A strategic evaluation of the introduction of the East Friesian sheep breed on a North Island hill country farm.

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Abstract

New Zealand sheep farming has changed dramatically over the past 20 years as it has adjusted to a market-led and unsubsidised economy. Despite this, new technology and management practices such as cross breeding offer exciting opportunities for improving sheep industry profitability. The introduction of new genetic material into the sheep flock can provide benefits through improved productivity and product attributes but it may also have negative consequences for industry growth if used incorrectly. The advantages of introducing a new sheep breed to a farm are usually widely published but not necessarily well researched. The East Friesian (EF) was made available to farmers in autumn 1996. It has a reputation for being highly fertile, a good milk producer and heavy-weight-lamb producer. However, no research has been published on how to develop a profitable management strategy for adopting EF's onto a hill country property. The purpose of this study was to test the hypothesis that the EF would improve the productivity and profitability of a lower North Island hill country farm.

A case farm analysis using the STOCKPOL farm simulation model was used to compare the productivity and profitability of the current Romney (Rn x Rn) flock with either an East Friesian (EF) x Rn crossbred flock or a purebred EF x EF flock. The STOCKPOL model was calibrated to simulate the existing sheep and beef cattle policy for the 324 ha hill country farm, Tuapaka. Pasture growth rate data were adjusted to sustain the reordered levels of animal production and establish a basis against which the EF x Rn and EF x EF flocks could be compared. The cattle policy was fixed for all options. Ewe numbers, with a 20 % replacement rate, were adjusted for the live weight profiles and production levels of the EF x Rn (67 kg at mating; 148 lambs born:100 ewes mated) and EF x EF (80 kg at mating; 230 lambs born:100 ewes mated) breeds until the farm system was just biologically feasible. This indicated 1315 EF x Rn sheep or 909 EF x EF could be farmed compared to 1930 Romneys (52 kg; 117 lambs born:100 ewes mated). In stock unit terms (SU) the EF x Rn was 1.25 and the EF x EF 1.54 compared to the Rn x Rn ewe (1.00) which consumed 526 kgDM per year.

The STOCKPOL outputs were copied into an enterprise margin (EM) format and the profitability of the sheep breeds calculated after adjusting for the cost of capital (CoC) of sheep wintered. The EM's (per ha) were \$324, \$340 and \$351 for the Rn x Rn, EF x Rn and EF x EF breeds, respectively. The EF x EF was the preferred option for all risk preferences. A sheep age structure model was developed to simulated the transition to an EF x Rn crossbred flock. This took six years. The additional net present value (NPV) in 1998 dollars of the EF x Rn vs. the Rn x Rn was \$ 92,133. The transition to a purebred EF flock would take 24 years if a grading up strategy were adopted.

An important finding was the breed x pasture production interaction. Annual pasture consumption was 869 t DM for the Rn x Rn flock, 780 t DM for the EF x Rn policy and 647 t DM for the EF x EF flock. Reduced pasture production occurred because of the higher lamb:ewe ratio of the EF sheep contributed to increased pasture senescence and decay in the summer and autumn. Ways to prevent this occurring need to be explored through further modelling studies using

STOCKPOL and by evaluating the experience of farmers who have adopted EF's. The study confirmed the hypothesis: EF sheep would improve production and profit on the hill country case farm. Recent farmer experience with the East Friesian should now be evaluated against this result.

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Table of contents

List of tables

List of Figures

List of Appendices

Chapter One: Introduction

1.1 Introduction

Sheep farming in New Zealand has gone though some traumatic times over the last 20 years as it has adjusted to a market led and unsubsidised economy (Sandrey and Reynolds, 1990). Despite this there are now a number of new initiatives, such as cross breeding, that will greatly benefit the New Zealand sheep industry. Price (1997) therefore suggested that far from being a "sunset industry", sheep farming now provides some of the best prospects for the agricultural sector and particularly for pastoral farming.

1.2 Problem statement

The introduction of new sheep breeds, and the genetic material they are able to contribute to the New Zealand sheep flock can provide substantial benefits to farmers and the sheep industry (Price, 1997) but they may also have serious consequences for industry growth if not used correctly (Parker et al., 1998). The recession in wool prices over the past four years and the general improvement in the meat sector (NZMWBES, 1998) have brought a new focus to sheep farming and particularly on the policies and management of individual farms with respect to lamb production.

The productive advantages of introducing a new sheep breed to a hill country farm have been widely studied and publicised in both the scientific literature and in the popular farming press (Hight, 1979). Early examples of 'new' breeds included New Zealand developed genotypes such as the Perendale and Coopworth (Hight, 1979), as well as imported breeds such as Texel, Suffolk and Wiltshire (Purchas et al., 1990). Field trials have been conducted with the new breeds to estimate their production efficiency (e.g. the Whatawhata Romney vs Coopworths vs Perendale) comparison in the 1970's (Clarke, 1982) but these were often criticised by farmers because the same management was applied to all breeds when this clearly (at least to them) was not appropriate. Consequently, farmers often achieved better levels of performance with the new breeds than the research data suggested. More recently the bioeconomic effect of introducing a new sheep breed has been estimated by Allison (1997) and Parker et al. (1998). This has been supported by computer simulation analysis (Brookes et al., 1998) which has identified some aspects of the management systems and technology necessary to obtain profitable ewe and lamb performance from alternative sheep breeds. However, no research has been published on how to develop a profitable management strategy for adopting the recently introduced East Friesian sheep breed to a case farm on North Island hill country.

1.3 Hypothesis

The introduction of the East Friesian sheep will improve hill country sheep farm production and financial returns compared to the continued use of a traditional breed (New Zealand Romney).

The objectives investigated in relation to this hypothesis were:

1.- To develop a procedure for evaluating a new sheep breed in New Zealand (or in other countries).

2.- To develop a management strategy for introducing a new sheep breed to a case farm.

3.- To critically evaluate the method developed for the New Zealand situation in relation to the introduction of a new sheep breed to Mexican farms.

1.4 Thesis outline

The thesis comprises a further four chapters. In Chapter Two, background literature on sheep farming in New Zealand, and the Romney and East Friesian sheep breeds are presented. The methodology used to study a lower North Island hill country sheep farm is described in Chapter Three. Results from the simulation analysis are presented in Chapter Four. In the final chapter, the implications of the research to the investigation of sheep breed changes in Mexico are discussed and areas of the methodology that could be improved are suggested.

Chapter Two: Literature Review

2.1 Introduction

In this Chapter sheep farm systems, sheep production and characteristics of the East Friesian and Romney sheep breeds are reviewed.

2.2 Sheep Farm Systems in New Zealand

A considerable proportion of New Zealand's total land area of 26.9 million hectares and farmed area of 14.4 million hectares is used for grazing sheep (NZMPB Annual Plan 1990). New Zealand sheep farming has a well-defined pattern of meat and wool production due to its almost exclusive reliance on pasture grazed *in situ*. International competitiveness in the sale of meat and wool largely arises from this dependence on the relatively low cost of pasture (Holmes and Hudges, 1993). It means, however, that the supply of animal products from pastoral farms to processing companies has a pronounced seasonal pattern (Sherlock et al., 1998).

The land area utilised for sheep and beef cattle farming reached a peak of 11.4 million hectares (in 1985) after a period of subsidies, including the Livestock Incentive Scheme and Land Development Encouragement Loans (Ward, 1996). Since 1985 the area in sheep and beef cattle farming has declined to 9.5 million hectares (in 1996), a drop of 14%. Correspondingly, sheep numbers have declined from a peak of 68 million in 1986 to approximately 44 million in 1998, the lowest level since 1960 (Figure 2.1). This decline in sheep numbers reflects land use changes, and the lower relative profitability of sheep compared to dairying, beef cattle and deer in recent years (Agriculture Production Statistics, June 1996 and Annual Review of New Zealand Sheep and Beef Industry 1996-97). Over the same period beef cattle numbers have marginally increased from 4.9 million to 5.0 million, and (until 1998) more dairy bull beef cattle have been finished each year on sheep and beef cattle properties. Forestry expansion since 1985 is estimated to have taken up 0.6 million hectares and dairying 0.4 million hectares of sheep and beef cattle farmland. It is estimated that approximately 70,000 hectares of former sheep and beef land were planted in forestry in the three years from 1993 (MAF Policy Technical Paper, 96/5).

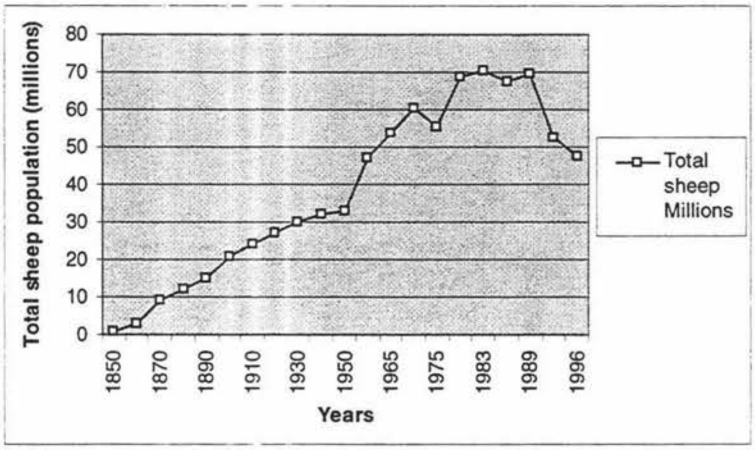

Figure 2.1: Growth of the New Zealand sheep population from 1950 to 1997. (NZMWBES 1996-97).

Between 1986 and 1996 the number of farms with predominantly *sheep* in the North Island and South Island decreased by 52.2 and 37.5%, respectively. In 1996, the total number of predominantly sheep farms was 14,300 – this was 34.4% less than in 1990 and a 44.4% decrease on the 1986 figures.

The long-term trends in the number of sheep and lambs tailed in New Zealand are presented in Figure 2.2. Lambs tailed reached a peak of 50 million in 1984/85 (see Figure 2.2), and had declined to 36,975,000 in 1996/97. The number of lambs tailed in the North Island and South Island decreased by 5.0 % in 1995/96 due to 1.31 million fewer lambs tailed in Southland and Otago (NZMWBES, 1996-97). The number of lambs tailed in the North Island in the same year decreased slightly, by 0.9 % to 15.34 million (Agriculture Production Statistics, June 1996).

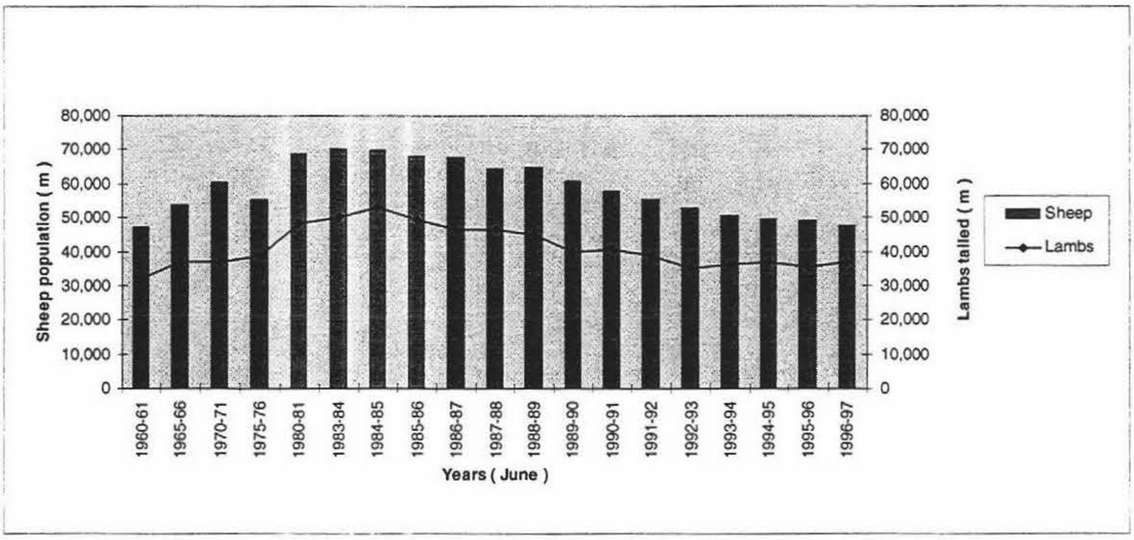

Figure 2.2: Sheep numbers and lambs tailed 1960-1997 (Source: NZMWBES 1996-97).

