3.00, 18.000), (4.00, 10.000), (5.00, 11.000), (6.00, 5.000), (7.00, 16.000), (8.00, 5.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 12.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Jun_GR_1 = GRAPH(GR_1)
(1.00, 10.000), (2.00, 25.000), (3.00, 18.000), (4.00, 10.000), (5.00, 11.000), (6.00, 5.000), (7.00, 16.000), (8.00, 5.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Jun_GR_2 = GRAPH(GR_Free_steep)
(1.00, 10.000), (2.00, 25.000), (3.00, 18.000), (4.00, 10.000), (5.00, 11.000), (6.00, 5.000), (7.00, 16.000), (8.00, 5.000), (9.00, 5.000), (10.00, 5.000), (11.00, 0.000), (12.00, 0.000), (13.00, 0.000), (14.00, 5.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Jun_ME_0 = 30*Area_Slope_L*Utilisation_Slope_L*"%_sheep_Slope_L"*Jun_qual_0*Jun_GR_0*Slope_effect_Slope_L
Jun_ME_1 = 30*Area_1*Utilisation_1*"%_Sheep_Slope_M"*Jun_qual_1*Jun_GR_1*Slope_effect_1
Jun_ME_10 = Jun_ME_0*Beef_land_use_Convertor
Jun_ME_11 = Jun_ME_1*Beef_land_use_Convertor
Jun_ME_12 = Jun_ME_2*Beef_land_use_Convertor
Jun_ME_2 = 30*Area_Free_steep*Utilisation_Free_steep*"%_sheep_Free_steep"*Jun_qual_2*Jun_GR_2*Slope_effect_Free_steep
Jun_ME_9 = Jun_ME_12+Jun_ME_11+Jun_ME_10+Jun_feedout_1-Jun_conserve_1
Jun_ME_sheep = Jun_ME_0+Jun_ME_1+Jun_ME_2+Jun_feedout-Jun_conserve
Jun_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 10.000), (2.00, 10.800), (3.00, 11.700), (4.00, 10.900), (5.00, 10.900), (6.00, 11.000), (7.00, 10.700), (8.00, 10.600), (9.00, 8.400), (10.00, 10.300), (11.00, 9.100), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jun_qual_1 = GRAPH(Qual_1)
(1.00, 10.000), (2.00, 10.800), (3.00, 11.700), (4.00, 10.900), (5.00, 10.900), (6.00, 11.000), (7.00, 10.700), (8.00, 10.600), (9.00, 8.400), (10.00, 10.300), (11.00, 9.100), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Jun_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 10.000), (2.00, 10.800), (3.00, 11.700), (4.00, 10.900), (5.00, 10.900), (6.00, 11.000), (7.00, 10.700), (8.00, 10.600), (9.00, 8.400), (10.00, 10.300), (11.00, 9.100), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Mar_conserve = 0
Mar_conserve_1 = 0
Mar_feedout = 0
Mar_feedout_1 = 0
Mar_GR_0 = GRAPH(GR_Slope_L)
(1.00, 10.000), (2.00, 50.000), (3.00, 32.000), (4.00, 39.000), (5.00, 30.000), (6.00, 35.000), (7.00, 21.000), (8.00, 34.000), (9.00, 16.000), (10.00, 31.000), (11.00, 27.000), (12.00, 7.000), (13.00, 7.000), (14.00, 24.000), (15.00, 25.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Mar_GR_1 = GRAPH(GR_1)

(1.00, 10.000), (2.00, 50.000), (3.00, 32.000), (4.00, 39.000), (5.00, 30.000), (6.00, 35.000), (7.00, 21.000), (8.00, 34.000), (9.00, 16.000), (10.00, 31.000), (11.00, 27.000), (12.00, 7.000), (13.00, 7.000), (14.00, 24.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Mar_GR_2 = GRAPH(GR_Free_steep)
(1.00, 10.000), (2.00, 50.000), (3.00, 32.000), (4.00, 39.000), (5.00, 30.000), (6.00, 35.000), (7.00, 21.000), (8.00, 34.000), (9.00, 16.000), (10.00, 31.000), (11.00, 27.000), (12.00, 7.000), (13.00, 7.000), (14.00, 24.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Mar_ME_0 = 31*Mar_GR_0*Mar_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Mar_ME_1 = 31*Mar_GR_1*Mar_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Mar_ME_10 = Mar_ME_0*Beef_land_use_Convertor
Mar_ME_11 = Mar_ME_1*Beef_land_use_Convertor
Mar_ME_12 = Mar_ME_2*Beef_land_use_Convertor
Mar_ME_2 =
31*Mar_GR_2*Mar_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Mar_ME_9 = Mar_ME_12+Mar_ME_11+Mar_ME_10+Mar_feedout_1-Mar_conserve_1
Mar_ME_sheep = Mar_ME_0+Mar_ME_1+Mar_ME_2-Mar_conserve+Mar_feedout
Mar_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 8.500), (2.00, 9.600), (3.00, 10.700), (4.00, 10.300), (5.00, 10.400), (6.00, 10.400), (7.00, 10.600), (8.00, 9.900), (9.00, 8.800), (10.00, 8.800), (11.00, 7.800), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Mar_qual_1 = GRAPH(Qual_1)

(1.00, 8.500), (2.00, 9.600), (3.00, 10.700), (4.00, 10.300), (5.00, 10.400), (6.00, 10.400), (7.00, 10.600), (8.00, 9.900), (9.00, 8.800), (10.00, 8.800), (11.00, 7.800), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Mar_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 8.500), (2.00, 9.600), (3.00, 10.700), (4.00, 10.300), (5.00, 10.400), (6.00, 10.400), (7.00, 10.600), (8.00, 9.900), (9.00, 8.800), (10.00, 8.800), (11.00, 7.800), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
May_conserve = 0
May_conserve_1 = 0
May_feedout = 0
May_feedout_1 = 0
May_GR_0 = GRAPH(GR_Slope_L)
(1.00, 15.000), (2.00, 32.000), (3.00, 24.000), (4.00, 15.000), (5.00, 20.000), (6.00, 15.000), (7.00, 25.000), (8.00, 8.000), (9.00, 8.000), (10.00, 10.000), (11.00, 3.000), (12.00, 1.000), (13.00, 0.000), (14.00, 9.000), (15.00, 15.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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10 - Winchmore irrigated (C-80)
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12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

May_GR_1 = GRAPH(GR_1)
(1.00, 15.000), (2.00, 32.000), (3.00, 24.000), (4.00, 15.000), (5.00, 20.000), (6.00, 15.000), (7.00, 25.000), (8.00, 8.000), (9.00, 8.000), (10.00, 10.000), (11.00, 3.000), (12.00, 1.000), (13.00, 0.000), (14.00, 9.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

May_GR_2 = GRAPH(GR_Free_steep)
(1.00, 15.000), (2.00, 32.000), (3.00, 24.000), (4.00, 15.000), (5.00, 20.000), (6.00, 15.000), (7.00, 25.000), (8.00, 8.000), (9.00, 8.000), (10.00, 10.000), (11.00, 3.000), (12.00, 1.000), (13.00, 0.000), (14.00, 9.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)

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Pasture unless stated otherwise

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4 - Gisborne hill (C-78)
5 - Hawera (C-79)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

May_ME_0 = 31*May_GR_0*May_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
May_ME_1 = 31*May_GR_1*May_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
May_ME_10 = May_ME_0*Beef_land_use_Convertor
May_ME_11 = May_ME_1*Beef_land_use_Convertor
May_ME_12 = May_ME_2*Beef_land_use_Convertor
May_ME_2 =
31*May_GR_2*May_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
May_ME_9 = May_ME_12+May_ME_11+May_ME_10+May_feedout_1-May_conserve_1
May_ME_sheep = May_ME_0+May_ME_1+May_ME_2-May_conserve+May_feedout
May_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 9.500), (2.00, 9.600), (3.00, 11.900), (4.00, 11.000), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 8.000), (10.00, 10.000), (11.00, 8.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
May_qual_1 = GRAPH(Qual_1)
(1.00, 9.500), (2.00, 9.600), (3.00, 11.900), (4.00, 11.000), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 8.000), (10.00, 10.000), (11.00, 8.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
May_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 9.500), (2.00, 9.600), (3.00, 11.900), (4.00, 11.000), (5.00, 10.700), (6.00, 11.000), (7.00, 11.200), (8.00, 10.500), (9.00, 8.000), (10.00, 10.000), (11.00, 8.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
ME_total_Free_Slope_Sheep =
(Jun_ME_2+Jul_ME_2+Aug_ME_2+Sep_ME_2+Oct_ME_2+Nov_ME_2+Dec_ME_2+Jan_ME_2+Feb_ME_2+Mar_ME_2+Apr_ME_2+May_ME_2)/"%_sheep_Free_steep"
ME_total_Slope_L_Beef =
(Jun_ME_10+Jul_ME_10+Aug_ME_10+Sep_ME_10+Oct_ME_10+Nov_ME_10+Dec_ME_10+Jan_ME_10+Feb_ME_10+Mar_ME_10+Apr_ME_10+May_ME_10)
ME_total_Slope_L_Beef_1 =
(Jun_ME_11+Jul_ME_11+Aug_ME_11+Sep_ME_11+Oct_ME_11+Nov_ME_11+Dec_ME_11+Jan_ME_11+Feb_ME_11+Mar_ME_11+Apr_ME_11+May_ME_11)
ME_total_Slope_L_Beef_2 =
(Jun_ME_12+Jul_ME_12+Aug_ME_12+Sep_ME_12+Oct_ME_12+Nov_ME_12+Dec_ME_12+Jan_ME_12+Feb_ME_12+Mar_ME_12+Apr_ME_12+May_ME_12)
ME_total_Slope_L_Sheep =
(Jun_ME_0+Jul_ME_0+Aug_ME_0+Sep_ME_0+Oct_ME_0+Nov_ME_0+Dec_ME_0+Jan_ME_0+Feb_ME_0+Mar_ME_0+Apr_ME_0+May_ME_0)/"%_sheep_Slope_L"
ME_total_Slope_M_sheep =
(Jun_ME_1+Jul_ME_1+Aug_ME_1+Sep_ME_1+Oct_ME_1+Nov_ME_1+Dec_ME_1+Jan_ME_1+Feb_ME_1+Mar_ME_1+Apr_ME_1+May_ME_1)/"%_Sheep_Slope_M"
Nov_conserve = 0
Nov_conserve_1 = 0
Nov_feedout = 0

Nov_feedout_1 = 0
Nov_GR_0 = GRAPH(GR_Slope_L)
(1.00, 40.000), (2.00, 63.000), (3.00, 38.000), (4.00, 52.000), (5.00, 46.000), (6.00, 50.000), (7.00, 51.000), (8.00, 51.000), (9.00, 27.000), (10.00, 41.000), (11.00, 48.000), (12.00, 17.000), (13.00, 20.000), (14.00, 47.000), (15.00, 29.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
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Pasture unless stated otherwise

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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18
Nov_GR_1 = GRAPH(GR_1)
(1.00, 40.000), (2.00, 63.000), (3.00, 38.000), (4.00, 52.000), (5.00, 46.000), (6.00, 50.000), (7.00, 51.000), (8.00, 51.000), (9.00, 27.000), (10.00, 41.000), (11.00, 48.000), (12.00, 17.000), (13.00, 20.000), (14.00, 47.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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5 - Hawera (C-79)
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8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Nov_GR_2 = GRAPH(GR_Free_steep)
(1.00, 40.000), (2.00, 63.000), (3.00, 38.000), (4.00, 52.000), (5.00, 46.000), (6.00, 50.000), (7.00, 51.000), (8.00, 51.000), (9.00, 27.000), (10.00, 41.000), (11.00, 48.000), (12.00, 17.000), (13.00, 20.000), (14.00, 47.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)

7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Nov_ME_0 = 30*Nov_GR_0*Nov_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Nov_ME_1 = 30*Nov_GR_1*Nov_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Nov_ME_10 = Nov_ME_0*Beef_land_use_Convertor
Nov_ME_11 = Nov_ME_1*Beef_land_use_Convertor
Nov_ME_12 = Nov_ME_2*Beef_land_use_Convertor
Nov_ME_2 =
30*Nov_GR_2*Nov_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Nov_ME_9 = Nov_ME_12+Nov_ME_11+Nov_ME_10+Nov_feedout_1-Nov_conserve_1
Nov_ME_sheep = Nov_ME_0+Nov_ME_1+Nov_ME_2-Nov_conserve+Nov_feedout
Nov_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 9.800), (2.00, 11.400), (3.00, 11.600), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 10.500), (8.00, 10.300), (9.00, 9.900), (10.00, 11.200), (11.00, 9.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Nov_qual_1 = GRAPH(Qual_1)
(1.00, 9.800), (2.00, 11.400), (3.00, 11.600), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 10.500), (8.00, 10.300), (9.00, 9.900), (10.00, 11.200), (11.00, 9.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Nov_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 9.800), (2.00, 11.400), (3.00, 11.600), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 10.500), (8.00, 10.300), (9.00, 9.900), (10.00, 11.200), (11.00, 9.700), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
NS_Total_area = Shrub.Free_Steep_slope+Land_Module."L.Slope_M"+Land_Module."L.Slope_L"
NS_Total_ME_Beef =
Jun_ME_9+Jul_ME_9+Aug_ME_9+Sep_ME_9+Oct_ME_9+Nov_ME_9+Dec_ME_9+Jan_ME_9+Feb_ME_9+Mar_ME_9+Apr_ME_9+May_ME_9
NS_Total_ME_Sheep =
(Jun_ME_sheep+Jul_ME_sheep+Aug_ME_sheep+Sep_ME_sheep+Oct_ME_sheep+Nov_ME_sheep+Dec_ME_sheep+Jan_ME_sheep+Feb_ME_sheep+Mar_ME_sheep+Apr_ME_sheep+May_ME_sheep)
Oct_conserve = 0
Oct_conserve_1 = 0
Oct_feedout = 0
Oct_feedout_1 = 0
Oct_GR_0 = GRAPH(GR_Slope_L)
(1.00, 45.000), (2.00, 58.000), (3.00, 47.000), (4.00, 46.000), (5.00, 46.000), (6.00, 55.000), (7.00, 70.000), (8.00, 51.000), (9.00, 37.000), (10.00, 40.000), (11.00, 39.000), (12.00, 24.000), (13.00, 18.000), (14.00, 46.000), (15.00, 25.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)

