A Bio-economic Feasibility Study of Sheep Dairy Systems in Canterbury

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This research study outlines the investigative process to determine relevant factors initiating a change from conventional sheep farms to sheep dairy farms on the Canterbury plains and the potential of a sheep milking industry developing with regard to current environmental restraints. It addresses the current issues in Canterbury regarding the trend towards dairy farming on the plains and the impact this is having on the environment. Water use, quality and management are key components, concerning waste management and nitrate leaching. Regulations on irrigation and nutrient leaching is a primary concern for farmers in the region. Cows have a high environmental foot print and urine patches are a source of high N loading to pastures which can leach into ground water. A brief evaluation of the sheep meat and wool industry has been touched on to gauge how farmers are coping in the current environment and to provide an indication of motives which have initiated a shift from sheep farming to sheep dairying. Sheep milking in New Zealand is a very small industry and literature on production is limited therefore the review touches on the potential the industry has, given changing global demographics and the demand for protein products. The method utilised to study a range of sheep milking systems is a quantitative normative approach based on the collation of research material with the aim to draw positive conclusions. Computer modelling tools have been used to simulate the set-up of a sheep milking scenarios in Canterbury and provide an insight into the expected performance. Results between systems have been compared and also contrasted with a traditional sheep farming model. The scenarios provide an indication of the variety of systems possible which incorporate the milking of sheep. The major varying factors are the lamb weaning treatments. The overall outcome of the study is that given an industry presence in the region, sheep milking in Canterbury is a feasible farming operation which is gentler to the environment than cow dairy counterparts.

Keywords: Sheep, milking, dairy, lamb rearing, linear programming, weaning treatments, genetics, environment, meat and wool industry, grazing management, wintering, genetics

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Table of Contents

List of Tables

List of Figures

Chapter 1 Literature Review

Introduction

New Zealand has a small sheep dairy industry with approximately 30,000 sheep milked per annum by four main producers. The main producer (Blue River dairy) creates milk powder for export. With some product diverted for use in cheeses and ice cream. There are also a number of small scale producers which occupy a niche market for cheese etc. The industry is comprised of these separate enterprises. There is no large 'umbrella' cooperative which encompasses these businesses. There is however a huge potential for sheep milking to be successful in New Zealand. Sheep are versatile animals in terms of production, providing meat and wool to growers. The addition of milk would add value to farm systems. Unlike the bovine dairy industry there is a ready export market for cull ewes and surplus lambs. The three avenues of production would enable management to be flexible and adjust accordingly to market signals. In addition, contrasting with cow dairy systems, there are a number of favourable properties to sheep milk such as its higher whey content which provides easier digestion than cows' milk (McDermott, Saunders, Zellman, Hope, & Fisher, 2008). It also contains high levels of calcium and vitamin D. It is similar in properties to goats' milk. The goat industry has been particularly successful and the MS pay out from the goat cooperative can reach up to $18/kg of MS (Trafford, 2013). This is an indication of the potential direction a sheep milking industry could head. In comparison to dairy cows, sheep have a lower environmental impact which would suit the Canterbury region. An issue for farmers is that the trend in irrigating pastures and converting to cow dairy farming has caused the price of land to increase. This is an issue for dry land farmers because they have to compete with the exorbitant land prices created by the dairy industry if they want to upscale. However, legislations regarding the ability to irrigate have been included in the Canterbury Water Management strategy. In several zones of the region, limitations have been placed on the ability to gain consents to irrigate which has reduced the feasibility of many further cow dairy conversions. Milking sheep could be an option for farmers wishing to increase profitability and do so within current environmental constraints. Such reasons may eventuate in sheep milking becoming prevalent in Canterbury and creating a more robust industry in New Zealand.

1.1 Overview of the New Zealand Sheep Industry

The New Zealand sheep industry has evolved and transformed overtime to be in response to ever changing markets. There are several factors that can be attributed to transforming the sheep meat industry overtime and can to some extent explain the current nature of the industry. Historically New Zealand has had preferential market access to the EU with tariff free quotas. The security of this market

discouraged diversification of export markets. Producers are also exposed to a market economy and full risks associated as a result of the 1980s government de-regulation. The market trend in favour of chilled meat is also an issue for New Zealand's seasonal pasture based system which limits its potential export markets because supply is not possible all year round. Seasonality is a favourable aspect to EU export markets. Farmer and processor behaviour is a key factor which has influenced industry progress. Farmers typically take a short term view and are primarily concerned with their business success (McDermott et al., 2008). A profit focussed approach results in lack of commitment to processing companies which leads to no certainty of supply. Such conduct gives rise to competitive performance between processors in order to secure supply. This fragmented structure and lack of collaboration from involved parties is a difficult foundation for the industry to grow on.

A rising tide of cow dairy farm conversions particularly across Canterbury is evidence that the dairy industry is currently lucrative, and an indicator that farmers can see a long term future in the stability of the industry. The sheep meat industry in comparison has been characterised with low profitability which has recently been exacerbated with the nationwide drought in 2013 and the strong NZ dollar (Knutson R. McNeill J. Armstrong K. and Forbes R., 2009). The outlook for the sheep meat industry deteriorates with the growing success of the dairy industry. Firstly input costs increase such as higher land prices from dairy demand which lowers profitability. There has also been a shift in the land use and dry land sheep operations are being driven to the fringes of extensive hill country. Less productive land cannot support similar stocking rates as fertile flats, another factor leading to decline of profitability. Utilising more extensive terrain could be a potential risk for sheep and beef farmers if the forestry industry outlook improved. The national sheep and beef farm land area dropped 2% between 2002 and 2006(Ministry for Primary Industries, 2013) .

In 2008 MAF completed a Delphi survey which encompasses contributors from across the industry. The participants expected sheep and beef land area to further decrease by 5-10% in the next 10-15 years (Knutson R. McNeill J. Armstrong K. and Forbes R., 2009). This is a continuation of the trend experienced since the mid 1980's (see figure 1-1).

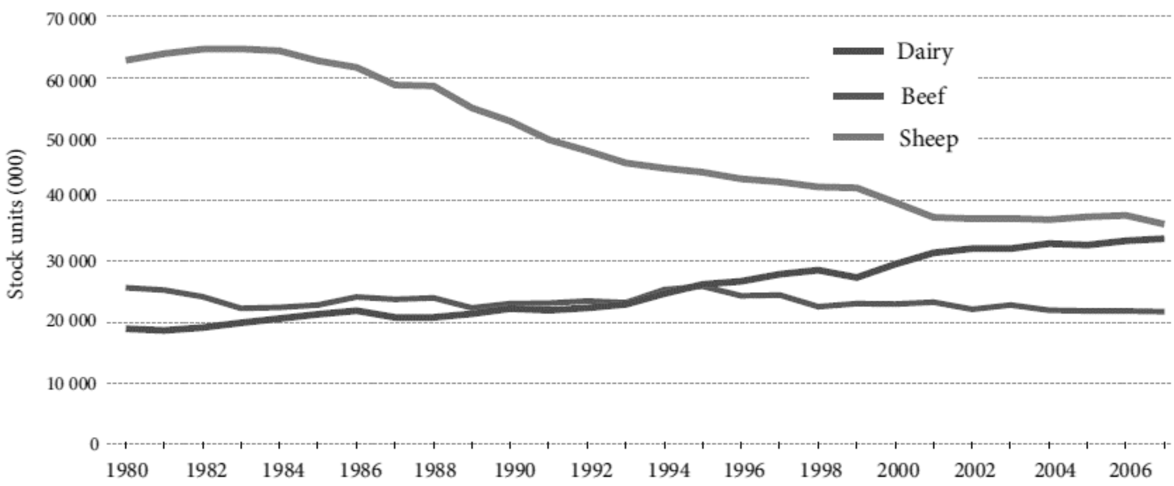

Figure 1-1 Trend in Stock Units in New Zealand from 1980-2007(Knutson R. McNeill J. Armstrong K. and Forbes R., 2009)

Some of the decline in sheep stock units can be explained by advances in production such as improved genetics and lambing percentages. Beef numbers are relatively static, however the dairy stock units have increased over the past 20 years which reflects the rising success of the industry.

The wool industry has also been fraught with disappointment ever since the introduction of synthetic fibres. Synthetics are man-made from oil by-products and fabrics/fibres can be produced to direct specifications. Wool, on the other hand is a biological product in which there is a lot of variation which can be frustrating for processors. Lack of education and information flows in the supply chain has negatively impacted demand. Prices received at the farm gate are low and are barely sufficient to cover shearing costs. The industry focus shift from wool to meat has initiated a change in breeds resulting in greater cross bred wool production. Cross bred wool is destined for carpets and upholstery and achieves lower prices than fine wool such as Merino. The export prices are led by China's domestic demand and the export markets of finished wool products in Europe, Japan and the US. In these markets synthetic based carpets are a prime competitor because consumers are so far removed from the production process, they make uneducated purchase decisions. Since 2011 the export price for wool has fallen 40% from USD6.52 per kilogram of product weight to USD3.98 in 2013 (Ministry for Primary Industries, 2013).

These are factors which reduce the profitability and attractiveness of sheep and beef farming. They are also a reason explaining the increase in more profitable cow dairying on the Canterbury plains.

1.2 Issues Surrounding Water for Agriculture

New Zealand has traditionally marketed its products with an image of a 'Clean and Green' producer nation. This has a specific market appeal to highly populated urban areas of Asia because the image symbolises a healthy product and food safety. Statistics from (Pangborn & Woodford, 2011) indicate there has been exponential growth in land area utilised for cow dairy farming in Canterbury since 1982-2009. If such growth continues there will be a trade off with the environment and a loss of the country's reputable reputation. Sheep milking may provide the alternative to continuation of production of a milk product at a lower environmental cost.

Dairying has only been possible in Canterbury through the extensive development of spray irrigation. Figure 1-2 indicates the exponential like growth in dairying land area on the Canterbury plains.

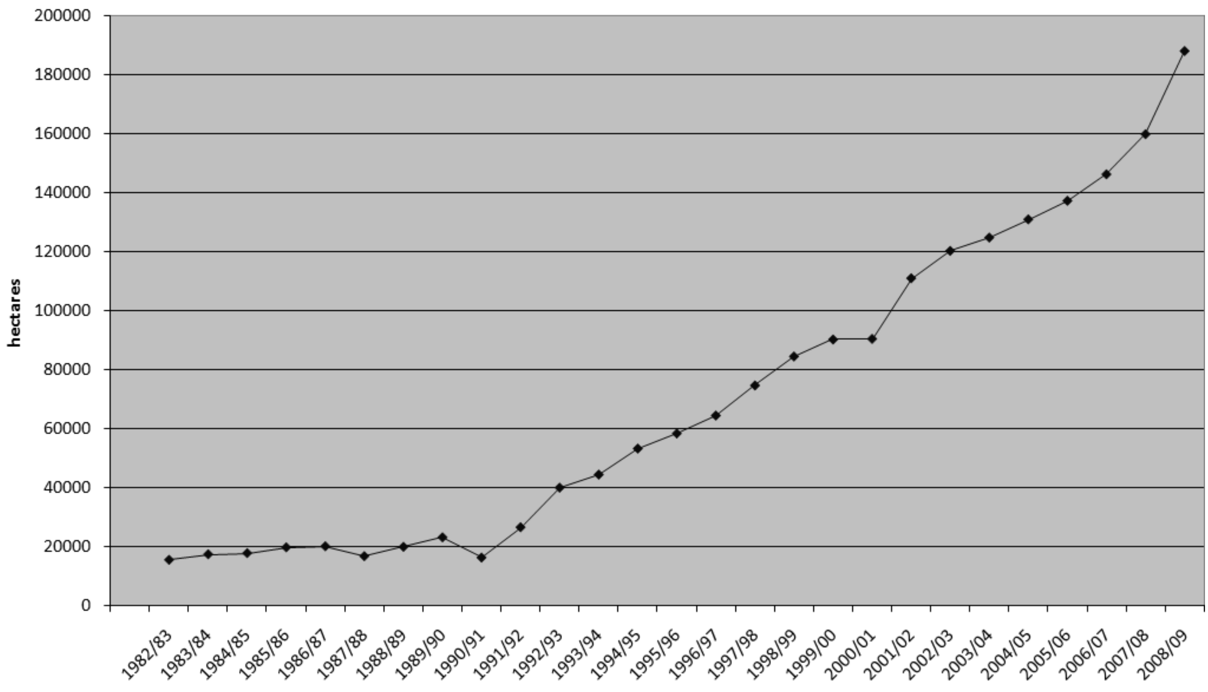

Figure 1-2 Canterbury dairy farming area (ha) 1982-83 to 2008-09 (Pangborn & Woodford, 2011)

As a region, Canterbury occupies 17% of the countries land mass and uses 58% of allocated water. Of this 58%, 70% is destined for irrigation(Pangborn & Woodford, 2011).

The Canterbury water management strategy (CWMS) is aimed to provide a standard for water use and management in the region. The region is divided into 10 zones in which each have their own policies with objectives pertaining to the main goals of the CWMS. Strategies have been set up with the input from water users. There has been huge pressure to act and implement water use and management policies by various water users, organisations and environmentalists. An example is Fish and Game who have investigated the water quality and aquatic life of the Selwyn Waihora zone which is home to the two most fished rivers in New Zealand, the Waimakariri and the Rakaia (Morgan M., 2002). In 1949

approximately 65,000 fish were known to be spawning up these rivers however data released by Fish and Game in 2007 recorded only 257 (Hawker, 2011)Suggesting that the lowland brown trout fisheries have suffered a demise in these areas due to reduced lowland stream flows and poorer water quality. For this zone, allocation limits of 35% for ground and surface water extraction have been implemented. All new applications for consent will be prohibited and future land use intensification must not allow N leaching levels to exceed 15kgs per ha. Water transfers are allowed, however 50% of the volume will have to be surrendered. Also there will be a requirement for efficient and justified water use included in audited farm environment plans (Environment Canterbury, 2013). This is a significant issue for farmers without irrigation. With consents for irrigation no longer being processed, the saleability of the land is suddenly reduced. For farmers on the verge of retirement, expecting a decent return on the sale of their property, this is a disappointing outcome. It is also a factor which can hinder succession progress as a dry land property may only sufficiently support one family as opposed to irrigated land supporting two.

In relation to water use, farmers will be encouraged to improve the efficiency and effectiveness of their irrigation to ensure they comply with the new standards. It also might encourage better use of effluent waste. With regard to extraction, new regulations will deter farmers from converting to dairying within this zone because of inability to irrigate. Likewise in converting a block or shifting irrigation consents to other areas, a reduction of 50% of allocated water will have a significant negative impact on production.

1.3 Environmental Impact

Nitrate leaching from agricultural production systems is a specific concern regarding water quality of surface and ground water. Leaching occurs when there is excess nitrate in the soil profile coinciding with high drainage. Waste effluent, nitrogen fertiliser or urine patches contribute to high nitrate levels in the soil. This is a leading issue for the dairy industry as cows are notorious for having a high N loading urine patch at over 1000kg/N/ha. One cow can relieve herself 10-12 times per day with each patch covering an area ranging between 0.5-0.7$m^{2.}$ On a grazed 1 ha pasture this equates to 20-30% of area assigned to urine patches (H. J. Di & Cameron, 2007). A combination of urine patches, N fertiliser and shed effluent can severely exacerbate leaching potential especially during autumn and winter when there is low evapotranspiration and more drainage.

In comparison to cows, sheep do not have the same leaching effect because they have a lower volume of urine. Cows produce 10L/m^2 and sheep produce 5L/m^2 (Magesan, White, & Scotter, 1996). In a trial (Magesan et al., 1996) nitrate leaching levels of a sheep grazed on ryegrass and clover pasture did not increase compared to a similar pasture from which hay was cut and there was no stock access. A comparable study (Haynes & Williams, 1993) with similar soil types measured the effect of leaching

from dairy cows and found that the leaching levels increased 5 times for a pasture grazed system with cows than without.

In terms of marketing, the low nitrate leaching potential of sheep versus cattle could be a beneficial factor which can be highlighted through marketing. As perception of and the value of the environment increases, so does the market for environmentally sustainable products. An example of this is the Taupo Beef branding. Farming in the Taupo region with compliance standards regarding nutrient loading with the aim to preserve water quality, has enabled farmers to brand their beef and receive premiums on the menus of two 'up market' restaurants (Waikato Regional Council, 2013). The environmentally sustainable farming message has generated positive public responses. Indicating that there is a consumer group whom environment preservation is of high importance to.

1.4 Introduction to Sheep Milking in New Zealand

Sheep milk is not a traditional beverage consumed by people in the western world. This can be partly associated to cultural behaviours and also to the development of agriculture which has advanced the bovine dairy industry. Cow's milk production is advantageously higher than production achieved by sheep milk. Cow's milk is more widely consumed in its original form in western developed countries.

In contrast sheep milk is often transformed into other dairy products such as cheese, yoghurt and ice cream. These are the products which are most notably exported. In 2013 the United states imported 50% of the world's sheep cheese (Radio New Zealand News, 2014). However the countries where sheep milk is predominantly produced are large consumers of the product as it is culturally ingrained. The majority of sheep milk produced is destined for domestic consumption.

Table 1-1 Major Sheep Milk Producer Nations

Country	Sheep milk production (tonnes)
China	1,150,000
Greece	780,000
Turkey	734,219
Syrian Arab Republic	706,023
Romania	600,444
Italy	599,500
Sudan	513,000
Spain	506,700
France	253,270

As detailed in Table 1-1 the major milk producing nations are localised in the Mediterranean region, Northern Africa and China. Favourable sheep milk production genetics stem from these areas. Sheep are essentially a tri use animal which raises their value and increases flexibility in farming in harsh conditions. Figure 1-3 provides a visual indication of the localities of where the major sheep milk producing nations.