New Zealand's total meat production for the year 30 September 1997 was estimated to be 1,291,900 tonnes bone-in (Table 2.1). Lamb production was 418,000 tonnes. Mutton production was 121,000 tonnes, while beef production was 587,000 tonnes. Wool production has declined in association with the sheep population and reached 104,000 tonnes (clean) in 1996/97.

Table 2.1: New Zealand lamb, mutton, beef and wool production. (Source: NZMWBES 1996-97).

Class of meat	1995/96	1996/97
	Tonnes (000)	
Lamb	376	418
Mutton	134	121
Beef	606	587
Total	1116	1126
Wool (clean)	107	104

The number of lambs slaughtered increased (+ 6.1 %) in 1996-97 but fewer sheep (-7.4 %) were processed in the same period. The increase in lamb slaughter resulted from a record lambing percentage in the spring of 1996. Lamb weights were a record average of 15.91 kg in the 1995/96 season, and mutton slaughter weights reached a record average of 22.22 kg.

The trade of live sheep, mainly to the Middle East, is in direct competition with the slaughter of stock. Since October 1994 live lamb shipments have declined from 252,000 to 2,700 due to a ban on shipping lambs under the age of 10 months (NZMWBES, 1996/97). Total live sheep exports declined 72% (from 598,900 to 165,600) from 1994 to 1997 (Table 2.2)

Table 2.2: Sheep livestock export from New Zealand (Source: NZMWBES, 1996-97).

September Year	Total live Lambs (000)	Total live Sheep (000)
1990	1,126.5	256.2
1991	510.1	431.3
1992	810.6	526.7
1993	343	1,020.8
1994	252	598.9
1995	10.4	634.7
1996	80.2	573
1997e	2.7	165.6

2.3 North Island Hill Country Pastoral Land

Most hill country farms have limited or no area of pastoral land. Hence, livestock production systems are constrained by the inability to grow forage crops, or conserve surplus pasture. Animal production systems comprise mainly breeding ewes, cows and their replacements, with varying degrees of finishing of lambs and beef weaners. The extent of finishing depends on land contour and fertility, and summer rainfall, as well as the farmers personal preference. Animals not finished are generally sold as stores in either early summer or autumn, in the case of lambs, or at autumn weaner sales in the case of calves. Surplus ewe lambs are sold either as ewe lambs in the late summer or as two-tooths one year later. An important challenge to grazing research for hill country is to devise systems that achieve efficient utilisation of pasture grown, and to identify ways to overcome technological constraints to system performance caused by the seasonality of pasture growth (McCall, 1984).

2.4 New Zealand Sheep Flock

2.4.1 Introduction

The origins of New Zealand's sheep can be traced from their initial importation in the 1830's, mainly from Britain and Australia. The evolution of sheep production and types of sheep has been determined in part by tradition, in part by the availability of animals and their adaptation to the environmental conditions, and in part by market returns from alternative products. Some breeds (e.g. Borderdale, Southdown and South Dorset Down) once popular with farmers, have declined significantly in numbers as new alternatives (eg. Suffolk, Finn) have become available that have greater productivity or are better suited to the market. New breeds have also been established in New Zealand, notably the Perendale, Coopworth and Drysdale (Wickham and McDonald 1982).

2.4.2 Sheep Breeds in New Zealand

New breeds are usually introduced to bring productive characteristics not present in the national flock, such as carcass conformation (Texel), fecundity (Finnish Landrace) and heavy weight carcass production (Oxford Down) (Stonyer, 1982). Small numbers of White Headed Marsh, Gotland Pelt, Karakul and Awassi sheep have also been introduced to the national flock (Allison, 1995).

Breed Definition and Breed Societies

A breed is a sub-group of a species possessing certain recognisable characteristics and is maintained as a closed breeding population historically in a single geographical area after which it is frequently named. The New Zealand Sheep Breeders' Association (NZSBA) published the first national flockbook in 1895. This represented 11 breeds. Separate flockbooks were later issued annually for the North Island (1902-25) and South Island (1906-26). Breed societies have established independent flockbooks (eg. Romney), in some cases (Lincoln, Ryeland, Dorset Horn) only temporarily (Wickham and McDonald, 1982).

2.4.3 Sheep breeds and their productive traits

The most reliable source of New Zealand's sheep breed numbers is the breed census, carried out for Statistics New Zealand. Table 2.3 shows breeds as a percentage of the national flock over the last three censuses and the estimated percentage of breeds in 1994. The category of minor breeds, crosses and unspecified breeds has increased from 1.7 to18.4 % (from 1979 to 1989). The explanation for this increase is that the census format may not allow an accurate response from farmers using crossbreeding and composite breeding programs (Stewart, 1996).

Table 2.3: New Zealand's registered sheep commercial population (Source: Stewart, 1996)

	Percentage of sheep by breed			
Breed	**1979**	**1984**	**1989**	**1994**
Romney	44.7	39.7	45.8	43.6
Coopworth	17.8	19.3	12.5	11.5
Perendale	17.9	15.3	7.9	7.2
Corriedale	7.8	5.5	4.5	7.1
Halfbred	3.8	3.5	3.8	
Merino	2	2.1	4.1	8.3
Borderdale	1.3	2	0.9	
Border Leicester	1.3	1	0.9	3.8
Drysdale	0.9	0.8	0.9	
South Suffolk	0.1	0.2	0.1	3.1
Suffolk	0.1	0.2	0.1	6.2
Dorset	0.1	0.2	0.1	5.5
Southdown	0.3	0.1	0	
Dorset Down	0.1	0.1	0	3.6
South Dorset Down	0.1	0.1	0.1	
Minor breeds, crosses and unspecified	1.7	9.8	18.4	

Changes in the breed composition of the national flock have historically reflected shifts in international market demand for products. For instance the fall in lamb prices from $24 in the 1984-85 season to $13 the following year (1985-86), followed the removal of Government subsidies, and changed the farming emphasis from meat to wool. As a result, Down breeds renowned for meat production, became less popular while dual-purpose breeds maintained their numbers. In 1996/97 the reverse meat: wool price ratio applied: lamb prices were high relative to wool, and a notable portion of sheep farmers began adopting breeds, or their crosses, with high fecundity and lamb growth rates (e.g. Finnish Landrace and East Friesian).

The Romney breed is still the most popular registered breed, despite a 12.3 % drop in the number of registered ewes between 1989 and 1994 (Table 2.5). Coopworth and Perendale numbers may increase in the next five years due to their easy-care attributes and propensity to produce high bulk wool, which provides greater market, return (Gavigan and Everit-Hincks, 1998). Merinos have grown in popularity in the 1990s, with registered ewe numbers increasing by around 23%. This increase has been associated with the better returns for fine compared to coarse wools. As with the commercial flock the meat breeds apart from the Suffolk have declined (Stewart, 1996).

Table 2.4: The registered sheep population in New Zealand (Source: Stewart, 1996).

	Number of registered ewes		
Breed	**1989**	**1994**	**% change**
Romney	149,426	130,937	-12.3
Coopworth	46,359	34,668	-25.2
Perendale	25,194	21,510	-14.6
Corriedale	24,443	21,434	-12.3
Merino	18,791	24,848	24.3
Border Leicester	15,672	11,292	-27.9
Poll Dorset	18,299	16,556	-9.5
Suffolk	14,955	18,718	25.1
South Suffolk	8,469	9,243	8.3
Dorset Down	8,334	10,925	23.6
Lincoln	5,106	2,155	-57.7

2.5 Breed comparative performance

2.5.1 East Friesian breed

Origin

The East Friesian (EF) breed, also known as the East Friesland, German Milksheep and East Friesian Milksheep were developed from the Marsh sheep native to the coast and islands of the North Sea (Eastwood et al., 1975; Schwintzer, 1976; Graham, 1997). They are particularly prevalent in the East Friesland region in northern Germany and the East Friesian Islands. A slightly different type is raised in the Province of Friesland in The Netherlands (Fotsch, 1994). From its place of origin, the EF breed has spread into Europe as far as Scandinavia and Poland (Fotsch, 1994: Cited by A. H. Farid and M.H. Fahmy, 1996), and into the high altitudes of the Alps. The sheep are currently concentrated mostly in the Rhineland and Westfalia regions of Germany (Schwintzer, 1976).

East Friesian sheep in New Zealand

In December 1972, five pregnant East Friesian ewes and one ram were imported to New Zealand from Britain. Unfortunately, none of these sheep or their offspring were released from quarantine because in November 1976, 700 East Friesian sheep and their crossbred progeny were destroyed following the diagnosis of scrapie in a dead ewe of this breed (Scott and Sorrenson, 1977; Wickham and McDonald, 1982).

Twenty years later, on Christmas Day 1992, eleven pregnant ewes and four rams of the East Friesian breed arrived at Auckland from Sweden. The fifteen sheep were quarantined at Silverstream's private station, near Dunedin (Allison, 1995). The first release of these sheep occurred in March 1996, when 40 rams were sold. In the same autumn there were significant sales of EF semen to farmers for artificial insemination programmes. The first release of pure-breed ewes occurred in 1997.

Description

The German EF Milksheep is described as a white, thin-tailed breed, with high fecundity and milk production (Graham, 1997). Mills (1982) described the breed as follows: "The polled, somewhat long head with slightly Roman nose, is free of wool and covered only with fine hairs through which the pink skin is visible. The solid, long and broad back is firm over an udder that has good capacity for milk production". The wool is a 'medium crossbred' with a diameter of 36-37 microns (Mills, 1982; Schwintzer, 1976). The head, until well beyond the ears, legs, inner thighs and scrotum are void of wool (Mills, 1982; Fotch, 1994).

The ewe lambs of the East Friesian reach puberty at around seven months of age (Schwintzer, 1976). They continue regular cyclic activity for approximately five months, showing an average of 8.8 normal cycles during this period (Ward and Williams, 1993).

In England, a rule of thumb is that a ewe lamb should not go to the ram until she weighs at least 35-38 kg (around 80 lb.). A ram lamb should not be used for mating in his first season until he weighs a minimum of 40 kg, but cases are recorded of EF being fertile and sexuality mature at earlier ages and lower weights (Mills, 1982). In New Zealand rams were used for mating at an average weight of 40.5 kg (Steans, 1997).

Lambing percent and litter size

After the Finn sheep (F) and Romanov (Rv), the EF is the most prolific sheep breed in Europe (Cumlivski, 1986, 1987; Drozdz, 1986). Brune (1986) reported an annual lambing rate of 200-220 %. When proper management is provided, lambing rates of 210 to 230 % are achievable (Fotsch, 1994). Graham (1997) reported a breeding/lambing average of 280 % in mature ewes. Niznikowski (1992) reported a litter size of 1.49, a lamb rearing percentage of 82.8, and lambs weaned per ewe joined of 1.04 for the EF breed. In New Zealand, Allison (1995) reports a 230 % lamb drop in mature ewes.

In Czechoslovakia, lamb mortality in large flocks (586 to 728 ewes per flock in summer and 290 to 445 ewes per flock in winter) from birth to 120 days of age was 24.0, 23.5 and 14.5 % in EF, F and Rv, respectively. The corresponding figures in small flocks (5 to 20 ewes per flock) were 7.5, 10.1 and 5.8 %, respectively (Cumlivski, 1986). These figures may indicate a greater sensitivity of EF to environmental stress compared with other prolific breeds when sufficient care is not provided during lambing. The same author in 1987 reported that the lamb mortality in the EF (11.55 %) was higher than in the F (8.25) and Rv (5.25) breeds.

Growth rate and bodyweight:

At birth EF lambs range between 4.0 and 5.2 kg in weight (Niznikowski and Rant, 1992 b). Peters (1989) reported an average birth weight of 4.59 kg for ram and 4.33 kg for ewe EF lambs. The birth weight of twins, triplets and quadruplets was 13.2, 21.3 and 26 % lower than that of single-born lambs, respectively (Peters, 1989). In the study of Niznikowski and Rant (1992 b), the average daily gain from birth to 40 kg was 145 g/d while Peters (1989) recorded a growth rate of 286 g/d from birth to 200 days of age.