13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Oct_GR_1 = GRAPH(GR_1)
(1.00, 45.000), (2.00, 58.000), (3.00, 47.000), (4.00, 46.000), (5.00, 46.000), (6.00, 55.000), (7.00, 70.000), (8.00, 51.000), (9.00, 37.000), (10.00, 40.000), (11.00, 39.000), (12.00, 24.000), (13.00, 18.000), (14.00, 46.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Oct_GR_2 = GRAPH(GR_Free_steep)
(1.00, 45.000), (2.00, 58.000), (3.00, 47.000), (4.00, 46.000), (5.00, 46.000), (6.00, 55.000), (7.00, 70.000), (8.00, 51.000), (9.00, 37.000), (10.00, 40.000), (11.00, 39.000), (12.00, 24.000), (13.00, 18.000), (14.00, 46.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
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5 - Hawera (C-79)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15
Oct_ME_0 = 31*Oct_GR_0*Oct_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Oct_ME_1 = 31*Oct_GR_1*Oct_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Oct_ME_10 = Oct_ME_0*Beef_land_use_Convertor
Oct_ME_11 = Oct_ME_1*Beef_land_use_Convertor
Oct_ME_12 = Oct_ME_2*Beef_land_use_Convertor
Oct_ME_2 = 31*Oct_GR_2*Oct_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Oct_ME_9 = Oct_ME_12+Oct_ME_11+Oct_ME_10+Oct_feedout_1-Oct_conserve_1
Oct_ME_sheep = Oct_ME_1+Oct_ME_0+Oct_ME_2-Oct_conserve+Oct_feedout
Oct_qual_0 = GRAPH(Qual_Slope_L)

(1.00, 10.000), (2.00, 11.400), (3.00, 12.000), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 11.300), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 10.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Oct_qual_1 = GRAPH(Qual_1)
(1.00, 10.000), (2.00, 11.400), (3.00, 12.000), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 11.300), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 10.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Oct_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 10.000), (2.00, 11.400), (3.00, 12.000), (4.00, 11.400), (5.00, 11.600), (6.00, 11.500), (7.00, 11.300), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 10.000), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Qual_1 = 10
DOCUMENT: Which pasture/feed quality curve. Mostly from Burggraaf et al 2018 https://www.mpi.govt.nz/dmsdocument/32866/direct

Except 1 is from Bown et al

In MJ ME/kgDM

1 - Sheep+Beef Bown
2 - Sheep+Beef Hill Country
3 - Dairy
4 - NZ ave
5 - Taupo
6 - Southern North Island
7 - South Island
8 - Sheep+Beef Southland
9 - Sheep+Beef Canterbury
10 - Sheep+Beef Hawke's Bay
11 - Sheep+Beef Waikato
12 -
13 -
14 -
15 -
16 -
17 -
18 -
19 -
20 -

Qual_Free_steep = 10
DOCUMENT: Which pasture/feed quality curve. Mostly from Burggraaf et al 2018 https://www.mpi.govt.nz/dmsdocument/32866/direct

Except 1 is from Bown et al

In MJ ME/kgDM

1 - Sheep+Beef Bown
2 - Sheep+Beef Hill Country
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5 - Taupo
6 - Southern North Island
7 - South Island
8 - Sheep+Beef Southland
9 - Sheep+Beef Canterbury
10 - Sheep+Beef Hawke's Bay
11 - Sheep+Beef Waikato
12 -
13 -
14 -

15 -
16 -
17 -
18 -
19 -
20 -

Qual_Slope_L = 10
DOCUMENT: Which pasture/feed quality curve. Mostly from Burggraaf et al 2018
https://www.mpi.govt.nz/dmsdocument/32866/direct

Except 1 is from Bown et al

In MJ ME/kgDM

1 - Sheep+Beef Bown
2 - Sheep+Beef Hill Country
3 - Dairy
4 - NZ ave
5 - Taupo
6 - Southern North Island
7 - South Island
8 - Sheep+Beef Southland
9 - Sheep+Beef Canterbury
10 - Sheep+Beef Hawke's Bay
11 - Sheep+Beef Waikato
12 -
13 -
14 -
15 -
16 -
17 -
18 -
19 -
20 -

Season = 0
DOCUMENT: 1= Summer
2= Autumn
3= Winter
4= Spring
0= All

Sep_conserve = 0
Sep_conserve_1 = 0
Sep_feedout = 0
Sep_feedout_1 = 0
Sep_GR_0 = GRAPH(GR_Slope_L)
(1.00, 30.000), (2.00, 50.000), (3.00, 47.000), (4.00, 25.000), (5.00, 36.000), (6.00, 40.000), (7.00, 56.000), (8.00, 32.000), (9.00, 30.000), (10.00, 31.000), (11.00, 16.000), (12.00, 15.000), (13.00, 1.000), (14.00, 25.000), (15.00, 21.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
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7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)

10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
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14 - Taieri Hill (C-82)
15 - North hawkes bay farmax 2017/18

Sep_GR_1 = GRAPH(GR_1)
(1.00, 30.000), (2.00, 50.000), (3.00, 47.000), (4.00, 25.000), (5.00, 36.000), (6.00, 40.000), (7.00, 56.000), (8.00, 32.000), (9.00, 30.000), (10.00, 31.000), (11.00, 16.000), (12.00, 15.000), (13.00, 1.000), (14.00, 25.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Sep_GR_2 = GRAPH(GR_Free_steep)
(1.00, 30.000), (2.00, 50.000), (3.00, 47.000), (4.00, 25.000), (5.00, 36.000), (6.00, 40.000), (7.00, 56.000), (8.00, 32.000), (9.00, 30.000), (10.00, 31.000), (11.00, 16.000), (12.00, 15.000), (13.00, 1.000), (14.00, 25.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
DOCUMENT: Average growth rate (kg DM/ha/day)
From Lincoln Farm Technical Manual 2011 (page number)
Pasture unless stated otherwise

1 - Average North Island hill soils (C-88)
2 - Dargaville (C-78)
3 - Manutuke Gisborne (C-78)
4 - Gisborne hill (C-78)
5 - Hawera (C-79)
6 - Developed Manawatu hill (C-88)
7 - Masterton (C-79)
8 - Greymouth (C-80)
9 - Winchmore dryland (C-80)
10 - Winchmore irrigated (C-80)
11 - Cromwell (C-81)
12 - Poolburn (C-81)
13 - Otago plateau Alexandra (C-82)
14 - Taieri Hill (C-82)
15

Sep_ME_0 = 30*Sep_GR_0*Sep_qual_0*"%_sheep_Slope_L"*Utilisation_Slope_L*Area_Slope_L*Slope_effect_Slope_L
Sep_ME_1 = 30*Sep_GR_1*Sep_qual_1*"%_Sheep_Slope_M"*Utilisation_1*Area_1*Slope_effect_1
Sep_ME_10 = Sep_ME_0*Beef_land_use_Convertor
Sep_ME_11 = Sep_ME_1*Beef_land_use_Convertor
Sep_ME_12 = Sep_ME_2*Beef_land_use_Convertor
Sep_ME_2 =
30*Sep_GR_2*Sep_qual_2*"%_sheep_Free_steep"*Utilisation_Free_steep*Area_Free_steep*Slope_effect_Free_steep
Sep_ME_9 = Sep_ME_12+Sep_ME_11+Sep_ME_10+Sep_feedout_1-Sep_conserve_1

Sep_ME_sheep = Sep_ME_0+Sep_ME_1+Sep_ME_2-Sep_conserve+Sep_feedout
Sep_qual_0 = GRAPH(Qual_Slope_L)
(1.00, 9.900), (2.00, 11.400), (3.00, 11.700), (4.00, 11.400), (5.00, 11.700), (6.00, 11.300), (7.00, 11.100), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Sep_qual_1 = GRAPH(Qual_1)
(1.00, 9.900), (2.00, 11.400), (3.00, 11.700), (4.00, 11.400), (5.00, 11.700), (6.00, 11.300), (7.00, 11.100), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Sep_qual_2 = GRAPH(Qual_Free_steep)
(1.00, 9.900), (2.00, 11.400), (3.00, 11.700), (4.00, 11.400), (5.00, 11.700), (6.00, 11.300), (7.00, 11.100), (8.00, 10.300), (9.00, 9.200), (10.00, 10.800), (11.00, 9.600), (12.00, 0.000), (13.00, 0.000), (14.00, 0.000), (15.00, 0.000), (16.00, 0.000), (17.00, 0.000), (18.00, 0.000), (19.00, 0.000), (20.00, 0.000)
Sheep_Land_Use = 0.6
Slope_effect_1 = "%_DM_slope_M"
DOCUMENT: If flat land put "1"
If medium slope put "0.462"
If steep slope put "0.319"
Slope_effect_Free_steep = Shrub_Area_Pasture."%_DM_slope_H"
DOCUMENT: If flat land put "1"
If medium slope put "0.462"
If steep slope put "0.319"
Slope_effect_Slope_L = 1
DOCUMENT: If flat land put "1"
If medium slope put "0.462"
If steep slope put "0.319"
"Total_DM_kg/ha_H" = "DM_kg/ha_H"/Utilisation_Free_steep
"Total_DM_kg/ha_L" = "DM_kg/ha_L"/Utilisation_Slope_L
"Total_DM_kg/ha_M" = "DM_kg/ha_M"/Utilisation_1
Total_Farm_ME = Total_ME_for_Sheep+NS_Total_ME_Beef
Total_ME_for_Sheep = NS_Total_ME_Sheep+Total_Shrub_Area_ME
Total_Shrub_Area_ME = IF Season=0 THEN (Shrub_Area_Feed_Supply.Shrub_Area_ME_jun+Shrub_Area_Feed_Supply.Shrub_Area_ME_jul+Shrub_Area_Feed_Supply.Shrub_Area_ME_aug+Shrub_Area_Feed_Supply.Shrub_Area_ME_sep+Shrub_Area_Feed_Supply.Shrub_Area_ME_oct+Shrub_Area_Feed_Supply.Shrub_Area_ME_nov+Shrub_Area_Feed_Supply.Shrub_Area_ME_dec+Shrub_Area_Feed_Supply.Shrub_Area_ME_jan+Shrub_Area_Feed_Supply.Shrub_Area_ME_feb+Shrub_Area_Feed_Supply.Shrub_Area_ME_mar+Shrub_Area_Feed_Supply.Shrub_Area_ME_apr+Shrub_Area_Feed_Supply.Shrub_Area_ME_may) ELSE IF Season=1 THEN (Shrub_Area_Feed_Supply.Shrub_Area_ME_dec+Shrub_Area_Feed_Supply.Shrub_Area_ME_jan+Shrub_Area_Feed_Supply.Shrub_Area_ME_feb) ELSE IF Season=2 THEN (Shrub_Area_Feed_Supply.Shrub_Area_ME_mar+Shrub_Area_Feed_Supply.Shrub_Area_ME_apr+Shrub_Area_Feed_Supply.Shrub_Area_ME_may) ELSE IF Season=3 THEN (Shrub_Area_Feed_Supply.Shrub_Area_ME_jun+Shrub_Area_Feed_Supply.Shrub_Area_ME_jul+Shrub_Area_Feed_Supply.Shrub_Area_ME_aug) ELSE IF Season=4 THEN (Shrub_Area_Feed_Supply.Shrub_Area_ME_sep+Shrub_Area_Feed_Supply.Shrub_Area_ME_oct+Shrub_Area_Feed_Supply.Shrub_Area_ME_nov) ELSE (Shrub_Area_Feed_Supply.Shrub_Area_ME_jun+Shrub_Area_Feed_Supply.Shrub_Area_ME_jul+Shrub_Area_Feed_Supply.Shrub_Area_ME_aug+Shrub_Area_Feed_Supply.Shrub_Area_ME_sep+Shrub_Area_Feed_Supply.Shrub_Area_ME_oct+Shrub_Area_Feed_Supply.Shrub_Area_ME_nov+Shrub_Area_Feed_Supply.Shrub_Area_ME_dec+Shrub_Area_Feed_Supply.Shrub_Area_ME_jan+Shrub_Area_Feed_Supply.Shrub_Area_ME_feb+Shrub_Area_Feed_Supply.Shrub_Area_ME_mar+Shrub_Area_Feed_Supply.Shrub_Area_ME_apr+Shrub_Area_Feed_Supply.Shrub_Area_ME_may)
UNITS: MJ
Utilisation_1 = 0.70
DOCUMENT: Proportion of feed consumed (e.g. excluding dead matter)
Utilisation_Free_steep = 0.70
DOCUMENT: Proportion of feed consumed (e.g. excluding dead matter)
Utilisation_Slope_L = 0.70
DOCUMENT: Proportion of feed consumed (e.g. excluding dead matter)
Estimates from;
Pasture and supplements for grazing animals / editors: P.V. Rattray, I.M. Brookes and A.M. Nicol (2007), page 199