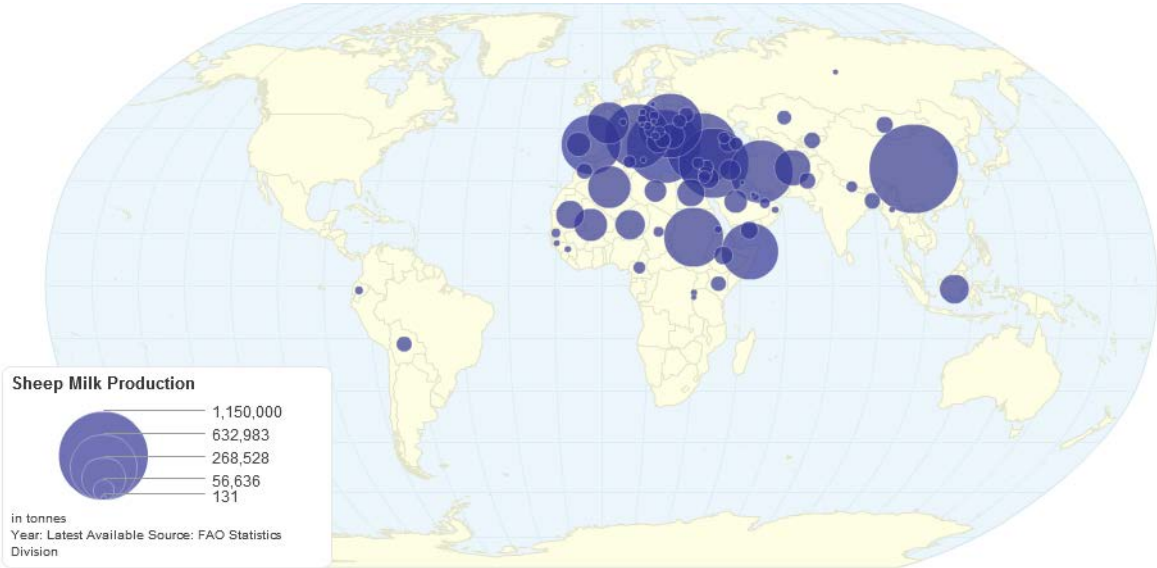

Figure 1-3 Significant Global Sheep Milk Production Locations (FAO Statistics Division, 2011)

Exportation of sheep milk as a raw product is relatively rare. The milk has physical properties which are favourable for cheese, yoghurt and butter manufacture. These are the products which are most widely exported. In terms of export scale, sheep milk products occupy a 1.4% share of the global dairy market. The majority of production coming from the Middle East and Northern Africa, China and South East Asia as detailed in Table 1-2

Table 1-2 Sheep Milk Export Production

Area	Proportion of global dairy market
Middle East and Northern Africa	7.5%
China	4%
South East Asia	3.9%

In New Zealand commercial sheep milking operations are a relatively new venture. There are 2 major producers, a North Island producer, Waituhi Kuratau and the South Island based Blue River Dairy milking approximately 1,300 and 20,000 ewes respectively. With figures as such, New Zealand is unable to compete in the global market with any form of scale for niche products such as cheese. The industry in New Zealand is also relatively young and the lack of a rich culture or product history/heritage cannot

provide additional value to differentiated products. An example of where this can be beneficial in marketing products is the world renowned Roquefort cheese of France. Products from the Blue River Dairy initially were destined to service the domestic industry with cheese and ice cream as best sellers however the opportunity to move into the milk powder market and infant formula product range has been identified as a lucrative opportunity.

There is however an opportunity in the milk powder market. Since cheese and other milk derivatives have immense popularity. The milk powder market in the sheep milk sector has been over looked. This could be ascertained to the fact that cows have greater volume in production and therefore there is sufficient scale for large production of milk powder.

Providing sheep milk powder to the global market has several advantages for New Zealand. Firstly there is the low cost competitive advantage which is associated with pastoral based agriculture. Animals grazing pasture outdoors is a highly cost efficient farming system as there is no capital expenditure for animal housing and there is no labour requirement for cut and carry feed operations. There are additional positives in that there is low competition for products domestically. Sheep's milk is not widely consumed in New Zealand therefore the industry is able to fully focus on building and strengthening its export markets.

The significance of the sheep milk industry to the New Zealand market is at present very low. This is partly due to lack of knowledge of the product as New Zealanders are traditionally reared on cow's milk. Also the New Zealand sheep industry is focused on meat and wool, therefore it would be likely to assume that milking sheep is a novel industry. Also the scale of the industry is very small and until recently has been concentrated on supplying products to a niche market which only a small proportion of the population access. However the recent overseas investment into Blue River has sparked public attention and a stream of media continues to highlights the potential of the industry as an export gold mine for the economy. The New Zealand bovine dairy industry has been largely successful because the industry has developed and there has been an explosive demand trend arising from emerging countries led by China (Tiwari, 2014). This has been extremely valuable to the New Zealand economy and has thrust the dairy industry into the public eye. A rising demand for dairy products is also favourable to the New Zealand sheep milk industry as it falls into the dairy category. An estimated 50% of Asians are intolerant of cow's milk (Primary Production Committee, 2013). This provides an opportunity for the sheep milk industry to fill the gap and market to consumers whom are intolerant of cow's milk. The infant milk formula avenue has huge potential because food safety is paramount for consumers in Asian countries. With China's one child policy, almost six incomes are in support of the upbringing of one child, thus there is a market for premium infant formula. For New Zealand's sheep milk industry to tap into this market there is potential for valuable revenue for the economy through exports. Milking sheep is far less intensive on the land and there are fewer environmental issues associated. In terms

of the clean green image New Zealand promotes, milking sheep on lush pastures is an accurate semblance.

1.5 Characteristics of the Milk and Marketing Potential

Sheep milk consists of a higher proportion of short to medium chain saturated fatty acids which aids lactose absorption which can benefit mildly lactose intolerant people. Sheep's milk is also 3x higher in the amount of whey which is removed when cheese is made. Whey is another component which aids digestion (Raynal-Ljutovac, Lagriffoul, Paccard, Guillet, & Chilliard, 2008). The milk has other beneficial qualities such as higher calcium levels than cows at 110mg/100g and 162mg/100g respectively. Vitamin D levels are also higher at 0.18g/100g than cow's milk at 0.04g/100g (Raynal-Ljutovac et al., 2008).Vitamin D is associated with the regulation of phosphorous and calcium absorption in bones.

Sheep milk also is lacking the a1 beta-casein milk protein which classifies the milk as a2. There is controversy over the theory that a1 milk facilitates the immunological processes that lead to type 1 diabetes and coronary heart disease. In contrast milk that contains the a2 beta casein has not the disadvantages of the a1 classed milk (Woodford, 2006). A2 milk was discovered and initially marketed by the New Zealand A2 milk company in the 1990s. It has been very successful and is now the leading premium milk brand in Australia. Sheep milk falls into the A2 category and therefore there could be huge market potential.

Sheep milk is suitable for many end use products because of its physical composition. Stepping aside from the large picture and scaling back to niche market products. Sheep milk produces high quality cheese and ice cream. An example would be the famous French cheese, Roquefort. This cheese is derived from sheep milk of the Lacaune breed and it is aged for 5 months in ancient limestone caves of the Roquefort region in southern France. The limestone caves are essential to the ageing process as a warm humid environment is fundamental to the formation of the blue/green veins which create the unique tang in the cheese. The fungi which helps to develop this flavour is thought to be unique to the soils within the caves of the Roquefort region. The naming rights for the cheese is specifically refined to the area. Cheese made out of the region cannot bear the Roquefort name. This is a unique branding and marketing aspect which ensures the superiority of the product is not degraded through mass production in other locations. Although this research proposal is aimed at designing a system to produce milk powder for an export market. It does not detract from the fact there is potential for New Zealand to develop a similar niche product with the same marketing and branding concept.

The growing middle class in Asia creates a very high demand for digestible milks, particularly sheep and goats, in the infant formula and milk powder market. This could lead to huge potential for sheep milk to become a successful industry in New Zealand. So far the industry has been curbed by two major

constraints. They are; one, a lack of an identifiable processor to collect, process and market the product and two, a limited genetic pool for milking sheep in New Zealand. These two constraints have deterred others from entering the industry and therefore there are few farms with which to bench mark performance and returns. Scarce information on investment potential or certainty is a factor which discourages banks or investors to provide financial backing for new business ventures in the Industry (Trafford, 2013).

1.6 Sheep Milking Genetics

Another issue which a growing sheep dairy industry in New Zealand would face is the limited genetics available. Predominantly the East Friesian breed is utilised for sheep milking however this breed has historically within New Zealand, been selected for traits to improve fertility and milk production in meat breeds. There has been low selection for milking ability and udder conformation (Trafford, 2013). Another breed used for milking is the Awassi. However this breed has a lower fertility than the East Friesian variety. A cross between the Awassi and the East Friesian has been developed in Israel. It is called the Assaf. It has improved fecundity and is a dual purpose animal. It is adapted to semi extensive production systems and can produce up to 450L of milk per year. Under Israeli conditions ewes can lamb 3 times in 2 years, a concept described in figure 3.0. The breed is yet to become established in New Zealand, however it could be a potential breed option for sheep milking in New Zealand.

The French dairy ewe industry has developed a breed called the Laucane. Characteristically Laucane sheep are robust animals with good udder conformation and milk production traits. A French government agency initiated a large scale rigorous selection programme resulting in the insemination of several million ewes. It resulted in a 6.3% milk yield increase per ewe per annum over the 30 year period. Of which 2.4% was genetic and 3.9% phenotypic (Jeremy Clark, 2014). It is the most widely used dairy sheep breed in Southern France and the milk product is primarily used for the nation's traditional Roquefort cheese. The hardy nature of this breed would suit various New Zealand climates however the breed is not as fertile as the East Friesian. Fertility is a key element which characterises any dairying industry. The animals' ability to become pregnant dictates the lactation period and is a positive factor for genetic gain. Fast genetic gain requires a large gene pool. Currently in New Zealand the low milking sheep numbers will mean that genetic advances will be a long slow process.

1.7 The Potential of Sheep Milking

Profitability of sheep milking in New Zealand would depend on a number of factors. They are production, processor or marketing price for milk solids, and set up and running costs etc. Production is a variable measurement and is conditional on a number of external and genetic influences. For the East Friesian breed, New Zealand milk producers receive between one and two litres per sheep per day (Trafford, 2013). Research on the Assaf breed of sheep indicates there is potential to achieve high

milk yields such as 334L over a short 173 day lactation which equates to nearly two litres per day (Pollott & Gootwine, 2004). Sheep milk has a high milk solid percentage of 19.3 % in comparison to cows at 12% (Haenlein, 2002). This of course is off set by the greater volume in production of cow's milk. The milk solid component is made up of protein and fat, in which sheep milk is very high. This is one of the factors why sheep's milk produces high quality cheese, combined, protein and fat equate to approximately 10 % of the milk. Protein and fat content can vary between different breeds of sheep and are also influenced by milk yield during the lactation period. If lambs are removed 24 hours after birth, the lactation curve is similar to dairy cows. For the first 20-40 days the milk yield increases before reaching a peak and steadily declining. As milk yield decreases the percentage of fat, protein and lactose increase in proportion to volume reduced.

Effects on production are components of management and day length is also an influencing factor in milk production. Extensive research into the effect of photoperiod on sheep lactation is lacking, however, a study on Assaf sheep under intensive management indicated that the difference between mid-summer and mid-winter day length had a 0.44L impact on daily lactation (Pollott & Gootwine, 2004). This might be an item of consideration if contemplating the Cornell star breeding regime mating every 7.2 months to result in 3 lambing's over 2 years and a 12 month supply of milk (M. Thonney, 2013).

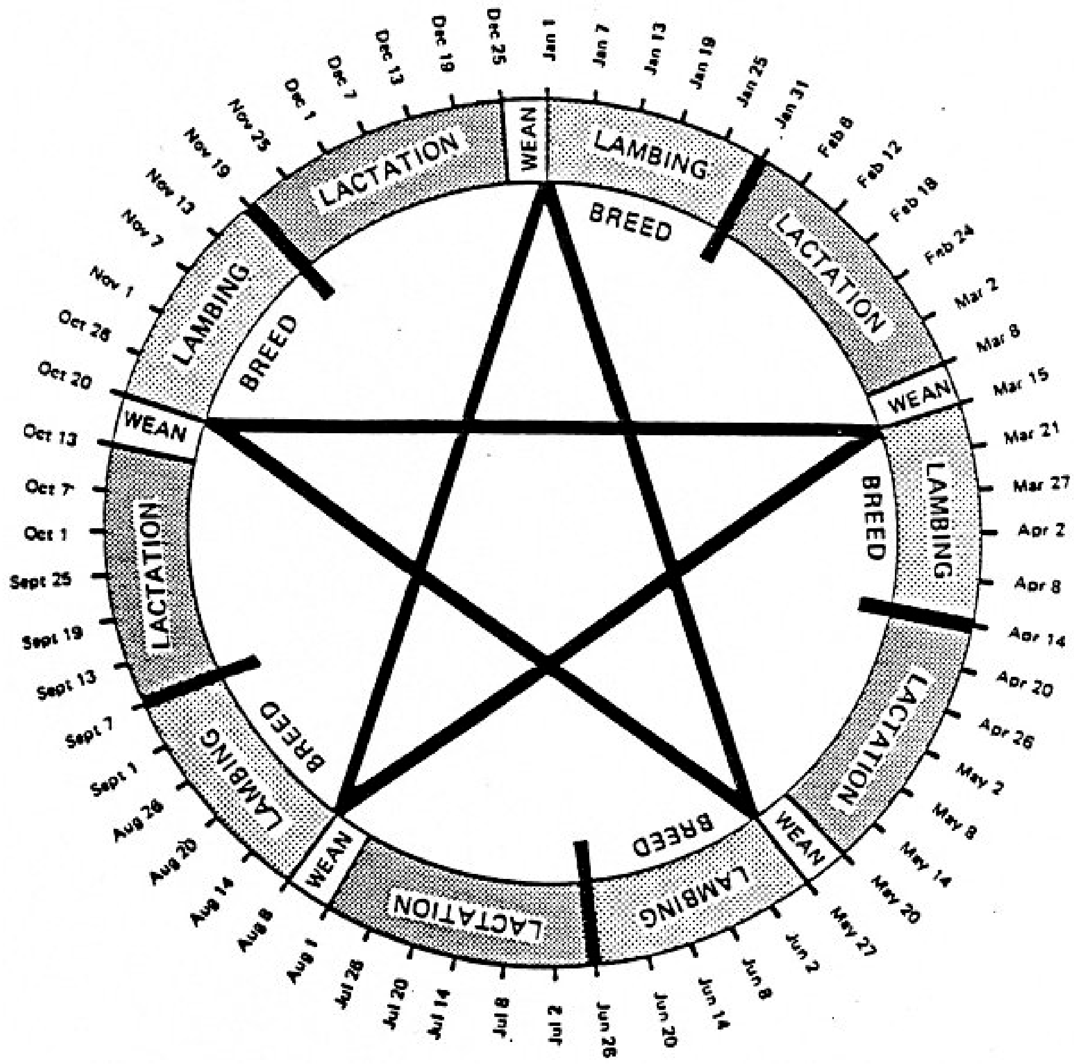

Figure 1-4 Cornell star sheep management program (M. Thonney, 2013)

However production modelled for a non-seasonal system indicated a higher performance in Table 1-3 in comparison to a seasonal system Table 1-4

Table 1-3 Non seasonal Sheep milking performance (Trafford, 2013)

	Litres per ewe(equivalent)	%MS	Daily milk production	MS production
MA	450.00	12%	1.23	54.00
2th	340.00	12%	0.93	40.80
Hogget	135.00	12%	0.37	16.20

Table 1-4 Conventional Sheep milking performance (Trafford, 2013)

Milking Performance				
	Litres per ewe	%MS	Kgs MS per ewe	MS Daily milk production
MA	300	12%	36.00	1.42
2th	220	12%	26.40	1.04
Hogget	85	12%	12.00	0.47

In comparison to cow dairy farming there are several immediate benefits to management which are evident. Sheep are lighter on the land and do not require housing in cooler conditions and do not have the same environmental toll as dairy cows with effluent and nitrate leaching. They also provide several forms of income; milk, meat and wool. There is a strong market for male lambs, which can be finished or sold store depending on feed supply and the farm system. Wool is a tertiary income, generated from all the stock classes.

With regard to economics, sheep dairying might be a more profitable venture than a conventional dry land sheep farm. Figures sourced from (Trafford, 2013) report for Synlait Ltd, were based on a variety of modelled scenarios. A conventional sheep breeding and finishing system, a sheep milking system and a cow dairy farm. A comparison between the return on assets showed that the dry land sheep farm model returned 2.8%, an irrigated sheep dairy returned 7.8% and an irrigated cow dairy retuned 7.2% (Trafford, 2013).To achieve these figures many production assumptions were insinuated and values were kept conservative. It does however provide an insight into the potential profitability of a sheep milking system. Although it appears that the sheep milking has a slightly higher return than a cow system, the current economic environment and the peak in milk solid pay out price at $8.65/kg of MS for the 2013/14 year (Piddock, 2014) would definitely influence the profitability of the system as the model was based on a $7/kg of MS. Also the capital structure cost for a dairy farm is higher than a sheep dairy farm. The industry structure and stability is also another attractive attribute to the cow dairy system with reliability of a strong successful cooperative over a sheep milking industry which at this stage is almost inexistent. However, evaluating a dry land sheep operation with a sheep dairy system, there is a 5% return on asset difference which could be potentially attractive to farmers wishing to improve profitability while remaining involved with working sheep. Sheep milking encompasses similar workings to that of a dry land sheep operation such as shearing, mating, lamb rearing however there is a slight shift in objective, from lamb growth and development to ewe condition and lactation.

1.8 Adoption of Change

The potential and growth of a sheep milking industry in New Zealand is dependent on farmers' willingness and ability to change their farm systems and adopt new practises and technology. A shift in Canterbury towards cow dairying is driven by farmers seeking higher returns. They are generally assured that the change will have a positive outcome for their business, others who have converted previously are operating examples. It is a different concept when there is not an already established industry. Initial development in a new industry is a pioneering feat and it is a gamble which relies on the banding together of farmers to follow suit. However, decision making by farmers is not only production driven, there are external factors with increasing pressures toward environmentally sustainable farming which may alleviate production (Gasson & Potter, 1988).

Decision making regarding a farm systems change is associated with risk. Attitudes towards risk taking are of major importance. Farmers are constantly addressing risk because they are working in an inherently uncertain environment. However this does not insinuate that farmers are comfortable with taking risks. A review of farmers' attitudes, objectives and behaviours established that farmers are risk averse and slow to accept unproved ideas. This could be stemmed from an abhorrence of debt which in an "all gone wrong" scenario could consequence a loss of farm (Willock et al., 1999). A risk aversion attitude may limit adoption of new technology and innovative practices. In regard to the sheep milking industry risk aversion could inhibit the growth and potential of the industry.

1.9 Conclusion

A combination of a struggling sheep meat and wool industry, a booming dairy industry and the option of irrigation has initiated the desire for many to change farming systems. Until recently converting dry land sheep, beef and arable farms on the Canterbury plains to cow dairy farms has been a growing trend. The ability to irrigate has enabled farmers to maintain a firm control on pasture growth and management. High pasture growth rates and flat land has led to farm intensification and an increase in stocking rate to achieve high milk solid production per ha. Rising land prices are also a factor which encourages growth of production. Intensification has had several negative implications on the environment. Irrigation places a strain on water ways, and the aquatic health of low land streams in Canterbury has suffered. Also high stocking rates, effluent waste and nitrogen fertiliser has increased the level of Nitrogen application to the soil, to a level over and beyond what is reasonable for plant uptake, which results in leaching losses. Nutrient leaching into ground water is an environmental concern, therefore several environmental constraints have been actioned. Nutrient capping for properties and irrigation consent restrictions have halted cow dairy conversions in different zones of Canterbury. This provides an entry point for a potential sheep milking industry on the plains. It is an industry yet to take off in New Zealand. However, in the current environmental and economic climate, it might be the way forward. Sheep have a lower environmental foot print, are flexible within the farm

management system, and produce an easily digestible product. Establishing a sound processor is an obstacle to overcome, however, if there is interest and a willingness to commit to the industry, there is great potential for sheep milking to be as lucrative an alternative to dairy cow farming without the severe environmental implications.

Chapter 2
Research Method

2.1 Introduction

This is a quantitative study which is testing the theory of feasibility of sheep milking on the Canterbury plains as an alternative land use and system to traditional sheep farms and current land use. Following the line of a quantitative study, the objective is to test the theory by collecting data and reflecting in order to verify or disprove the theory. It becomes the framework for which the research project is based on.

The method of inquiry will be a normative approach, data and records will be collated from other researcher's work, to evaluate the potential of the study and produce a theory of practise. It will aim to produce a design which consists of recommendations and standards. The computer modelling tool, Linear Programing, will be used to establish on-farm parameters to achieve optimum profitability and production of a sheep milking system in Canterbury. The results will be associated to a comparable conventional sheep farm system to gauge and determine the bio-economic feasibility of sheep dairying in Canterbury.