Ward and Williams (1993) reported ewe lambs weighed 30 kg at 7 months of age, 46 kg at six months and 50 - 70 kg at twelve to eighteen months (report of Expert Panel appointed by the Animal Production Committee of standing Committee on Agriculture, Australia). Niznikowski and Rant, (1992 b) indicated a weight of 48 kg at one year and an 18 month weight of 63 to 69 kg was reported by Tsvetanov and Konstantinov (1988). At maturity ewes weigh 57 to 75 kg (Schwintzer, 1976; Zygoyiannis et al., 1990; Niznikowski et al., 1992), depending on the stage of production and level of nutrition. Allison (1996) reported an average weight of 80-85 kg for four tooth ewes. Mature rams weigh between 90 and 120 kg (Schwintzer, 1976). Graham (1997) reported a bodyweight of 75-95 kg for ewes and 100-125 kg for rams.

In common with other dairy and prolific sheep breeds, EFs have lower subcutaneous fat and higher body cavity fat, and thus leaner carcasses, compared with other meat-type breeds. Dressing out percentages of 41.8 % and a rib-eye muscle area of 12.1 cm² were reported by Niznikowski (1992) for EF male lambs slaughtered at 40 kg liveweight.

Milk production and composition

The EF is recognised as one of the best dairy sheep breeds in the world. Nevertheless, the amount of milk per lactation is very much influenced by the management applied and the nutrition level of the flock. This is reflected in the different estimates reported for yearly average milk production: 500-600 L per 210 to 230 day lactation (Graham, 1997); 400-600 L per 200- 220 day lactation in New Zealand (Allison, 1997); and 433 – 520 L in Germany (Schwintzer, 1976). In Uruguay, 196 L per ewe in an average milking period of 235 days was reported (Kugler et al., 1995). In Bulgaria, the average milk production under experimental conditions was 275 L per ewe in the first lactation and 308 L per ewe in the second lactation (Tsevanov, 1988). In Poland, EF sheep produced 375 ml per day (Niznikowski et al., 1992). Mills (1984) suggested a EF ewe in her second to sixth lactation can be expected to give three to four litres a day for the first 90 days, two litres for the next 90 days and a litre a day until either being tupped or dried off. Some ewes have produced up to 1248 L in one lactation (Schwintzer, 1976).

The lactation period in milking EF sheep usually ranges between 180 and 210 days (Fotsch, 1994), but this can be extend to 260 days, well into their next pregnancy (Fotsch, 1994). In dry regions, such as the Mediterranean, milk production of the EF is lower and the lactation period shorter than in the north European countries. In Greece, for example, the EF ewes produced 178 to 183 kg of milk during a 140-170-day lactation period (Katsaounis and Zygoyiannis, 1986).

In Germany, the milkfat content of EF milk has ranged between 5.5 and 6.0 % (Schwintzer, 1976), however, data from other countries indicates lower values. In Poland, for example, the milkfat content for EF ewes (4.86%) was 1 % lower than that for the Polish Corriedale (Niznikowski et al., 1992). In another study, the fat content of EF milk was lower (4.15%) compared with the Polish Mountain (5.09%), F (5.23 %), Polish Hill (6.28%) and Polish Merino (9.25%) breeds (Skolasinski and Charon, 1996). The milk protein percentage of EF ranges between 4.48 and 4.72%, which is somewhat lower than in other breeds maintained under similar conditions. The lactose percentage of EF ranges between 4.56 and 4.79% (Skolasinski and Charon, 1996; Niznikowski et al., 1992).

While sheep milking has a higher cost per stock unit than dairy cows, the potential returns are much higher, even at modest milk prices. (Allison 1995) 4.2 pure-bred East Friesian ewes, on a corrected milk fat basis, equated to one dairy cow in terms of milk production. The milk from the ewes at $1 per litre was calculated by Allison, 1997; cited by Owens, 1997) to produce a gross income of $2100 per "cow equivalent" compared with $1100 from one cow.

The EF have been used in crossbreeding programs in many countries to improve milk production and the lambing rate of native and lower performing breeds.

Wool production

The EF hogget produces approximately 3 kg of wool under Polish farming conditions (Niznikowski and Rant, 1992a). In New Zealand, mature ewes produce 4.5 kg of bulky 36-37 micron wool (Allison, 1997). Two-year-old ewes produced 3.6 to 6.2 kg of wool in Germany, Poland and Bulgaria (Tsvetanov and Konstantinov, 1988; Niznikowski and Rant, 1992a; Fotsch, 1994), and 3.3 kg in Greece (Katsaounis and Zygoyiannis, 1986). The EF fleece is classified as a crossbred wool and when graded for spinning has a count of 48's to 52's. Staple length, under a once yearly shearing regimen, ranges from 11 to 20 cm Niznikowski and Rant, 1992a; Fotsch, 1994), and the fibre diameter averages 40 microns (Peters, 1991).

Behaviour

In Europe, the EF as a dairy breed is handled frequently, almost every day, and they therefore have become easier to handle than other breeds that have less contact with humans (Lankin et al., 1988). In contrast with many other breeds, EF sheep can be easily kept individually or in small flocks of only a few sheep. Consequently, their herding instinct is not well developed (Fotch, 1994) and some owners have expressed concerns that they may not perform well within large flocks or when added to an existing flock of other breeds (Schwintzer, 1976; Mills, 1984).

Environmental adaptation

Having evolved in the marshlands of north-western Europe and been maintained under the harsh conditions of high altitudes in the Alps, the EF breed is well adapted to mountain conditions, such as those in Switzerland (Krummenacher, 1992). Their evolution in the colder Northern Hemisphere climates means the breed does not perform well in hot and dry regions. For example, pure-bred EF sheep have performed poorly in Greece and the pink skin of the face and head, which is not protected by wool cover, is easily sunburned when exposed to direct sunshine (Katsaounis and Zygoyiannis, 1986).

Resistance to disease

Having been developed in the footrot-prone areas of Europe, the EF sheep are more resistant to footrot than breeds that have evolved in arid areas (Shimshony, 1989). Crossbreeding with EF could thus reduce the susceptibility of other breeds to footrot.

2.5.2 The New Zealand Romney

Origin

The New Zealand Romney was developed from the Romney Marsh, a breed that evolved in the low wet marshlands of the Romney marshes in Kent, south-east England (Eastwood et al., 1975; Graham, 1997). For centuries the breed was effectively isolated while developing the capability necessary to survive in this harsh environment (Graham, 1997).

The Romney Marsh was imported to New Zealand from England in 1853 (Eastwood et al., 1975). In 1904, a separate Romney Marsh society was registered, and the first flock book was published in 1905 (Eastwood et al., 1975; Graham, 1997). Pure-bred and straightbred Romney numbers increased rapidly in the next 60 years. In recognition of the changes it had undergone from its original ancestors, the name of the breed was changed from Romney Marsh to the New Zealand Romney in 1966 (Wickham and McDonald, 1982). A distinct type of Romney with a heavier fleece than its ancestors has developed in New Zealand. In 1989, 45.8 % of the sheep in New Zealand were Romney (Breeding Matters, 1996; see also Table 2.2). By 1997, 53.8 % (25.5 million) of the sheep population were New Zealand Romney.

Description

The New Zealand Romney is a medium-large breed and typically weighs 50-65 kg. It has good fertility and mothering ability and a moderate lambing (100-110%) capability. The breed has developed with equal emphasis on meat and wool. The Romney ewe is also mated to terminal sires for prime lamb production (Graham, 1997).

Lambing rate

Lambing percentages in Romney flocks vary tremendously. For a Northland hill country flock, Eastwood et al. (1975) suggested 85% was acceptable. More recent lambing percentage figure for Romneys are 20-30% greater for both Islands. On Southland's fertile flats, 150 % from Romney's is common.

Asofi (1984) reported a mean liveweight of Romney hoggets at time of joining of 39 kg and for the 2-year-old ewes. Moore (1983) showed differences in reproductive performance between Romney hoggets that weighed 35 and 29 kg at mating: 82 and 47 % were mated respectively, and lambs weaned per hogget joined of 50 and 13 %, respectively, were achieved.

Lamb mortality - Survival

High and Jury (1970) reported a range of 75 – 95 % for lamb survival (lamb weaned/100 lambs born) in hill country flocks. Dalton et al. (1980) showed lamb survival in the New Zealand Romney sheep breed from 1969-76 on New Zealand hill country was 78.2 and 65.6 % for singles and multiples, respectively. Asofi (1984) reported a total lamb mortality between birth and weaning of 20 % and 16 % for Romney hoggets and 2-year-old ewes, respectively.

Growth rate and body weight

The weight of the lambs from Romney hoggets was 3.80 kg, and from 2-year-old ewes was 4.26 kg (Asofi, 1984). Two tooth ewes on dryland pastures reached a mean live weight of 63 to 79 kg prior to premating (Muir et al., 1998). The daily growth rates of the offspring in the Muir et al. (1998) study were 183 g and 249 g for both hoggets and two-year-old ewes, respectively. The growth rates of lambs from two-year-old ewes was generally higher than those for the progeny of hoggets and single lambs reared by hoggets were comparable at least with those of twins reared by animal's one year older

Milk production and composition

Muir et al. (1998) report on dryland a mean milk production of 1.49 and 0.79 L per day for ewes rearing singles at 3 and 6 weeks of lactation, respectively, and 1.59 and 0.75 L/d for ewes rearing twins at 9 and 12 weeks of lactation, respectively.

Wool production

The New Zealand Romney sheep has a heavy fleece with wool of medium lustre (Meadows, 1997). The fibre diameter is 33-40 microns and an annual staple length of 125-175 mm can usually be grown. The fleece weight ranges from 4.5-6.0 kg with an average of 5.5 kg (Meadows, 1997).

Chapter Three: Case Farm Description and Modeling Methods

3.1 Introduction

In this Chapter, the case study farm used for the analysis is described. The STOCKPOL computer model is outlined and the physical and financial analyses undertaken to compare the current pure-bred Romney (Rn x Rn) sheep with an East Friesian x Romney (EF x Rn) crossbred flock and a pure-bred East Friesian (EF x EF) flock are presented.

3.2 Farm case study

Massey University's Tuapaka farm was selected as a case farm because a historical data base, accumulated since 1976, that describes both farm attributes and livestock performance was available. Specific data concerning sheep performance was collated for the1996 and 1997 years (MacDonald 1998, pers. comm.) for the simulation analysis.

3.2.1 Physical features

The original 420 ha Tuapaka property was acquired by Massey University in 1938. In 1971 a further 56.5 ha was purchased. In 1983 the farm was divided into two blocks so that better commercial use could be made of the farm: the bull unit of 110 ha (McRae and Morris, 1981) and the hill sheep and bull beef unit of 365 ha. The hill unit was intensively subdivided with electric fencing and rotational grazing was implemented to improve pasture production and utilisation.

Tuapaka is located in the Manawatu district of the North Island, New Zealand. It lies to the south-east of the Manawatu river on the flanks of the Tararua ranges, 13 km from Palmerston North. The farm area of 365 ha comprises 322.5 ha (effective) of pasture, 31 ha of pinus radiata plantation and 11.5 ha of "waste".

The land rises steeply from 80 m above sea level (asl) at the front of the property to an altitude of 140 m asl, and then more gently from this point to 340 m asl at the back boundary.

The property faces north-west and is deeply bisected by a number of primary and secondary gullies toward the back boundary. These gullies are steep-sided and ultimately drain into the Manawatu river. The topography of the hill block can be divided into 261 ha of easy to moderately steep hill country, of which 50 % is discable, and 104 ha is steep to very steep hill country (Gray, 1987).

Annual rainfall averages 1000 to 1100 mm per annum. Summers are warm, with hot dry south easterly and westerly winds causing moisture deficits for pasture growth in most years. Winter air temperatures are 6-12°C during daylight hours, but overnight frosts, and windy conditions can create chilling conditions for livestock, especially new born lambs during the spring (August to mid-October).

The steepland soils are related to the Yellow Brown Earth (YBE) series (Makara Steepland soils). These soils are derived from greywacke and slope deposits. Natural fertility is generally low to very low. The gully and steepland soils are related to the Yellow Grey Earth (YGE) series (Halcome hill and Steepland soils). These soils are derived from loess, unconsolidated sediments and slope deposits. Their natural fertility is generally low. The YGE – YBE intergrades (Shannon and Tuapaka series) are derived from loess overlying marine sands and have a low natural fertility. The Korokoro series are derived from loess and slope deposits overlying greywacke. These soils are generally free draining also have a low natural fertility. In summary, the soils are generally free draining medium to step in slope and of low natural fertility. Regular inputs of superphosphate fertiliser (250-350 kg/ha) are necessary to sustain improved clover species on all of the soils.