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purebred_flock:
"1yo"(t) = "1yo"(t - dt) + (Keeping - "1yo_culls" - "1yo_deaths" - become_2yo) * dt {NON-NEGATIVE}
    INIT "1yo" = 516
    UNITS: sheep
    INFLOWS:
        Keeping = (MF_singles_kept+MF_twins_kept) {UNIFLOW}
            UNITS: sheep/year
    OUTFLOWS:
        "1yo_culls" = "1yo_cull_rate"*"1yo" {UNIFLOW}
            UNITS: sheep/year
        "1yo_deaths" = "1yo"*"1yo_Death_rate" {UNIFLOW}
            UNITS: sheep/year
        become_2yo = ("1yo"-"1yo_culls"-"1yo_deaths") {UNIFLOW}
            UNITS: sheep/year
"2yo"(t) = "2yo"(t - dt) + (become_2yo - become_3yo - "2yo_deaths" - "2yo_culls") * dt {NON-NEGATIVE}
    INIT "2yo" = 500
    UNITS: sheep
    INFLOWS:
        become_2yo = ("1yo"-"1yo_culls"-"1yo_deaths") {UNIFLOW}
            UNITS: sheep/year
    OUTFLOWS:
        become_3yo = ("2yo"-"2yo_deaths"-"2yo_culls") {UNIFLOW}
            UNITS: sheep/year
        "2yo_deaths" = "2yo"*Death_rate_MAE {UNIFLOW}
            UNITS: sheep/year
        "2yo_culls" = "2yo"*(MAE_cull_rate+Cull_all) {UNIFLOW}
            UNITS: sheep/year
"3_yo"(t) = "3_yo"(t - dt) + (become_3yo - become_4yo - "3yo_deaths" - "3yo_culls") * dt {NON-NEGATIVE}
    INIT "3_yo" = 375
    UNITS: sheep
    INFLOWS:
        become_3yo = ("2yo"-"2yo_deaths"-"2yo_culls") {UNIFLOW}
            UNITS: sheep/year
    OUTFLOWS:
        become_4yo = ("3_yo"-"3yo_deaths"-"3yo_culls") {UNIFLOW}
            UNITS: sheep/year
        "3yo_deaths" = "3_yo"*Death_rate_MAE {UNIFLOW}
            UNITS: sheep/year
        "3yo_culls" = "3_yo"*(MAE_cull_rate+Cull_all) {UNIFLOW}
            UNITS: sheep/year
"4_yo"(t) = "4_yo"(t - dt) + (become_4yo - become_5yo - "4yo_deaths" - "4yo_culls") * dt {NON-NEGATIVE}
    INIT "4_yo" = 282
    UNITS: sheep
    INFLOWS:
        become_4yo = ("3_yo"-"3yo_deaths"-"3yo_culls") {UNIFLOW}
            UNITS: sheep/year
    OUTFLOWS:
        become_5yo = ("4_yo"-"4yo_deaths"-"4yo_culls") {UNIFLOW}
            UNITS: sheep/year
        "4yo_deaths" = "4_yo"*Death_rate_MAE {UNIFLOW}
            UNITS: sheep/year
        "4yo_culls" = "4_yo"*(MAE_cull_rate+Cull_all) {UNIFLOW}
            UNITS: sheep/year
"5_yo"(t) = "5_yo"(t - dt) + (become_5yo - become_6yo - "5yo_deaths" - "5yo_culls") * dt {NON-NEGATIVE}
    INIT "5_yo" = 212
    UNITS: sheep
    INFLOWS:
        become_5yo = ("4_yo"-"4yo_deaths"-"4yo_culls") {UNIFLOW}
            UNITS: sheep/year
    OUTFLOWS:
        become_6yo = (IF(End_at_5yo?=1)THEN(0)ELSE("5_yo"-"5yo_deaths"-"5yo_culls")) {UNIFLOW}
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        UNITS: sheep/year
      "5yo_deaths" = "5_yo"*Death_rate_MAE {UNIFLOW}
        UNITS: sheep/year
      "5yo_culls" = IF(End_at_5yo?=1)THEN("5_yo")ELSE((MAE_cull_rate+Cull_all)*"5_yo") {UNIFLOW}
        UNITS: sheep/year
"6_yo"(t) = "6_yo"(t - dt) + (become_6yo - become_7yo - "6yo_deaths" - "6yo_culls") * dt {NON-NEGATIVE}
   INIT "6_yo" = 152
   UNITS: sheep
   INFLOWS:
      become_6yo = (IF(End_at_5yo?=1)THEN(0)ELSE("5_yo"-"5yo_deaths"-"5yo_culls")) {UNIFLOW}
        UNITS: sheep/year
   OUTFLOWS:
      become_7yo = (IF(End_at_6yo?=1)THEN(0)ELSE("6_yo"-"6yo_deaths"-"6yo_culls")) {UNIFLOW}
        UNITS: sheep/year
      "6yo_deaths" = "6_yo"*Death_rate_MAE {UNIFLOW}
        UNITS: sheep/year
      "6yo_culls" = IF(End_at_6yo?=1)THEN("6_yo")ELSE((MAE_cull_rate+Cull_all)*"6_yo") {UNIFLOW}
        UNITS: sheep/year
"7_yo"(t) = "7_yo"(t - dt) + (become_7yo - "7yo_deaths" - "7yo_culls") * dt {NON-NEGATIVE}
   INIT "7_yo" = 0
   UNITS: sheep
   INFLOWS:
      become_7yo = (IF(End_at_6yo?=1)THEN(0)ELSE("6_yo"-"6yo_deaths"-"6yo_culls")) {UNIFLOW}
        UNITS: sheep/year
   OUTFLOWS:
      "7yo_deaths" = "7_yo"*(Death_rate_MAE+0.02) {UNIFLOW}
        UNITS: sheep/year
      "7yo_culls" = "7_yo"-"7yo_deaths" {UNIFLOW}
        UNITS: sheep/year
Ewes_to_Change(t) = Ewes_to_Change(t - dt) + (Ewe_changing - Ewes_changed) * dt
   INIT Ewes_to_Change = 0
   INFLOWS:
      Ewe_changing = Ewe_Change
   OUTFLOWS:
      Ewes_changed = Ewes_to_Change
maternal_female_Multis(t) = maternal_female_Multis(t - dt) + (Maternal_Female_twins_weaned - MF_twins_kept -
MF_twins_finished) * dt {NON-NEGATIVE}
   INIT maternal_female_Multis = 174
   INFLOWS:
      Maternal_Female_twins_weaned = (Twins_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MF_twins_kept =
IF(maternal_female_Multis>Replacement_req)OR(maternal_female_Multis=Replacement_req)THEN(Replacement_req)ELSE(mater
nal_female_Multis) {UNIFLOW}
      MF_twins_finished = maternal_female_Multis-MF_twins_kept + Maternal_Female_Trips+Maternal_Female_Quads {UNIFLOW}
Maternal_Female_Quads(t) = Maternal_Female_Quads(t - dt) + (Female_Quads_Weaned - MF_Quads_Finished) * dt {NON-
NEGATIVE}
   INIT Maternal_Female_Quads = 0
   INFLOWS:
      Female_Quads_Weaned = (Quads_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MF_Quads_Finished = Maternal_Female_Quads {UNIFLOW}
Maternal_female_singles(t) = Maternal_female_singles(t - dt) + (Maternal_Female_singles_weaned - MF_singles_finished -
MF_singles_kept) * dt {NON-NEGATIVE}
   INIT Maternal_female_singles = 797
   INFLOWS:
      Maternal_Female_singles_weaned = IF((IF(Msingle_scan>0)THEN(Msingle_scan*(1-
Msingles_loss_rate)*0.5)ELSE(Maternal_lambs_born*Msingles*0.5))<10)THEN(0)ELSE(IF(Msingle_scan>0)THEN(Msingle_scan*(1-
Msingles_loss_rate)*0.5)ELSE(Singles_Born*0.5)) {UNIFLOW}
   OUTFLOWS:
      MF_singles_finished = Maternal_female_singles-MF_singles_kept {UNIFLOW}
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      MF_singles_kept = IF(MF_twins_kept<Replacement_req)THEN(Replacement_req-MF_twins_kept)ELSE(0) {UNIFLOW}
Maternal_Female_Trips(t) = Maternal_Female_Trips(t - dt) + (Female_Trips_Weaned - MF_Trips_Finished) * dt {NON-NEGATIVE}
   INIT Maternal_Female_Trips = 0
   INFLOWS:
      Female_Trips_Weaned = (Trips_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MF_Trips_Finished = Maternal_Female_Trips {UNIFLOW}
Maternal_Male_Multis(t) = Maternal_Male_Multis(t - dt) + (Maternal_male_twins_weaned - MM_Multis_finished) * dt {NON-
NEGATIVE}
   INIT Maternal_Male_Multis = 174
   INFLOWS:
      Maternal_male_twins_weaned = (Twins_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MM_Multis_finished = Maternal_Male_Multis+Maternal_Male_Trips+Maternal_Male_Quads {UNIFLOW}
Maternal_Male_Quads(t) = Maternal_Male_Quads(t - dt) + (Male_Quads_Weaned - MM_Quads_Finished) * dt {NON-NEGATIVE}
   INIT Maternal_Male_Quads = 0
   INFLOWS:
      Male_Quads_Weaned = (Quads_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MM_Quads_Finished = Maternal_Male_Quads {UNIFLOW}
Maternal_male_singles(t) = Maternal_male_singles(t - dt) + (Maternal_male_singles_weaned - MM_singles_finished) * dt {NON-
NEGATIVE}
   INIT Maternal_male_singles = 797
   INFLOWS:
      Maternal_male_singles_weaned = IF((IF(Msingle_scan>0)THEN(Msingle_scan*(1-
Msingles_loss_rate)*0.5)ELSE(Maternal_lambs_born*Msingles*0.5))<10)THEN(0)ELSE(IF(Msingle_scan>0)THEN(Msingle_scan*(1-
Msingles_loss_rate)*0.5)ELSE(Singles_Born*0.5)) {UNIFLOW}
   OUTFLOWS:
      MM_singles_finished = Maternal_male_singles {UNIFLOW}
Maternal_Male_Trips(t) = Maternal_Male_Trips(t - dt) + (Male_Trips_Weaned - MM_Trips_Finished) * dt {NON-NEGATIVE}
   INIT Maternal_Male_Trips = 0
   INFLOWS:
      Male_Trips_Weaned = (Trips_Born*0.5) {UNIFLOW}
   OUTFLOWS:
      MM_Trips_Finished = Maternal_Male_Trips {UNIFLOW}
kept_wether = IF("#_wethers">0)THEN(Wether_flock.Replacement_req)ELSE(0) {UNIFLOW}
Rams = ROUND((Ewe_flock-"1yo")/Ram_ratio_MAE+Rams_for_1yo) {UNIFLOW}
"#_wethers" = 0
"%_Lambs_from_1yo" = Lambs_from_1yo/(Maternal_lambs_born+Terminal_lambs_weaned+Lambs_from_1yo+0.0001)
"%_MAE_to_M/W" = 0
"%_MAE_to_Terminal" = 0
"1yo_cull_rate" = 0
   UNITS: sheep
"1yo_Death_rate" = 0.032
"1yo_lambing_rate" = 0
">1yo_Ewe_Flock" = Ewe_flock-"1yo"
Breeding_Ram_ratio_1yo = 50
Converter_1 = Singles_Born+Twins_Born+Trips_Born+Quads_Born
Cull_all = IF(Ewe_flock<Minimum_purebred_flock_size)AND(Minimum_purebred_flock_size>0)THEN(1)ELSE(0)
Death_rate_MAE = 0.052
Deaths = Wastage+"7yo_culls"-Ewe_culls
End_5y = GRAPH(TIME)
(0.00, 0.0), (1.00, 0.0), (2.00, 0.0), (3.00, 0.0), (4.00, 0.0), (5.00, 0.0), (6.00, 0.0), (7.00, 0.0), (8.00, 0.0), (9.00, 0.0), (10.00, 0.0),
(11.00, 0.0), (12.00, 0.0), (13.00, 0.0), (14.00, 0.0), (15.00, 0.0), (16.00, 0.0), (17.00, 0.0), (18.00, 0.0), (19.00, 0.0), (20.00, 0.0)
End_at_5yo? = End_5y
End_at_6yo? = 1
Ewe_Change = INT (Sheep_ME_Change/6682.3)
   DOCUMENT: The feed requirement in ME for ewe estimates of 6682.3 are obtained from
   Pasture and supplements for grazing animals / editors: P.V. Rattray, I.M. Brookes and A.M. Nicol (2007), page 205
Ewe_culls = "2yo_culls"+"3yo_culls"+"4yo_culls"+"5yo_culls"+"6yo_culls"+"7yo_culls"+"1yo_culls"
```

Ewe_flock =
IF(("7_yo"+"6_yo"+"5_yo"+"4_yo"+"3_yo"+"2yo"+"1yo")<10)THEN(0)ELSE("7_yo"+"6_yo"+"5_yo"+"4_yo"+"3_yo"+"2yo"+"1yo")
UNITS: sheep
flock_Age = ("2yo"*2+"3_yo"*3+"4_yo"*4+"5_yo"*5+("6_yo"+"7_yo")*6)/("2yo"+"3_yo"+"4_yo"+"5_yo"+"6_yo"+"7_yo"+0.00001)
Lambs_from_1yo = "1yo_lambing_rate"*"1yo"
Lambs_ME_change = IF Sheep_ME_Change>0 THEN Sheep_ME_Change ELSE 0
M_barren_rate = .04
"M_lambs_born/_ewe_lambing" = Maternal_lambs_born/(1-MEAN(Mmultiples_loss_rate, Msingles_loss_rate))/((Ewe_flock-"1yo")*(1-M_barren_rate-"%_MAE_to_Terminal"-"%_MAE_to_M/W")+0.00001)
MAE_cull_rate = 0.2
Maternal_lambing_rate = 1.4
Maternal_lambs_born = (Singles_Born+Twins_Born+Trips_Born+Quads_Born)
Minimum_purebred_flock_size = 100
Mmultiple_scan = 0
Mmultiples_loss_rate = .15
MQuads = GRAPH(Maternal_lambing_rate)
(1.000, 0.000), (1.100, 0.000), (1.200, 0.000), (1.300, 0.000), (1.400, 0.000), (1.500, 0.000), (1.600, 0.000), (1.700, 0.000), (1.800, 0.000), (1.900, 0.000), (2.000, 0.000), (2.100, 0.000), (2.200, 0.000), (2.300, 0.000), (2.400, 0.035), (2.500, 0.105)
Msingle_scan = 0
Msingles = GRAPH(Maternal_lambing_rate)
(1.000, 1.000), (1.100, 0.900), (1.200, 0.800), (1.300, 0.700), (1.400, 0.600), (1.500, 0.500), (1.600, 0.406), (1.700, 0.328), (1.800, 0.278), (1.900, 0.240), (2.000, 0.205), (2.100, 0.180), (2.200, 0.150), (2.300, 0.120), (2.400, 0.110), (2.500, 0.115)
Msingles_loss_rate = .15
MTrips = GRAPH(Maternal_lambing_rate)
(1.000, 0.000), (1.100, 0.000), (1.200, 0.000), (1.300, 0.000), (1.400, 0.000), (1.500, 0.000), (1.600, 0.006), (1.700, 0.028), (1.800, 0.078), (1.900, 0.140), (2.000, 0.205), (2.100, 0.280), (2.200, 0.350), (2.300, 0.420), (2.400, 0.450), (2.500, 0.405)
MTwins = GRAPH(Maternal_lambing_rate)
(1.000, 0.000), (1.100, 0.100), (1.200, 0.200), (1.300, 0.300), (1.400, 0.400), (1.500, 0.500), (1.600, 0.588), (1.700, 0.644), (1.800, 0.644), (1.900, 0.620), (2.000, 0.590), (2.100, 0.540), (2.200, 0.500), (2.300, 0.460), (2.400, 0.400), (2.500, 0.375)
Quad_Loss_Rate = .475
Quads_Born = 4*MQuads*">1yo_Ewe_Flock"
Ram_ratio_MAE = 100
DOCUMENT: Ewes per ram
Rams_for_1yo = ROUND(IF("1yo_lambing_rate">0)THEN("1yo"/Breeding_Ram_ratio_1yo+"1yo"/Teaser_Ram_ratio_1yo)ELSE(0))
Replacement_req = ("7yo_culls"+Wastage+Ewes_to_Change)
UNITS: sheep
Sheep_Annual_Feed_Bal = Feed_Supply.Total_ME_for_Sheep-Sheep_Feed_balance.Sheep_Total_me_req
Sheep_ME_Change = IF Sheep_Annual_Feed_Bal> 7300 THEN Sheep_Annual_Feed_Bal ELSE IF Sheep_Annual_Feed_Bal<-7300 THEN Sheep_Annual_Feed_Bal ELSE 0
Singles_Born = Msingles*">1yo_Ewe_Flock"
T_barren_rate = .04
Teaser_Ram_ratio_1yo = 75
Terminal_lambing_rate = 0
Terminal_lambs_weaned = "%_MAE_to_Terminal"*Terminal_lambing_rate
Tmultiple_scan = 0
Tmultiples_loss_rate = 0
Total_sheep = Replacement_req+Ewe_flock+Rams
Trip_Loss_Rate = .375
Trips_Born = 3*MTrips*">1yo_Ewe_Flock"
Tsingle_scan = 0
Tsingles_loss_rate = 0
Twins_Born = 2*MTwins*">1yo_Ewe_Flock"
Wastage = "2yo_deaths"+"3yo_deaths"+"4yo_deaths"+"5yo_deaths"+"1yo_deaths"+"6yo_deaths"+"7yo_deaths"+Ewe_culls-"7yo_culls"
UNITS: sheep
Wether_flock:
"1yo"(t) = "1yo"(t - dt) + (become_1yo - "1yo_culls" - become_2yo - "1yo_deaths") * dt {NON-NEGATIVE}
INIT "1yo" = 20
UNITS: sheep
INFLOWS:
become_1yo = purebred_flock.kept_wether {UNIFLOW}