2.2 Linear Programming

Linear programming is a mathematical technique which is used in computer modelling. It is used to create scenarios of maximum profit, minimise cost or provide optimum situations given the limited resources of the business. Originally linear programming was developed after World War 2 when the use of computers became more prevalent. It was used in military operations to increase the effectiveness and efficiency of operations with given resources. However Linear programming and its extensions have come into wide academic use and scientific circles (Dantzig, 1965).

For this study linear programming is utilised to optimise the profits for milk supply with pasture, feed supply and livestock demand and production as the limited resources. It is used to find the most profitable system within the constraints of the model. The programme used is an 'Add in' for Microsoft Excel and relies on the 'SUM PRODUCT' and 'solver' function.

2.3 Budgets

Since there will be no external investigation or on farm visits, costs for this research will be low. Other than printing and binding the final report, there are no foreseeable expenses related to this study.

2.4 Timetable

Table 2-1 Outline of Timetable for the Completion of the Project

Study of Literature	**30th May 2014**
Linear Programming Model	13th June 2014
Farmax Farm Model	13th June 2014
Overseer Model	15th August 2014
Investment Analysis	12th September 2014
Discussion of Results Section	7th November 2014
Total Completion	**14th November 2014**

2.5 Health and Safety

This study is investigated with the use of others research material, there will be no field work to instigate a health and safety requirement to this project.

2.6 Outcome

The aims for the outcome of the study are to investigate the following questions.

- Is sheep dairying economically feasible In Canterbury?
- In relation to the environmental concerns regarding farming in Canterbury, is the proposal of sheep dairying a positive advancement for farming in the region?
- Which aspects to the industry or the systems will be limiting to the success of sheep dairying in Canterbury?

Positive results from this research could fortify the likelihood of farmers considering sheep milking as an option to improve production and profitability of their farms. It could also be useful for a processing company contemplating involvement in the sheep milking industry. Any growth in a review of profitability and literature regarding the industry will be useful for potential investors.

Chapter 3

Results Section

3.1 Modelled Scenarios

To establish an optimum sheep milking system, a range of systems require comparison. The term optimum is generalist terminology when considering a farming system for a region. Naturally there is diversity between property types and individual requirements will also differ. However for the purpose of inaugurating a demonstrative farm, an evaluation of a variety of scenarios will be conducted.

The scenarios are:

1. Conventional non-milking sheep breeding and finishing
2. Seasonal sheep dairy system with lambs weaned at 3 days old and reared until 6 weeks old
3. Seasonal sheep dairy system with lambs remaining with ewes until 6 weeks
4. Seasonal sheep dairy system with Ewes milked in conjunction with rearing lambs
5. Wintering and rearing young stock off farm.

All scenarios are pasture based and derived from assumptions that the farming location will be Canterbury with the ability to irrigate. Pasture growth for all scenarios is outlined in Figure 3-1. Total pasture production potential is assessed as 12.2tonnes per ha.

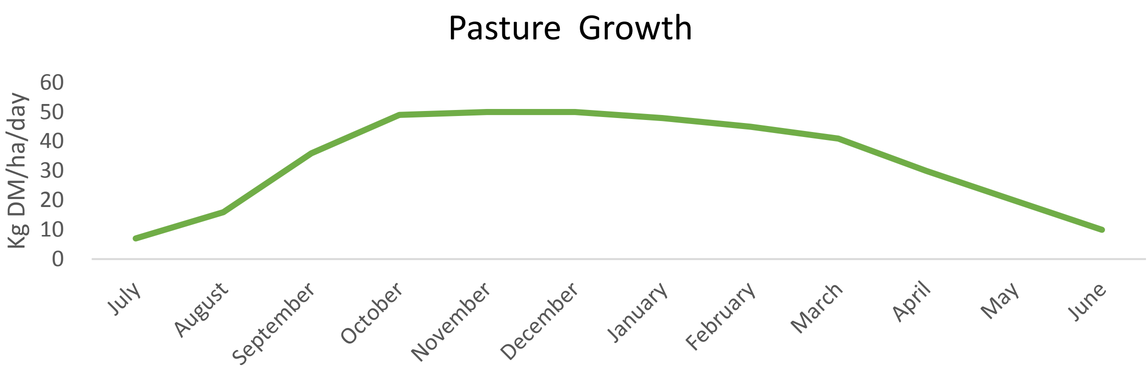

Figure 3-1 Pasture Growth and Quality for Modelled Scenarios

Pasture quality deviates slightly between seasons (Figure 3-2 Annual Pasture Quality Variation), the metabolisable energy (ME) value declines from 11.8 in the spring and early summer seasons to 10.2 during winter. The reason for this is that despite irrigation, grass growth slows during cooler seasons. Less vegetative growth leads to a build-up of lignified and dead material which is lower quality and less palatable to stock. In spring the ME value increases because there is a flourish of vegetative growth. Young leaves have a lower structural carbohydrate component and thus have a higher ME value.

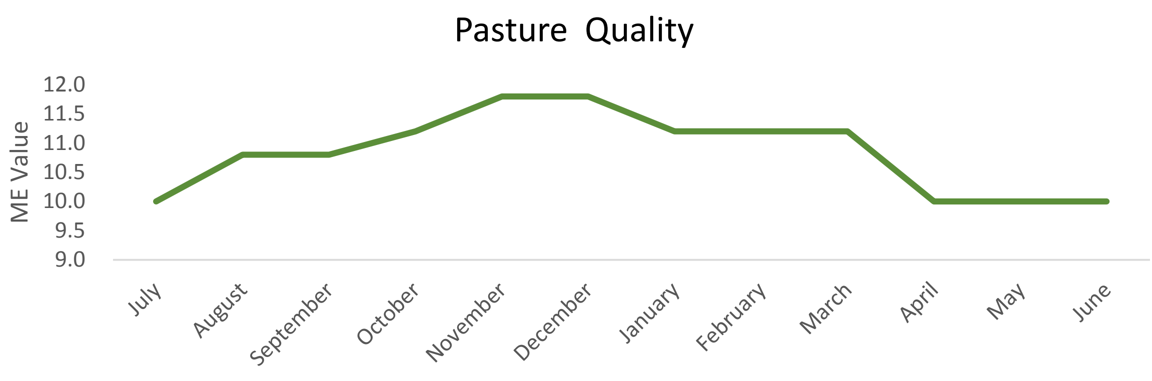

Figure 3-2 Annual Pasture Quality Variation

The primary difference between the scenarios are the lamb rearing and weaning events. Each scenario incorporates hogget mating however, hoggets are not included in any of the milking flocks. Animals are milked from 2ths onwards.

3.1.1 Assumptions for the development of Scenarios

The information required for the construction of linear programme models include the physical assumptions of the base model. Pasture production for the scenarios is assumed using regional data as the source. Assumptions regarding stock value, animal health costs and energy requirements are derived from national averages and the 2010 farm financial budget manual and technical manual. The milk solid price is based on the MS pay out which Blue River Dairy in Southland pays to its farm suppliers.

3.1.2 Animal Production Considerations

In a typical sheep grazing system, once lambs are weaned a ewe becomes a low priority stock class and are often used to clean up pastures. This factor along with having recently reared a lamb is a major cause of weight loss of ewes in a conventional system. Prior to mating in autumn it is necessary to gain live weight otherwise reproductive performance will be challenged. Lighter ewes have less multiple ovulations and live weight gain prior to mating is beneficial to ovulation (Kenyon & Webby, 2007). This is why farmers flush their ewes prior to mating, to increase live weight and have a positive impact on ovulation. There is generally pressure to flush ewes, especially if farmers have tried to finish a lot of stock over the summer. Pasture herbage is usually insufficient for the desired flushing period of over three weeks.

In the milking scenarios the approach to live weight gain and maintenance of ewes is very different from a simple breeding finishing operation. Ewes will be gaining weight through the gestation period as the lamb develops. After birth the lambs will be removed after three days and hand reared. From this point on feeding of the ewe is important to ensure high milk production. All the scenarios (milking)

are based on a milking flock of East Friesian breed sheep. Typically this is a large framed breed and can reach weights exceeding 80 kg. To reach this weight the growth rates from ewe lambs through to 2ths have to be high.

To simplify the milking models a typical cow dairy system will be emulated and ewes will be wintered off farm. This will help to maintain appropriate pasture cover on the milking platform in order to achieve adequate feed supply and demand for lactation. Also the option of wintering off farm means that ewe condition can be better controlled in an environment where maintaining and preserving pasture is a concern. Milk yield is significantly affected by the nutrition of the ewe and body condition (Kenyon & Webby, 2007).

The metabolic energy requirement for maintenance of adult ewes of 70 kg is 11 MJME per day. This is achieved from the equation of 0.48MJME x $LW^{0.75.}$, based on the assumption that the sheep are grazing flat land (Nicol & Brookes, 2007). Because sheep milking is a relatively new initiative (In New Zealand) there is limited scientific data regarding the energy requirements for milk production. Generally the figure is estimated in accordance with lamb energy requirements for growth. In a cow dairy system, energy requirements for lactation are derived from measuring the composition of the milk (fat, protein and lactose). Similar to dairy cows, milking ewes need to be offered adequate feed energy to prevent weight loss during lactation in order to achieve maximum milk production potential. Inadequate feeding can result in reduction of daily milk yield and total lactation length.

To provide an indication of feed energy required, a ewe rearing a lamb to 35 kg after lambing requires at least 26 MJME/ day for lactation and maintenance. Alternatively if maximum daily intake was 4% of a ewes body weight. A 70 kg ewe will require 2.8kg of DM. In order to ensure ewes are receiving correct nutrition, the systems incorporate in-shed feeding of grain. Barley grain has approximately 12 MJ ME MJ/Kg DM which is higher than a good quality pasture. In shed feeding is also a way of enticing animals into the milking shed however it also reduces the effect of grazing activity on energy requirements and is therefore an efficient form of energy gain.

3.1.3 Restraints and Limitations of the Scenarios

The scenarios have been limited to make profitable and realistic representations of normal farming systems. A general constraint of the system is the lack of research and scientific data that identifies with a New Zealand sheep milking model. Assumptions based on overseas data has been made to overcome this limitation however it may have an impact on the reality of the model.

3.2 Conventional non milking sheep breeding and finishing

Typically sheep breeding and finishing operations are operated with the incorporation of other stock classes such as cattle. Diverse operations provide variety in labour, management decisions, parasite control, as well as improving pasture performance through grazing management. To simplify and

ensure comparable results a sheep breeding and finishing operation will be considered without the diversity of another stock class.

The lighter body weight and lesser milk demands of the conventional sheep system therefore leads to the assumption that a greater number of ewes can be carried on a given area all other things being equal. To the find a true comparison of the respective systems a comprehensive whole farm system analysis needs to be conducted. To achieve this a linear programming model has been constructed to simulate the different sheep systems.

Table 3-1 Sheep breeding and finishing production and performance

Farm Production Data Scenario 0			
Region	Canterbury		
Area (Ha)	200		
Kg DM/Ha/yr	12,201		
Production Performance			
Lambing %	160		
Lamb Price		$ 100	
Ewe Lamb Price		$ 95	
Cull Ewe Price		$ 55	
Stock Performance	**Average Weight Kg**	**Weight at Mating Kg**	**Stock Numbers**
Ewe Lambs	29	-	636
Ewe Hoggets	60	52	636
2ths	64	64	573
4ths	64	64	458
4 yr	64	64	367
5 yr	64	64	293
6yr	64	64	235
Rams	80	80	32
Total			**3,230**
Cash Cost/Profit			**$ 113,352**
Cash Cost/Profit (ha)			**$ 566.76**

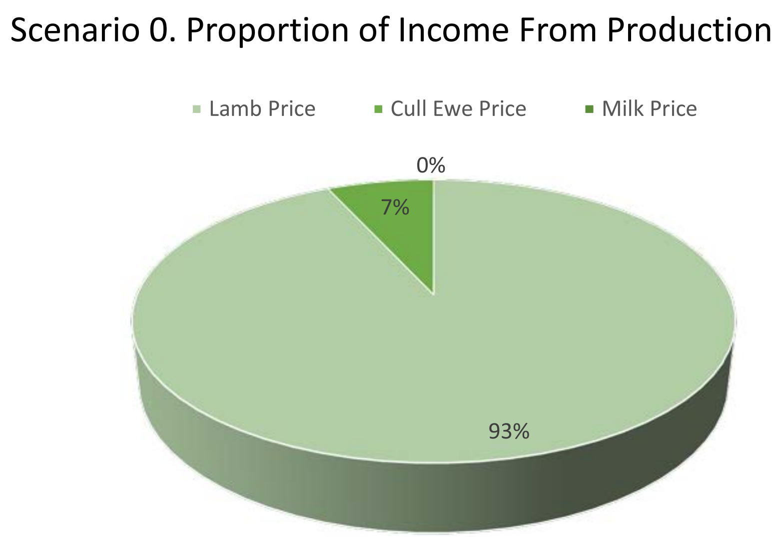

Figure 3-3 Percentage of income from on farm production avenues

The outcome of a linear programming scenario for a conventional sheep system produced a cash cost profit of $38,256. The income is derived based on the income of meat from lamb and cull ewe sales. It is assumed that the flock is of cross breed wool and the income from the wool is equalised by the cost of the shearing. Dispersing the income over 200 ha produces a profit of $191.28 per ha. This system is highly sensitive to the meat price because it is the only form of income for this stock class (disregarding wool).

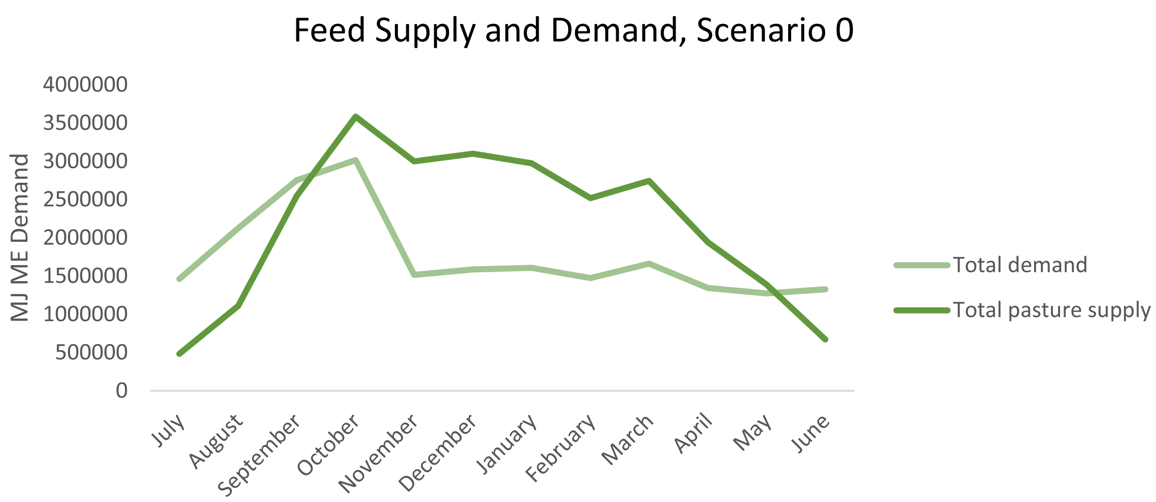

Figure 3-4 Annual feed supply and demand trend for a low input conventional sheep breeding and finishing operation

The conventional sheep system is very low input. No supplements are incorporated into the system and as indicated in Figure 3-4 the balance between feed supply and demand is relatively even, a high peak in pasture supply during spring is matched with high demand. Feed produced on the farm, if managed accordingly is able to sustain the flock without the need for introduction of purchased

supplements. Irrigation provides a certain element of control for grass growth during the summer and shoulder seasons.

3.3 Seasonal sheep dairy system, lambs weaned at 3 days old

This scenario of a seasonal sheep dairy system requires the removal of lambs at 3 days old and the subsequent rearing until 6 weeks of age. Leaving a lamb with its mother for 3 days is reasoned through enabling the lamb to receive an adequate amount of first colostrum from its mother. There is flexibility in this time period and lambs can be removed after 2 days as the first 24-48 hours are the most critical for the absorption of immunoglobulins. The benefit of weaning lambs early is associated with milk production. The model used to create this scenario is a derivative of the conventional sheep model from a production view point. The additional production of milk requires the incorporation of greater supplementary feed inputs. This is due to animals having to maintain higher production. There is also a greater maintenance requirement with larger framed animals from milking breeds. The Model has high production and operates at 170% lambing on the 10th of August as indicated in Figure 3-5.

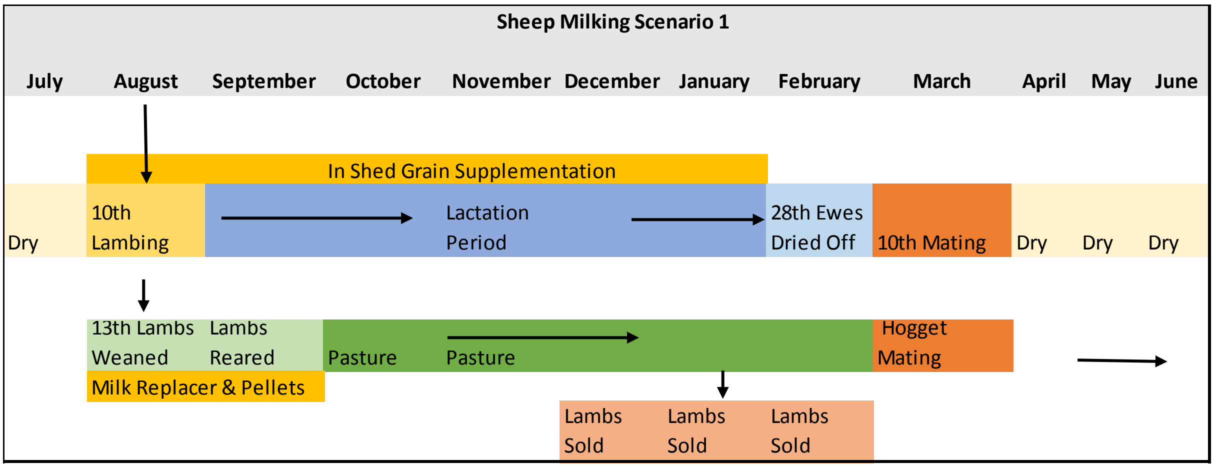

Figure 3-5 Annual Events Outline of Sheep milking scenario 1, lambs weaned at 3 days old

The breed most commonly utilised as milking stock are East Friesian ewes. These are large framed animals, larger animals are typically assumed to have a higher output and greater milk production ability. However larger animals have a higher maintenance energy requirement which reduces their feed conversion efficiency. An East Friesian base breed of sheep and the circumstance of milking leads to the incorporation of Baleage and grain into the feeding operation.