3.2.2 Stock Policy

Prior to 1996, two Romney flocks were run on the farm: 900 recorded ewes generating ewe replacements and rams for the Massey University 'commercial' farms, including Limestone Downs, and a flock of 600 commercial ewes mated to either Romney or Suffolk sires that produced predominantly store lambs for sale in December and January. Since 1996 a flock of 1455 commercial Romney ewes, mated to either Romney or Suffolk rams, has been farmed. Lambs have predominantly been sold store at weaning in December-January.

The beef cattle policy comprises a 55 cow herd. Heifers are mated at 15 months of age and calves are sold as weaners. Hereford x Friesian crossbred heifers are purchased for replacements. If summer pasture growth is poor, cows can be weaned early. Friesian calves are purchased for bull beef production at 3 months of age and grown to slaughter at 18 months and 30 months of age at a target slaughter live weight of 470 kg. Sub-maintenance feeding of cows and Rising two (R 2) year bulls can be adopted during the winter months to "clean-up" rank surplus growth (Journeaux et al., 1987) and liberal pasture allowances can adopted during late spring-early summer to control the flush of pasture growth and maximise their own (and their calves in the case of the cows) rate of live weight gain. The beef cows and bulls therefore provide flexibility to grazing management.

3.2.3 Pastures

Tuapaka has typical hill country pastures, consisting of browntop, crested dogstail with perennial ryegrass, prairie grass and white clover present on the flatter regions of the farm (Gray, 1987). On cultivated areas improved ryegrass and white clover species have been established.

3.2.4 Pasture growth rate data

Pasture growth rate values for the modeling study were initially taken from Gray (1989) and MacDonald (1998, pers. comm.) as shown in Table 3.1. These were calibrated with the STOCKPOL program to obtain a feasible system, given the animal live weights and performance levels recorded for the farm in 1996/97 and other years. The data from Gray (1989) and MacDonald (1998, pers. comm.) were obtained by recording positive growth rates for paddocks not grazed between farm pasture cover walks and, during periods of set stocking, from reverse engineering calculations using estimated animal intake data (Parker, 1997).

Table 3.1: Net herbage accumulated rates for the base Rn x Rn system at Tuapaka.

Month	Gray 1987	Mac Donald 1998	Calibrated[1]
	(kg DM / ha / day)		
Jul	10	10	12
Aug	13	13	15
Sep	17	17	19
Oct	28	20	29
Nov	43	43	43
Dec	31	31	31
Jan	20	20	20
Feb	16	16	16
Mar	22	22	22
Apr	16	16	16
May	12	12	14
Jun	8	8	13

[1]STOCKPOL derived values for a biologically feasible system with current livestock numbers and performance levels.

3.3 Current system

The Rn x Rn flock represents the current sheep enterprise at Tuapaka. The system consists of pure-bred Romney ewes producing wool and store lambs. The performance attributes of the Rn x Rn policy are shown in Table 3.2

Table 3.2: Characteristics and performance parameters for Romney sheep flock at Tuapaka.

Description		**Rn x Rn**
Total SU		3630
Total ha		324
SU/ha		11.2
Beef SU		1795
SC Ratio		51:49:00
Sheep SU		1835
Head:		
	Ewe hoggets	455
	Ewes	1455
	Rams	20
	Total	1930
	Beef	290
Capital Value $		194,279
Lambs weaned %		117
Calves weaned %		86
Wool (kg)		8408
Wool kg/SSU		4.6
Lamb sale wt (kg)		20.7
Beef sale wt (kg)		653

The proposed sheep policies and the characteristics of the different systems and their performance parameters are presented in Table 3.3. The average live weight (including mating, lambing and weaning) for the EF x EF policy was 37 and 17% greater than that for the Rn x Rn and EF x Rn policies, respectively. The lambing percentage for the ewes of the EF x EF policy was 49 and 36% higher than that for the Rn x Rn and EF x Rn policies, respectively. The ewe hogget lambing percentage was 100% for the EF x EF policy and 86% for the EF x Rn policy. The Rn x Rn ewe hoggets were not considered for mating because the target live weight by 1 May (35 kg) and a high mating percentage are difficult to achieve with this breed on hill country (Moore, 1983). The performance parameters for the Rn x Rn policy were obtained from the Tuapaka sheep unit data, while those for the EF x Rn and EF x EF policies were adapted from Allison (1996). The shearing policy was three times every two years (8-monthly) (Parker and Gray 1985). Lambs were shorn in January and hoggets in September and March. Other management characteristics and parameters remained the same for the three sheep policies. The beef cattle policy of breeding cows and a two-year bull beef policy was assumed to be the same for all three sheep systems.

Table 3.3: Characteristics and performance parameters for the three sheep policies.

Farm Description	1 Rn x Rn	2 EF x Rn	3 EF x EF
Live weight kg (Flc.free)			
Mating	52	67	80
Lambing	54	71	88
Weaning	47	62	75
Mating start date	1-May	1-May	1-May
Lambing percentage (Ewes)	117	148	230
Lambing percentage (Hoggets)		86	100
Ewe replacement %	20	20	20
Weaning age (weeks)	12	12	12
Shearing date			
Lambs	15-Jan	15-Jan	15-Jan
Ewe hoggets	Sep. 16 / Mar.10	Sep. 16 / Mar.10	Sep. 16 / Mar.10
Ram hoggts	16-Sep	16-Sep	16-Sep
Ewes	Jan. 1/May 1/Oct.31	Jan. 1/May 1/Oct.31	Jan. 1/May 1/Oct.31
Rams and wethers	1-Jan	1-Jan	1-Jan
Deaths (% wintered)			
Ewes	5	5	5
Others	3	3	3
Calves weaned age (Weeks)	22	22	22
Wool price ($/kg)			
Adults	2.41	2.41	2.41
Hoggets	2.53	2.53	2.53
Lambs	2.54	2.54	2.54
Bull sale weight (kg)	653	653	653
Shearing avg cost ($/hd)	1.8	1.8	1.8
Animal health ($/sheep SU)	2.51	2.51	2.51

3.4 Modeling Process

STOCKPOL was used to model the current production system of the case study farm. Pasture production characteristics and livestock policies for Taupaka were inputted for the base Rn x Rn system as shown in Table 3.3. The model was calibrated to achieve a feasible system by modifying the monthly pasture growth rates to balance with animal demand. A system is 'feasible' if the farm pasture cover during all time steps of the period modeled is sufficient to allow the required animal intake (and therefore performance) levels to be achieved (Marshal et al., 1991). Thus, biological feasibility was tested in terms of the monthly pasture cover necessary to sustain the sheep DMI required. The animal performance levels and calendar of management events were used to guide these adjustments to pasture growth which, as shown in Table 3.1, were relatively small (5, 2 and 2 kg DM/ha/day in June, July and August, respectively, otherwise recorded values applied).

The calibrated and feasible Rn x Rn system was then used as a basis to assess the introduction of a pure-bred East Friesian (EF x EF) or a East Friesian-Romney crossbred (EF x Rn) flock to Tuapaka. The STOCKPOL program was used to test these two different breeds in terms of the maximum numbers at which the farm remained biologically feasible and to estimate the changes in production and management relative to the pure-bred Romney system. The initial live weight of the EF x Rn and EF x EF was used as a starting point to define an annual live weight profile. This profile, and the calendar of management events (e.g. shearing, weaning), dictated the daily DMI of the ewes. Similarly, a profile for the replacement ewe hoggets was defined. A constant flock replacement rate (20% per annum) was adopted for each sheep option. The new sheep policy was thus defined for the same management calendar as the Rn x Rn system by adjusting ewe numbers wintered until a new feasible system was just achieved using the STOCKPOL feasibility test (Marshal et al., 1991). Some minor modifications, however, were made to lamb selling dates in order to finally obtain a feasible system and to allow the advantage of heavier lamb production by the EF x Rn and EF breeds to be expressed.

3.4.1 Physical comparison

The Rn x Rn system was used as the basis for comparing the EF x Rn and EF x EF systems in terms of key physical and financial performance indicators. Key performance indicators (KPIs) are the drivers of the business: together they play an important role in measuring the performance of farm businesses (Shadbolt, 1997). The physical comparison of the three systems consisted of area (effective ha) livestock numbers wintered, lambing percentage, live weight profiles (for ewes and hoggets), total and per hectare live weight, feed supply and demand, annual dry mater intake (DMI) and meat and wool production. The key physical parameters used to compare the three sheep policies are shown in Table 3.4. Livestock numbers wintered (i.e. stocking rate) were considered to be a KPI because they, through annual DMI, reflect differences in live weight and performance of the different breeds.

Table 3.4: Key physical and financial performance indicators using in the comparison of the alternative sheep policies.

Indicator	Unit
Area	ha effective
Stocking rate (s.u. / ha)	SU/ha
Pasture production	kg DM/ha
Pasture utilisation	% grown
Lambing	%
Average lamb price	$/head
Average wool price	$/kg
Total wool produced	kg
Wool	kg/SU
Gross Margin	$/ha & farm
Farm Enterprise Margin	$/ha & farm

Total SU's wintered were used to standardise the measures of financial performance. The SU conversion factors used to standardise between flocks were those derived from the STOCKPOL calculated feed intake by each sheep class relative to the Rn x Rn ewe. The number of ewes and flock replacements wintered also determined the pasture utilisation rate. The lambing percentage affected meat and wool yields for the different systems and the pattern of feed demand, especially during the summer months because of the large difference in lamb: ewe ratio between the sheep breeds.

The systems were also compared in terms of meat and wool production. Meat production parameters consisted of the number and live weight of ram and ewe lambs, and culled ewes. The meat yield for the different systems was expressed as kg meat per ha, kg meat per ewe, and kg meat per SU. Wool production was compared on a per ewe, per hectare and per SU basis.

3.4.2 Financial comparison

The financial performance of the sheep policies was compared in terms of the average price of animals sold, weight of wool sold, cost of capital, and gross margin. The relative profitability of the systems was estimated by standard gross margin analysis (Parker 1997) and the total sheep and farm enterprise margins were calculated by correcting for the cost of capital (CoC) invested in livestock wintered. The CoC was estimated from differences in live weight at a common schedule value (see Table 3.5) and an interest rate of 5.6% on the capital invested in livestock (see Appendix I). No premium was assumed for the scarcity of EF x Rn and EF x EF ewes, since the populations of these breeds are expected to grow quickly in the next 3-5 years. However, EF rams were more expensive than Rn rams ($243 vs. $2000) (see Table 4.9).

The meat and wool values used in the analysis are summarised in Table 3.5. The base meat prices were derived from the meat schedule published for the week beginning 30 April 1998 (Keeling, 1998). Wool prices were those from Teletex (1 May 1998).

Table 3.5 : Sheep schedule prices and wool values for the different sheep policies ($/head).

Animal class	Meat $/head			Wool $/kg greasy		
	Rn x Rn	EF x Rn	EF x EF	Rn x Rn	EF x Rn	EF x EF
Sheep						
Ewe lamb	15.00	24.00	29.00	2.54	2.54	2.54
Ram lamb	23.00	35.00	43.00	2.54	2.54	2.54
Ewe hogget	38.54	45.05	51.00	2.53	2.53	2.53
Ewe	35.88	46.92	55.89	2.41	2.41	2.41
Ram	243.00	400.00	2000.00	2.41	2.41	2.41
Beef	$/head					
R1yr Heifer	285	285	285			
R1yr Bulls	354	354	354			
R2yr Bull	914	914	914			
Cow/IC Heifer	427	427	427			
Bull	1090	1090	1090			

The performance parameters considered in the financial analysis are summarised in Table 3.6.

Table 3.6: Financial parameters used in the comparison of the sheep policies for the case farm.

Indicator	Unit
Lamb income	$
Average lamb price	$/head
Cull ewe income	$
Average wool price	$/kg
Wool income	$
Variables expenses	$/SU
Sheep Gross Margin	$/SU & /ha
Sheep Enterprise Margin	$/SU & /ha
Farm Gross Margin	$/ha & farm
Farm Enterprise Margin	$/ha & farm

3.4.3 Risk analysis

Simulation models, such as STOCKPOL can be used to predict the likely state of an agricultural system for a future period of time and the effect of non-controllable variables can be integrated by the model through "What if?" analysis of historical information or personal estimates. Nevertheless, it is the personal knowledge and experience of the manager that is critical in assuring good performance levels from the system (Montes de Oca, 1998). For this reason the sensitivity of the 'new' farm systems to different levels of production and price performance for the sheep breeds was investigated. Lamb and wool were assigned a range of prices to generate possible GM outcomes for different market circumstances. The probabilities of these prices occurring were subjectively assigned to quantify risk. A normal distribution about the 'must likely' value was assumed by triangulation relative to the minimum and maximum values for each parameter.