```
        UNITS: sheep/year
  OUTFLOWS:
     "1yo_culls" = "1yo_cull_rate"*"1yo" {UNIFLOW}
        UNITS: sheep/year
     become_2yo = "1yo"-"1yo_culls"-"1yo_deaths" {UNIFLOW}
        UNITS: sheep/year
     "1yo_deaths" = "1yo_Death_rate"*"1yo" {UNIFLOW}
        UNITS: sheep/year
"2yo"(t) = "2yo"(t - dt) + (become_2yo - become_3yo - "2yo_deaths" - "2yo_culls") * dt {NON-NEGATIVE}
  INIT "2yo" = 18
  UNITS: sheep
  INFLOWS:
     become_2yo = "1yo"-"1yo_culls"-"1yo_deaths" {UNIFLOW}
        UNITS: sheep/year
  OUTFLOWS:
     become_3yo = "2yo"-"2yo_deaths"-"2yo_culls" {UNIFLOW}
        UNITS: sheep/year
     "2yo_deaths" = "2yo_death_rate"*"2yo" {UNIFLOW}
        UNITS: sheep/year
     "2yo_culls" = "2yo"*"2yo_cull_rate" {UNIFLOW}
        UNITS: sheep/year
"3_yo"(t) = "3_yo"(t - dt) + (become_3yo - become_4yo - "3yo_deaths" - "3yo_culls") * dt {NON-NEGATIVE}
  INIT "3_yo" = 16
  UNITS: sheep
  INFLOWS:
     become_3yo = "2yo"-"2yo_deaths"-"2yo_culls" {UNIFLOW}
        UNITS: sheep/year
  OUTFLOWS:
     become_4yo = "3_yo"-"3yo_deaths"-"3yo_culls" {UNIFLOW}
        UNITS: sheep/year
     "3yo_deaths" = "3_yo"*"3yo_death_rate" {UNIFLOW}
        UNITS: sheep/year
     "3yo_culls" = "3_yo"*"3yo_cull_rate" {UNIFLOW}
        UNITS: sheep/year
"4_yo"(t) = "4_yo"(t - dt) + (become_4yo - become_5yo - "4yo_deaths" - "4yo_culls") * dt {NON-NEGATIVE}
  INIT "4_yo" = 15
  UNITS: sheep
  INFLOWS:
     become_4yo = "3_yo"-"3yo_deaths"-"3yo_culls" {UNIFLOW}
        UNITS: sheep/year
  OUTFLOWS:
     become_5yo = "4_yo"-"4yo_deaths"-"4yo_culls" {UNIFLOW}
        UNITS: sheep/year
     "4yo_deaths" = "4yo_death_rate"*"4_yo" {UNIFLOW}
        UNITS: sheep/year
     "4yo_culls" = "4yo_cull_rate"*"4_yo" {UNIFLOW}
        UNITS: sheep/year
"5_yo"(t) = "5_yo"(t - dt) + (become_5yo - become_6yo - "5yo_deaths" - "5yo_culls") * dt {NON-NEGATIVE}
  INIT "5_yo" = 13
  UNITS: sheep
  INFLOWS:
     become_5yo = "4_yo"-"4yo_deaths"-"4yo_culls" {UNIFLOW}
        UNITS: sheep/year
  OUTFLOWS:
     become_6yo = "5_yo"-"5yo_deaths"-"5yo_culls" {UNIFLOW}
        UNITS: sheep/year
     "5yo_deaths" = "5yo_death_rate"*"5_yo" {UNIFLOW}
        UNITS: sheep/year
     "5yo_culls" = "5yo_cull_rate"*"5_yo" {UNIFLOW}
        UNITS: sheep/year
"6_yo"(t) = "6_yo"(t - dt) + (become_6yo - become_7yo - "6yo_deaths" - "6yo_culls") * dt {NON-NEGATIVE}
```

```
   INIT "6_yo" = 12
   UNITS: sheep
   INFLOWS:
      become_6yo = "5_yo"-"5yo_deaths"-"5yo_culls" {UNIFLOW}
         UNITS: sheep/year
   OUTFLOWS:
      become_7yo = "6_yo"-"6yo_deaths"-"6yo_culls" {UNIFLOW}
         UNITS: sheep/year
      "6yo_deaths" = "6yo_death_rate"*"6_yo" {UNIFLOW}
         UNITS: sheep/year
      "6yo_culls" = "6yo_cull_rate"*"6_yo" {UNIFLOW}
         UNITS: sheep/year
"7_yo"(t) = "7_yo"(t - dt) + (become_7yo - "7yo_deaths" - "7yo_culls") * dt {NON-NEGATIVE}
   INIT "7_yo" = 11
   UNITS: sheep
   INFLOWS:
      become_7yo = "6_yo"-"6yo_deaths"-"6yo_culls" {UNIFLOW}
         UNITS: sheep/year
   OUTFLOWS:
      "7yo_deaths" = "7_yo"*"7yo_death_rate" {UNIFLOW}
         UNITS: sheep/year
      "7yo_culls" = "7_yo"-"7yo_deaths" {UNIFLOW}
         UNITS: sheep/year
"1yo_cull_rate" = 0.05
   UNITS: sheep
"1yo_Death_rate" = 0.05
"2yo_cull_rate" = 0.05
"2yo_death_rate" = 0.05
"3yo_cull_rate" = 0.05
"3yo_death_rate" = 0.05
"4yo_cull_rate" = 0.05
"4yo_death_rate" = 0.05
"5yo_cull_rate" = 0.05
"5yo_death_rate" = 0.05
"6yo_cull_rate" = 0.05
   UNITS: sheep
"6yo_death_rate" = 0.05
   UNITS: sheep
"7yo_death_rate" = 0.05
   UNITS: sheep
lost_wethers =
"7yo_culls"+"2yo_deaths"+"2yo_culls"+"3yo_deaths"+"3yo_culls"+"4yo_deaths"+"4yo_culls"+"5yo_deaths"+"5yo_culls"+"1yo_deat
hs"+"1yo_culls"+"7yo_deaths"+"6yo_deaths"+"6yo_culls"
   UNITS: sheep
Maintenance_req = Wether_flock*1.1*((0.28*(Wether_LW^0.75)*EXP(-
0.03*Wether_age))/(0.02*purebred_ME_calc."Pasture_ME_M/D"+0.5)*(IF(purebred_ME_calc.Activity=1)THEN(1.1)ELSE(1)))
Replacement_req =   IF((Wether_flock+lost_wethers)<purebred_flock."#_wethers")THEN(purebred_flock."#_wethers"-
Wether_flock+lost_wethers)ELSE(lost_wethers)
   UNITS: sheep
Wether_age =
("1yo"*1+"2yo"*2+"3_yo"*3+"4_yo"*4+"5_yo"*5+"6_yo"*6+"7_yo"*7)/(("1yo"+"2yo"+"3_yo"+"4_yo"+"5_yo"+"6_yo"+"7_yo")+0.0
01)
Wether_flock = "7_yo"+"6_yo"+"5_yo"+"4_yo"+"3_yo"+"2yo"+"1yo"
   UNITS: sheep
Wether_LW = 65