Table 3-2 Supplementary feed, grain

Grain Supplements				
1600 Ewes	0.200 Kg /day	211 days	**67,520**	**Kg**
		12 MJ ME		
			810,240	**MJME**

Table 3-3 Physical and Production Assumptions for Sheep Milking Scenario One

Scenario 1			
Farm Production Data			
Region	Canterbury		
Area (Ha)	200		
Kg DM/Ha/yr	12,201		
Supplements		**Price**	
Grain /kg DM		$ 0.35	
Balage /kg DM		$ 0.25	
Production Performance			
Lambing %	160		
Lactation Length days	199		
Milk Production Kg MS/Ewe	34		
Milk Price $/MS		$ 17	
Lamb Price		$ 100	
Ewe Lamb Price		$ 95	
Cull Ewe Price		$ 55	
Stock Performance	**Average Weight Kg**	**Weight at Mating Kg**	**Stock Numbers**
Ewe Lambs	33		577
Ewe Hoggets	64	56	577
2ths	72	72	519
4ths	72	72	415
4 yr	72	72	332
5 yr	72	72	266
6yr	72	72	213
Rams			29
Total			**3,972**
Total Milking Stock			**1,745**
Cash Cost/Profit	**$ 692,095**		
Cash Cost/Profit (ha)	**$ 3,460**		

Table 3-3 indicates outlines the physical and production assumptions of the scenario 1 model. The lactation length is 199 days which takes into account the period between weaning lambs on the 13th of August to Drying off Ewes on the 28th of February prior to mating on the 10th of March (Figure 3-5). The growth rates of young stock can be found in section A.2. The average weight at mating for hoggets is 56 Kg and the average mature weight of ewes is 72 Kg. Grain (barley/ wheat) has been used as a supplement because of its high metabolisable energy content of 11.4-12.6 MJ ME (Department of Agriculture and Food, 2014). Allocations will be administered in shed to facilitate training animals to

become accustomed to being milked. The grain provides an incentive. From a production view point it provides energy which would otherwise have to be achieved through grazing.

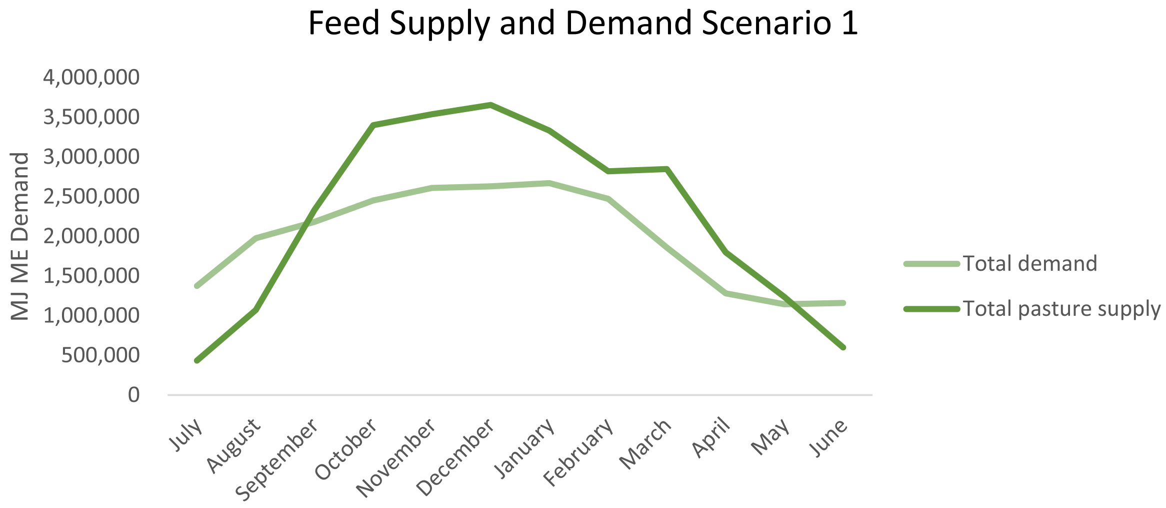

Figure 3-6 Feed, Supply and Demand for Scenario 1

In total there are 1745 ewes which make up the milking flock, consisting of mixed age ewes and 2ths. In this scenario the replacement hoggets are not milked. Their contribution to production is rearing lambs. Through irrigation, pasture growth and supplementary feed, feed demand is sufficiently covered by feed supply. A characteristic of this system is that 60% of the stock on farm, not including sale lambs are milked. Therefore there is high dependence on the milk price received from a wholesale processor for milk solids.

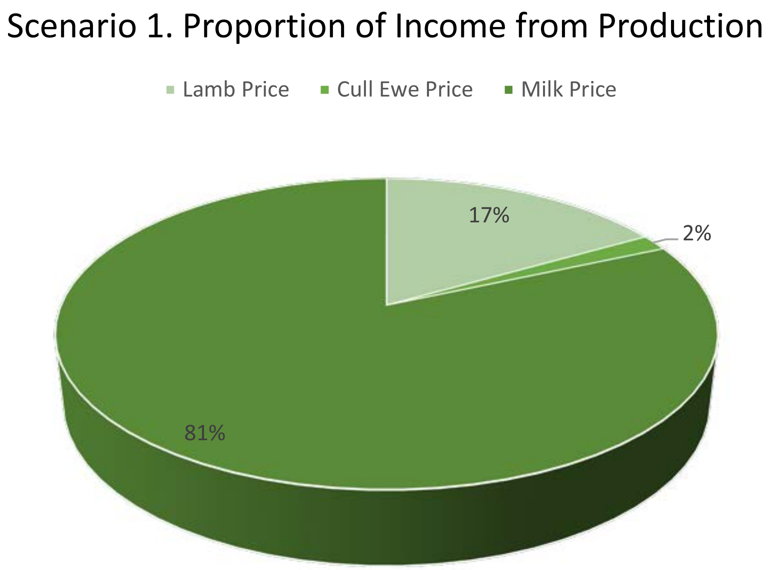

Figure 3-7 Income % of Production

The milk percentage of the income greatly exceeds the meat price for lambs and cull ewes. As indicated in Figure 3-7 the milk price accounts for 81% of the total income from meat and milk. While this is a profitable venture with returns of $3,460 ha, it does implicate that the system is highly dependent on the milk price.

3.4 Seasonal Sheep Dairy, Ewes milked after Lambs weaned at 6 weeks

In this scenario the lambs remain with their dams for 6 weeks, after which they are weaned and ewes are milked. The benefit of such a system is derived from the reduced labour with regard to rearing lambs. The estimated cost of rearing each lamb is approximately $50 / head, a sum which is retained when ewes are able to rear their lambs. The trade-off however is in the milk production. The first 30 days of lactation are the most important as they determine the peak lactation (Linda de Bie & Thomas, 2001). Since the ewes are bred to have a high milk production, there is the potential that lambs may not utilise the total milk on offer and as a result the ewes overall milk production may decline. Production events are detailed in Figure 3-8, lambing commences on the 10th of August and lambs remain with ewes until 6 weeks of age. After weaning, the lactation period is extended to the 28th of February with ewes milked twice a day.

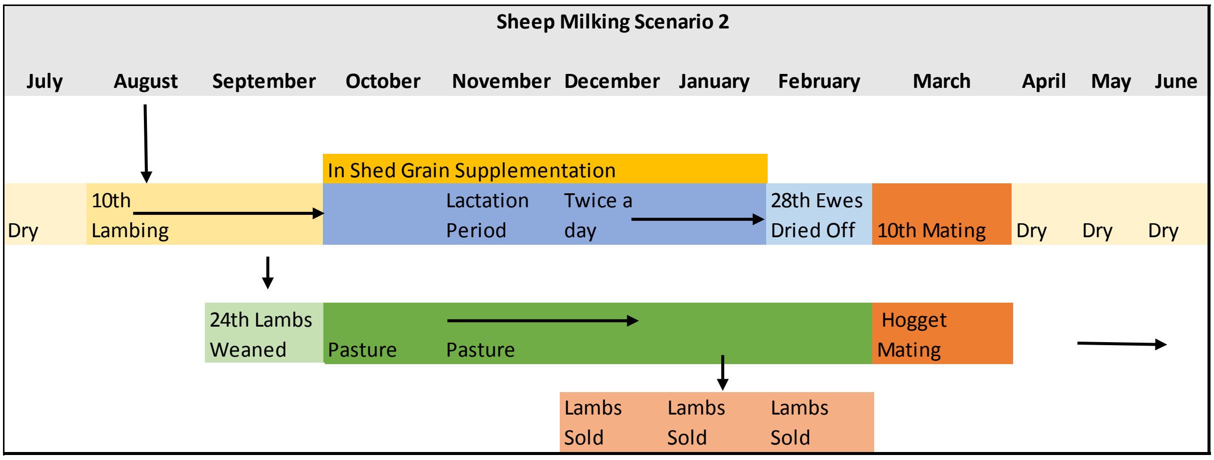

Figure 3-8 Annual Event Outline, Scenario 2

The major stock events are displayed in Figure 3-8 and it is evident that summer is a busy period for management with lambing, weaning, milking occurring. With these major events other activities such as crutching, shearing, weighing and drenching occur.

Table 3-4 Physical and Production Assumptions for Sheep Milking Scenario 2

Farm Production Data Scenario 2			
Region	Canterbury		
Area (Ha)	200		
Kg DM/Ha/yr	12,201		
Supplements		**Price**	
Grain /kg DM		$ 0.35	
Balage /kg DM		$ 0.25	
Production Performance			
Lambing %	160		
Lactation Length days	134		
Milk Production Kg MS/Ewe	23		
Milk Price $/MS		$ 17	
Lamb Price		$ 100	
Ewe Lamb Price		$ 95	
Cull Ewe Price		$ 55	
Stock Performance	**Average Weight Kg**	**Weight at Mating Kg**	**Stock Numbers**
Ewe Lambs	33		537
Ewe Hoggets	64	56	537
2ths	72	72	483
4ths	72	72	387
4 yr	72	72	309
5 yr	72	72	247
6yr	72	72	198
Rams			27
Total			**2,726**
Total Milking Stock			**1,625**
Cash Cost/Profit	**$ 479,948**		
Cash Cost/Profit (ha)	**$ 2,400**		

For this scenario the milking period was reduced by 6 weeks (42 days) and the peak in lactation was reduced from 1.8 Kg MS in November to 1.6 Kg MS (Appendix Table 6-7). The resulting decline in production was a decrease in profit / ha of $1,061. The viability of this option is heavily dependent on the milk price. A higher milk price would increase the feasibility of rearing lambs.

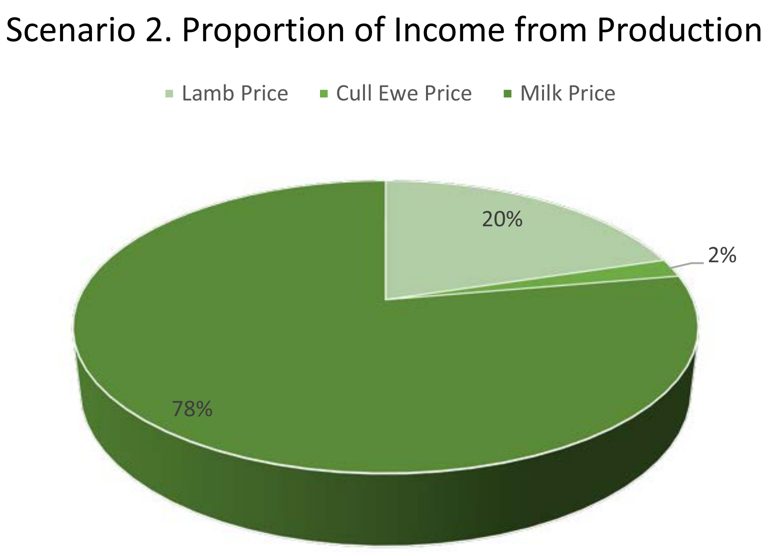

Figure 3-9 Proportion of Income from Production, Scenario 2

Due to a later weaning date, the lactation length is reduced. Therefore the proportion of income from milk price is slightly declined at 78% (Figure 3-9). This is still a significant proportion of the scenario income and is indicative that the system remains highly sensitive and reliant to an affordable milk solid pay out.

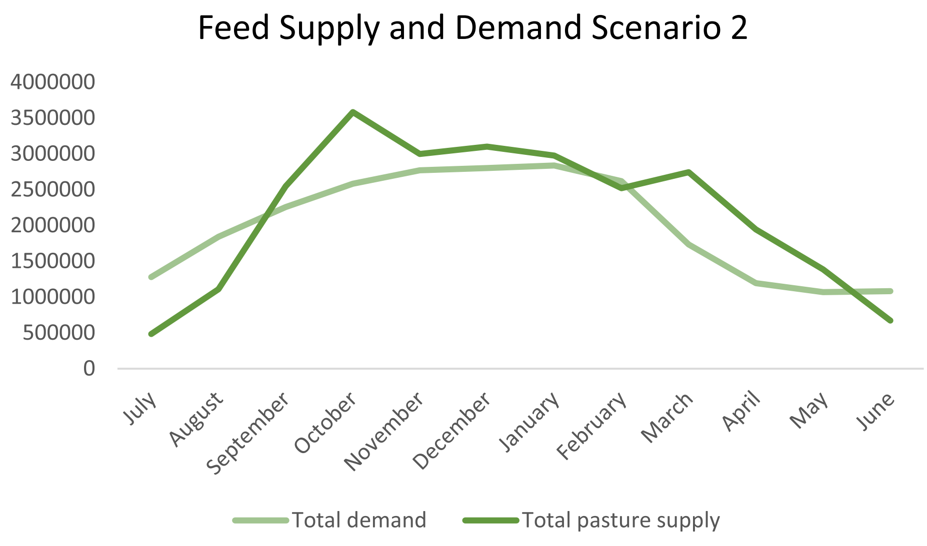

Figure 3-10 Feed Supply and Demand for Scenario 2

Pasture supply matches animal demand adequately throughout the year. There is a peak in October where the spring season initiates a flourish in vegetative growth. This coincides with the peak milk lactation yield. It is important to have a high level of good quality feed available during this period in order to sustain lactation production. Excess supply in the system enables flexibility for the creation of conserved feed to cover the slight deficit in the months of July and August.

3.5 Seasonal Sheep Dairy, Ewes milked once a day in conjunction with rearing lambs to 6 weeks

Another management system which can be utilised in a seasonal sheep dairy system is the milking of ewes in conjunction with their rearing of lambs. This is a method which reduces lamb rearing costs while maintaining income through milk production. Ewes are milked once a day for 6 weeks until the lambs are weaned. From this point milking increases to twice a day as indicated in Figure 3-11.

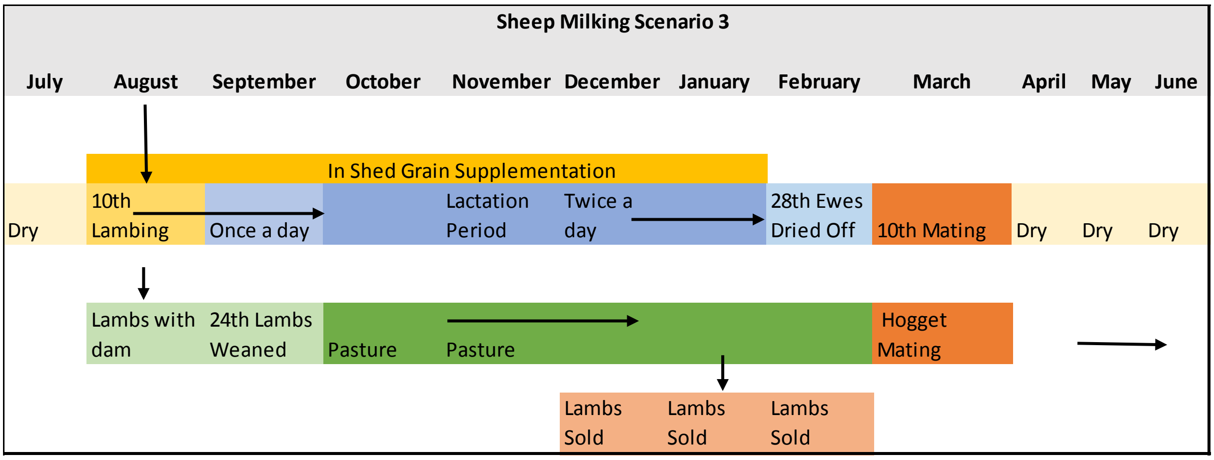

Figure 3-11 Annual production Events, Scenario 3

This scenario reduces the amount of marketable milk within the first 6 weeks of lactation because milk produced is shared with the lamb. There are however no rearing costs and the reduction of the additional labour requirement can be taken into account.

Table 3-5 Physical and Production Performance, Scenario 3

Farm Production Data Scenario 3			
Region	Canterbury		
Area (Ha)	200		
Kg DM/Ha/yr	12,201		
Supplements		**Price**	
Grain /kg DM		$ 0.35	
Balage /kg DM		$ 0.25	
Production Performance			
Lambing %	160		
Lactation Length days	199		
Milk Production Kg MS/Ewe	16		
Milk Price $/MS		$ 17	
Lamb Price		$ 100	
Ewe Lamb Price		$ 95	
Cull Ewe Price		$ 55	
Stock Performance	**Average Weight Kg**	**Weight at Mating Kg**	**Stock Numbers**
Ewe Lambs	33		537
Ewe Hoggets	64	56	537
2ths	72	72	483
4ths	72	72	387
4 yr	72	72	309
5 yr	72	72	247
6yr	72	72	198
Rams			27
Total			**2,726**
Total Milking Stock			**1,625**
Cash Cost/Profit	**$ 307,272**		
Cash Cost/Profit (ha)	**$ 1,536**		

Table 3-5 signifies the reduced lactation production of only 16 kg MS/ ewe over a 199 day lactation. This is due to once a day milking for a 6 week period while the ewe is rearing her lambs. The total cash profit per ha is $1,536

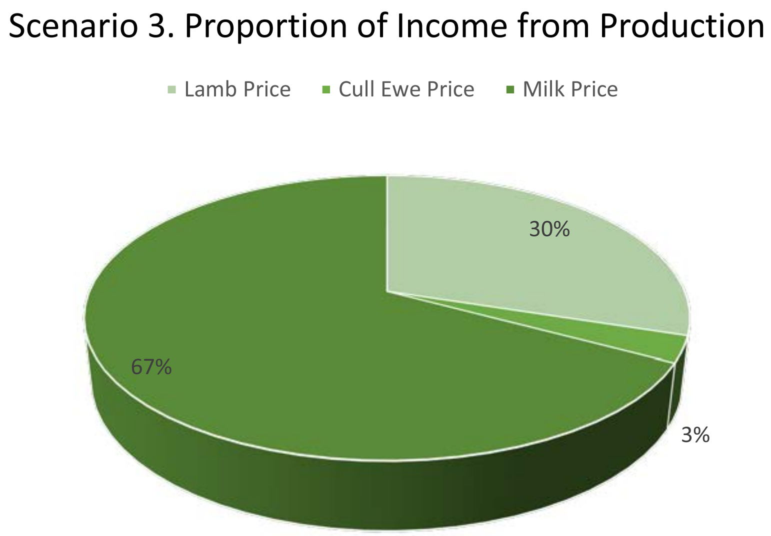

Figure 3-12 Proportion of income from production, Scenario 3

Once again the milk proportion of income has declined due to lesser production. Although the milk proportion of income has the majority share, an increased share from the lamb price reduces the scenarios reliance on the milk pay out price to a certain degree.