The average profitability of the three systems was obtained for a simulation of 50 iterations assuming stochastic lamb and wool prices (Shadbolt, 1996). The systems were compared in terms of the probability distribution of the Gross Margins generated by this simulation analysis (see Appendix II). Also the Hurwicz Optimism-Pessimism criterion (Halter and Dean, 1971) was used to compare the maxmin and maxmax GM for the three sheep policies. These measures, and the 'most likely' and 'best bet' options, reflect the different perspectives a farm manager might hold toward the risk associated with the introduction of a new sheep breed.

3.4.4 Investment analysis

The first step to complete the investment analysis was to create a model to simulate the age structure of the flock for different breeding strategies. In order to predict the potential offtake of sales and changes in the flock size, and to compare the productivity of the Rn x Rn vs. the EF x Rn system, a '*flock structure model*' was formulated (Upton, 1993) to simulate changes in the number of sheep in each age group as the new breed was introduced. The measure of performance for assessing the sheep breeding options was output per livestock unit. This was based on the feed consumed (kg DM). It was assumed that the levels of meat and wool production per animal class previously determined by the STOCKPOL for the whole farm analysis of the Rn x Rn and EF x Rn policies would apply to the investment analysis.

The construction of the sheep age structure model was based on age/class cohorts. The initial structure for the Rn x Rn flock is shown in Table 3.7. In order to predict changes in the flock structure over time, it was assumed that both the mortality and culling rate were 5% per annum. The lambing percentage was adjusted per annum for the breed type in each age group. This meant separate ewe hogget and older ewe lambing percentages were required. The lambing percentage thus reflected the proportions of EF x Rn ewes in the flock; that is the flock percentage gradually increase as more EF x Rn ewes were introduced and mating of the EF x Rn hoggets was adopted. It was assumed that production traits and culling rates remained constant so that the set of calculations could be applied repeatedly to predict a flock structure over any number of years.

A percentage (24%) of ewe lambs born were retained each year for the flock replacements (20 % as two tooths). Culled breeding stock were sold. The flock numbers were adjusted to consume the DM available to the flock (e.g. for the Rn x Rn flock this was 879 t DM per annum; Table 4.5). The amount of DM consumed by the EF x Rn sheep were progressively adjusted to reflect the whole farm situation under this type of sheep flock (780 t DM/annum). The quantity of wool and number of sheep sold formed the basis of the sheep revenue calculation for each year in the transition period and once the new flock was established. Variable expenses per sheep were assumed to be the same for all breeds and were only adjusted to reflect the number of animals farmed each year. The GM for each year of the transition was calculated from these data. Cost and prices were assumed to be remain constant at the 1998 levels used in the GM analysis. Additional revenue was earned from the sale of capital stock where the introduction of a new breed had a substitution rate per SU greater than one.

Table 3.7: Template describing the initial flock structure for the Rn x Rn flock.

0.001	25.1%		25 Sep 98		28 Dec 98		1 May 99					25 Sep 99		Requirements for DM	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total
5.0%	5.0%	0-1	851	43	808	182	626	31	31	564	0	636	Rn x Rn	377	226,652
5.0%	5.0%	1-2	341					17	17	307	1.17	564	Rn x Rn	526	172,191
5.0%	5.0%	2-3	306					15	15	275	1.17	307	Rn x Rn	526	154,518
5.0%	5.0%	3-4	287					14	14	258	1.17	275	Rn x Rn	526	144,924
5.0%	5.0%	4-5	274					14	14	247	1.17	258	Rn x Rn	526	138,359
1.3%		5-6	248	3	245							247	Rn x Rn	526	32,612
															869,256
										% Lambing	Hoggets	0%			
											Ewes	117%			
					Total Dry Matter Eaten										
						Total	869,256								
					Total DM eaten (Stockpol)										
					324	2683	869,292								
					Deficit or Execess										
							36								

The GM calculation was corrected for the cost of purchasing pure-bred EF rams to implement the crossbreeding strategy. Once crossbred ewes were generated, less expensive EF x Rn rams were purchased. While EF and EF x Rn rams were more expensive than the Romney ($2000 and $400 per ram, respectively) the farmer would save the normal annual cost of purchasing Rn rams. In addition, as the flock size decreased as the proportion of crossbred ewes increased, fewer rams were required if the same ram:ewe ratio (1:150) was maintained. The ram requirements for the transition to the EF x Rn flock are summarised in Table 3.8.

Table 3.8: Ram requirements for the transition from the Rn x Rn to the EF x Rn flock.

Breed rams	1998	1999	2000	2001	2002	2003	2004
Rams required	10	12	11	11	10	11	9
EF x EF	10	7	5	3	1	0	0
EF x Rn	0	5	6	7	9	11	9
Purchases (heads)							
EF x EF	10	0	0	0	0	0	0
EF x Rn	0	5	3	3	3	4	1
Ram cost ($)							
EF x EF	20000	0	0	0	0	0	0
EF x Rn	0	2000	1200	1200	1200	1600	400
Net cost ($)	20000	2000	1200	1200	1200	1600	400

The investment analysis was applied only to the sheep component of the farm system (since cattle were assumed to remain fixed for both breed options). Once the status quo age structure and numbers for the new breed were reached, the flock was assumed to remain unchanged in future years and therefore a 'constant' GM would be generated annually. The difference in the sheep GM during the transition years and between the two breeds at their respective status quo situations was calculated. The NPV was calculated by discounting the resultant stream of annual GM's for each breed at different rates (2.5, 5.0 and 7.5%) and adding the value of the status quo GM capitalised to infinity. The transition period from the Rn x Rn to an EF x Rn crossbred flock was 6 years.

Chapter Four: Results

4.1 Introduction

In this Chapter the results from the STOCKPOL analysis of the case farm are presented. These include details on: stock numbers, live weights, pasture production and consumption, financial returns and risk, and the investment analysis. In the final section a range of decision criteria are applied to identify the 'best' sheep breed in terms of the enterprise margins generated for different lamb: wool price combinations.

4.2 Livestock wintered and performance levels

The number of animals wintered by class under the three sheep policies are presented in Table 4.1. Cattle numbers were fixed for each policy and comprised a herd of 55 breeding cows. The ewe numbers, and the fixed proportion of flock replacements (20 %) and breeding rams (1 % of ewes), decreased from a total of 1930 sheep for the Rn x Rn policy to 909 sheep with the EF x EF option. At these numbers each policy was shown to be feasible by STOCKPOL, assuming a lambing percentage of 117, 148 and 230 % for the Rn x Rn , EF x Rn and EF x EF policies, respectively.

Table 4.1: Livestock wintered and performance levels for the three sheep policies.

Description	Rn x Rn	EF x Rn	EF x EF
Parameters			
Sheep wintered (1 July)	1930	1315	909
Lambing %	117	148	230
Hoggets lambing %	-	86	100
Replacements %	20	20	20
Ewe deaths %	5	5	5
Other deaths %	3	3	3
Lamb wean wt (kg)	20	29	38
Live weight (kg):			
Ewes	52	69	80
Hoggets	31	43	50
Rams	68	78	104
Cattle			
Breeding cows	55	55	55

4.3 Ewe live weight profiles

The annual pattern of the ewe live weight profiles (Figure 4.1) was similar for the three sheep policies, except in September when the EF x EF ewes showed a larger increase in weight compared with the Rn x Rn and EF x Rn ewes. This corresponds to the greater number of lambs (2.3) carried by the EF x EF ewes compared to the EF x Rn (1.48) and Rn x Rn (1.17) ewes.

Lower ewe live weights from October to December (Figure 4.1) reflect the effect of lambing and milking, and the shearing of ewes on October 31. On an annual basis the average live weight of the EF x EF ewes was 14 and 35 % greater than that of the EF x Rn and Rn x Rn ewes, respectively.

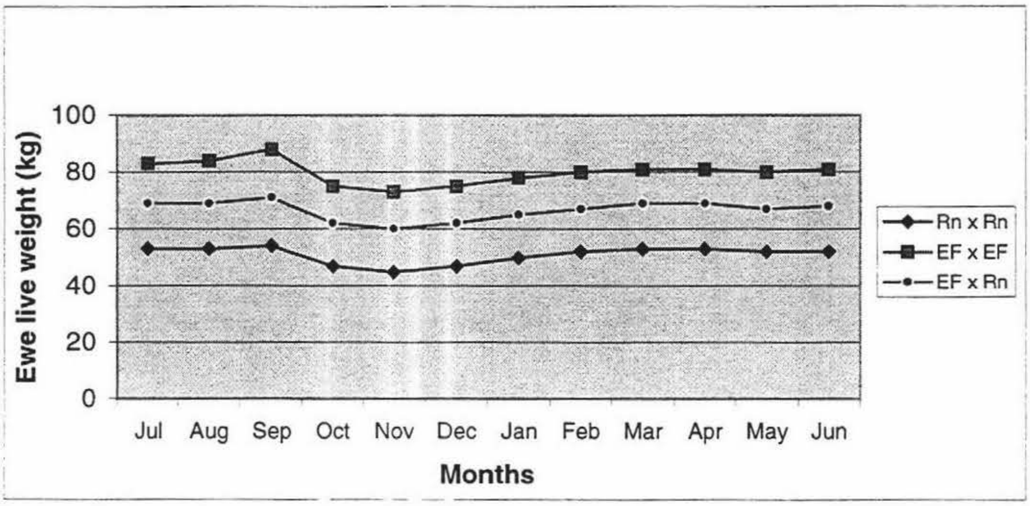

Figure 4.1 Ewe live weight profiles for the three sheep policies.

4.4 Hogget live weight profiles

The ewe hogget live weight growth profiles are presented in Figure 4.2. Shearing occurred on September 16 as hoggets and March 10 as two tooths. The pattern of liveweight gain (LWG) was similar for each policy, but the EF x EF two tooths went to the ram shorn at 59 kg, compared to 51 and 46 kg, for the EF x Rn and Rn x Rn flock replacements, respectively. The minimum LWG of 31g/d occurred in July, and the maximum growth of 115g/d occurred in October and November.

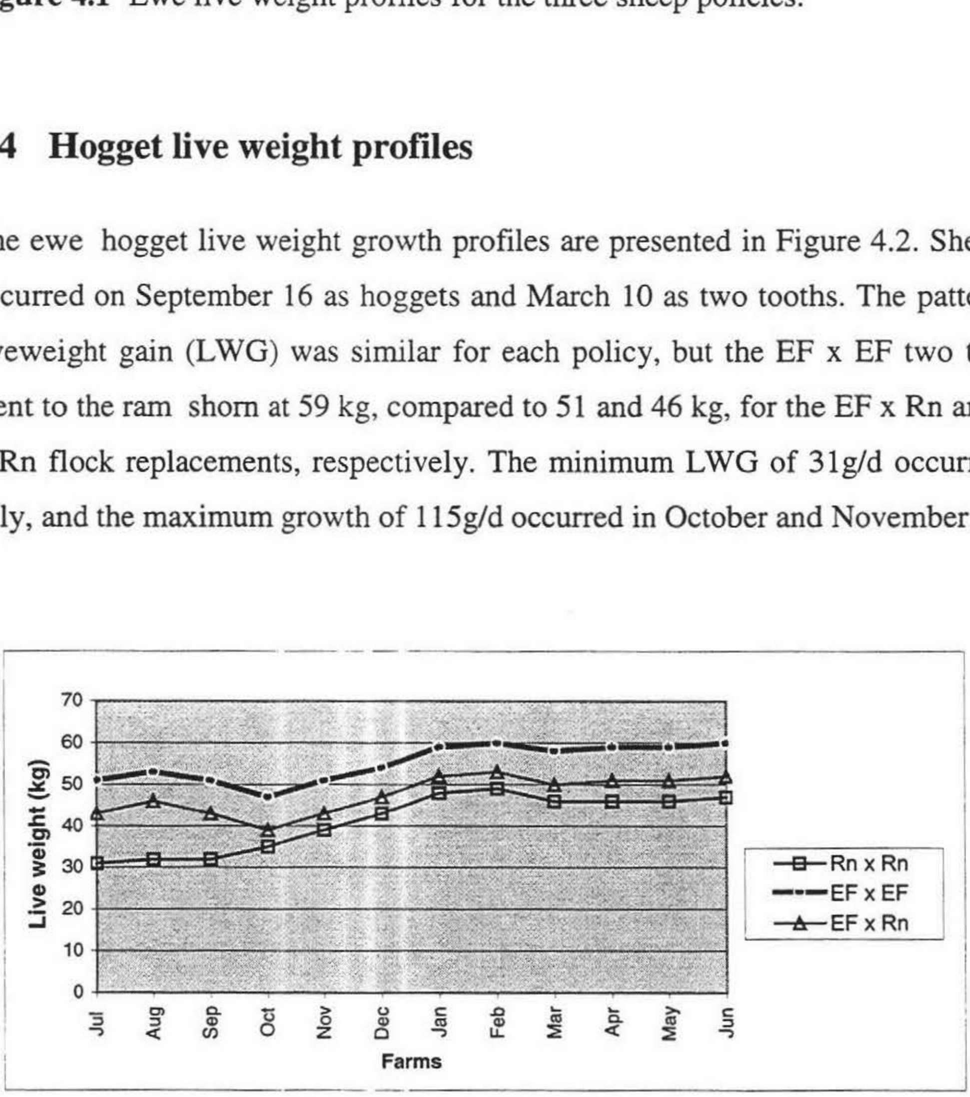

Figure 4.2: Ewe hogget flock replacement growth profiles by breed option.