purebred_ME_req:
"Cull_rate_exclu._barren" = (purebred_flock.Ewe_culls-purebred_flock.Ewe_flock*MEAN(purebred_flock.M_barren_rate,
purebred_flock.T_barren_rate))/(purebred_flock.Ewe_flock-purebred_flock.Ewe_flock*MEAN(purebred_flock.M_barren_rate,
purebred_flock.T_barren_rate)+0.00001)
"%_Culled_weaning" = .1
```

Delay_1yo_lambing_1mo = 1
DOCUMENT: Put 1 to delay hogget lambing to one month after ewe flock
Delayed_repro_5 = purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.1546
Delayed_repro_6 = purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.172
Delayed_repro_7 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>8)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.195)ELSE(0)+IF(purebred_ME_calc.Lambs_from_1yo_leave>12)THEN(0)ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))
Delayed_repro_8 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>10)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.2082)ELSE(IF(purebred_ME_calc.Lambs_from_1yo_leave>14)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(0))
Delayed_repro_9 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>12)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.2082)ELSE(IF(purebred_ME_calc.Lambs_from_1yo_leave>16)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(0))
F_1 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Lactation_maintenance/6+Repro_1
F_10 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2++Lambs_e_10+Lambs_f_10+LH_10+Lamb_ME.MFS_F_10+Lamb_ME.MMM_F_10+Lamb_ME.MFM_F_10
F_11 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_11+Lambs_f_11+LH_11+Lamb_ME.MFS_F_11+Lamb_ME.MMM_F_11+Lamb_ME.MFM_F_11
F_12 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26++MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_12+Lambs_f_12+LH_12+Lamb_ME.MFS_F_12+Lamb_ME.MMM_F_12+Lamb_ME.MFM_F_12
F_13 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Flushing_maintenance/3*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_13+Lambs_f_13+LH_13+Lamb_ME.MFS_F_13+Lamb_ME.MMM_F_13+Lamb_ME.MFM_F_13
F_14 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Flushing_maintenance/3*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_14+Lambs_f_14+LH_14+Lamb_ME.MFS_F_14+Lamb_ME.MMM_F_14+Lamb_ME.MFM_F_14
F_15 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Flushing_maintenance/3*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_15+Lambs_f_15+LH_15+Lamb_ME.MFM_F_15+Lamb_ME.MMM_F_15+Lamb_ME.MFS_F_15
F_16 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_16+Lambs_f_16+LH_16+Lamb_ME.MFS_F_16+Lamb_ME.MMM_F_16+Lamb_ME.MFM_F_16
F_17 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2++Lambs_e_17+Lambs_f_17+LH_17+Lamb_ME.MFM_F_17+Lamb_ME.MMM_F_17+Lamb_ME.MFS_F_17
F_18 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_18+Lambs_f_18+LH_18+Lamb_ME.MFM_F_18+Lamb_ME.MMM_F_18+Lamb_ME.MFS_F_18
F_19 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_19+Lambs_f_19+LH_19+Lamb_ME.MFM_F_19+Lamb_ME.MMM_F_19+Lamb_ME.MFS_F_19
F_2 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Lactation_maintenance/6+Repro_2

F_20 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_20+Lambs_f_20+LH_20+Lamb_ME.MFM_F_20+Lamb_ME.MMM_F_20+Lamb_ME.MFS_F_20
F_21 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_21+Lambs_f_21+LH_21
F_22 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_22+Lambs_f_22+LH_22
F_23 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_23+Lambs_f_23+LH_23+Repro_23
F_24 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_24+Lambs_f_24+LH_24+Repro_24
F_25 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_25+Lambs_f_25+LH_25+Repro_25
F_26 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Gestation_maintenance/11*(1-"Cull_rate_exclu._barren"-MEAN(purebred_flock.M_barren_rate, purebred_flock.T_barren_rate))+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_26+Lambs_f_26+LH_26+Repro_26
F_3 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Lactation_maintenance/6+Repro_3
F_4 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Lactation_maintenance/6*(1-"Cull_rate_exclu._barren"*"%_Culled_weaning")+Repro_4
F_5 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+IF(purebred_ME_calc.MAE_weaning_age=8)OR(purebred_ME_calc.MAE_weaning_age<8)THEN(purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_5+Lambs_f_5+MAE_Lactation_maintenance/6*(1-"Cull_rate_exclu._barren"))ELSE(purebred_ME_calc.ME_Lactation*0.195+MAE_Lactation_maintenance/6*(1-"Cull_rate_exclu._barren"*"%_Culled_weaning"))+LH_5
F_6 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+IF(purebred_ME_calc.MAE_weaning_age=12)OR(purebred_ME_calc.MAE_weaning_age<12)THEN(purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_6+Lambs_f_6+MAE_Lactation_maintenance/6*(1-"Cull_rate_exclu._barren"))ELSE(purebred_ME_calc.ME_Lactation*0.2082+MAE_Lactation_maintenance/6*(1-"Cull_rate_exclu._barren"*"%_Culled_weaning"))+LH_6+Lamb_ME.MMS_F6+Lamb_ME.MFS_F_6+Lamb_ME.MMM_F_6+Lamb_ME.MFM_F_6
F_7 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+LH_7+IF(purebred_ME_calc.MAE_weaning_age=12)OR(purebred_ME_calc.MAE_weaning_age<12)THEN(purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+Lambs_e_7+Lambs_f_7)ELSE(purebred_ME_calc.ME_Lactation*0.2187+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren"*"%_Culled_weaning"))+Lamb_ME.MMS_F_7+Lamb_ME.MFS_F_7+Lamb_ME.MMM_F_7+Lamb_ME.MFM_F_7
F_8 = IF(purebred_ME_calc.MAE_weaning_age=14)OR(purebred_ME_calc.MAE_weaning_age<14)THEN(purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_8+Lambs_f_8+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+LH_8+purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26)ELSE(purebred_ME_calc.ME_Lactation*0.2187+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren"*"%_Culled_weaning")+LH_8+purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26)+Lamb_ME.MMS_F_8+Lamb_ME.MFS_F_8+Lamb_ME.MMM_F_8+Lamb_ME.MFM_F_8

F_9 = purebred_ME_calc."1yo_ME_req"/26+purebred_ME_calc.Ram_ME_req/26+MAE_Summer_maintenance/6*(1-"Cull_rate_exclu._barren")+purebred_ME_calc.Replacements_ME_req/(52-purebred_ME_calc.MAE_weaning_age)*2+Lambs_e_9+Lambs_f_9+LH_9+Lamb_ME.MMS_F_9+Lamb_ME.MFS_F_9+Lamb_ME.MMM_F_9+Lamb_ME.MFM_F_9
Lambs_e_10 = IF(purebred_ME_calc.e_Leave>18)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_11 = IF(purebred_ME_calc.e_Leave>20)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_12 = IF(purebred_ME_calc.e_Leave>22)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_13 = IF(purebred_ME_calc.e_Leave>24)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_14 = IF(purebred_ME_calc.e_Leave>26)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_15 = IF(purebred_ME_calc.e_Leave>28)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_16 = IF(purebred_ME_calc.e_Leave>30)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_17 = IF(purebred_ME_calc.e_Leave>32)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_18 = IF(purebred_ME_calc.e_Leave>34)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_19 = IF(purebred_ME_calc.e_Leave>36)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_20 = IF(purebred_ME_calc.e_Leave>38)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_21 = IF(purebred_ME_calc.e_Leave>40)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_22 = IF(purebred_ME_calc.e_Leave>42)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_23 = IF(purebred_ME_calc.e_Leave>44)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_24 = IF(purebred_ME_calc.e_Leave>46)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_25 = IF(purebred_ME_calc.e_Leave>48)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_26 = IF(purebred_ME_calc.e_Leave>50)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_5 = IF(purebred_ME_calc.e_Leave>8)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_6 = IF(purebred_ME_calc.e_Leave>10)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_7 = IF(purebred_ME_calc.e_Leave>12)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_8 = IF(purebred_ME_calc.e_Leave>14)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_e_9 = IF(purebred_ME_calc.e_Leave>16)THEN (purebred_ME_calc.lambs_e_MEreq)ELSE(0)
Lambs_f_10 = IF(purebred_ME_calc.f_Leave>18)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_11 = IF(purebred_ME_calc.f_Leave>20)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_12 = IF(purebred_ME_calc.f_Leave>22)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_13 = IF(purebred_ME_calc.f_Leave>24)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_14 = IF(purebred_ME_calc.f_Leave>26)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_15 = IF(purebred_ME_calc.f_Leave>28)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_16 = IF(purebred_ME_calc.f_Leave>30)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_17 = IF(purebred_ME_calc.f_Leave>32)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_18 = IF(purebred_ME_calc.f_Leave>34)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_19 = IF(purebred_ME_calc.f_Leave>36)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_20 = IF(purebred_ME_calc.f_Leave>38)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_21 = IF(purebred_ME_calc.f_Leave>40)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_22 = IF(purebred_ME_calc.f_Leave>42)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_23 = IF(purebred_ME_calc.f_Leave>44)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_24 = IF(purebred_ME_calc.f_Leave>46)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_25 = IF(purebred_ME_calc.f_Leave>48)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_26 = IF(purebred_ME_calc.f_Leave>50)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_5 = IF(purebred_ME_calc.f_Leave>8)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_6 = IF(purebred_ME_calc.f_Leave>10)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_7 = IF(purebred_ME_calc.f_Leave>12)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_8 = IF(purebred_ME_calc.f_Leave>14)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
Lambs_f_9 = IF(purebred_ME_calc.f_Leave>16)THEN (purebred_ME_calc.lambs_f_MEreq)ELSE(0)
LH_10 = IF(purebred_ME_calc.Lambs_from_1yo_leave>18)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_11 = IF(purebred_ME_calc.Lambs_from_1yo_leave>20)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_12 = IF(purebred_ME_calc.Lambs_from_1yo_leave>22)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-

4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_13 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>24)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_14 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>26)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_15 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>28)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_16 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>30)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_17 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>32)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_18 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>34)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_19 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>36)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_20 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>38)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_21 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>40)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_22 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>42)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_23 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>44)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_24 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>46)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-

4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_25 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>48)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_26 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>50)THEN(IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age-4)/2))ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))ELSE(0)
LH_5 = IF(Delay_1yo_lambing_1mo=1)THEN(Delayed_repro_5)ELSE(Repro_5)
LH_6 = IF(Delay_1yo_lambing_1mo=1)THEN(Delayed_repro_6)ELSE(Repro_6)
LH_7 = IF(Delay_1yo_lambing_1mo=1)THEN(Delayed_repro_7)ELSE(Repro_7)
LH_8 = IF(Delay_1yo_lambing_1mo=1)THEN(Delayed_repro_8)ELSE(Repro_8)
LH_9 = IF(Delay_1yo_lambing_1mo=1)THEN(Delayed_repro_9)ELSE(Repro_9)
LWC_Flushing = 2
DOCUMENT: In kg of liveweight. Negative if liveweight is being lost
LWC_Gestation = 0
DOCUMENT: In kg of liveweight. Negative if liveweight is being lost
LWC_Lactation = -2
DOCUMENT: In kg of liveweight. Negative if liveweight is being lost
LWC_Summer = 0
DOCUMENT: In kg of liveweight. Negative if liveweight is being lost
MAE_Flushing_maintenance = (((0.28*(MAE_LW_Flushing^0.75)*EXP(-0.03*purebred_flock.flock_Age))/(0.02*purebred_ME_calc."Pasture_ME_M/D"+0.5)*(IF(purebred_ME_calc.Activity=1)THEN(1.1)ELSE(1)))*42+(IF(LWC_Flushing>0)THEN(LWC_Flushing*55)ELSE(LWC_Flushing*(-35)))+purebred_ME_calc.MAE_ME_Wool*42)*"Y2-7"
MAE_Gestation_maintenance = (((0.28*(purebred_ME_calc.MAE_LW_Gestation^0.75)*EXP(-0.03*purebred_flock.flock_Age))/(0.02*purebred_ME_calc."Pasture_ME_M/D"+0.5)*(IF(purebred_ME_calc.Activity=1)THEN(1.1)ELSE(1)))*155+(IF(LWC_Gestation>0)THEN(LWC_Gestation*55)ELSE(LWC_Gestation*(-35)))+purebred_ME_calc.MAE_ME_Wool*155)*"Y2-7"
MAE_Lactation_maintenance = (((0.28*(MAE_LW_Lactation^0.75)*EXP(-0.03*purebred_flock.flock_Age))/(0.02*purebred_ME_calc."Pasture_ME_M/D"+0.5)*(IF(purebred_ME_calc.Activity=1)THEN(1.1)ELSE(1)))*84+(IF(LWC_Lactation>0)THEN(LWC_Lactation*55)ELSE(LWC_Lactation*(-35)))+purebred_ME_calc.MAE_ME_Wool*84)*"Y2-7"
MAE_LW_Flushing = 66
DOCUMENT: Mixed age ewe average liveweight from Flushing to Pregnancy (FtoP)
MAE_LW_Lactation = 66
DOCUMENT: Mixed age ewe average liveweight from lambing to weaning (LtoW)
MAE_LW_Summer = 65
DOCUMENT: Mixed age ewe average liveweight from weaning to flushing (WtoF)
MAE_Summer_maintenance = (((0.28*(MAE_LW_Summer^0.75)*EXP(-0.03*purebred_flock.flock_Age))/(0.02*purebred_ME_calc."Pasture_ME_M/D"+0.5)*(IF(purebred_ME_calc.Activity=1)THEN(1.1)ELSE(1)))*84+(IF(LWC_Summer>0)THEN(LWC_Summer*55)ELSE(LWC_Summer*(-35)))+purebred_ME_calc.MAE_ME_Wool*84)*"Y2-7"
Repro_1 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.1188+purebred_ME_calc.gestation_req_lambs_from_1yo*0.2486+purebred_ME_calc.ME_Lactation*0.084)ELSE((purebred_ME_calc.ME_Lactation+purebred_ME_calc.ME_Lactation_Lambs_from_1yo)*0.084+(purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.1188)
Repro_2 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.016+purebred_ME_calc.gestation_req_lambs_from_1yo*0.3609+purebred_ME_calc.ME_Lactation*0.1304)ELSE((purebred_ME_calc.ME_Lactation+purebred_ME_calc.ME_Lactation_Lambs_from_1yo)*0.1304+(purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.016)
Repro_23 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.098)ELSE((purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.098)
Repro_24 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.1778)ELSE((purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.1778)

Repro_25 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.2486+purebred_ME_calc.gestation_req_lambs_from_1yo
*0.098)ELSE((purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.2486)
Repro_26 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.ME_Gestation*0.3609+purebred_ME_calc.gestation_req_lambs_from_1yo
*0.1778)ELSE((purebred_ME_calc.ME_Gestation+purebred_ME_calc.gestation_req_lambs_from_1yo)*0.3609)
Repro_3 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.gestation_req_lambs_from_1yo*0.1188+purebred_ME_calc.ME_Lactation
*0.1546+purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.084)ELSE((purebred_ME_calc.ME_Lactation+purebred_ME_calc.ME
_Lactation_Lambs_from_1yo)*0.1546)
Repro_4 =
IF(Delay_1yo_lambing_1mo=1)THEN(purebred_ME_calc.gestation_req_lambs_from_1yo*0.016+purebred_ME_calc.ME_Lactation*
0.172+purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.1304)ELSE((purebred_ME_calc.ME_Lactation+purebred_ME_calc.ME_
Lactation_Lambs_from_1yo)*0.172)
Repro_5 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>8)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.195)ELSE(0)+I
F(purebred_ME_calc.Lambs_from_1yo_leave>8)THEN(0)ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.La
mbs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2))
Repro_6 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>10)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.2082)ELSE(IF
(purebred_ME_calc.Lambs_from_1yo_leave>10)THEN(0)ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.La
mbs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))
Repro_7 =
IF(purebred_ME_calc.lambs_from_1yo_weaning_age>12)THEN(purebred_ME_calc.ME_Lactation_Lambs_from_1yo*0.2082)ELSE(IF
(purebred_ME_calc.Lambs_from_1yo_leave>12)THEN(0)ELSE(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.La
mbs_from_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2)))
Repro_8 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>14)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_f
rom_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2))ELSE(0)
Repro_9 =
IF(purebred_ME_calc.Lambs_from_1yo_leave>16)THEN(purebred_ME_calc.Lambs_from_1yo_MEreq/((purebred_ME_calc.Lambs_f
rom_1yo_leave-purebred_ME_calc.lambs_from_1yo_weaning_age)/2))ELSE(0)
Total_ME_req =
F_1+F_2+F_3+F_4+F_6+F_7+F_8+F_9+F_10+F_11+F_12+F_13+F_14+F_15+F_16+F_17+F_18+F_19+F_21+F_22+F_23+F_24+F_25+F_
26+F_5+F_20
"Y2-7" = purebred_flock.Ewe_flock-purebred_flock."1yo"

purebred_ME_calc:
Lamb_MFS_finishing = IF purebred_flock.MF_singles_finished<1 THEN 1 ELSE purebred_flock.MF_singles_finished {UNIFLOW}
Lamb_MFTW_finishing = IF purebred_flock.MF_twins_finished<1 THEN 1 ELSE purebred_flock.MF_twins_finished {UNIFLOW}