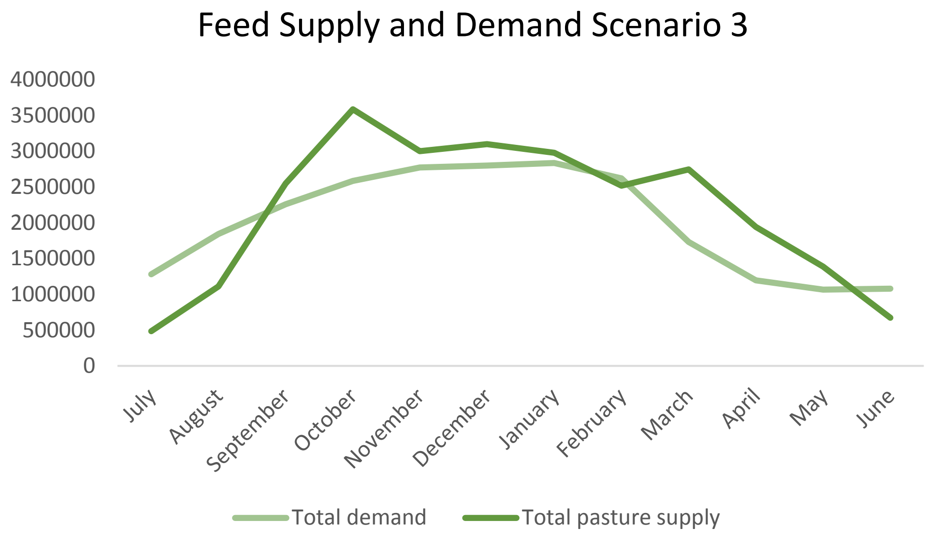

Figure 3-13 Feed Supply and Demand for Scenario 3

The feed supply and demand for scenario 3 is almost identical as for scenario 2 because the stock numbers have remained the same.

3.6 Wintering and rearing young stock off farm

The concept of wintering young stock or non-productive stock off farm is similar to a cow dairy farm. Utilising the property solely as a milking platform enables greater stock carrying capacity.

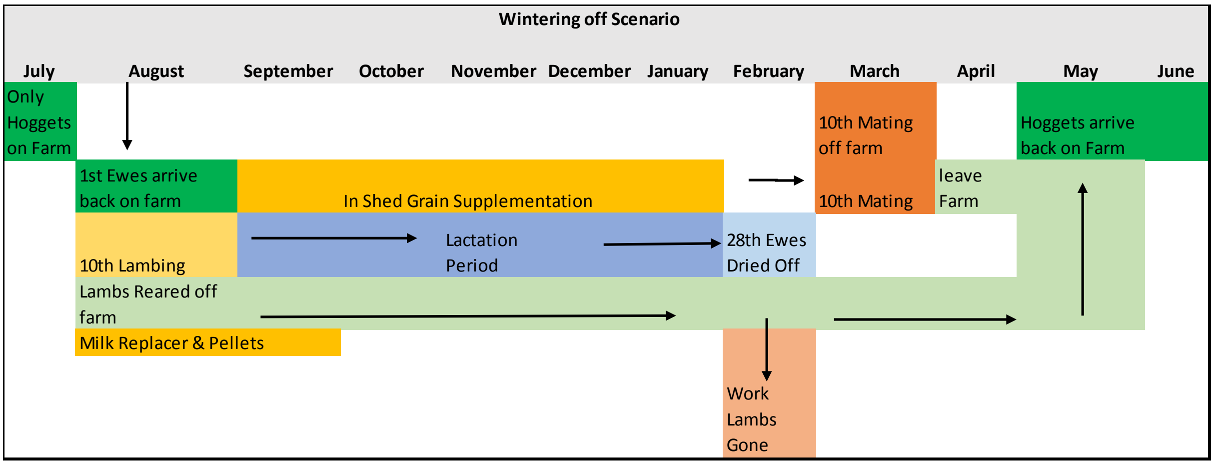

Figure 3-14 Annual Events, Wintering off Scenario

In comparison to the scenario 1 system, stock numbers have increased by 1,757 to 5,730. The total milking flock of mixed aged ewes and 2ths equates to 3,239 head of ewes. A greater flock size increases the scale of production leading to a profit of $5,052/ha as indicated in Table 3-6

Table 3-6 Physical production and performance comparison of wintering off farm and scenario 1

Scenario 1				Wintering Off Farm
Farm Production Data				
Region	Canterbury			
Area (Ha)	200			
Kg DM/Ha/yr	12,201			
Supplements		**Price**		
Grain /kg DM		$ 0.35		
Balage /kg DM		$ 0.25		
Production Performance				
Lambing %	160			
Lactation Length days	199			
Milk Production Kg MS/Ewe	34			
Milk Price $/MS		$ 17		
Lamb Price		$ 100		
Ewe Lamb Price		$ 95		
Cull Ewe Price		$ 55		
Stock Performance	**Average Weight Kg**	**Weight at Mating Kg**	**Stock Numbers**	**Stock Numbers**
Ewe Lambs	33		577	1,129
Ewe Hoggets	64	56	577	1,129
2ths	72	72	519	1,016
4ths	72	72	415	813
4 yr	72	72	332	650
5 yr	72	72	266	520
6yr	72	72	213	416
Rams			29	57
Total			**3,972**	5,730
Total Milking Stock			**1,745**	3,415
Cash Cost/Profit	**$ 692,095**			**953,939**
Cash Cost/Profit (ha)	**$ 3,460**			**4,770**

A consideration of wintering and rearing young stock off farm is the price of grazing per head. An additional livestock cost of $2.50/ head/ week for mature animals has been incorporated to the cost of livestock, appendix Table 6-5.

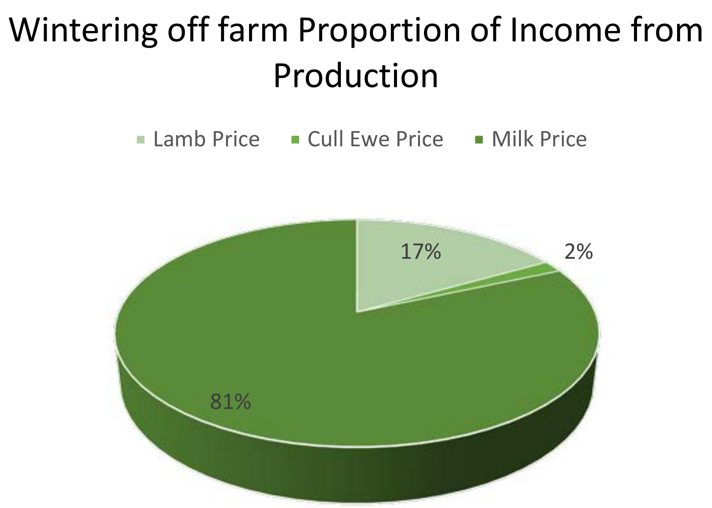

Figure 3-15 Proportion of Income from Production, Wintering Off Farm Scenario

The milk price remains to be a high proportion of the total income of the scenario as ratios have not been altered. The increase in scale has resulted in greater production however on a percentage basis the apportioned income is identical to the Scenario 1 system.

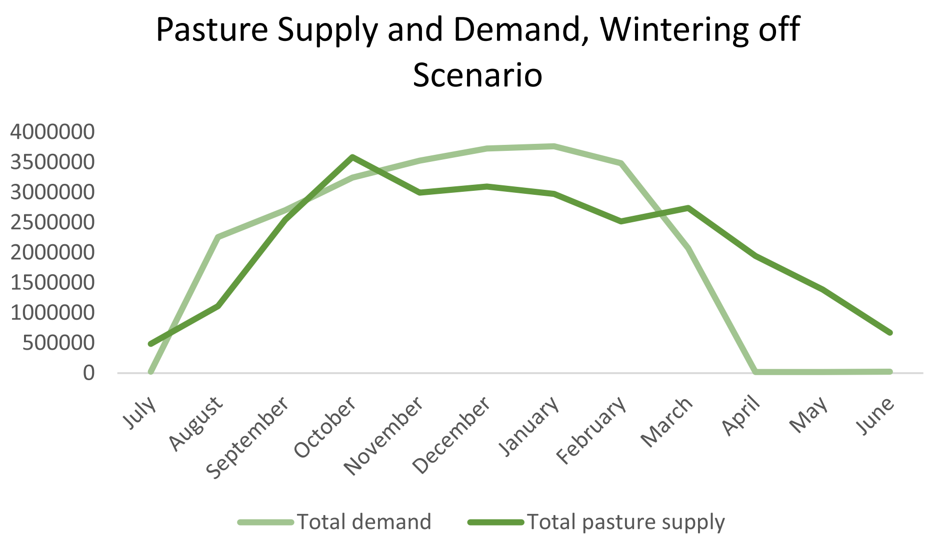

Figure 3-16 Pasture Supply and Demand for Wintering off Scenario

Because stock are wintered off farm and young stock do not enter the milking platform until they are productive, the property is able to facilitate higher stock numbers. However it is evident that this scenario is not feasible without the introduction of supplementary feed since the animal energy demand exceeds the total supply from pasture (Figure 3-16).

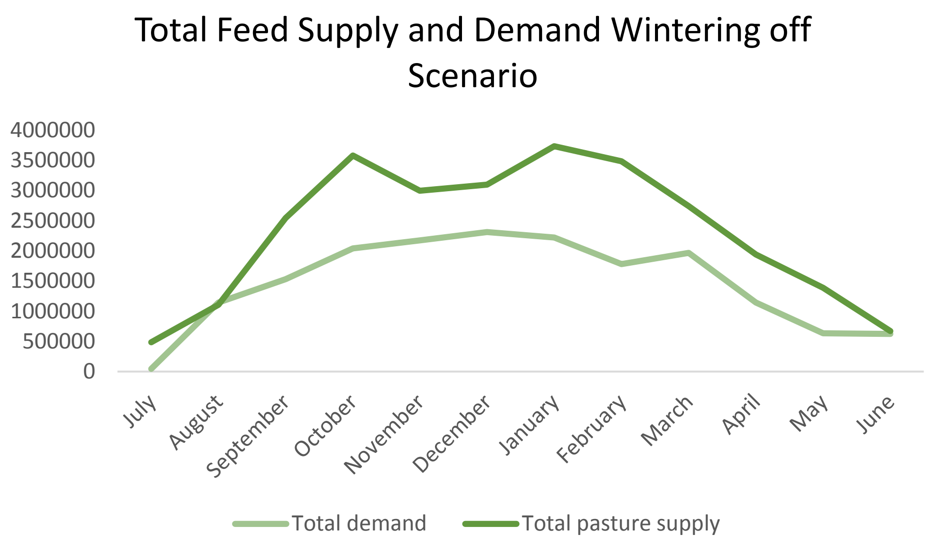

Figure 3-17 Total Feed Supply and Demand, Wintering Scenario

Figure 3-17 when compared with Figure 3-16 indicates how the incorporation of supplementary feed can more evenly distribute the supply to cover demand requirements.

3.7 Comparison of Scenarios

To further compare the scenarios Table 3-7 provides a comparison of certain key performance indicators (KPIs). Scenario 0 which is a sheep meat production only system has a lower $/ha income compared to all the other scenarios which incorporate sheep milking. Which indicates that milk production increases production per ha. Scenario 0 and the wintering off scenario have differing stock numbers to the milking scenarios 1, 2 &3. Scenario 0 has no supplementary feed incorporated and therefore has lower carrying capacity because the system is not as intensive. The wintering off scenario has greater stock carrying capacity because only productive stock are supported on the property. This increases the scale and intensity of the operation. A comparison factor utilised is the $ of saleable product in relation to Kg of DM of feed consumed without regard to the cost of production. When comparing the $ amount of saleable product / Kg DM consumed, the wintering off farm system had a value of 1.03 which was greater than the other scenarios. Scenario 1 had a result of 0.53 $ of saleable product/Kg DM. This indicates that per amount of feed consumed, the wintering off farm system has the greatest product output. This can be associated to the larger scale of the operation. However, all things considered, greater scale incurs greater costs of production since livestock grazed off farm. Of the scenarios incorporating milking, Scenario 3 had the lowest value for $ of saleable product/ Kg DM consumed. This can be linked to the reduced MS production per ewe value of 16Kgs MS.

The income spread of different areas of production over all the scenarios are not evenly distributed. All milking scenarios have milk solids as the dominate form of income, with the wintering off scenario

as the highest at 82% and Scenario 3 at the lowest 67%. Scenario 3 had the reduced milk production therefore the total production was lowered, increasing the proportion of income from lamb sales, despite no change in stock numbers.

Table 3-7 Key Performance indicators of scenarios

KPIs	Scenario 0	Scenario 1	Wintering Off Farm	Scenario 2	Scenario 3
Cash Cost/Profit	113,352	692,095	953,939	479,948	307,272
$/ha	567	3,460	4,770	2,400	1,536
MS/Ewe	-	34	34	23	16
Ewe No.	1,926	3,972	5,730	2,726	2,726
$ of saleable product/Kg DM Consumed	0.16	0.54	1.03	0.45	0.31
Income %					
Lamb Price	91%	18%	17%	20%	30%
Cull Ewe Price	9%	2%	2%	2%	3%
Milk Price	0%	80%	82%	78%	67%

Table 3-8 and Table 3-9 indicate the effect of varying lamb prices and milk solid prices on the scenarios percentage of income. A factor which is evident in both tables is that increasing or decreasing product prices does not have an overall significant impact on the proportion of income from that particular avenue of production. This is because the spread of income is highly definitive for all the scenarios, there is no even distribution. Proportion of income received from the lamb price is relatively low for all scenarios disregarding the sheep only Scenario 0. However a change in the price from $100 to $110/ head, only translates into a small percentage (maximum 2%) change of the total proportion of income from lamb sales. Similarly, the change in milk price emulates this effect of only marginal increases in

proportion of income from production. The greatest fluctuation being the increase from $17 MS to $20/MS resulting in a 3% increase in scenario 3.

Table 3-8 Impact of Changing Lamb prices on Scenario % Income

Lamb Price			
	$ 90.00	$ 100.00	$ 110.00
Scenario 0	68%	**71%**	72%
Scenario 1	12%	**13%**	14%
Scenario 2	14%	**16%**	17%
Scenario 3	21%	**23%**	25%
Wintering off	12%	**13%**	14%

Table 3-9 Impact of Changing Milk prices on Scenario % Income

Milk Price			
	$ 15.00	$ 17.00	$ 20.00
Scenario 0	0%	**0%**	0%
Scenario 1	75%	**83%**	80%
Scenario 2	70%	**79%**	76%
Scenario 3	58%	**69%**	65%
Wintering off	80%	**83%**	84%

Rearing young stock is a source of expense as part of the costs per livestock (Table 6-2) this is a matter for Scenario 1 where lambs are weaned at 3 days old and hand reared and also for the wintering off scenario because the latter applies and young stock and non-productive stock are further grazed off farm. However, the costs of rearing lambs does not have a significant impact on the overall cash profit for Scenario 1. Table 3-10 implies that there is only a $5,768 margin between a 20% rise and fall in lamb rearing prices/ head.

Table 3-10 Impact of varying lamb rearing costs on total cash cost/profit, Scenario 1

Lamb Rearing Costs/ Head				
	$ 40.00	$ 50.00	$ 60.00	$ 70.00
Impact on cash cost/ profit	697,863	**692,095**	686,327	680,560

The wintering off scenario is highly sensitive to grazing price with a $92,987 decline in total cash profit with the increase in grazing price to $3.50/ head. A similar increase was noted for a reduction in grazing price to $1.50, achieving a $92,986 increase in total profit as detailed in Table 3-11.

Table 3-11 Wintering off Scenario sensitivity to grazing price

Sensitivity to Grazing Price		
$ 1.50	$ 2.50	$ 3.50
1,148,546	1,090,837	1,033,129

Chapter 4

Discussion

4.1 Industry overview

There is a growing demand for milk products worldwide. It is forecasted that global milk demand will grow by over 100 billion litres by 2020 but New Zealand production will only increase by 5 billion litres. This indication of future demand will have a positive impact on any dairy or milk producing industry in New Zealand. New Zealand dairy exports have been influenced by trade agreements with its primary dairy consumer markets. Trade tariffs and quotas to the European market limits the amount of produce New Zealand can supply. This was set up by the EU to reduce competition in their local market from international competitors. The Chinese market is the greatest consumer of New Zealand dairy products. Currently in New Zealand, the dairy industry is booming as there is a huge demand for milk products in Asia and the Free Trade Agreement New Zealand has with China helps foster this (New Zealand China Trade Association, 2014). With increasing milk solid prices, the natural reflex is for farmers to increase their production, expand their operation or change their systems to take advantage of the profit window. However, with intensification and expansion there comes an environmental cost. Water quality and availability is a huge concern in Canterbury. Nutrient leaching from dairy farms has been targeted as the primary cause for deterioration in ground water and low land streams. To prevent an escalation of the issue, restrictions regarding nutrient leaching have come into play. This has caused farmers to review their current systems, destock and tighten their environmental practices. Nutrient capping has also caused restrictions for land use change. This is an issue for farmers wishing to convert to a dairying system from a dry land sheep and beef operation with lower recorded nutrient loading rates.

The increase in development of a sheep milking industry is a route which would enable farmers to take advantage of the prices received from dairy production while also maintaining adequate environmental standards and low nitrate leaching levels. To benefit from global dairy prices the industry would need to have an export focus with milk powder and infant formula as the primary export product in view. The New Zealand goat cooperative have had large successes with supplying infant formula to Asian markets including Taiwan, Singapore, Malaysia, Hong Kong and China. Sheep milk is similar in property to goats' milk and the market success reflected in the New Zealand dairy goat industry could be replicated in the sheep milk sector. Sheep milk is more easily digestible to humans than cows' milk which is a favourable characteristic for milk powder being the end product (Park, Juárez, Ramos, & Haenlein, 2007).

The scenarios outlined in Chapter 3 are all based on the assumption that the sheep milk industry is established and there is a ready processor accepting milk and marketing it.

4.2 Lamb Weaning Treatments and Rearing

When considering the different scenarios, they all depend on the success and understanding the importance of lamb rearing. It is an integral part of any livestock breeding operation and the management of lamb weaning and rearing can have substantial impacts on milk production.

Colostrum is the first secretion of the mammary gland and it occurs in the several days prior to parturition and it ceases four to five days after lactation commences. Colostrum has three roles, it serves primarily as a food, however, it is also a laxative and a valuable source of immunity. Immunization is achieved through the absorption of immunoglobulins through the intestines without being digested at gastric level. Within the first six hours of life the absorption rate of the lamb is high, it progressively diminishes and ceases after 36-48 hours (Brandano, Rassu, & Lanza, 2004). With regard to this there is flexibility within the removal of a lamb. Any time after two days would be sufficient to ensure the lamb has had an adequate amount of colostrum. A greater period of time increases the maternal bond and can induce stress on the lamb after removal.

The rearing of lambs is a key element to a sheep milking operation. Raising lambs successfully and following commendable practices can reduce labour and have a considerable impact on farming profit. There are several ways to implement a lamb rearing regime and it is dependent on intensity of the farming system, production goals and the resources and labour available. In the three milking scenarios outlined in this study, lambs are weaned early and hand reared, remain with the ewe until six weeks of age or they remain with their mother and share the available milk with a once a day milking for up to six weeks.