4.5 Total and per hectare live weight

The total live weight of sheep on the farm at 1 July was 91.8, 81.7 and 67.5 tonnes, respectively for the Rn x Rn, EF x Rn and EF x EF policies (Table 4.2). A further 147.2 tonnes of beef cattle were supported by each system. The total per hectare live weight was 738, 706 and 663 kg for the three policy options, or a 11 % difference between the extremes. The variation in live weight related to the pasture production and utilisation for the three sheep policies (see Table 4.4).

Table 4.2: Live weight of animals on the farm (total and per hectare) on 1 July for the three sheep policies.

	Rn x Rn		EF x Rn		EF x EF	
	Total	/ha	Total	/ha	Total	/ha
Sheep	(kg)		(kg)		(kg)	
Ewe hogget	13,725	42	13,009	40	10,585	33
Ewes	76,846	237	67,557	209	56,137	173
Ram	1,277	4	1,091	3	821	3
Sub-total sheep	91,848	283	81,657	252	67,542	208
Cattle	147,222	454	147,222	454	147,222	454
Farm total	239,070	738	228,879	706	214,764	663

4.6 Feed supply and sheep demand

Sheep feed demand was 13.6 and 7.6 % less for the EF x EF policy than the Rn x Rn and EF x Rn policies, respectively (Table 4.3). Feed grown did not meet sheep demand from May to July for the Rn x Rn system. For the EF x Rn and EF x EF policy, with fewer ewes (Table 4.1), pasture growth was insufficient only in June and July (Figure 4.3). Feed demand in the deficit months was met by transferring pasture cover (i.e. feed) forward from periods of surplus, and by a slight reduction in ewe live weight (excluding the weight gained due to pregnancy).

Table 4.3: Total feed supply and sheep and cattle demand per month (kg pasture DM equiv./ha/d) for the three sheep policies. The cattle feed demand (3275 kg DM/ha) was identical for each sheep policy.

Month	Pasture Production	Feed demand Rn x Rn	EF x Rn	EF x EF
	(net kg DM/ha/d)			
Jul	12	13.4	12.7	11.9
Aug	15	14.3	13.7	13.1
Sep	19	15.9	14.8	14.3
Oct	29	20.3	20.7	20.3
Nov	43	22.2	21.8	20.5
Dec	31	23.6	22.2	20.2
Jan	20	17.1	15.7	14.0
Feb	16	13.2	12.2	10.7
Mar	22	14.3	13.3	12.1
Apr	16	14.0	13.0	11.9
May	14	14.3	13.3	12.1
Jun	13	14.4	13.4	12.3
Total kg/ha	7600	5990	5674	5272

Figure 4.3 illustrates the annual pattern of pasture supply and demand for the sheep policies. Surplus pasture production occurred especially in November, and to a lesser extent in October, December and March. Sheep demand was greatest during the lactation period (October to December).

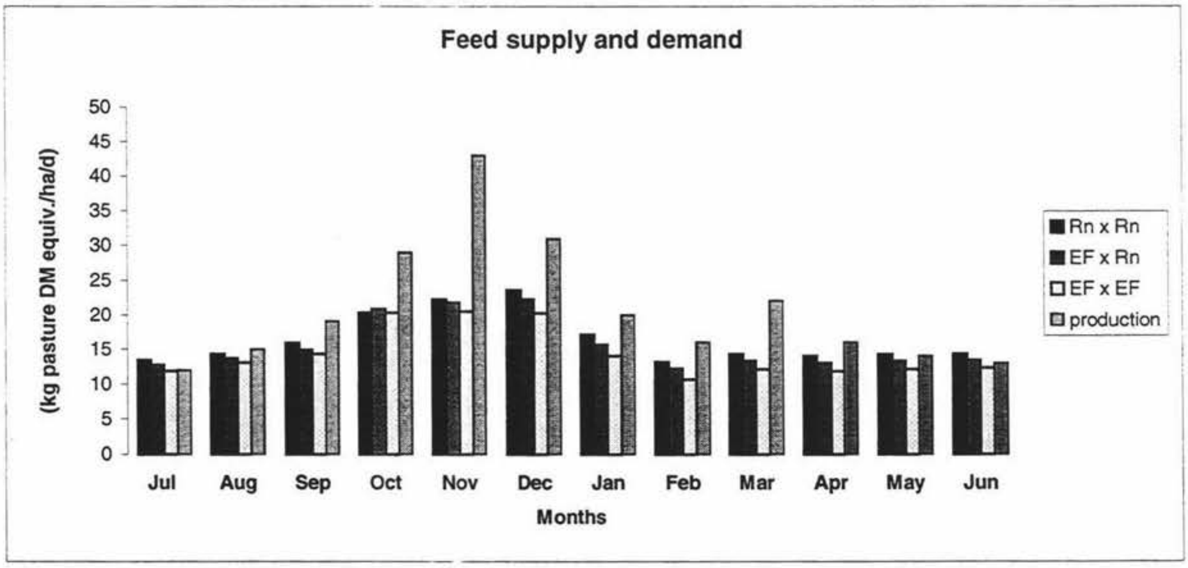

Figure 4.3: Annual distribution of feed supply and total demand for the three sheep policies (kg DM equivalents per hectare per day).

4.7 Pasture cover

A similar annual pattern of pasture cover (kg DM/ha) was observed for the three sheep policies (Figure 4.4). The lowest pasture covers occurred between June and September. The pasture cover in August was the point of biological unfeasibility for all three systems (i.e. more sheep could have been carried if the feed supply in August could have been increased). On annual bases, the EF x EF policy had an average pasture cover 5 to 10 % higher than the Rn x Rn and EF x Rn policies, respectively.

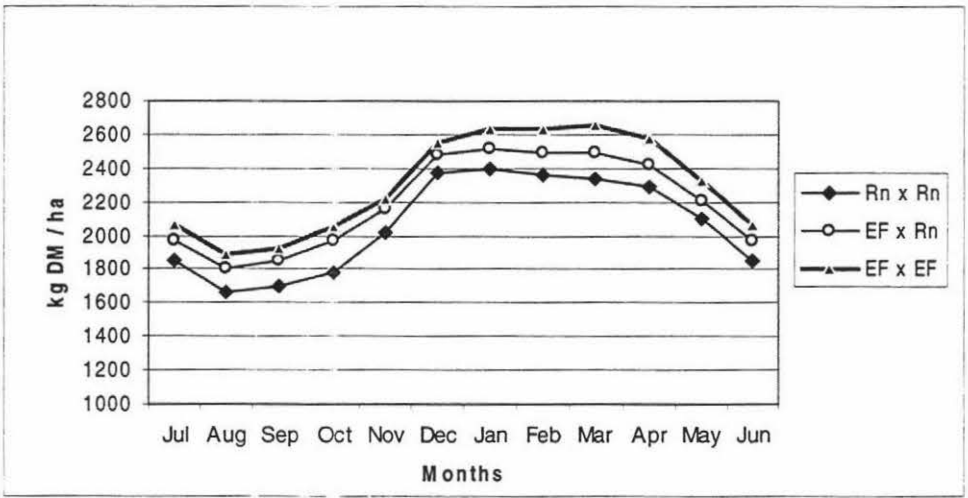

Figure 4.4: Pasture cover profiles for the three sheep policies.

4.8 Pasture production and utilisation

On an annual basis, 3 and 7% less pasture DM per hectare was grown under the EF x Rn and EF x EF sheep policies, respectively, than the current Rn x Rn system (Table 4.4). Lower pasture production for the former breeds reflected poorer pasture control during the summer and autumn period. This contributed to greater losses through decay (Table 4.4) and thus, lower overall pasture utilisation (Korte et al., 1987). Under all three systems of management the cattle were assumed to consume a fixed amount of feed: in practice the reduction in pasture productivity and quality may have affected cattle feed intake and their productivity. Pasture utilisation of 90, 88 and 85% per annum respectively, for the Rn x Rn, EF x Rn and EF x EF policies, is high because pasture growth data are net herbage accumulation rates (i.e. some pasture growth lost through decay has already been excluded (Korte et al., 1987)). The lower number of ewes in the crossbred and EF x EF flocks, and therefore lower ewe:lamb ratio compared to the Rn x Rn system during the summer and autumn, was the primary cause of higher senescence and decay rates (Table 4.4) under these policies.

Cattle consumed 3275 kg DM per hectare, but there was a 26% difference in total intake by sheep between the Rn x Rn and the EF x EF policies. As noted earlier, this reflected greater pasture decay under the later sheep system (961 vs. 693 kg DM/ha) which in turn had a negative feedback effect on pasture growth rates and therefore annual DM production. Compared to the Rn x Rn policy (100%), sheep feed intake was 89% for the EF x Rn and 74% for the EF x EF breed. The greater annual intake of DM by the EF x Rn hoggets relative to the Rn x Rn system is due to the impact of hogget lambing (86% lambed) (Table 4.1).

Table 4.4: Pasture grown (kg DM per ha) and its utilisation (%) under three breed policies. The DM consumption of the sheep is decomposed by class and the percentage values are the annual consumption per class relative to the Rn x Rn policy.

	Rn x Rn	EF x Rn		EF x EF	
(kg DM/ha)	Total	Total	(%)	Total	(%)
Pasture grown*	6683	6459	97	6233	93
Sheep consumption:	2714	2408	89	1996	74
ewe lambs	197	164	83	128	65
ewe hoggets	444	450	101	346	78
ewe	2042	1769	87	1503	74
ram	31	25	80	19	60
Cattle consumption	3275	3275	100	3275	100
Farm consumption	5990	5684	189	5272	174
Decay	693	775	112	961	139
Utilisation (%)	90	88	98	85	94
*kg DM pasture standardised to 10.5 MJ ME/kg DM.					

4.9 Stock Unit (SU) equivalents.

The SU equivalents of the various sheep classes for the three policies were derived from the annual feed consumption data (Table 4.5). Relative to the Rn x Rn ewe, expressed as 1.0 SU for a STOCKPOL calculated DM intake of 526 kg per annum, the EF x EF and EF x Rn ewe were 1.54 and 1.25 SU's, respectively. The ewe hogget SU equivalents were 0.73, 1.06 and 1.14, respectively, for the Rn x Rn, EF x Rn and EF x EF policies. The derived SU factors represent the per head substitution rates between the various sheep classes under different breeding policies for the case farm.

Table 4.5: Calculated annual DM intake of sheep classes of three breed policies and estimated SU equivalents for each stock class relative to the base ewe consuming 526 kg DM/ewe.