Lamb_MMS_finishing = IF purebred_flock.MM_singles_finished<1 THEN 1 ELSE purebred_flock.MM_singles_finished {UNIFLOW}
Lamb_MMTW_finishing = IF purebred_flock.MM_Multis_finished<1 THEN 1 ELSE purebred_flock.MM_Multis_finished {UNIFLOW}
"1yo_LW" = MAE_LW_Gestation*0.8
"1yo_ME_LWG" = 55*(MAE_LW_Gestation-"1yo_LW")
"1yo_ME_Maintenance" = ((0.28*(MEAN("1yo_LW", MAE_LW_Gestation)^0.75)*EXP(-
0.03))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1)))
"1yo_ME_req" = ("1yo_wool_ME"+"1yo_ME_Maintenance"*365+"1yo_ME_LWG")*purebred_flock."1yo"
"1yo_multiples" = GRAPH(Lambs_born_per_1yo)
(1.000, 0.000), (1.100, 0.050), (1.200, 0.200), (1.300, 0.300), (1.400, 0.400), (1.500, 0.480), (1.600, 0.600), (1.700, 0.680), (1.800,
0.720), (1.900, 0.780), (2.000, 0.800), (2.100, 0.820), (2.200, 0.830), (2.300, 0.860), (2.400, 0.880), (2.500, 0.880)
"1yo_singles" = GRAPH(Lambs_born_per_1yo)
(1.000, 1.000), (1.100, 0.950), (1.200, 0.800), (1.300, 0.700), (1.400, 0.600), (1.500, 0.500), (1.600, 0.400), (1.700, 0.320), (1.800,
0.280), (1.900, 0.220), (2.000, 0.200), (2.100, 0.180), (2.200, 0.170), (2.300, 0.140), (2.400, 0.120), (2.500, 0.120)
"1yo_wool_ME" = 0.13*((Wool_purebred.Ave_FW_MAE*0.95)*1000/365-6)
Activity = 1
DOCUMENT: If on hill country then: "1"
Otherwise is assumed to be gently rolling or flat land

All_lambs =
purebred_flock.Maternal_Female_singles_weaned+purebred_flock.Maternal_Female_twins_weaned+purebred_flock.Maternal_male_singles_weaned+purebred_flock.Maternal_male_twins_weaned
Cold = 0
e_CW = 17.5
DOCUMENT: Liveweight when the lambs leave the farm
e_Dressing% = .426
e_Leave = 19
DOCUMENT: When lambs are leaving the farm (either to slaughter or as store) as "X" weeks after the start of lambing. Please keep as an even number (options are therefore limited to every two weeks) and after weaning
f_CW = 17.5
DOCUMENT: Liveweight when the lambs leave the farm
f_Dressing% = .426
f_Leave = 24
DOCUMENT: When lambs are leaving the farm (either to slaughter or as store) as "X" weeks after the start of lambing. Please keep as an even number (options are therefore limited to every two weeks) and to after weaning
Finished_Lamb_ME_req =
Lambs_from_1yo_MEreq+Lamb_ME.Lamb_MMS_ME_Req+Lamb_ME.Lamb_MFS_ME_Req+Lamb_ME.Lamb_MMM_ME_Req+Lamb_ME.Lamb_MFM_ME_Req
gestation_req_lambs_from_1yo = Single_ME_req_gest_lambs_from_1yo/(1-loss_rate_lambs_from_1yo)*single_lambs_1yo+Multiple_ME_req_gest_lambs_from_1yo/(1-loss_rate_lambs_from_1yo)*multiple_lambs_1yo
Lambs_born_per_1yo = IF purebred_flock."1yo"=0 THEN 0 ELSE purebred_flock.Lambs_from_1yo/(1-loss_rate_lambs_from_1yo)/purebred_flock."1yo"
lambs_e_MEreq = (0.13*((Wool_purebred.Ave_FW_MAE*0.5)*1000/(e_Leave*7)-6)*((e_Leave-MAE_weaning_age)*7)+(e_CW/e_Dressing%-MAE_Weaning_wt_Single)*55+(0.28*(MEAN(MAE_Weaning_wt_Single, (e_CW/e_Dressing%))^0.75)*EXP(-0.03))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1))*((e_Leave-MAE_weaning_age)*7))/((e_Leave-MAE_weaning_age)/2)
lambs_f_MEreq = (0.13*((Wool_purebred.Ave_FW_MAE*0.5)*1000/(f_Leave*7)-6)*((f_Leave-MAE_weaning_age)*7)+(f_CW/f_Dressing%-MAE_Weaning_wt_multiple)*55+(0.28*(MEAN(MAE_Weaning_wt_multiple, (f_CW/f_Dressing%))^0.75)*EXP(-0.03))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1))*((f_Leave-MAE_weaning_age)*7))/((f_Leave-MAE_weaning_age)/2)
Lambs_from_1yo_leave = 16
DOCUMENT: When lambs from hoggets are leaving the farm (either to slaughter or as store) as "X" weeks after the start of their lambing on-farm. Please keep as an even number (options are therefore limited to every two weeks) and to after hogget weaning
Lambs_from_1yo_MEreq = (Lambs_from_1yo_sold_LW-single_lambs_from_1yo_weaning_wt)*55*purebred_flock.Lambs_from_1yo+(0.28*(MEAN(single_lambs_from_1yo_weaning_wt, Lambs_from_1yo_sold_LW)^0.75)*EXP(-0.03))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1))*((Lambs_from_1yo_leave-lambs_from_1yo_weaning_age-4)*7)*purebred_flock.Lambs_from_1yo+(0.13*(Wool_purebred.Ave_FW_MAE*0.5*1000/(Lambs_from_1yo_leave*7)-6))*purebred_flock.Lambs_from_1yo
Lambs_from_1yo_sold_LW = 24
lambs_from_1yo_weaning_age = 10
DOCUMENT: Age since start of hogget lambing in weeks. Can be between 8 and 12 weeks.
Leave_MFS = IF Shrub_Area_Feed_Supply.Shrub_ME>0 THEN Shrub_Leave_MFS ELSE 16
Leave_MFTW = IF Shrub_Area_Feed_Supply.Shrub_ME>0 THEN Shrub_Leave_MFTW ELSE 25
Leave_MMS = IF Shrub_Area_Feed_Supply.Shrub_ME>0 THEN Shrub_Leave_MMS ELSE 16
Leave_MMTW = IF Shrub_Area_Feed_Supply.Shrub_ME>0 THEN Shrub_Leave_MMTW ELSE 23
Length_of_cold = 0
loss_rate_lambs_from_1yo = 0.25
MAE_LW_Gestation = 65
DOCUMENT: Mixed age ewe average liveweight from mating to lambing (MtoL)
MAE_ME_Maintenance = ((0.28*(MAE_LW_Gestation^0.75)*EXP(-0.03*purebred_flock.flock_Age))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1)))
MAE_ME_req =
(MAE_ME_Maintenance*365+MAE_ME_Maintenance*(IF(Cold=1)THEN(0.2*Length_of_cold)ELSE(0))+MAE_ME_Wool*365)*purebred_flock.Ewe_flock
MAE_ME_Wool = 0.13*(Wool_purebred.Ave_FW_MAE*1000/365-6)
MAE_weaning_age = 12
UNITS: Weeks
DOCUMENT: In weeks since start of lambing

MAE_Weaning_wt_multiple = 27.5
MAE_Weaning_wt_Single = 33
Maternal_Multiple_birth_weight = 4.5
Maternal_Single_Birth_weight = 5.5
ME_Gestation = (((purebred_flock.Maternal_Female_singles_weaned+purebred_flock.Maternal_male_singles_weaned)/(1-purebred_flock.Msingles_loss_rate)/(1-purebred_flock.Tsingles_loss_rate))*Single_ME_req_preg+((purebred_flock.Maternal_Female_twins_weaned+purebred_flock.Maternal_male_twins_weaned)/(1-purebred_flock.Mmultiples_loss_rate)/(1-purebred_flock.Tmultiples_loss_rate))*Multiple_ME_req_preg)
ME_Lactation = ((purebred_flock.Maternal_Female_singles_weaned+purebred_flock.Maternal_male_singles_weaned)/(1-purebred_flock.Msingles_loss_rate)/(1-purebred_flock.Tsingles_loss_rate))*Single_ME_req_lact+(Multiple_ME_req_lact/2*1.35)*(1-purebred_flock.Tmultiples_loss_rate)+(purebred_flock.Maternal_Female_twins_weaned+purebred_flock.Maternal_male_twins_weaned)/(1-purebred_flock.Mmultiples_loss_rate)
ME_Lactation_Lambs_from_1yo = ME_req_lact_single_Lambs_from_1yo*single_lambs_1yo+(1.35*ME_req_lact_multiple_Lambs_from_1yo)*(multiple_lambs_1yo/2)
ME_req_lact_multiple_Lambs_from_1yo = -1808+51.4*multiple_lambs_from_1yo_weaning_wt+134.7*lambs_from_1yo_weaning_age
ME_req_lact_single_Lambs_from_1yo = -1808+51.4*single_lambs_from_1yo_weaning_wt+134.7*lambs_from_1yo_weaning_age
multiple_lambs_1yo = "1yo_multiples"*purebred_flock.Lambs_from_1yo
multiple_lambs_from_1yo_Birth_wt = 3.9
multiple_lambs_from_1yo_weaning_wt = 17.4
Multiple_ME_req_gest_lambs_from_1yo = GRAPH(multiple_lambs_from_1yo_Birth_wt)
(3.000, 155.0), (4.000, 200.0), (5.000, 255.0), (6.000, 300.0)
Multiple_ME_req_lact = -1808+51.4*(MAE_Weaning_wt_multiple*(1-Terminal_lambs_%)+Terminal_multiple_Weaning_wt*Terminal_lambs_%)+134.7*MAE_weaning_age
Multiple_ME_req_preg = GRAPH(Maternal_Multiple_birth_weight*(1-Terminal_lambs_%)+Terminal_multiple_birth_wt*Terminal_lambs_%)
(3.000, 155.0), (4.000, 200.0), (5.000, 255.0), (6.000, 300.0)
"Pasture_ME_M/D" = 10
Ram_Age = 3
Ram_LW = 70
Ram_ME_Maintenance = (((0.28*(Ram_LW^0.75)*EXP(-0.03*Ram_Age))/(0.02*"Pasture_ME_M/D"+0.5))*(IF(Activity=1)THEN(1.1)ELSE(1))*1.15)
Ram_ME_req = (Ram_ME_Maintenance*365+Ram_wool_ME*365+IF(Cold=1)THEN(Ram_ME_Maintenance*0.2*Length_of_cold)ELSE(0))*((1-purebred_flock."%_MAE_to_M/W")*purebred_flock.Rams)
Ram_wool_ME = 0.13*(Wool_purebred.Ram_GFW*1000/365-6)
Replacements_ME_req = (("1yo_LW"-MAE_Weaning_wt_Single)*55+(((0.28*(MEAN(MAE_Weaning_wt_Single, "1yo_LW")^0.75)*EXP(-0.03))/(0.02*"Pasture_ME_M/D"+0.5)*(IF(Activity=1)THEN(1.1)ELSE(1))))*(365-MAE_weaning_age*7)+(0.13*((Wool_purebred.Ave_FW_MAE*0.5)*1000/(365-MAE_weaning_age*7)-6)))*purebred_flock.Keeping
Shrub_Leave_MFS = 21
Shrub_Leave_MFTW = 42
Shrub_Leave_MMS = 21
Shrub_Leave_MMTW = 38
single_lambs_1yo = "1yo_singles"*purebred_flock.Lambs_from_1yo
single_lambs_from_1yo_Birth_wt = 4.5
single_lambs_from_1yo_weaning_wt = 23
Single_ME_req_gest_lambs_from_1yo = GRAPH(single_lambs_from_1yo_Birth_wt)
(3.000, 155.0), (4.000, 200.0), (5.000, 255.0), (6.000, 300.0)
Single_ME_req_lact = -1808+51.4*(MAE_Weaning_wt_Single*(1-Terminal_lambs_%)+Terminal_single_Weaning_wt*Terminal_lambs_%)+134.7*MAE_weaning_age
Single_ME_req_preg = GRAPH(Maternal_Single_Birth_weight*(1-Terminal_lambs_%)+Terminal_single_birth_wt*Terminal_lambs_%)
(3.000, 155.0), (4.000, 200.0), (5.000, 255.0), (6.000, 300.0)
Terminal_lambs_% = purebred_flock.Terminal_lambs_weaned/(purebred_flock.Maternal_lambs_born+purebred_flock.Terminal_lambs_weaned+0.0001)
Terminal_multiple_birth_wt = 4.86
Terminal_multiple_Weaning_wt = 31.5
Terminal_single_birth_wt = 5.94
Terminal_single_Weaning_wt = 33.9

Wool_purebred:
age = Shearing_date/52
DOCUMENT: Age of youngstock (younger than 2 years old) at this shearing event. If this event is not occurring then this needs to be "0"
Ave_FW_MAE = 4.8
UNITS: kg
DOCUMENT: Average wool production annually is about 5.4 per sheep
Coarse_wool_price = 2.42
FW_lambs = (Ave_FW_MAE*0.41)*(purebred_flock.MM_Multis_finished+purebred_flock.MF_twins_finished)
MAE_wool_income =
(purebred_flock."1yo"*(Ave_FW_MAE*0.95)+purebred_flock."2yo"*(Ave_FW_MAE*1.01)+purebred_flock."3_yo"*(Ave_FW_MAE*1.08)+purebred_flock."4_yo"*(Ave_FW_MAE*1.05)+purebred_flock."5_yo"*(Ave_FW_MAE*1.01)+purebred_flock."6_yo"*(Ave_FW_MAE*0.97)+purebred_flock."7_yo"*(Ave_FW_MAE*0.9))*Coarse_wool_price
Price_lambswool = 2.94
UNITS: NZ$
Ram_GFW = 4.8
Ram_wool_income = purebred_flock.Rams*Coarse_wool_price*Ram_GFW*(1-purebred_flock."%_MAE_to_M/W")+purebred_flock.Rams*Ram_GFW*purebred_flock."%_MAE_to_M/W"*Ram_wool_price
Ram_wool_price = 2.42
Shearing_date = 20
DOCUMENT: Weeks after the beginning of lambing
Total_wool_income = Wool_income_lambs+MAE_wool_income+Ram_wool_income
Wool_income_lambs = ((FW_lambs)+(purebred_flock.Keeping*(Ave_FW_MAE*0.41)))*Price_lambswool

Sheep_Feed_balance:
Bal_1 =
(IF(Lambing_date=1)THEN(Feed_Supply.Jul_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0))/2-purebred_ME_req.F_1
Bal_10 =
Bal_9+((IF(Lambing_date=1)THEN(Feed_Supply.Nov_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Feb_ME_sheep/2)ELSE(0))-purebred_ME_req.F_10)
Bal_11 =
Bal_10+((IF(Lambing_date=1)THEN(Feed_Supply.Dec_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Feb_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Feb_ME_sheep/2)ELSE(0))-purebred_ME_req.F_11)
Bal_12 =
Bal_11+((IF(Lambing_date=1)THEN(Feed_Supply.Dec_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Feb_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Feb_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Mar_ME_sheep/2)ELSE(0))-purebred_ME_req.F_12)
Bal_13 =
Bal_12+((IF(Lambing_date=1)THEN(Feed_Supply.Dec_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jan_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jan_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0))/2-purebred_ME_req.F_13)
Bal_14 =
Bal_13+((IF(Lambing_date=1)THEN(Feed_Supply.Jan_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jan_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0))/2-purebred_ME_req.F_14)
Bal_15 =
Bal_14+((IF(Lambing_date=1)THEN(Feed_Supply.Jan_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0))/2-purebred_ME_req.F_15)

Bal_16 =
Bal_15+((IF(Lambing_date=1)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.May_ME_sheep)ELSE(0))/2-purebred_ME_req.F_16)
Bal_17 =
Bal_16+((IF(Lambing_date=1)THEN(Feed_Supply.Feb_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Mar_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.May_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.May_ME_sheep)ELSE(0))/2-purebred_ME_req.F_17)
Bal_18 =
Bal_17+((IF(Lambing_date=1)THEN(Feed_Supply.Mar_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Mar_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Apr_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0))-purebred_ME_req.F_18)
Bal_19 =
Bal_18+((IF(Lambing_date=1)THEN(Feed_Supply.Mar_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0))-purebred_ME_req.F_19)
Bal_2 =
Bal_1+((IF(Lambing_date=1)THEN(Feed_Supply.Jul_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0))/2-purebred_ME_req.F_2)
Bal_20 =
Bal_19+((IF(Lambing_date=1)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0))-purebred_ME_req.F_20)
Bal_21 =
Bal_20+((IF(Lambing_date=1)THEN(Feed_Supply.Apr_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0))-purebred_ME_req.F_21)
Bal_22 =
Bal_21+((IF(Lambing_date=1)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0))-purebred_ME_req.F_22)
Bal_23 =
Bal_22+((IF(Lambing_date=1)THEN(Feed_Supply.May_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0))-purebred_ME_req.F_23)
Bal_24 =
Bal_23+((IF(Lambing_date=1)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0))-purebred_ME_req.F_24)
Bal_25 =
Bal_24+((IF(Lambing_date=1)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0))-purebred_ME_req.F_25)
Bal_26 =
Bal_25+((IF(Lambing_date=1)THEN(Feed_Supply.Jun_ME_sheep/3)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Jul_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Aug_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0))-purebred_ME_req.F_26)

Bal_3 =
Bal_2+((IF(Lambing_date=1)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Nov_ME_sheep)ELSE(0))/2-purebred_ME_req.F_3)
Bal_4 =
Bal_3+((IF(Lambing_date=1)THEN(Feed_Supply.Aug_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Sep_ME_sheep)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Nov_ME_sheep)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Nov_ME_sheep)ELSE(0))/2-purebred_ME_req.F_4)
Bal_5 =
Bal_4+((IF(Lambing_date=1)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0))-purebred_ME_req.F_5)
Bal_6 =
Bal_5+((IF(Lambing_date=1)THEN(Feed_Supply.Sep_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0))-purebred_ME_req.F_6)
Bal_7 =
Bal_6+((IF(Lambing_date=1)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Oct_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0))-purebred_ME_req.F_7)
Bal_8 =
Bal_7+((IF(Lambing_date=1)THEN(Feed_Supply.Oct_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0))-purebred_ME_req.F_8)
Bal_9 =
Bal_8+((IF(Lambing_date=1)THEN(Feed_Supply.Nov_ME_sheep)ELSE(0)+IF(Lambing_date=2)THEN(Feed_Supply.Nov_ME_sheep/2)ELSE(0)+IF(Lambing_date=3)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=4)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=5)THEN(Feed_Supply.Dec_ME_sheep/3)ELSE(0)+IF(Lambing_date=6)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0)+IF(Lambing_date=7)THEN(Feed_Supply.Jan_ME_sheep/2)ELSE(0))-purebred_ME_req.F_9)
Lambing_date = 5
DOCUMENT: Put appropriate (closest)
number for start of ewe lambing

1 - July 1st
2 - July 15th
3 - August 1st
4 - August 15th
5 - September 1st
6 - September 15th
7 - October 1st

Sheep_Total_me_req =
purebred_ME_req.F_1+purebred_ME_req.F_2+purebred_ME_req.F_3+purebred_ME_req.F_4+purebred_ME_req.F_5+purebred_ME_req.F_6+purebred_ME_req.F_7+purebred_ME_req.F_8+purebred_ME_req.F_9+purebred_ME_req.F_10+purebred_ME_req.F_11+purebred_ME_req.F_12+purebred_ME_req.F_13+purebred_ME_req.F_14+purebred_ME_req.F_15+purebred_ME_req.F_16+purebred_ME_req.F_17+purebred_ME_req.F_18+purebred_ME_req.F_19+purebred_ME_req.F_20+purebred_ME_req.F_21+purebred_ME_req.F_22+purebred_ME_req.F_23+purebred_ME_req.F_24+purebred_ME_req.F_25+purebred_ME_req.F_26

Lamb_ME:
Age = 0.5
C = 0.05
Current_LWt = IF purebred_ME_calc.MAE_Weaning_wt_Single/SR_Wt<1 THEN purebred_ME_calc.MAE_Weaning_wt_Single/SR_Wt ELSE 1
Current_LWt_MFM = IF purebred_ME_calc.MAE_Weaning_wt_multiple/SR_Wt<1 THEN purebred_ME_calc.MAE_Weaning_wt_multiple/SR_Wt ELSE 1

Current_LWt_MFS = IF purebred_ME_calc.MAE_Weaning_wt_Single/SR_Wt<1 THEN purebred_ME_calc.MAE_Weaning_wt_Single/SR_Wt ELSE 1
Current_LWt_MMM = IF purebred_ME_calc.MAE_Weaning_wt_multiple/SR_Wt<1 THEN purebred_ME_calc.MAE_Weaning_wt_multiple/SR_Wt ELSE 1
DMD = 0.68
DMI = 0.74
Duration = IF DELAY(TIME, 1, 0)>("L-W_MMS") THEN 0 ELSE DELAY(TIME, 1, 0)
Duration_1 = IF DELAY(TIME, 1, 0)>("L-W_MFS") THEN 0 ELSE DELAY(TIME, 1, 0)
Duration_3 = IF DELAY(TIME, 1, 0)>("L-W_MMM") THEN 0 ELSE DELAY(TIME, 1, 0)
Duration_4 = IF DELAY(TIME, 1, 0)>("L-W_MFM") THEN 0 ELSE DELAY(TIME, 1, 0)
EBC = 0.92*(LWt_G_MMS*1000)
EBC_MFM = 0.92*(LWt_G_MFM*1000)
EBC_MFS = 0.92*(LWt_G_MFS*1000)
EBC_MMM = 0.92*(LWt_G_MMM*1000)
Female_Constant = 1.0
Fleece_Wt = 5.0
  UNITS: kg
Green_Forage = 3.5
K_b = (0.02*purebred_ME_calc."Pasture_ME_M/D")+0.5
K_g = (0.42*purebred_ME_calc."Pasture_ME_M/D")+0.006
"L-W_MFM" = purebred_ME_calc.Leave_MFTW-purebred_ME_calc.MAE_weaning_age+1
"L-W_MFS" = purebred_ME_calc.Leave_MFS-purebred_ME_calc.MAE_weaning_age+1
"L-W_MMM" = purebred_ME_calc.Leave_MMTW-purebred_ME_calc.MAE_weaning_age+1
"L-W_MMS" = purebred_ME_calc.Leave_MMS-purebred_ME_calc.MAE_weaning_age+1
Lamb_LWt_MFM = IF TIME>"L-W_MFM" THEN purebred_ME_calc.MAE_Weaning_wt_multiple=0 ELSE (purebred_ME_calc.MAE_Weaning_wt_multiple+(LWt_G_MFM*Duration_4*7))
Lamb_LWt_MFS = IF TIME>"L-W_MFS" THEN purebred_ME_calc.MAE_Weaning_wt_Single=0 ELSE (purebred_ME_calc.MAE_Weaning_wt_Single+(LWt_G_MFS*Duration_1*7))
Lamb_LWt_MMM = IF TIME>"L-W_MMM" THEN purebred_ME_calc.MAE_Weaning_wt_multiple=0 ELSE (purebred_ME_calc.MAE_Weaning_wt_multiple+(LWt_G_MMM*Duration_3*7))
Lamb_LWt_MMS = IF TIME>"L-W_MMS" THEN purebred_ME_calc.MAE_Weaning_wt_Single=0 ELSE (purebred_ME_calc.MAE_Weaning_wt_Single+(LWt_G_MMS*Duration*7))
Lamb_ME_Week_1 = (MMS_Week_1+MFS_Week_1+MMM_Week_1+MFM_Week_1)
Lamb_ME_Week_10 = MFS_Week_10+MMM_Week_10+MFM_Week_10
Lamb_ME_Week_11 = MFS_Week_11+MMM_Week_11+MFM_Week_11
Lamb_ME_Week_12 = MFS_Week_12+MMM_Week_12+MFM_Week_12
Lamb_ME_Week_13 = MFS_Week_13+MMM_Week_13+MFM_Week_13
Lamb_ME_Week_14 = MFS_Week_14+MMM_Week_14+MFM_Week_14
Lamb_ME_Week_15 = MFS_Week_15+MMM_Week_15+MFM_Week_15
Lamb_ME_Week_16 = MFS_Week_16+MMM_Week_16+MFM_Week_16
Lamb_ME_Week_17 = MFS_Week_17+MMM_Week_17+MFM_Week_17
Lamb_ME_Week_18 = MFS_Week_18+MMM_Week_18+MFM_Week_18
Lamb_ME_Week_19 = MFS_Week_19+MMM_Week_19+MFM_Week_19
Lamb_ME_Week_2 = MMS_Week_2+MFS_Week_2+MMM_Week_2+MFM_Week_2
Lamb_ME_Week_20 = MFS_Week_20+MMM_Week_20+MFM_Week_20
Lamb_ME_Week_21 = MFS_Week_21+MMM_Week_21+MFM_Week_21