In an intensive system it is recommended to remove lambs from ewes as early as possible while still ensuring the lambs receive the adequate maternal colostrum. The main objective for this is that it increases the marketable volume of milk. However, there is also an indication that this strategy has the potential to improve total lactation milk production (Baldin, 2013). Similar to cows, ewes will produce more milk if they are milked more frequently. Ewes milked three times a day as opposed to twice produced 15% more milk over the first 30 days of lactation (Linda de Bie & Thomas, 2001). In most circumstances milking ewes greater than twice a day would be highly labour intensive and may not be profitable however the concept of the theory is to achieve a higher output through maximising the draw on milk. For example, if young lambs remain with the ewe and do not consume all the milk the ewe has produced, the milk draw is below the maximum level and future production may be affected (Baldin, 2013). Within the first 30 days of lactation, 25% of the total milk yield is produced

(Folman, Volcani, & Eyal, 1966). Weaning of lambs occurs within this time period and therefore the method in which this is done can have a significant impact on milk production. In a comparison of weaning systems detailing lambs weaned at 24 hours, 30 days or 6 weeks with the combination of milking ewes, the total milk production was greatest for the initial scenario of early lamb weaning. These ewes produced 261 kg of milk over their lactation; ewes which weaned lambs at 30 days achieved 172 kg/ ewe (McKusick, Thomas, & Berger, 2001), with the ewes being milked and sustaining their lambs producing 236 kg/ewe.

Another consideration is lamb growth. Lambs reared will become the future milking stock and non-replacements have a standing in the lamb meat market. Therefore rearing lambs and the subsequent impact on their growth rates is of notable importance. Depending on the superiority of management and the lamb rearing conditions varied results can be achieved. Table 4-1 outlines that lambs weaned at three days and hand reared have a higher growth rate (351 g/day) within their first 30 days and they are weaned earlier than lambs reared by their dams. However between the 30 day weight and the 120 day weight, the hand reared lambs are surpassed in growth by lambs reared on ewes milked once a day and the lambs reared by their dams (uninterrupted). Lambs weaned at 30 days had the highest 120 day weight average at 47.3 kg. Lambs reared by ewes which were milked once a day reached 45.9 kg at 120 days however they had the lower 30 day weight of the treatments at 14.5 kg.

The results from this treatment indicate that it is possible to achieve high growth rates while hand rearing lambs, this may be an effect of an earlier weaning date equating to a higher average daily weight gain. However it is noticeable that once weaned lambs do not perform as well as lambs which were reared without intervention. This could be an effect of the earlier weaning date and a loss in production during the transition to a pasture diet. Lambs which were reared on ewes milked once a day appeared not to perform as well leading up to the 30 day weight, suggesting that milking the ewe was having an effect on lamb growth. It has been evident that in some cases lambs reared with this mixed system have benefitted because milk fat can be retained in the udder during machine milking. Suckling lambs induce milk ejection where they can receive richer milk (Folman et al., 1966).

However other reports indicate there is no difference in growth rates of lambs from differing weaning and rearing systems (Lawlor, Louca, & Mavrogenis, 1974). If the latter is such, deciding upon an appropriate system would be dependent on other factors such as resources available, farm management goals in terms of milk production, managerial experience and external factors such as milk price, lamb price, rearing costs.

Table 4-1 Lamb Growth traits by weaning system treatments (McKusick et al., 2001)

Trait	Lambs Weaned at 3 days and hand reared	Lambs reared on ewes milked once a day	Lambs weaned at 30 days
Weaning Age (days)	25	27	32
ADG, birth to 30 d (g/d)	351	322	338
30 d weight (kg)	15.4	14.5	15
120 d weight (kg)	43.7	45.9	47.3

NB: ADG- average daily gain

Weaning is a stressful time for ewes and lambs. When ewes are stressed they can retain their milk which can be an issue for milking ewes. Therefore careful management regarding this stock event is required. The greatest stress time for weaning is during the period when lambs are 4-20 days old (Stephanon, Colitti, Gabi, Knight, & Wilde, 2002). In Chapter 3 section 3.3 Scenario 1, lambs are removed at 3 days old and are hand reared while ewes are diverted to being milked twice a day for the duration of their lactation. Since the critical period for colostrum intake is the first 24 hours, lambs can be removed from ewes at any time after this. The early removal of lambs will reduce the stress circumstances for the ewe and lambs however it is paramount that weaning is not carried out too prematurely so as to limit the amount of colostrum received by the lambs.

4.3 Milking Ewe Considerations

In terms of per ewe total milk solid production, Scenario 1 indicated the highest performance at 34 MS/ ewe over a 199 day lactation. Since the income from milk production equated to 81% of the total income this had a positive effect on the overall farm profitability. The model was based off the concept that consistent machine milking early after birth enabled the ewe to achieve a higher milk yield which equated to a peak in yield of 1.8 litres per day. Scenario 2 weaned lambs at six weeks of age and milking of ewes commenced from this point, such is evident through the reduced lactation period of 134 days. However the total milk solid production per ewe is lower also, with ewes achieving 23 kg MS over the entire machine milked lactation period. Milking ewes 6 weeks after the commencement of lactation can reduce milk yield by greater than 14%, evident in Scenario 2. Also milking ewes once a day for the entire lactation can reduce milk yield by 48% (Stephanon et al., 2002). This is a factor which applies to the reduced the milk yield in Scenario 3 as ewes were milked once a day for a 6 week period while they mothered their lambs.

The modelled scenarios do not take into account the occasions of milking ewes prior to lambing. It is common in young ewes and 2ths to have large udder swelling prior to lambing, something which can be relieved through milking. This is a factor which may have an influence on the total lactation and also on the drying off date. However this practise reduces the amount of colostrum which is available to

the lamb. When daily milk yield is declining to amounts lower than 700 mls/ ewe, milking can commence once daily as there is no reduction in yield (Bencini, Knight, & Hartmann, 2003). Drying off can occur when milk production ceases to produce greater income than the cost of production.

4.4 Wintering off farm

The wintering off scenario provided an insight into another farm management system where the sheep dairy system emulates a typical dairy farm. To increase production and run an efficient system, the entire property is designed to be a milking platform and all young stock and non-productive stock are grazed off farm. This enables management to focus solely on milk production during the lactation period however it also is reliant on the availability of consistent grazing contracts with other land holders or the use of a run off block. Wintering non-productive stock off farm provides an opportunity to increase scale and intensity as more productive stock can be carried on the milking platform. This increases the milk and lamb production output and in the modelled scenario the wintering option produced the highest profit per ha at $5,052. When comparing the $ of saleable product production in relation to the Kg of Dry matter consumed, the wintering option was surpassed by Scenario 1 which did not encompass the option of grazing stock off the property. This is a factor which can be associated to the increased costs per livestock class due to grazing off farm.

4.5 Rearing systems a holistic view

When considering Scenario one, two and three and their different rearing systems, Scenario one achieved the highest total profit, profit per ha and $ of saleable product per Kg DM consumed. The sensitivity analysis in section 3.7 (Table 3-10) indicated that while there were additional lamb rearing costs associated with the system, the impact of this on the overall profit of the venture proved to be minimal. Artificial lamb rearing enabled ewes to reach their lactation potential and increased the scenarios saleable product. However, as detailed in Table 4-1, growth rates of lambs preceding artificial rearing are not equal to their counterparts whom were reared by their dams. This is a factor which was not taken into consideration when modelling Scenario one and could perhaps become a costing factor within a farm system. Lambs with slower growth rates remain on farm and result in a greater amount of feed consumed which is costing the system (Trafford, 2011). Lamb rearing also requires greater capital infrastructure as successful lamb rearing systems are operated in sheds where a high level of environmental control can be maintained. Additional labour and management to oversee this operation is also required. The benefits of the system lie in the profitability of the milk and the greater yield achieved by the ewes.

In contrast Scenario two details a system where ewes rear their lambs until 6 weeks of age and milking commences from this period onwards. Lactation length and milk yield is decreased in this scenario

which is translated to the overall cash profit of the venture. The reduced milk production equates to a profit $769/ha less than Scenario one. Although a loss of income is notable, the simplicity of the system from a management view point is desirable. Housing lambs and additional labour is not required and ewes are still achieving a reasonable milk output. Table 4-1 suggests that lambs reared by ewes have faster growth rates after weaning than artificially reared counterparts. A factor which would enable lambs to be finished earlier and reduce the total cost of feed required to grow lambs to a saleable weight.

Scenario three operates a mixed system where ewes are milked once a day while also being suckled by their lambs. Resulting in reduced milk production over a long lactation period (199 days). It is debateable whether it is worth carrying out a milking while ewes are rearing lambs since the returns in milk volume are very low at approximately 300 ml per milking (Bencini et al., 2003). The additional labour required to milk ewes and operate the milking shed may not be worth it. Also the daily separation of ewes and lambs may impose unnecessary stress on both parties. Ewes entering the milking parlour with high stress levels tend to retain milk (Gosling, 1997). Lambs reared under this system tend to have slower growth rates in the first 30 days of life than lambs reared by other systems (Baldin, 2013), however when monitored at 120 days old they are a similar weight to lambs which were reared by ewes (Table 4-1).

Scenarios one, two and three are highly comparable because essentially they operate under the same physical parameters with identical stock numbers. This enables an accurate comparison of the different weaning scenarios and conditions. In each system there is flexibility with lamb and milk production. Higher income is achievable from milking production and therefore is of a higher priority within the farm management systems. However there is opportunity to extend and advance the capabilities of the lamb raising systems through the use of terminal sires over non-replacement ewes. Once a flock has been stabilised with East Friesian genetics, pure bred rams can be put over ewes which demonstrate favourable milking traits. Using terminal rams over the majority of a flock will result in the production of lambs with adequate meat production traits and will potentially grow faster than a pure bred East Friesian lambs.

4.6 Use of Supplementary Feed

When considering the milking ability of sheep, it is a common misconception to assume they are small dairy cows. When allocating feed and estimating feed requirements this assumption is incorrect as there are factors which need to be considered. Cattle on the whole are more efficient at feed digestion. This is related to their size in relation to sheep. Cattle are 10-12 times larger and typically the gastrointestinal (digestive) tract is 13-18% of the body volume. In comparison to sheep, cattle have a greater capacity to store more feed. Sheep have a lower rumen capacity and as a result they have to

ruminate more regularly to maintain an adequate food passage rate through the digestive system. This explains why sheep consume approximately 4-6% of their body weight in feed and cattle rarely exceed 4% (Pulina, 2004). Sheep also have less powerful jaws and have to spend longer chewing more fibrous feeds, therefore they benefit from particle size of feed being smaller as it increases passage rate as there is lower fibre digestibility.

The nutrition of ewes during lactation requires careful management. Intensive milking systems have a higher nutritive requirement than what is necessary for meat and wool production. The quality of feed and supplementary feed provided is important considering the nature of the farming systems where animals are removed from pasture during the lactation period for milking.

There is a restricted time which animals are able to graze since they need to allocate time for rumination and rest. Animals tend to graze for up to 10-12 hours a day in different 'meal shifts (Hodgson, 1985). This is a factor which needs to be taken into consideration. If animals are operating at high production levels and are also part of an intensive farming system, the ability to achieve their ME demand can be reduced. Especially if their ability to graze is removed through stock shifts, walking to the dairy shed, yard work or any other activity which withdraws the animal from pasture.

Sheep tend to graze in bouts for varied periods of time. Approximately 70-99% of grazing occurs during daylight with their most active periods in the early morning and late afternoon (Times which typically coincide with milking). Around 25-48% of intake time is in the hours preceding sunset (Parsons, Newman, Penning, Harvey, & Orr, 1994). A higher rate at this time of day is assumed to ensure the animal reaches a high level of gut fill in the evening. Also late afternoon grazing coincides with diurnal peaks in the concentration in dry matter, soluble sugars and starches in grasses and legumes (Orr, Rutter, Penning, & Rook, 2001). There is also a behavioural aspect associated to the time spent grazing as animals in groups tend to graze at the same time. Understanding the grazing patterns of sheep can support the establishment of appropriate feed allocation management.

High producing animals can graze for longer to satiate their feed demand however this can have implications for time spent ruminating as they are inclined to reduce ruminating time, costing the animal in digestive efficiency.

Supplementary feed incorporated into milking systems, require selection to be based around the most efficient form of feed for utilisation. This is not exclusive to metabolisable energy value of the feed. The physical properties such as particle size is relevant to the amount and time required to consume the feed. In comparison to cattle, sheep benefit from feed with smaller particle size as it increases chewing efficiency. Also diets which contain too much long fibre will limit intake due to their filling effect. Enabling a ewe to achieve her optimum intake will be rewarded with unhindered milk production. Table 4-2 fortifies the argument that feed particle size can have production implications for milking ewes. The difference in particle size of ryegrass silage resulted in a 36% increase in feed

intake which correlated to a 19% greater daily milk yield. Lambs also performed well on the short silage, gaining a difference of 54 g between the treatments.

Table 4-2 The effect of ryegrass silage particle size on intake and milk production of ewes in the first 4 weeks of lactation (Cannas, 2004)

Type of Silage	Intake (Kg DM /day)	Milk Yield (Kg/day)	Lamb Growth (g/day)
Short	1.45	2.67	254
Long	0.93	2.17	200

Grain feeding is an integral aspect to milking operations as it not only provides additional energy to ewes, it also facilitates the training of ewes to be milked and provides an incentive for ewes to enter the shed. Sheep have good memory of handling procedures, therefore training of sheep to enter a milking platform is important, and the enticement of food can reduce stress levels and encourage ewes to cooperate in the milking process. It is also useful to mix older more accustomed ewes with younger ewes to lead the way.

4.7 Grazing Management Considerations

Similar to the allocation of supplementary feed the management of grazed pastures is highly important to the performance of milking ewes as it provides the foundation for production. In order for ewes to produce to their full potential, they have to be fed well. To achieve optimum results pasture management requires more intervention than normal. Any time spent cleaning up seed heads and rough feed is counteractive to the overall objective of grazing management. In such cases it is important to avoid reduction in pasture quality. The mouth parts and biting mechanisms for sheep somewhat determine the type of pasture and covers which are most appropriate. Sheep bite the foliage off at the plant or it is severed as they jerk their heads back. They have molar teeth in the upper jaw which is a rubbery muscular pad instead of incisor teeth. They have a cleft upper lip which permits close grazing and they have a smaller mouth which enables them to be selective.

The ability to select forage material is a beneficial and also problematic factor for feed management of milking stock. Animals will select the highest quality diet which is useful from a production view point however sporadic grazing of species is unsustainable for the maintenance of pasture quality.

Grazing intake can be modelled by the equation Intake = time spent grazing x bite size x rate of biting (Pulina, 2004). There is a close relationship between the three components which model the intake rate for grazing animals. Accessibility is an influential parameter effecting intake rate. The bite mass of

sheep increases with the availability of pasture. As the sward surface height rises, the bite mass increases in a curvilinear manner prior to plateauing (Edwards, Parsons, Penning, & Newman, 1995).

The increase in bite mass is primarily due to the increase in bite depth. The bite depth of sheep is positively correlated with sward height. Bite depth is regulated between 30 and 50% a proportion of sward surface height, this results in a constant level of pasture removal with each successive bite (Parsons et al., 1994). However these changes do not directly increase intake rate since there is a decline in prehension rate as bite mass increases. Therefore the intake rate increases with sward height and pasture availability until an asymptote is reached.

Although pasture height can be an indicator of animal bite mass, there can be varying affects which can be associated with the structure of pasture. The leaf to stem ratio may also have a role in determining bite mass and intake rate. Grazing duration can be also used as a compensatory mechanism that counters the effect of variation in bite mass and intake rate. It is also an indicator of behavioural decisions by animals. The time spent grazing can be a compensatory reaction to intake rate. For example restricted forage or swards which are shorter in height are more difficult to graze and animals will tend to increase their grazing time to compensate for the reduced intake as a derivative of restricted feeding (Cosgrove & Edwards, 2007).

The importance of this is that high producing sheep have a higher energy demand and therefore they will tend to graze for a longer duration to satisfy their demand. Cows increase their grazing duration by 5-16 minutes for every additional kilogram of milk production (Cosgrove & Edwards, 2007), a factor which is most likely emulated in sheep. This factor associated with time limitations for grazing of dairy stock is another grazing and pasture management consideration.

To achieve a high level of production a scientific based pasture management approach which encompasses the nutritional and physical grazing requirements will ensure avoidance of production loss.

Adequate feeding of ewes is highly important as it not only has an impact on milk production but also on the fertility. Breeding is a fundamental aspect of any dairying system, the ability of a ewe to commence lactation through producing lambs is a function of ewe condition. Therefore it is paramount that feed availability is not limiting throughout the year. In the modelled scenarios the supply is an appropriate match for animal demand to reduce the occurrence of live weight and ewe condition loss.

4.8 Wool Consideration

The scenarios have not taken into account the cost benefit production of wool. Energy requirements for wool production are approximately 40-50 MJ ME per kg of wool. Over the period it takes to produce this amount, the energy requirement is fairly inconsequential and is incorporated into the ewes maintenance (Nicol & Brookes, 2007). The cost of shearing and crutching has been additional to the

costs of livestock (appendix Table 6-1). East Friesians produce cross bred wool which requires consideration when milking. Firstly wool length has implications on the flow of stock in and out of a milking shed. Ewes carrying a heavy fleece are more bulky and will not flow as easily into a milking shed as their wool can catch on rails. Milking bails can become constrictive to full wool ewes. Another consideration is that wool can be a hindrance to production. In the milking environment there is high use of water to maintain cleanliness in the yards and sheds. It is likely that animals may become damp, in warm conditions, damp wool provides a humid environment which attracts flies. Fly strike is a high risk from November through to March as this is a warm period which allows for rapid increases in blowfly populations. When sheep are affected by fly strike production losses can be high through either death or loss of milk and wool production. In a conventional sheep operation, chemical dips are able to be used to prevent against fly strike however when ewes are lactating for market production, there is a risk of chemical contamination in the milk. Since sheep products are typically designed for meat production animals, the majority of products on the market do not detail animal withholding periods with regard to milk production. It is recommended that animals are not dipped 4-6 weeks prior to lambing (Gosling, 1997). Since in most cases sheep are being handled twice daily, the detection of fly strike should be noticeable and vigilant staff can deal with problems accordingly. The risk is reduced if wool is short therefore six monthly shearing is advisable. Since ewes are lactating throughout the summer months, it is imperative that water use in the dairy shed is kept to a minimum to avoid such risks of dampening wool. There is also a greater risk of lice in long wool animals. Lice can be highly irritating and itchy for stock and they will tend to spend time rubbing against fence posts and gates, this is time which could be spent grazing, consuming energy which could attribute to milk production.

4.9 Genetics

There is also the issue of genetics which requires addressing, as the industry progresses in New Zealand the pool of favourable milking genetics will expand however currently the predominate milking breed in New Zealand is the East Friesian. In terms of production these animals are high performing, however they originated from Holland where they were farmed indoors. Therefore they are not suitably conditioned to New Zealand environments. One particular downfall of the breed is its very pink skin, when shorn they are highly susceptible to sunburn and can develop skin cancer. Currently there has been low experimentation however, the option of milking a black East Friesian is feasible. These animals have a darker skin tone which is more tolerant of exposure to sunlight. The breed would need to be crossed or adapted to ensure the majority of the flock produced white wool. Coloured wool has a lower value than white wool because it is not suited to as many end uses because it is harder to dye. Another point of consideration is the breeding characteristics for male lambs. Lambs are a significant output/ by product of milking ewes and approximately 20% of ewe lambs are retained as replacement stock. The remainder are grown out for the lamb trade. Typically pure East Friesian stock are not as

suitable for this end use as they are large framed and produce lean carcasses (Meadows, 1997). Large framed animals are desirable for milk production as they generally have higher output however; they take longer to fill out which is a negative aspect for the finishing of lambs. When the genetics of a flock are stabilised it is likely that terminal sires will be used over all non-replacement stock to improve the performance of lambs destined for the meat trade. However, there are options to cross breed for the production of animals with complimentary traits for both meat and milk. Crossing East Friesian ewes with Poll Dorset genetics is an option producing animals with favourable traits. Poll Dorset's are also large framed animals with high milking ability, they are also hardy animals with vigorous, rapid growth rates. Another aspect to this breed which is a useful factor to incorporate into a milking flock is the well suited ability to produce out of season lambs, environment permitting. Non seasonal breeding has not been incorporated into the modelled scenarios of this study however; it is a factor which can be considered for the production of year round milk supply.