Farm Description	1 Rn x Rn	2 EF x Rn	3 EF x EF
		kg DM / year	
Total feed cons.	879,379	780,298	646,838
Ewe lamb	139[1]	169	189
Ewe hogget	382	558	602
Ewe	526	657	810
Ram	461	530	590
		SU equivalents	
Ewe lamb	0.26	0.32	0.36
Ewe hogget	0.73	1.06	1.14
Ewe	1.00	1.25	1.54
Ram	0.88	1.01	1.12

[1] kg DM pasture standarised to 10.5 MJ ME/kg DM.

4.10 Annual Dry Mater Intake (DMI)

Total annual DMI by sheep was 11 and 26 % greater for the Rn x Rn policy compared to the EF x Rn and EF x EF flocks, respectively (Table 4.6). This reflected the larger number of sheep wintered for the Rn x Rn policy and the interaction between sheep breed and pasture production (Table 4.5). The annual DMI by ewe hoggets for the EF x Rn policy was 1 and 23% greater than that for the Rn x Rn and EF x EF policies, respectively. This corresponded to the larger number of EF x Rn hoggets lambing (310) compared with 214 and 0 hoggets lambing under the EF x EF and Rn x Rn policies, respectively.

Table 4. 6: Decomposition of annual DM intake by sheep class for the three sheep policies. Values are per flock and per hectare, and the proportional intake of other sheep classes relative to the ewes for each breed (=1.000). The percentage (%) of feed eaten are by class within the respective breeds.

Farm Description	1 Rn x Rn				2 EF x Rn				3 EF x EF			
	kg DM / year											
	Total	/ha	%	Prop	Total	/ha	%	Prop	Total	/ha	%	Prop
Sheep feed cons	879,397	2,714			780,298	2,408			646,837	1,996		
Sheep class												
Ewe lamb	63,870	197	0.07	0.097	53,254	164	0.07	0.093	41,535	128	0.06	0.085
Ewe hogget	143,806	444	0.16	0.217	145,717	450	0.19	0.254	112,114	346	0.17	0.230
Ewe	661,614	2,042	0.75	1.000	573,242	1,769	0.73	1.000	487,098	1,503	0.75	1.000
Ram	10,107	31	0.01	0.015	8,085	25	0.01	0.014	6,090	19	0.01	0.013

* kg DM pasture standarised to 10.5 MJ ME/kg DM.

4.11 Sheep and wool sales.

Sheep and wool sales are presented in Table 4.7. Under the EF x EF system, 331 and 173 more lambs were sold than for the Rn x Rn and EF x Rn policies, respectively. In percentage terms, the EF x EF policy enabled 27 % more animals to be sold than the Rn x Rn flock and 11 % more than the EF x Rn policy. The total live weight of animals sold for the EF x EF policy was 80 and 43% (39,502 and 21,121 kg) greater than for the Rn x Rn and EF x Rn policies, respectively. In all of the sheep classes, the Rn x Rn sheep produced more wool than the other two breeds. Wool sold (kg greasy) from ewes in the Rn x Rn policy was 28% greater than for EF x Rn option, and 295 % greater than that for the EF x EF policy (Table 4.7).

Table 4.7: Characteristics of animal and wool sales for the three sheep policies.

Farm Description	1 Rn x Rn			2 EF x Rn			3 EF x EF		
	Animal sold		wool sold	Animal sold		wool sold	Animal sold		wool sold
Animal class	(No)	(kg)	(kg)	(No)	(kg)	(kg)	(No)	(kg)	(kg)
Ewe lambs	383	7928	429	542	17723	365	669	28031	239
Ram lambs	838	24805		852	38851		883	49448	
Ewe hoggets	150	7155	1979	102	5335	1015	70	4151	519
Ewes	212	9540	5862	144	8640	4579	100	7300	1985
Rams	3		137	2		64	2		49
Total	1586	49428	8407	1642	70549	6023	1724	88930	2792

4.12 Meat and wool income.

The main income from meat sold was from lambs, especially ram lambs (Table 4.8). Total income for the EF x EF policy from meat sold was 38 and 18% greater than for the Rn x Rn and EF x Rn policies, respectively. This was because of the greater number and heavier, and therefore more valuable EF x EF lambs (($36.97 average sale price vs. $30.72 for EF x Rn and $20.49 for Rn x Rn lambs).

Table 4. 8: Live weight sold and wool income for the three sheep policies.

Farm Description	1 Rn x Rn		2 EF x Rn		3 EF x EF	
Animal class	Meat sold ($)	Wool sold ($)	Meat sold ($)	Wool sold ($)	Meat sold ($)	Wool sold ($)
Ewe lambs	5,745	1,090	13,008	927	19,401	607
Ram lambs	19,274		29,820		37,969	
Ewe hoggets	5,700	5,027	3,876	2,568	2,660	1,313
Ewes	8,056	14,127	5,472	11,035	3,800	4,784
Rams	1,050	330	700	154	700	118
Sub-totals ($)	39,825	20,574	52,876	14,685	64,530	6,822
Sheep income ($)	60,399		67,561		71,352	

4.13 Cost of Capital (CoC)

The total and per animal class CoC values are presented in Table 4.9. On an annual basis, the Rn x Rn policy was 11 and 10 % more expensive in terms of the CoC than the EF x Rn and EF x EF policies, respectively. The lower annual cost of capital for sheep the EF x Rn ($478) and EF x EF ($412) flocks reflected fewer animals for these policies than for the Rn x Rn option. The annual CoC ($/ha) per class (ewe hoggets and ewes) was 11% greater for the Rn x Rn, than for the EF x EF policy. The EF x Rn were slightly (2 %) less expensive to fund than the EF x EF, principally because of less expansive rams. The total capital invested in cattle ($144,141) incurred an annual opportunity cost of $8,081.

Table 4.9: Per head values and the total farm and per animal class cost of capital (CoC, $) values for the three sheep policies, assuming an interest rate of 5.6% per annum.

Farm Description	1 Rn x Rn			2 EF x Rn			3 EF x EF		
Sheep	**Heads**	**$/hd**	**Capital**	**Heads**	**$/hd**	**Capital**	**Heads**	**$/hd**	**Capital**
Ewe hoggets	455	38.54	17,536	310	45.05	13,966	214	51.00	10,914
Ewes	1455	35.88	52,205	991	46.92	46,498	686	55.90	38,341
Rams	20	243	4,860	14	400[1]	5,600	9	2000[1]	18,000
Totals	**1930**		**74,601**	**1315**		**66,063**	**909**		**67,255**
Sheep CoC			**4,182**			**3,704**			**3,770**
Cattle									
1yr Heifers	14	285	3,990	14	285	3,990	14	285	3,990
Cows	55	427	23,485	55	427	23,485	55	427	23,485
1yr Bulls	153	354	54,162	153	354	54,162	153	354	54,162
2yr Bulls	66	914	60,324	66	914	60,324	66	914	60,324
Bulls	2	1090	2,180	2	1090	2,180	2	1090	2,180
Totals	**290**		**144,141**	**290**		**144,141**	**290**		**144,141**
Cattle CoC			**8,081**			**8,081**			**8,081**

[1]EF and F1-EF x Rn ram prices from Silvestream (July 1998).

4.14 Enterprise Margins (EM)

Farm income and expenditure for the breed options are shown in Table 4.10. Derived SU's equivalents (see Table 4.5) were used in order to get this parameters. The EF x EF policy with 10 % more sheep capital, earned a 37% greater sheep EM than the Rn x Rn option. Compared to the EF x Rn policy, the EF x EF system earned a 7% higher EM.

The results reflect, in part, the greater proportion of annual income from wool (34%) for the Rn x Rn policy, in comparison with only 21 and 10 % for the EF x Rn and EF x EF policies, respectively. Wool at 1998 prices returned less than lambs, and the production differences (kg meat sold) per ewe for lambs were much greater than for wool (less than 1.0 kg per ewe). Therefore differences in the number and value of lambs sold was an important reason why the EM's differed. Shearing expenses were 53, 51 and 49% of the total variable costs for the Rn x Rn, EF x Rn and EF x EF, respectively. The variables influencing income and expenditure for the EM were the same for the three sheep policies. The farm EM for the EF x EF policy was 15% greater than that for the Rn x Rn policy and 12 % greater than that for the EF x Rn policy.

Table 4.10: Financial attributes of the three breed policies: income, expenditure, enterprise margin (EM) and the farm EM.

Farm	1			2			3		
Description	Rn x Rn			EF x Rn			EF x EF		
Sheep SU	1803			1581			1311		
Sheep Income	**$ Total**	**$ / SSU**	**$ / ha**	**$ Total**	**$ / SSU**	**$ / ha**	**$ Total**	**$ / SSU**	**$ / ha**
Income									
Sheep	39,825	22.09	122.92	52876	33.44	163.20	64,530	49.22	199.17
Wool	20,541	11.39	63.40	14675	9.28	45.29	6,818	5.20	21.04
Sub-total	60,366	33.48	186.31	67551	42.73	208.49	71,348	54.42	220.21
Expenses									
Shearing	8010	4.44	24.72	5475	3.46	16.90	3795	2.89	11.71
Sheep feed	1565	0.87	4.83	1451	0.92	4.48	1284	0.98	3.96
Ram purchases	972	0.54	3.00	1200	0.76	3.70	4000	3.05	12.35
Sheep An.Health	4606	2.55	14.22	3137	1.98	9.68	2169	1.65	6.69
Sub-total	15153	8.40	46.77	11263	7.12	34.76	11248	8.58	34.72
Sheep margin	**45,213**	**25.08**	**139.55**	**56,288**	**35.60**	**173.73**	**60,100**	**45.84**	**185.49**
Sheep capital	**4,178**	**2.32**	**12.89**	**3,700**	**2.34**	**11.42**	**3,766**	**2.87**	**11.62**
Sheep EM	**41,035**	**23**	**127**	**52,588**	**33**	**162**	**56,334**	**43**	**174**
Cattle SU	1795			1795			1795		
Beef Income	**$ Total**	**$ / CSU**	**$ / ha**	**$ Total**	**$ / CSU**	**$ / ha**	**$ Total**	**$ / CSU**	**$ / ha**
Income									
Cattle sales	68229	38.01	210.58	68229	38.01	210.58	68229	38.01	210.58
Expenses									
Beef feed	1935	1.08	5.97	2053	1.14	6.34	2216	1.23	6.84
Bull purchases	1421	0.79	4.39	1421	0.79	4.39	1421	0.79	4.39
Beef An.Health	2621	1.46	8.09	2621	1.46	8.09	2621	1.46	8.09
Sub-total	5977	3.33	18.45	6095	3.40	18.81	6258	3.49	19.31
Beef margin	62,252	34.68	192.14	62,134	34.62	191.77	61,971	34.52	191.27
Beef capital	4,525	2.52	13.97	4,525	2.52	13.97	4,525	2.52	13.97
Cattle EM	57,727	32.16	178.17	57,609	32.09	177.81	57,446	32.00	177.30
FARM MARGIN	**107,465**	**59.76**	**331.68**	**118,422**	**70.22**	**365.50**	**122,071**	**80.37**	**376.76**
FARM CAPITAL	**8,703**	**4.84**	**26.86**	**8,225**	**4.86**	**25.38**	**8,291**	**5.39**	**25.59**
FARM EM	**98,762**	**54.92**	**304.82**	**110,197**	**65.36**	**340.12**	**113,780**	**74.97**	**351.17**

4.15 Risk assessment and decision criteria

The cumulative frequency distribution for the total farm EM/ha for the EF x EF option was generally, but not consistently, greater than that for the Rn x Rn and EF x Rn policies (Figure 4.5) (see Appendix I, II and III for full details). This indicates that although 'business' risk in general would be less for the EF x EF policy (i.e. it has the smallest area under the curve), the advantage over the other policies is small. The application of other decision criteria for a breed choice that account for risk in different ways, is shown in Table 4.11.