Lamb_ME_Week_22 = MFS_Week_22+MMM_Week_22+MFM_Week_22
Lamb_ME_Week_23 = MFS_Week_23+MMM_Week_23+MFM_Week_23
Lamb_ME_Week_24 = MFS_Week_24+MMM_Week_24+MFM_Week_24
Lamb_ME_Week_25 = MFS_Week_25+MMM_Week_25+MFM_Week_25
Lamb_ME_Week_26 = MFS_Week_26+MMM_Week_26+MFM_Week_26
Lamb_ME_Week_27 = MFS_Week_27+MMM_Week_27+MFM_Week_27
Lamb_ME_Week_28 = MFS_Week_28+MMM_Week_28+MFM_Week_28
Lamb_ME_Week_29 = MFS_Week_29+MMM_Week_29+MFM_Week_29
Lamb_ME_Week_3 = MFS_Week_3+MMM_Week_3+MFM_Week_3+MMS_Week_3
Lamb_ME_Week_30 = MFS_Week_30+MMM_Week_30+MFM_Week_30
Lamb_ME_Week_4 = MMS_Week_4+MFS_Week_4+MMM_Week_4+MFM_Week_4
Lamb_ME_Week_5 = MMS_Week_5+MFS_Week_5+MMM_Week_5+MFM_Week_5
Lamb_ME_Week_6 = MMS_Week_6+MFS_Week_6+MMM_Week_6+MFM_Week_6
Lamb_ME_Week_7 = MMS_Week_7+MFS_Week_7+MMM_Week_7+MFM_Week_7
Lamb_ME_Week_8 = MMS_Week_8+MFS_Week_8+MMM_Week_8+MFM_Week_8

Lamb_ME_Week_9 = MFS_Week_9+MMM_Week_9+MFM_Week_9
Lamb_MFM_ME_Req =
(MFM_Week_1+MFM_Week_2+MFM_Week_3+MFM_Week_4+MFM_Week_5+MFM_Week_6+MFM_Week_7+MFM_Week_8+MFM_Week_9+MFM_Week_10+MFM_Week_11+MFM_Week_12+MFM_Week_13+MFM_Week_14)*7
Lamb_MFS_ME_Req =
(MFS_Week_1+MFS_Week_2+MFS_Week_3+MFS_Week_4+MFS_Week_5+MFS_Week_6+MFS_Week_7+MFS_Week_8+MFS_Week_9+MFS_Week_10+MFS_Week_11+MFS_Week_12+MFS_Week_13+MFS_Week_14)*7
Lamb_MMM_ME_Req =
(MMM_Week_1+MMM_Week_2+MMM_Week_3+MMM_Week_4+MMM_Week_5+MMM_Week_6+MMM_Week_7+MMM_Week_8+MMM_Week_9+MMM_Week_10+MMM_Week_11+MMM_Week_12+MMM_Week_13+MMM_Week_14)*7
Lamb_MMS_ME_Req =
(MMS_Week_1+MMS_Week_2+MMS_Week_3+MMS_Week_4+MMS_Week_5+MMS_Week_6+MMS_Week_7+MMS_Week_8)*7
LWt_G_MFM = 0.1
LWt_G_MFS = 0.2
LWt_G_MMM = 0.1
LWt_G_MMS = 0.2
Male_Constant = 1.15
MFM_F_10 = (MFM_Week_9+MFM_Week_10)*14
MFM_F_11 = (MFM_Week_11+MFM_Week_12)*14
MFM_F_12 = (MFM_Week_13+MFM_Week_14)*14
MFM_F_13 = (MFM_Week_15+MFM_Week_16)*14
MFM_F_14 = (MFM_Week_17+MFM_Week_18)*14
MFM_F_15 = (MFM_Week_19+MFM_Week_20)*14
MFM_F_16 = (MFM_Week_21+MFM_Week_22)*14
MFM_F_17 = (MFM_Week_23+MFM_Week_24)*14
MFM_F_18 = (MFM_Week_25+MFM_Week_26)*14
MFM_F_19 = (MFM_Week_27+MFM_Week_28)*14
MFM_F_20 = (MFM_Week_29+MFM_Week_30)*14
MFM_F_6 = (MFM_Week_1+MFM_Week_2)*14
MFM_F_7 = (MFM_Week_3+MFM_Week_4)*14
MFM_F_8 = (MFM_Week_5+MFM_Week_6)*14
MFM_F_9 = (MFM_Week_7+MFM_Week_8)*14
MFM_ME_Req = (IF Lamb_LWt_MFM=0 THEN 0 ELSE (Sheep_Constant*Female_Constant*(((0.28*Lamb_LWt_MFM^0.75)*EXP(-0.03*Age))/K_b)+(1.1*((((6.7+Rate_Wt_Gain_MFM)+((20.3-Rate_Wt_Gain_MFM)/(1+EXP(-6*(Current_LWt_MFM-0.4)))))*LWt_G_MFM*0.92)/K_g+0.13*((((Fleece_Wt*1000)/Time_in_days)/2)-6)))+(((C*DMI*(0.9-DMD))+(0.05*(Slope/(Green_Forage+3))))*Lamb_LWt_MFM)/K_b))
UNITS: MJ ME/d
MFM_Week_1 = (IF 1>"L-W_MFM" THEN 0 ELSE HISTORY (MFM_ME_Req, 1))*purebred_ME_calc.Lamb_MFTW_finishing
MFM_Week_10 = IF 10>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_9/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_9/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_9/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_9/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_11 = IF 11>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_10/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_10/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_10/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_10/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_12 = IF 12>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_11/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_11/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_11/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_11/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_13 = IF 13>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_12/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing

ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_12/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_12/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_12/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_14 = IF 14>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_13/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_13/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_13/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_13/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_15 = IF 15>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_14/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_14/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_14/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_14/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_16 = IF 16>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_15/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_15/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_15/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_15/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_17 = IF 17>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_16/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_16/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_16/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_16/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_18 = IF 18>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_17/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_17/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_17/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_17/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_19 = IF 19>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_18/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_18/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_18/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_18/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_2 = IF 2>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_1/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_1/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_1/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_1/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_20 = IF 20>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_19/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_19/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_19/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_19/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0

MFM_Week_21 = IF 21>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_20/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_20/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_20/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_20/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_22 = IF 22>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_21/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_21/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_21/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_21/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_23 = IF 23>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_22/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_22/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_22/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_22/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_24 = IF 24>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_23/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_23/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_23/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_23/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_25 = IF 25>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_24/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_24/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_24/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_24/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_26 = IF 26>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_25/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_25/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_25/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_25/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_27 = IF 27>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_26/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_26/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_26/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_26/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_28 = IF 28>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_27/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_27/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_27/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_27/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_29 = IF 29>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN
((MFM_Week_28/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing
ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_28/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN
((MFM_Week_28/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing

ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_28/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_3 = IF 3>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_2/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_2/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_2/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_2/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_30 = IF 30>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_29/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_29/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_29/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_29/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_4 = IF 4>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_3/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_3/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_3/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_3/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_5 = IF 5>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_4/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_4/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_4/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_4/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_6 = IF 6>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_5/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_5/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_5/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_5/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_7 = IF 7>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_6/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_6/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_6/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_6/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_8 = IF 8>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_7/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_7/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_7/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_7/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFM_Week_9 = IF 9>"L-W_MFM" THEN 0 ELSE IF LWt_G_MFM=0.4 THEN ((MFM_Week_8/purebred_ME_calc.Lamb_MFTW_finishing)+(0.4198*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.3 THEN ((MFM_Week_8/purebred_ME_calc.Lamb_MFTW_finishing)+(0.3189*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.2 THEN ((MFM_Week_8/purebred_ME_calc.Lamb_MFTW_finishing)+(0.2154*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE IF LWt_G_MFM=0.1 THEN ((MFM_Week_8/purebred_ME_calc.Lamb_MFTW_finishing)+(0.109*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MFTW_finishing ELSE 0
MFS_F_10 = (MFS_Week_9+MFS_Week_10)*14
MFS_F_11 = (MFS_Week_11+MFS_Week_12)*14
MFS_F_12 = (MFS_Week_13+MFS_Week_14)*14

MFS_F_13 = (MFS_Week_15+MFS_Week_16)*14
MFS_F_14 = (MFS_Week_17+MFS_Week_18)*14
MFS_F_15 = (MFS_Week_19+MFS_Week_20)*14
MFS_F_16 = (MFS_Week_21+MFS_Week_22)*14
MFS_F_17 = (MFS_Week_23+MFS_Week_24)*14
MFS_F_18 = (MFS_Week_25+MFS_Week_26)*14
MFS_F_19 = (MFS_Week_27+MFS_Week_28)*14
MFS_F_20 = (MFS_Week_29+MFS_Week_30)*14
MFS_F_6 = (MFS_Week_1+MFS_Week_2)*14
MFS_F_7 = (MFS_Week_3+MFS_Week_4)*14
MFS_F_8 = (MFS_Week_5+MFS_Week_6)*14
MFS_F_9 = (MFS_Week_7+MFS_Week_8)*14
MFS_ME_Req = (IF Lamb_LWt_MFS=0 THEN 0 ELSE (Sheep_Constant*Female_Constant*(((0.28*Lamb_LWt_MFS^0.75)*EXP(-0.03*Age))/K_b)+(1.1*((((6.7+Rate_Wt_Gain_MFS)+((20.3-Rate_Wt_Gain_MFS)/(1+EXP(-6*(Current_LWt_MFS-0.4)))))*LWt_G_MFS*0.92)/K_g+0.13*((((Fleece_Wt*1000)/Time_in_days)/2)-6)))+(((C*DMI*(0.9-DMD))+(0.05*(Slope/(Green_Forage+3))))*Lamb_LWt_MFS)/K_b))
UNITS: MJ ME/d
MFS_Week_1 = (IF 1>"L-W_MFS" THEN 0 ELSE HISTORY (MFS_ME_Req, 1))*purebred_ME_calc.Lamb_MFS_finishing
MFS_Week_10 = IF 10>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_9/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_9/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_9/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_9/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_11 = IF 11>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_10/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_10/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_10/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_10/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_12 = IF 12>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_11/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_11/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_11/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_11/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_13 = IF 13>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_12/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_12/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_12/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_12/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_14 = IF 14>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_13/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_13/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_13/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_13/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_15 = IF 14>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_14/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_14/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_14/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_14/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_16 = IF 16>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_15/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_15/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_15/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_15/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0

MFS_Week_17 = IF 17>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_16/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_16/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_16/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_16/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_18 = IF 18>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_17/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_17/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_17/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_17/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_19 = IF 19>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_18/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_18/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_18/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_18/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_2 = IF 2>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_1/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_1/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_1/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_1/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_20 = IF 20>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_19/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_19/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_19/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_19/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_21 = IF 21>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_20/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_20/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_20/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_20/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_22 = IF 22>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_21/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_21/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_21/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_21/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_23 = IF 23>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_22/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_22/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_22/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_22/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_24 = IF 24>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_23/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_23/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_23/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_23/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_25 = IF 25>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_24/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_24/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_24/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_24/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0