4.10 Environment

Agricultural production in Canterbury has grown significantly over the past two decades as a result of increasing input factors which enable farms to intensify. These are inputs such as fertiliser, supplementary feed and irrigation water. The conversion of plantation forests and extensive sheep and beef grazing into dairy farms has imposed environmental issues. Nitrate leaching is a primary concern for environmentalists in Canterbury. It occurs when there is an accumulation of nitrate in the soil which is followed by a period of high drainage, enabling the leaching of nutrients into ground water sources. There are many on farm practices which can attribute to the escalation of this environmental issue such as the timing and amounts of fertiliser and effluent applications (H. Di & Cameron, 2002). Improving pasture management and having an environmental management focus can help to reduce the imminence of leaching on a farm however an area which is unavoidable in a grazed pasture based agricultural system is the contribution to leaching from livestock. Cows are known to have a high N loading rate through urine patches which is increasing nutrient leaching into ground water sources. The approximate amount of nitrogen in a urine patch is 1000 Kg of N/ha, an amount which exceeds the requirements for plant uptake. Grazing animals return between 60-90% of consumed nitrogen to the pasture in the form of urine and dung with a high proportion (90%) returned as urea in urine (H. Di & Cameron, 2002). A combination of urine patches, fertiliser use and effluent spreading is resulting in high levels of nitrates leaching into ground water. Winter is the most likely time for this to occur because of prolonged wet periods and saturated soils, such factors facilitate leaching. In relation to farming in Canterbury, awareness of this environmental issue is growing. Proposals such as an allocation approach to nitrate discharges and consents for irrigation and land use undertaken by Environment Canterbury impose constraints on farming practices. When considering the affect which stock classes have on the land and environment, there is a remarkable difference between the impacts

of cattle and sheep. Size difference of the animals is an associate factor as cows are 10-12 times larger than sheep and therefore have a greater nutrient consumption and total nutrient output. For an environment with an average rainfall of 750mm per year, an irrigated sheep operation on light soils equates to a nitrate loss of approximately 27 Kg N/ha. In the same environment a 4 cow/ha dairy farm with animals wintered off the property results in losses of 90kg N/ha (Lilburne, Webb, Ford, & Bidwell, 2010). In the same trial, the influence of irrigation types on the rate of drainage was studied. As drainage is a factor which facilitates nitrate leaching, the effectiveness and type of irrigation can have an impact on leaching levels of a farming system.

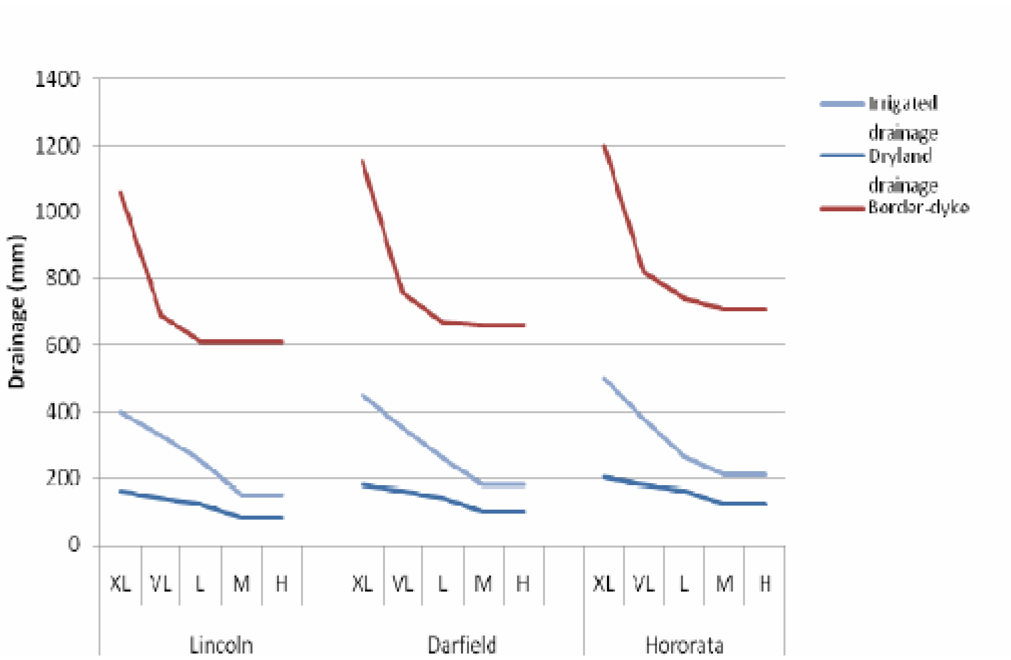

Figure 4-1 Comparison of Irrigation methods and their effect on drainage (Lilburne et al., 2010)

Figure 4-1 is indicative of the rate of drainage of irrigation systems over a variety of soils in various locations. Dry land has consistently low drainage over the array of soils. For irrigation, spray irrigation has a lower drainage capacity than border dyke irrigation which is the highest. Border dyke is a flooding technique which is a cheap form of irrigation however it is highly inefficient and from an environmental aspect it has a greater contribution to nutrient leaching through increased drainage capacity of soils.

For an intensive pasture based livestock system in a low rainfall area such as Canterbury, irrigation is essential for maintaining control over pasture growth during summer and the subsequent animal production. As a result of the growing awareness of environmental concerns and the impacts of poorly managed systems, dairy farmers are trending towards improving their systems. Research is being undertaken regarding the introduction of more controlled farming environments such as housing livestock in order to appropriately manage waste and effluent while still maintaining high production (Journeaux, 2013). Housing is an effective environmental regulation technique however it incurs an

entire change in farming system and there is high capital cost associated with structures as well as the loss of a competitive advantage for low cost animal production.

For the continuation of dairy farming in Canterbury, sheep milking provides an alternative avenue for farmers to explore. The remarked reduction of environmental foot print of sheep compared to cattle indicates that sheep milking is more 'environmentally friendly', a concept which could be used advantageously through marketing of products.

4.11 Economic Comparison of modelled scenarios with industry relevant models

To provide a context for the modelled scenarios, the profit performance per ha has been compared with industry relevant models for dairy farming and sheep breeding and finishing for the Canterbury and wider Canterbury regions. The comparison is based off income before tax figures. The models which incorporate sheep milking surpass the primary industry model figures. An outcome which would be expected for the comparison to a conventional sheep and beef breeding and finishing system. The comparison to the Canterbury dairy model is noteworthy since for this instance sheep milking appears to be more profitable on a hectare basis. Factors which may attribute to this are lower farm working expenses and costs for sheep milking. Several costs have not been included with the model, such as the costs of the systems being related to an industry body. The models include a farm working expenses cost which is based on a national sheep and beef cost which therefore may be slightly unrealistic for a sheep milking system. Despite these factors, the modelled scenarios are directing towards the concept that sheep milking is on a comparable platform to the profitability of Canterbury cow dairy farming.

Table 4-3 Comparison of profit per ha of modelled scenarios and industry relevant models (Ministry for Primary Industries, 2012)

Farming Systems	Cash Cost/Profit (ha)	
Scenario 0	$	566.76
Scenario 1	$	1,744.98
Scenario 2	$	1,624.88
Scenario 3	$	1,624.88
Wintered off Scenario	$	5,454.19
Canterbury Dairy Model	$	713.00
Canterbury/Marlborough, Breeding and Finishing Sheep and Beef	$	387.00

Chapter 5

Conclusion

A combination of a struggling sheep meat and wool industry, a booming dairy industry and the option of irrigation has initiated the desire for many to change farming systems. Until recently converting dry land sheep, beef and arable farms on the Canterbury plains to cow dairy farms has been a growing trend. The ability to irrigate has enabled farmers to maintain a firm control on pasture growth and management. High pasture growth rates and flat land has led to farm intensification and an increase in stocking rates to achieve high milk solid production per ha. Rising land prices are also a factor which encourages growth of production. Intensification has had several negative implications on the environment. High stocking rates, effluent waste and nitrogen fertiliser has increased the level of Nitrogen application to the soil, to a level over and beyond what is reasonable for plant uptake, resulting in leaching losses. Nutrient leaching into ground water is an environmental concern, therefore several environmental constraints have been actioned. Nutrient capping for properties and irrigation consent restrictions have halted cow dairy conversions in various zones of Canterbury. This provides an entry point for a potential sheep milking industry on the plains.

The aim of this study was to identify a response to the following research questions.

- **Is sheep dairying economically feasible In Canterbury?**

  A study of the modelled scenarios indicate that there is profit to be made through various sheep milking systems. The models proved that any sheep milking system can achieve higher profits than a traditional sheep breeding and finishing system due to the production of an additional high value product. The sheep only scenario was highly sensitive to lamb price as was the sheep milking scenarios to the milk price. The primary difference in the systems being that sheep milking scenarios also had the meat sector as a complimentary income option. The sheep milking is a venture which can be incorporated and complimented with lamb finishing to avoid market reliance risk.

- **In relation to the environmental concerns regarding farming in Canterbury, is the proposal of sheep dairying a positive advancement for farming in the region?**

  Using nitrate leaching as the comparable factor for the impact sheep and cattle farming systems have on the environment, dairy farming of cows equates to approximately 63 kg / ha of nitrate leaching greater than that of an intensive sheep system (Lilburne et al., 2010). In relation to current land use, a comparison of the profitability outcomes for the modelled scenarios with industry relevant data for regional dairy and traditional sheep and beef systems

indicated that a profit can be sustained at a superior level to current land use systems, given market circumstances.

- **Which aspects to the industry or the systems will be limiting to the success of sheep dairying in Canterbury?**

  The present lack of a sound established industry is a limitation to the success of sheep dairying in Canterbury. A fully operation industry body would provide the market for sheep farmers to supply and without such, the results of the study are presumptuous. Other requirements of industry establishment are genetic improvement of animals with milking performance and meat enhancing traits, industry support in the form of grazing contracts for the management of milking sheep and industry support services to provide infrastructure and technology.

Currently the results are speculative since there is not an established processor of sheep milk in Canterbury. It is an industry yet to take off in New Zealand. However, in the current environmental and economic climate, it might be the way forward. From this study it can be determined that a range of sheep dairying systems are feasible in Canterbury. Sheep have a lower environmental foot print, are flexible within the farm management system, and produce an easily digestible product. The systems are economically viable and it can be foreseen that the systems would achieve a higher return than a conventional sheep farm. Establishing a sound processor is an obstacle to overcome, however if there is interest and a willingness to commit to the industry, there is great potential for sheep milking to be a lucrative and alternative to a sheep meat operation or cow dairy farming without as severe environmental implications

Chapter 6 Limitations of the Study

The study has aimed to compare and determine optimum systems for a futuristic sheep milking industry in Canterbury. The results of this study are clearly defined by the parameters set out by the nature of the systems. First and foremost the current realism of results from the study are hypothetical since there is an absence of an established processor of sheep milk for export product in the Canterbury region. This is an integral assumption of the study as it is a factor which ensures demand for product and a determinant of price. Expansion of the industry and increased production of product needs to be incorporated with market growth to sustain the viability of the industry and maintain an acceptable product price standard.

The linear programming model was a useful tool to compare different management systems based on similar physical properties however discrepancies within the model prevent absolutely realistic results with regard to pasture covers in the feed supply and demand modelling. Although pasture covers remain realistic, circular referencing of the model prevented the constraints of the maintenance of covers between 1500 and 3000 Kg DM/ha. Towards the end of the annual growth season, pasture covers were increasing towards 4000 Kg DM/ha. Realistically this would be an undesirable outcome because of the decline in pasture quality.

Another factor which has limited this study is the limited amount of literature and scientific studies of milking sheep and related data specific for the New Zealand environment. With regard to animal production requirements, assumptions had to be made based on overseas data and the productive requirements for animals destined for the meat trade.

Points of interest and areas which could benefit the progress of industry development in New Zealand would be further study on complimentary cross breeding of animals to accord with New Zealand farming environments. Also lamb rearing is a significant aspect of intensive milking operations and further studies on New Zealand specific methods of rearing for the most desirable growth outcomes to supply a meat trade, would be valuable to the industry. Improved knowledge of the genetic, management and environmental factors to enhance milk production will not only be advantageous for sheep milking, it will also be beneficial to the sheep breeding and finishing industry. With Regard to the modelled scenarios, hogget mating was utilised although they were not milked. This is an area which could be further investigated, measuring the effects of the additional stock class to a milking operation.

Since there is a void in the availability of information, any New Zealand based research will present a benefit to the industry.

Appendix A

Linear Programming Constraints and Variables

A.1 Costs per Livestock Class

Table 6-1 Scenario 0, Costs per Livestock Class

Costs	Capital Value	Interest Rate.	% Months on Farm in Year.	Interest Cost.	Animal health	% Deaths	Cost of deaths	Breeding Costs	Cartage	Shearing/ Dagging	FEW	Rearing Costs	Total Annual Costs of having Animal on Farm.	S/Us
MA ewes	90	10%	100%	9.00	12	5%	4.05	1	1.95	3.48	$ 70.11		**101.59**	1.3
2th Ewes	95	10%	75%	7.13	12	4%	3.80	1	0	3.48	$ 70.11	0	**97.51**	1.3
Wet Hoggets	75	10%	75%	5.63	12	5%	3.75	1	0	3.28	$ 53.93	0	**79.58**	1
Dry Hoggets	65	10%	75%	4.88	3	2%	1.30	0	0	3.28	$ 37.75	0	**50.20**	0.7
Ewe Lambs	60	10%	25%	1.50	3	5%	3.00	0	1.7	3.28	$ 21.57	0	**34.05**	0.4
Ram Lambs	63	10%	25%	1.58	3	5%	3.15	0	1.7	3.28	$ 21.57	0	**34.28**	0.4
Rams	250	10%	100%	25.00	5	3%	7.50	0	0	10	$ 43.14	0	**90.64**	0.8

Table 6-2 Scenario 1, Costs per Livestock Class

Costs	Capital Value	Interest Rate.	% Months on Farm in Year.	Interest Cost.	Animal health	% Deaths	Cost of deaths	Breedin g Costs	Cartage	Shearing/ Dagging	Rearing Costs	FWE/SU	Total Annual Costs of having Animal on Farm.	S/Us
MA ewes	90	10%	100%	9.00	12	5%	4.05	1	1.95	3.48		151.67	**183.15**	1.3
2th Ewes	95	10%	75%	7.13	12	4%	3.80	1	0	3.48	0	151.67	**179.08**	1.3
Wet Hoggets	75	10%	75%	5.63	12	5%	3.75	1	0	3.28	0	70.11	**95.76**	1.3
Dry Hoggets	65	10%	75%	4.88	3	2%	1.30	0	0	3.28	0	37.75	**50.20**	0.7
Ewe Lambs	60	10%	25%	1.50	3	5%	3.00	0	1.7	3.28	50	21.57	**84.05**	0.4
Ram Lambs	63	10%	25%	1.58	3	5%	3.15	0	1.7	3.28	50	21.57	**84.28**	0.4
Rams	250	10%	100%	25.00	5	3%	7.50	0	0	10	0	43.14	**90.64**	0.8

Table 6-3 Scenario 2, Costs per Livestock Class

Costs	Capital Value	Interest Rate.	% Months on Farm in Year.	Interest Cost.	Animal health	% Deaths	Cost of deaths	Breedin g Costs	Cartage	Shearing/ Dagging	Rearing Costs	FEW/SU	Total Annual Costs of having Animal on Farm.	S/Us
MA ewes	90	10%	100%	9.00	12	5%	4.05	1	1.95	3.48	0	151.67	**183.15**	1.3
2th Ewes	95	10%	75%	7.13	12	4%	3.80	1	0	3.48	0	151.67	**179.08**	1.3
Wet Hoggets	75	10%	75%	5.63	12	5%	3.75	1	0	3.28	0	53.93	**79.58**	1
Dry Hoggets	65	10%	75%	4.88	3	2%	1.30	0	0	3.28	0	37.75	**50.20**	0.7
Ewe Lambs	60	10%	25%	1.50	3	5%	3.00	0	1.7	3.28	0	21.57	**34.05**	0.4
Ram Lambs	63	10%	25%	1.58	3	5%	3.15	0	1.7	3.28	0	21.57	**34.28**	0.4
Rams	250	10%	100%	25.00	5	3%	7.50	0	0	10	0	43.14	**90.64**	0.8

Table 6-4 Scenario 3, Costs per Livestock Class

Costs	Capital Value	Interest Rate.	% Months on Farm in Year.	Interest Cost.	Animal health	% Deaths	Cost of deaths	Breeding Costs	Cartage	Shearing/ Dagging	Rearing Costs	FEW/SU	Total Annual Costs of having Animal on Farm.	S/Us
MA ewes	90	10%	100%	9.00	12	5%	4.05	1	1.95	3.48		151.7	**183.15**	1.3
2th Ewes	95	10%	75%	7.13	12	4%	3.80	1	0	3.48	0	151.7	**27.41**	1.3
Wet Hoggets	75	10%	75%	5.63	12	5%	3.75	1	0	3.28	0	116.7	**25.66**	1
Dry Hoggets	65	10%	75%	4.88	3	2%	1.30	0	0	3.28	0	81.7	**12.46**	0.7
Ewe Lambs	60	10%	25%	1.50	3	5%	3.00	0	1.7	3.28	0	46.7	**12.48**	0.4
Ram Lambs	63	10%	25%	1.58	3	5%	3.15	0	1.7	3.28	0	46.7	**12.71**	0.4
Rams	250	10%	100%	25.00	5	3%	7.50	0	0	10	0	93.3	**47.50**	0.8

Table 6-5 Wintering off Scenario, Costs per Livestock Class

Costs	Capital Value	Interest Rate.	% Months on Farm in Year.	Interest Cost.	Animal health	% Deaths	Cost of deaths	Breedin g Costs	Cartage	Shearing/ Dagging	Grazing Cost	Weeks off Farm	Rearing Costs	Total Annual Costs of having Animal on Farm.	S/Us
MA ewes	90	10%	100%	9.00	12	5%	4.05	1	1.95	3.48	2.5	17		**75.05**	1.3
2th Ewes	95	10%	75%	7.13	12	4%	3.80	1	0	3.48	2.5	17	0	**70.98**	1.3
Wet Hoggets	75	10%	75%	5.63	12	5%	3.75	1	0	3.28	2.5	17	0	**69.23**	1.3
Dry Hoggets	65	10%	75%	4.88	3	2%	1.30	0	0	3.28	2.5	17	0	**56.03**	0.7
Ewe Lambs	60	10%	25%	1.50	3	5%	3.00	0	1.7	3.28	2.5	17	50	**106.05**	0.4
Ram Lambs	63	10%	25%	1.58	3	5%	3.15	0	1.7	3.28	2.5	17	50	**106.28**	0.4
Rams	250	10%	100%	25.00	5	3%	7.50	0	0	10	2.5	17	0	**91.07**	0.8