MFS_Week_26 = IF 26>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_25/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_25/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_25/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_25/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_27 = IF 27>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_26/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_26/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_26/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_26/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_28 = IF 12>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_27/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_27/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_27/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_27/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_29 = IF 13>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_28/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_28/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_28/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_28/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_3 = IF 3>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_2/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_2/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_2/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_2/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_30 = IF 14>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_29/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_29/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_29/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_29/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_4 = IF 4>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_3/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_3/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_3/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_3/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_5 = IF 5>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_4/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_4/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_4/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_4/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_6 = IF 6>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_5/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_5/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_5/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_5/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_7 = IF 7>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_6/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_6/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_6/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_6/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0

MFS_Week_8 = IF 8>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_7/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_7/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_7/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_7/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MFS_Week_9 = IF 9>"L-W_MFS" THEN 0 ELSE IF LWt_G_MFS=0.4 THEN ((MFS_Week_8/purebred_ME_calc.Lamb_MFS_finishing))+((0.4154*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.3 THEN ((MFS_Week_8/purebred_ME_calc.Lamb_MFS_finishing)+(0.3153*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.2 THEN ((MFS_Week_8/purebred_ME_calc.Lamb_MFS_finishing)+(0.2128*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MFS_finishing ELSE IF LWt_G_MFS=0.1 THEN ((MFS_Week_8/purebred_ME_calc.Lamb_MFS_finishing)+(0.1075*EXP(-0.003*2))) ELSE 0
MMM_F_10 = (MMM_Week_10+MMM_Week_9)*14
MMM_F_11 = (MMM_Week_12+MMM_Week_11)*14
MMM_F_12 = (MMM_Week_14+MMM_Week_13)*14
MMM_F_13 = (MMM_Week_16+MMM_Week_15)*14
MMM_F_14 = (MMM_Week_18+MMM_Week_17)*14
MMM_F_15 = (MMM_Week_20+MMM_Week_19)*14
MMM_F_16 = (MMM_Week_22+MMM_Week_21)*14
MMM_F_17 = (MMM_Week_24+MMM_Week_23)*14
MMM_F_18 = (MMM_Week_26+MMM_Week_25)*14
MMM_F_19 = (MMM_Week_28+MMM_Week_27)*14
MMM_F_20 = (MMM_Week_30+MMM_Week_29)*14
MMM_F_6 = (MMM_Week_2+MMM_Week_1)*14
MMM_F_7 = (MMM_Week_4+MMM_Week_3)*14
MMM_F_8 = (MMM_Week_6+MMM_Week_5)*14
MMM_F_9 = (MMM_Week_8+MMM_Week_7)*14
MMM_ME_Req = (IF Lamb_LWt_MMM=0 THEN 0 ELSE (Sheep_Constant*Male_Constant*(((0.28*Lamb_LWt_MMM^0.75)*EXP(-0.03*Age))/K_b)+(1.1*((((6.7+Rate_Wt_Gain_MMM)+((20.3-Rate_Wt_Gain_MMM)/(1+EXP(-6*(Current_LWt_MMM-0.4)))))*LWt_G_MMM*0.92)/K_g+0.13*((((Fleece_Wt*1000)/Time_in_days)/2)-6)))+(((C*DMI*(0.9-DMD))+(0.05*(Slope/(Green_Forage+3))))*Lamb_LWt_MMM)/K_b))
UNITS: MJ ME/d
MMM_Week_1 = (IF 1>"L-W_MMM" THEN 0 ELSE HISTORY (MMM_ME_Req, 1))*purebred_ME_calc.Lamb_MMTW_finishing
MMM_Week_10 = IF 10>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN ((MMM_Week_9/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_9/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN ((MMM_Week_9/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN ((MMM_Week_9/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_11 = IF 11>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN ((MMM_Week_10/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_10/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN ((MMM_Week_10/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN ((MMM_Week_10/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_12 = IF 12>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN ((MMM_Week_11/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_11/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN ((MMM_Week_11/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN ((MMM_Week_11/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_13 = IF 13>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN ((MMM_Week_12/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-

0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_12/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_12/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_12/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_14 = IF 14>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_13/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_13/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_13/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_13/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_15 = IF 15>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_14/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_14/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_14/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_14/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_16 = IF 16>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_15/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_15/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_15/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_15/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_17 = IF 17>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_16/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_16/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_16/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_16/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_18 = IF 18>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_17/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_17/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_17/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_17/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_19 = IF 19>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_18/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_18/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_18/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_18/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0

MMM_Week_2 = IF 2>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_1/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_1/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_1/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_1/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_20 = IF 20>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_19/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_19/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_19/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_19/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_21 = IF 21>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_20/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_20/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_20/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_20/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_22 = IF 22>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_21/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_21/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_21/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_21/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_23 = IF 23>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_22/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_22/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_22/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_22/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_24 = IF 24>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_23/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_23/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_23/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_23/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_25 = IF 25>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_24/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_24/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_24/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN

((MMM_Week_24/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_26 = IF 26>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_25/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_25/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_25/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_25/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_27 = IF 27>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_26/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_26/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_26/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_26/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_28 = IF 28>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_27/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_27/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_27/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_27/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_29 = IF 29>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_28/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_28/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_28/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_28/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_3 = IF 3>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_2/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_2/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_2/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_2/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_30 = IF 30>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_29/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-
0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.3 THEN
((MMM_Week_29/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_29/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_29/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_4 = IF 4>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_3/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_3/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_3/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN

((MMM_Week_3/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_5 = IF 5>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_4/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_4/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_4/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_4/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_6 = IF 6>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_5/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_5/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_5/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_5/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_7 = IF 7>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_6/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_6/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_6/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_6/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_8 = IF 8>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_7/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_7/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_7/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_7/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMM_Week_9 = IF 9>"L-W_MMM" THEN 0 ELSE IF LWt_G_MMM=0.4 THEN
((MMM_Week_8/purebred_ME_calc.Lamb_MMTW_finishing)+(0.471*EXP(-0.008*2)))*purebred_ME_calc.Lamb_MMTW_finishing
ELSE IF LWt_G_MMM=0.3 THEN ((MMM_Week_8/purebred_ME_calc.Lamb_MMTW_finishing)+(0.358*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.2 THEN
((MMM_Week_8/purebred_ME_calc.Lamb_MMTW_finishing)+(0.2418*EXP(-
0.006*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE IF LWt_G_MMM=0.1 THEN
((MMM_Week_8/purebred_ME_calc.Lamb_MMTW_finishing)+(0.1224*EXP(-
0.004*2)))*purebred_ME_calc.Lamb_MMTW_finishing ELSE 0
MMS_F_7 = (MMS_Week_3+MMS_Week_4)*14
MMS_F_8 = (MMS_Week_5+MMS_Week_6)*14
MMS_F_9 = (MMS_Week_7+MMS_Week_8)*14
MMS_F6 = (MMS_Week_1+MMS_Week_2)*14
MMS_ME_Req = (IF Lamb_LWt_MMS=0 THEN 0 ELSE (Sheep_Constant*Male_Constant*(((0.28*Lamb_LWt_MMS^0.75)*EXP(-
0.03*Age))/K_b)+(1.1*((((6.7+Rate_Wt_Gain_MMS)+((20.3-Rate_Wt_Gain_MMS)/(1+EXP(-6*(Current_LWt-
0.4)))))*LWt_G_MMS*0.92)/K_g+0.13*((((Fleece_Wt*1000)/Time_in_days)/2)-6)))+(((C*DMI*(0.9-
DMD))+(0.05*(Slope/(Green_Forage+3))))*Lamb_LWt_MMS)/K_b))
UNITS: MJ ME/d
MMS_Week_1 = (IF 1>"L-W_MMS" THEN 0 ELSE HISTORY (MMS_ME_Req, 1))*purebred_ME_calc.Lamb_MMS_finishing
MMS_Week_2 = (IF 2>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN
(MMS_Week_1/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE
IF LWt_G_MMS=0.3 THEN (MMS_Week_1/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-
0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN
(MMS_Week_1/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE
IF LWt_G_MMS=0.1 THEN (MMS_Week_1/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-
0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_3 = (IF 3>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN
(MMS_Week_2/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE

IF LWt_G_MMS=0.3 THEN (MMS_Week_2/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_2/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_2/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_4 = (IF 4>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN (MMS_Week_3/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE IF LWt_G_MMS=0.3 THEN (MMS_Week_3/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_3/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_3/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_5 = (IF 5>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN (MMS_Week_4/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE IF LWt_G_MMS=0.3 THEN (MMS_Week_4/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_4/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_4/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_6 = (IF 6>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN (MMS_Week_5/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE IF LWt_G_MMS=0.3 THEN (MMS_Week_5/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_5/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_5/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_7 = (IF 7>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN (MMS_Week_6/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE IF LWt_G_MMS=0.3 THEN (MMS_Week_6/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_6/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_6/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
MMS_Week_8 = (IF 8>"L-W_MMS" THEN 0 ELSE IF LWt_G_MMS=0.4 THEN (MMS_Week_7/purebred_ME_calc.Lamb_MMS_finishing+(0.4659*EXP(-0.008*2))*purebred_ME_calc.Lamb_MMS_finishing) ELSE IF LWt_G_MMS=0.3 THEN (MMS_Week_7/purebred_ME_calc.Lamb_MMS_finishing+(0.3538*EXP(-0.007*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.2 THEN (MMS_Week_7/purebred_ME_calc.Lamb_MMS_finishing+(0.2417*EXP(-0.006*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE IF LWt_G_MMS=0.1 THEN (MMS_Week_7/purebred_ME_calc.Lamb_MMS_finishing+(0.1296*EXP(-0.005*2)))*purebred_ME_calc.Lamb_MMS_finishing ELSE 0)
Rate_Wt_Gain_MFM = (EBC_MFM/(4*SR_Wt^0.75))-1
Rate_Wt_Gain_MFS = (EBC_MFS/(4*SR_Wt^0.75))-1
Rate_Wt_Gain_MMM = (EBC_MMM/(4*SR_Wt^0.75))-1
Rate_Wt_Gain_MMS = (EBC/(4*SR_Wt^0.75))-1

Sheep_Constant = 1
Slope = 1.5
SR_Wt = 35.5
UNITS: kg
DOCUMENT: Standard Reference Weight (SRW)
The weight of a dry adult animal that is bare shorn and in good condition (CS 3). This is reflects the frame size of the sheep.
Source: http://www.lifetimewool.com.au/glossary.aspx

Lambs SRW
SRW=Target LWt-BCS Change-Gut fill- Fleece weigh
Where;
Target LWt=40kg
BCS Change= (Lamb BCS- BSC3)*0.19. e.g. Lamb BSC3 weight is 40, current BSC2, then (1-40)*0.19.
Gut fill= 0.05*Target LWt
Fleece weight= 5.0kg/2
SRW=40-0-(0.05*4.0)-(5/2)
SRW=35.5kg
Time_in_days = 365
Total_Weekly_ME_lamb =
(Lamb_ME_Week_1+Lamb_ME_Week_2+Lamb_ME_Week_3+Lamb_ME_Week_4+Lamb_ME_Week_5+Lamb_ME_Week_6+Lamb_ME_Week_7+Lamb_ME_Week_8+Lamb_ME_Week_9+Lamb_ME_Week_10+Lamb_ME_Week_11+Lamb_ME_Week_12+Lamb_ME_Week_13+Lamb_ME_Week_14+Lamb_ME_Week_15+Lamb_ME_Week_16+Lamb_ME_Week_17+Lamb_ME_Week_18+Lamb_ME_Week_19+Lamb_ME_Week_20+Lamb_ME_Week_21+Lamb_ME_Week_22+Lamb_ME_Week_23+Lamb_ME_Week_24+Lamb_ME_Week_25+Lamb_ME_Week_26+Lamb_ME_Week_27+Lamb_ME_Week_28+Lamb_ME_Week_29+Lamb_ME_Week_30)*7