A.2 Livestock Growth Rates

							Not Milking						
Ewe Lambs													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	21.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		0.0	4.0	12.4	24.4	30.6	35.1	39.8	44.4	48.6	51.7		
daily weight gain kg			0.4	0.4	0.2	0.2	0.2	0.2	0.15	0.10			
Total Weight gain/month kg			8.4	12.0	6.2	4.5	4.7	4.7	4.2	3.1			
Maintenance (0.8 MJ ME/kg^0.75	0.8		2.3	5.3	8.8	10.4	11.5	12.7	13.8	14.7			
ME for LWG	55.0		22.0	22.0	11.0	8.3	8.3	8.3	8.3	5.5			
Total ME requirements			24	27	20	19	20	21	22	20			
Monthly ME Requirements			509.5	818.6	613.3	559.7	613.4	648.4	616.3	627.0			
Kg DM/Hd/day			2.4	2.3	1.7	1.7	1.8	1.9	2.0	1.9			
Ewe Hoggets													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		60.9	64.0	64.0	64.0	64.0	64.0	64.0	64.0	48.6	51.7	54.7	57.8
daily weight gain kg		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Total Weight gain/month kg		3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.0	3.1	3.0
Maintenance (0.8 MJ ME/kg^0.75	0.8	17.4	18.1	18.1	18.1	18.1	18.1	18.1	18.1	14.7	15.4	16.1	16.8
ME for LWG	55.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	5.5	5.5	5.5	5.5
ME for pregnancy and Lamb(s)		3.0	5.0	14.0	18.0					1.0	1.0	1.0	2.0
Total ME requirements		25.9	28.6	32.1	36.1	18.1	18.1	18.1	18.1	21.2	21.9	22.6	24.3
Monthly ME Requirements		804.1	886.7	963.1	1,119.2	543.1	561.2	561.2	506.9	658.0	657.7	700.3	728.1
Kg DM/Hd/day		2.6	2.9	2.7	3.1	1.6	1.6	1.6	1.6	2.0	2.0	2.3	2.4

2-ths													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.8 MJ ME/kg^0.75	0.8	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
ME for LWG	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	6.0	14.0	18.0						2.0	2.0	3.0
Total ME requirements		22.1	24.1	32.1	36.1	18.1	18.1	18.1	18.1	18.1	20.1	20.1	21.1
Monthly ME Requirements		685.2	747.2	963.1	1,119.2	543.1	561.2	561.2	506.9	561.2	603.1	623.2	633.1
Kg DM/Hd/day		2.2	2.4	2.7	3.1	1.6	1.6	1.6	1.6	1.7	1.9	2.0	2.1

4-ths													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.7	0.6	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
LWG : at MJ ME/kg LWG:	65.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0						2.0	2.0	3.0
Total ME requirements		13.4	19.4	26.4	30.4	12.4	12.4	12.4	12.4	12.4	14.4	11.4	12.4
Monthly ME Requirements		416.5	602.8	793.4	943.8	373.4	385.8	385.8	348.5	385.8	433.4	354.8	373.4
Kg DM/Hd/day		1.3	1.9	2.2	2.6	1.1	1.1	1.1	1.1	1.2	1.3	1.1	1.2

4-yr													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.7	0.6	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
LWG : at MJ ME/kg LWG:	65.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0						2.0	2.0	3.0
Total ME requirements		13.4	19.4	26.4	30.4	12.4	12.4	12.4	12.4	12.4	14.4	11.4	12.4
Monthly ME Requirements		416.5	602.8	793.4	943.8	373.4	385.8	385.8	348.5	385.8	433.4	354.8	373.4
Kg DM/Hd/day		1.3	1.9	2.2	2.6	1.1	1.1	1.1	1.1	1.2	1.3	1.1	1.2

5yr													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.7	0.5	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
LWG : at MJ ME/kg LWG:	60.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0						2.0	2.0	3.0
Total ME requirements		12.3	18.3	25.3	29.3	11.3	11.3	11.3	11.3	11.3	13.3	10.3	11.3
Monthly ME Requirements		381.4	567.7	759.4	908.7	339.4	350.7	350.7	316.8	350.7	399.4	319.7	339.4
Kg DM/Hd/day		1.2	1.8	2.1	2.5	1.0	1.0	1.0	1.0	1.0	1.2	1.0	1.1

6yr		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0	64.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.7	0.5	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
LWG : at MJ ME/kg LWG:	60.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0					1.0	2.0	2.0	3.0
Total ME requirements		12.3	18.3	25.3	29.3	11.3	11.3	11.3	11.3	12.3	13.3	10.3	11.3
Monthly ME Requirements		381.4	567.7	759.4	908.7	339.4	350.7	350.7	316.8	381.7	399.4	319.7	339.4
Kg DM/Hd/day		1.2	1.8	2.1	2.5	1.0	1.0	1.0	1.0	1.1	1.2	1.0	1.1

Rams													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
LWG : at MJ ME/kg LWG:	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
ME for weight gain		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0	0.0
LWG : at MJ ME/kg LW Loss	30.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	-0.1	-0.1	0.0
Maintenance (0.55 MJ ME/kg^0.7	0.6	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Total ME requirements		14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	11.6	11.6	14.7
Monthly ME Requirements		456.1	456.1	441.4	456.1	441.4	456.1	456.1	411.9	456.1	348.4	360.0	441.4
Kg DM/Hd/day		1.5	1.5	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.1	1.2	1.5

Milking

Ewe Lambs													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	21.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		0.0	4.0	12.4	24.4	33.7	42.7	47.4	52.0	56.2	59.3		
daily weight gain kg			0.4	0.4	0.3	0.3	0.2	0.2	0.15	0.10			
Total Weight gain/month kg			8.4	12.0	9.3	9.0	4.7	4.7	4.2	3.1			
Maintenance (0.8 MJ ME/kg^0.75)	0.8		2.3	5.3	8.8	11.2	13.4	14.4	15.5	16.4			
ME for LWG	55.0		22.0	22.0	16.5	16.5	8.3	8.3	8.3	5.5			
Total ME requirements			24	27	25	28	22	23	24	22			
Monthly ME Requirements			509.5	818.6	783.8	830.7	670.0	703.4	664.8	679.5			
Kg DM/Hd/day			2.4	2.3	2.1	2.5	1.9	2.0	2.1	2.0			

Ewe Hoggets													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		65.4	68.5	68.5	68.5	68.5	68.5	68.5	68.5	56.2	59.3	62.3	62.3
daily weight gain kg		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Total Weight gain/month kg		3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.0	0.0	0.0
Maintenance (0.8 MJ ME/kg^0.75)	0.8	18.4	19.0	19.0	19.0	19.0	19.0	19.0	19.0	16.4	17.1	17.7	17.7
ME for LWG	55.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	5.5	5.5	0.0	0.0
ME for pregnancy and Lamb(s)		3.0	5.0							1.0	1.0	1.0	2.0
Total ME requirements		26.9	29.5	19.0	19.0	19.0	19.0	19.0	19.0	22.9	23.6	18.7	19.7
Monthly ME Requirements		833.8	916.0	571.5	590.5	571.5	590.5	590.5	533.4	710.5	707.9	580.9	592.2
Kg DM/Hd/day		2.7	3.0	1.6	1.6	1.7	1.7	1.7	1.7	2.1	2.2	1.9	2.0

2-ths													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.8 MJ ME/kg^0.75)	0.8	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
ME for LWG	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	6.0	14.0	18.0	21.0	21.0	21.0	21.0	1.0	2.0	2.0	3.0
Total ME requirements		23.0	25.0	33.0	37.0	40.0	40.0	40.0	40.0	20.0	21.0	21.0	22.0
Monthly ME Requirements		714.5	776.5	991.5	1,148.5	1,201.5	1,241.5	1,241.5	1,121.4	621.5	631.5	652.5	661.5
Kg DM/Hd/day		2.3	2.5	2.8	3.1	3.6	3.6	3.6	3.6	1.9	1.9	2.1	2.2

4-ths													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.75	0.6	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
LWG : at MJ ME/kg LWG:	65.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0	21.0	21.0	21.0	21.0	1.0	2.0	2.0	3.0
Total ME requirements		14.1	20.1	27.1	31.1	34.1	34.1	34.1	34.1	14.1	15.1	12.1	13.1
Monthly ME Requirements		436.7	623.0	812.9	964.0	1,022.9	1,057.0	1,057.0	954.7	437.0	452.9	375.0	392.9
Kg DM/Hd/day		1.4	2.0	2.3	2.6	3.0	3.0	3.0	3.0	1.3	1.4	1.2	1.3

4-yr													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.75	0.6	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
LWG : at MJ ME/kg LWG:	65.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0	21.0	21.0	21.0	21.0	1.0	2.0	2.0	3.0
Total ME requirements		14.1	20.1	27.1	31.1	34.1	34.1	34.1	34.1	14.1	15.1	12.1	13.1
Monthly ME Requirements		436.7	623.0	812.9	964.0	1,022.9	1,057.0	1,057.0	954.7	437.0	452.9	375.0	392.9
Kg DM/Hd/day		1.4	2.0	2.3	2.6	3.0	3.0	3.0	3.0	1.3	1.4	1.2	1.3

5yr													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.75	0.5	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
LWG : at MJ ME/kg LWG:	60.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0	21.0	21.0	21.0	21.0	1.0	2.0	2.0	3.0
Total ME requirements		12.9	18.9	25.9	29.9	32.9	32.9	32.9	32.9	12.9	13.9	10.9	11.9
Monthly ME Requirements		399.8	586.1	777.2	927.1	987.2	1,020.1	1,020.1	921.3	400.1	417.2	338.1	357.2
Kg DM/Hd/day		1.3	1.9	2.2	2.5	2.9	2.9	2.9	2.9	1.2	1.3	1.1	1.2

6yr													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Weight gain/month kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance (0.55 MJ ME/kg^0.75	0.5	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
LWG : at MJ ME/kg LWG:	60.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
ME for weight gain		-3.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0
LWG : at MJ ME/kg LW Loss	30.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ME for pregnancy and Lamb(s)		4.0	10.0	14.0	18.0	21.0	21.0	21.0	21.0	1.0	2.0	2.0	3.0
Total ME requirements		12.9	18.9	25.9	29.9	32.9	32.9	32.9	32.9	12.9	13.9	10.9	11.9
Monthly ME Requirements		399.8	586.1	777.2	927.1	987.2	1,020.1	1,020.1	921.3	400.1	417.2	338.1	357.2
Kg DM/Hd/day		1.3	1.9	2.2	2.5	2.9	2.9	2.9	2.9	1.2	1.3	1.1	1.2

Rams													
Period		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Season		Winter	Winter	Spring	Spring	Summer	Summer	Summer	Summer	Autumn	Autumn	Winter	Winter
MJ ME/kgDM		10.0	10.0	11.8	11.8	11.2	11.2	11.2	11.2	10.8	10.8	10.0	10.0
Days		31.0	31.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0
Average Weight kg		80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
daily weight gain kg		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
LWG : at MJ ME/kg LWG:	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
ME for weight gain		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.0	-3.0	0.0
LWG : at MJ ME/kg LW Loss	30.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	-0.1	-0.1	0.0
Maintenance (0.55 MJ ME/kg^0.75	0.6	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Total ME requirements		14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	11.6	11.6	14.7
Monthly ME Requirements		456.1	456.1	441.4	456.1	441.4	456.1	456.1	411.9	456.1	348.4	360.0	441.4
Kg DM/Hd/day		1.5	1.5	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.1	1.2	1.5

A.3 Milk Production

Table 6-6 Milk Production Scenario 1

		July	August	September	October	November	December	January	February	March	April	May	June	TOTAL SEASON
Autumn	Litres	0.0	1.4	1.4	1.6	1.8	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Litres to kg milk	3%	0.0	1.4	1.4	1.6	1.9	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Fat		0.0%	5.5%	5.5%	5.6%	5.7%	5.8%	6.0%	6.0%	0.0%	0.0%	0.0%	0.0%	
Protein		0.0%	5.0%	5.0%	5.1%	5.2%	5.3%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	
Total MS		0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	
Days/month		31.0	18.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0	
kgMS/month		0.0	2.7	4.5	5.5	6.1	5.7	5.1	4.6	0.0	0.0	0.0	0.0	**34.2**

Table 6-7Milk Production Scenario 2

		July	August	September	October	November	December	January	February	March	April	May	June	TOTAL SEASON
Autumn	Litres	0.0	0.0	1.4	1.6	1.8	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Litres to kg milk	3%	0.0	0.0	1.4	1.6	1.9	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Fat		0.0%	0.0%	5.5%	5.6%	5.7%	5.8%	6.0%	6.0%	0.0%	0.0%	0.0%	0.0%	
Protein		0.0%	0.0%	5.0%	5.1%	5.2%	5.3%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	
Total MS		0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	
Days/month		31.0	21.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0	
kgMS/month		0.0	0.0	0.0	5.5	6.1	5.7	5.1	4.6	0.0	0.0	0.0	0.0	**26.9**

Table 6-8 Milk Production Scenario 3

		July	August	September	October	November	December	January	February	March	April	May	June	TOTAL SEASON
Autumn	Litres	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.0	0.0	0.0	0.0	
Litres to	3%	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.0	0.0	0.0	0.0	
Fat		0.0%	5.5%	5.5%	5.6%	5.7%	5.8%	6.0%	6.0%	0.0%	0.0%	0.0%	0.0%	
Protein		0.0%	5.0%	5.0%	5.1%	5.2%	5.3%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	
Total MS		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	
Days/month		31.0	18.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0	
kgMS/month		0.0	1.4	2.3	2.4	2.4	2.5	2.5	2.3	0.0	0.0	0.0	0.0	**15.7**

Table 6-9 Milk Production Wintering off scenario

		July	August	September	October	November	December	January	February	March	April	May	June	TOTAL SEASON
Autumn	Litres	0.0	1.4	1.4	1.6	1.8	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Litres to	3%	0.0	1.4	1.4	1.6	1.9	1.6	1.4	1.4	0.0	0.0	0.0	0.0	
Fat		0.0%	5.5%	5.5%	5.6%	5.7%	5.8%	6.0%	6.0%	0.0%	0.0%	0.0%	0.0%	
Protein		0.0%	5.0%	5.0%	5.1%	5.2%	5.3%	5.4%	5.4%	0.0%	0.0%	0.0%	0.0%	
Total MS		0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	
Days/month		31.0	18.0	30.0	31.0	30.0	31.0	31.0	28.0	31.0	30.0	31.0	30.0	
kgMS/month		0.0	2.7	4.5	5.5	6.1	5.7	5.1	4.6	0.0	0.0	0.0	0.0	**34.2**

A.4 Pasture Production

Pasture Growth Rates				
Month	**kg/DM/ha/day**	**Days in Month**	**ME Value**	**Total ME produced/ month**
July	7	31	10.0	2,170
August	16	31	10.8	5,357
September	36	30	10.8	11,664
October	49	31	11.2	17,013
November	50	30	11.8	17,700
December	50	31	11.8	18,290
January	48	31	11.2	16,666
February	45	28	11.2	14,112
March	41	31	11.2	14,235
April	30	30	10.0	9,000
May	20	31	10.0	6,200
June	10	30	10.0	3,000
				135,406
Source: Farm Tech Manual				

				Sheep		Rams	ewe lamb	Hgt	2th	4th	4yr	5yr	6yr	Sale ewe lambs	Works Lamb Sales	Cull ewes	MS price	Buy Grain	Feed Grain April	Feed Grain May	Feed Grain June	Feed Grain July	Feed Grain August	Feed Grain Sept	Feed Grain Oct	Feed Grain Nov	Feed Grain Dec	Feed Grain Jan	Feed Grain Feb	Feed Grain March
Land	200	>=	200																											
Baleage stores	0	>=	0																											
Buy Grain	883,658	=	883,658															1												
Grain Silo	0	>=	0															-1	1	1	1	1	1	1	1	1	1	1	1	1
July	0	>=	-0			456	0	834	714	437	416	400	400									-1								
August	0	>=	0			456	510	916	776	623	603	586	586										-1							
September	0	>=	0			441	819	571	991	813	437	777	777											-1						
October	0	>=	0			456	784	590	1,148	964	623	927	927												-1					
November	0	>=	0			441	831	571	1,201	1,023	813	987	987													-1				
December	0	>=	0			456	670	590	1,241	1,057	964	1,020	1,020														-1			
January	0	>=	0			456	703	590	1,241	1,057	1,023	1,020	1,020															-1		
February	0	>=	0			412	665	533	1,121	955	1,057	921	921																-1	
March	0	>=	0			456	680	711	621	437	1,057	400	400																	-1
April	0	>=	-0			348	0	708	631	453	453	417	417						-1											
May	0	>=	-0			360	0	581	652	375	437	338	338							-1										
June	0	>=	-0			441	0	592	661	393	393	357	357								-1									
Rams	0	>=	0			-1.00	0.00	0.02	0.01	0.01	0.01	0.01	0.01																	
ewelamb/hogget tie	0	>=	0				-1.00	1.00																						
Hogget/2th tie	0	>=	0					-0.90	1.00																					
2th/4th tie	0	>=	-0						-0.80	1.00																				
4th/4yr tie	0	>=	-0							-0.80	1.00																			
4yr/5yr tie	0	>=	0								-0.80	1.00																		
5yr/6yr tie	0	>=	0		0							-0.80	1.00																	
Cull ewe tie	0	>=	-0						-0.10	-0.10	-0.10	-0.10	-0.95			1														
Ewe lamb tie	0	>=	-0				1.00	0.00	-0.80	-0.80	-0.80	-0.80	-0.80	1																
Works Lamb tie	0	>=	-0					-0.85	-0.80	-0.80	-0.80	-0.80	-0.80		1															
MS per ewe	0	>=	-0						-29.04	-34.17	-34.17	-34.17	-34.17				1													
Sheep S/Us	0	=	-0	1		-0.86	-0.94	-1.30	-1.83	-1.43	-1.38	-1.36	-1.36																	
Stock Units	0	>=	0																											
Switch	0		0																											
Cash Cost/Profit			692,095			-91	-84	-96	-179	-183	-183	-183	-137	95	100	55	17	-0.032	0	0	0	0	0	0	0	0	0	0	0	0
Activity Levels				3,972	0	29	577	577	519	415	332	266	213	819	1,886	355	56,959	883,658	0	0	0	0	83,759	125,639	129,827	125,639	129,827	129,827	117,263	41,880

Figure 6-1 Example of Linear Program

Make Baleage Feb	Make Baleage Mar	Make Baleage April	Feed Baleage July	Feed Baleage August	Feed Baleage Sept	Feed Baleage Oct	Feed Baleage Nov	Feed Baleage Dec	Feed Baleage Jan	Feed Baleage Feb	Feed Baleage Mar	Feed Baleage April	Feed Baleage May	Feed Baleage June	July	August	September	October	November	December	January	February	March	April	May	June	Feed Input
																											1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1													
															-0.85	1.00											-2,170
				1												-0.85	1.00										-5,357
					1												-0.85	1.00									-11,664
						1												-0.85	1.00								-17,013
							1												-0.85	1.00							-17,700
								1												-0.85	1.00						-18,290
									1												-0.85	1.00					-16,666
-1										1												-0.85	1.00				-14,112
	-1										1												-0.85	1.00			-14,235
		-1										1												-0.85	1.00		-9,000
													1												-0.85	1.00	-6,200
														1	1.00											-0.85	-3,000
-0.025	-0.025	-0.025	-0.025																								-600
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,246,903	967,885	0	274,838	1,313,193	2,169,610	3,000,127	3,342,357	3,307,236	3,838,483	3,778,472	3,304,878	200

Figure 6-2 Linear Program Example Continued

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