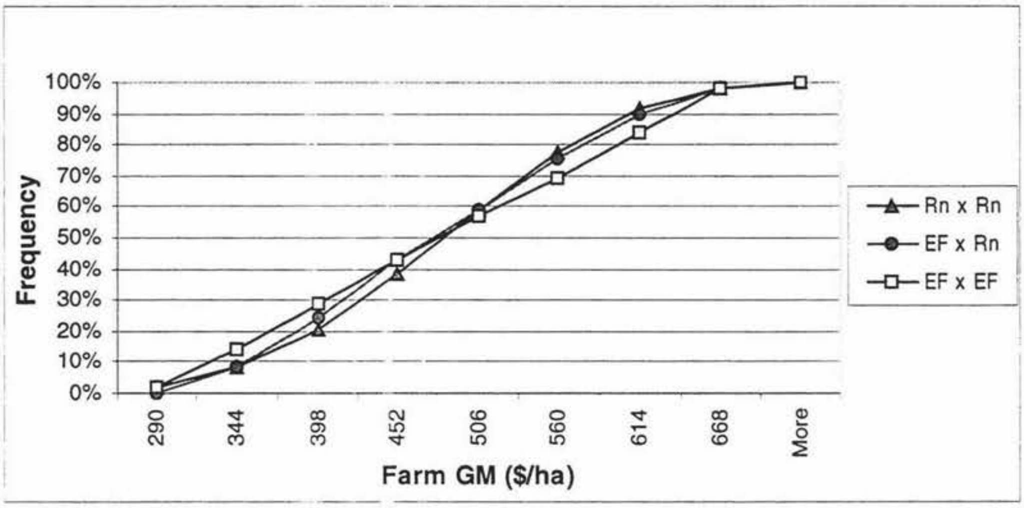

Figure 4.5: Summary of the cumulative frequency of the total farm Enterprise Margin (EM, $/ha) for each sheep policy and assuming an identical cattle policy.

Each of the alternative decision criteria applied to the selection of a sheep policy on the basis of the EM per hectare indicated the EF x EF policy would be the best choice of the sheep policies considered (Table 4.11). The minimum EM of the EF x EF policy was 35 and 4% greater than that for the Rn x Rn and EF x Rn policies, respectively (see Appendix IV for the original EM data). The maxmax EM for the EF x EF policy was 15% greater than that for the Rn x Rn policy, and 1% less than that for the EF x Rn policy. The Expected Utility Value (EUV) of the EF x EF policy at $170/ha was 29 % greater than for the Rn x Rn ($132/ha) and 2% more than the EF x Rn ($167/ha) policy.

Table 4.11: Application of alternative decision criteria reflecting the different emphasis a farmer may place on risk in the selection of a sheep policy on the basis of EM per hectare ($).

Criterion	Rn x Rn	EF x Rn	EF x EF	Choice	Emphasis
Maxmin	79	116	121	EF x EF	Pessimism
Maxmax	186	221	220	EF x EF	Optimism
Most likely state	132	164	170	EF x EF	Best bet'
EUV[1]	132	167	170	EF x EF	Neutral

[1]Expected Utility Value; see Appendix IV for the full set of EUVs.

4.16 Flock Transition and Investment Analysis

To illustrate the transition effects of changing from the Rn x Rn flock, the flock structural changes due to the introduction of EF and EF x Rn rams was investigated. Over a six year period a half-breed EF x Rn flock was generated. The age structure of the flock for each year it would take to achieve a transition to an EF x Rn flock is shown in Table 4.12 (the full data set is presented in Appendix V). The 1998 situation represents the status quo and an annual DM consumption by sheep of 869 tonnes Table (4.5). This would continue to apply if the Rn x Rn flock was maintained and no other changes to the farming systems were made.

The transition to the EF x Rn flock requires a reduction in sheep numbers for two reasons: first, the crossbred sheep are heavier and consume more per SU (see Table 4.6) and second the breed x pasture production interaction (see Table 4.5) means pasture DM consumption declines from 869 tonnes to 780 tonnes per annum. Annual pasture production was assumed to decrease incrementally by 17.8 tonnes DM/year as illustrated in Figure 4.6. Consequently, total sheep numbers progressively adjusted from 2307 head in 1998 to 1885 head in 2004 (Table 4.12).

Table 4.12: Age structure, production, and gross margin of the Rn x Rn flock from 1998 to 2004, the period it would take to achieve a transition to an EF x Rn flock.

	1998	1999	2000	2001	2002	2003	2004	2005
Age structure								
0 - 1	851	841	841	817	804	784	734	777
1 - 2	341	477	189	301	237	260	381	217
2 - 3	306	307	429	170	271	213	234	343
3 - 4	287	275	276	386	153	244	192	211
4 - 5	274	258	248	249	347	138	220	173
5 - 6	248	247	232	223	224	313	124	198
Total sheep	2307	2405	2215	2146	2036	1952	1885	1918
Production								
Lambs and hoggets	1114	1398	1280	1302	1253	1086	1165	1156
Cull ewes	296	300	278	267	263	340	169	235
Wool (kg)	5955	6494	5968	5898	5644	5482	5338	5374
Gross Margin								
Sheep GM	37980	67170	61255	61905	59739	56189	53210	54955
$/ha	117	207	189	191	184	173	164	170

Wool production and lamb sales reflect both the change in productivity due to the EF influence, as well as the reduction in total sheep numbers due to the introduction of a heavier and more prolific breed.

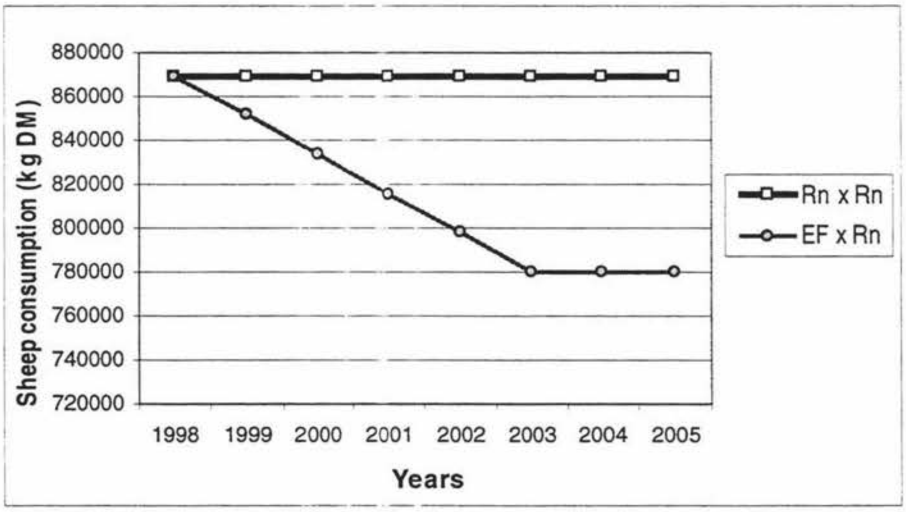

Figure 4.6: Annual pasture consumption by sheep if the Rn x Rn flock is maintained versus the transition to an EF x Rn crossbred flock.

Table 4.13: Age structure (at 25 September) production and gross margin of the Rn x Rn flock from 1988 to 200.

Age structure	1998	1999	2000	2001	2002	2003	2004
0 - 1	851	636	739	710	728	723	648
1 - 2	341	564	318	392	352	364	496
2 - 3	306	307	507	286	352	317	328
3 - 4	287	275	276	457	257	317	285
4 - 5	274	258	248	249	411	232	286
5 - 6	248	247	232	223	224	370	208
Total sheep	2307	2287	2321	2316	2325	2323	2251
Production							
Lambs and hoggets	1021	873	991	978	999	851	869
Cull ewes	296	304	288	281	281	413	268
Wool (kg)	6270	6442	6435	6452	6460	6460	6317
Gross Margin							
Sheep GM	43474	39940	43184	42573	43247	42673	38524
$/ha	134	123	133	131	133	132	119

The investment analysis considered the net difference in the farm GM's during the transition period and capitalised the farm GM to infinity once the new status quo for the EF x Rn flock was reached. Figure 4.7 shows that at a 5% discount rate the difference in NPV ($92,133; Table 4.14) in favour of the EF x Rn policy was significant. While sales of capital Rn x Rn sheep in the initial years of the transition increased returns (eg. $37,980 in 1998 versus $67,170 in 1999), the farm GM for the EF x Rn flock was also greater (i.e. $39,940 in 1999 versus $43,184 in 2000) once the EF x Rn flock was established.

The NPV increased to $102,784 at a discount rate of 2.5% (Table 4.14). Higher long-term returns added to the earlier profit advantage during the transition period. The investment analysis confirms the earlier Enterprise Margin study which showed that the EF x Rn would be selected in preference to the Rn x Rn (and the EF x EF in turn would be preferred over the EF x Rn sheep).

Table 4.14: Effect of different discount rates on the Net Present Value (NPV) for the Rn x Rn versus the EF x Rn breed options (including the 6 year transition).

Sheep policy	Discount rate (%)		
	2.5%	5.0%	7.5%
Rn x Rn	$302,286	$272,554	$247,066
EF x Rn	$405,070	$364,687	$330,022
Difference	$102,784	$92,133	$82,956
IRR	467%		

Figure 4.7 shows the annual farm GM for the sheep enterprise during and after the transition from a Rn x Rn flock to an EF x Rn crossbred flock. The status quo Rn x Rn cashflow is included for comparative purposes.

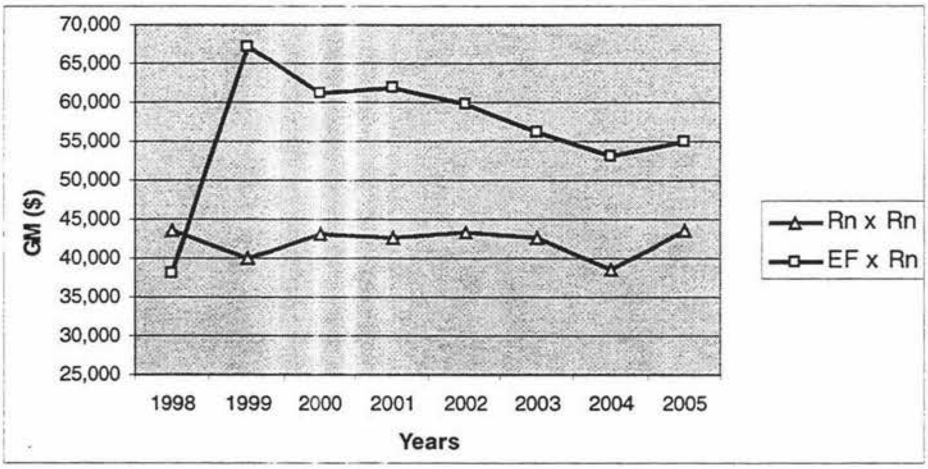

Figure 4.7: Annual farm GM for the sheep enterprise during and after the transition from a Rn x Rn flock to an EF x Rn crossbred. The GM from 2006 was assumed to the same as that for 2005.

The EF x EF analysis would follow the same format but the transition from a purebred Rn x Rn flock to EF's (30/32 or 93.75% pure breed) would take 24 years if grading up from within the flock was adopted. The reduction in Rn x Rn sheep as EF's were adopted would marginally increase sheep net income each year and the GM once the status quo was reached (2022) would be higher (for the Romney's). A positive NPV for the EF x EF option can be expected but the long time frame for the full transition has associated high price risk for sheep meats and wool However, the previous risk analysis (see Table 4.11) suggests that even if lamb returns 'crashed' the EF x EF option would be worth pursuing.

4.17 Discussion

The results derived from this research showed that the EF x EF sheep system was more efficient in terms of financial returns and less 'risky' in terms of both pasture production and utilisation. The high prolificacy of the breed compensated for their higher live weight, and thus feed consumption compared to the Rn x Rn ewes. The

EF x EF ewes produced more and heavier lambs, resulting in higher financial returns for the system. The risk analysis and the NPV both indicated adoption of EF genetics would be worthwhile on the case farm

Fewer adult sheep in the EF x EF system reduced pasture utilisation through increased decay. Excess pasture production could be utilised by modifying livestock policies to compensate for this deficiency. Increasing cattle numbers or finishing more lambs are two possibilities that could be explored.

The faster growth rates of EF x EF hoggets enable them to be mated earlier than the rest of the systems analysed (Allison, 1995). This increases the productivity of the system (Geenty and Cameron, 1998) and improves pasture utilisation. While hogget replacements for the Rn x Rn system largely remain unproductive except for wool production for the first two years (Moore and Sumner, 1983), the EF x Rn and EF x EF systems can obtain financial returns in the first year.

The annual DMI of EF x EF ewes was 1.4 times more than that of their smaller, less prolific Rn x Rn counterparts. Brookes et al. (1998) suggested a SU substitution rate of 1.5:1.0 for the EF x Rn crossbred ewes compared to Romneys. Montes de Oca (1998) estimated an EF x Coopworth breed ewe weighting 66 kg and lambing 155 % was equivalent to 1.3 SUs. Parker et al. (1998) used a simple decision support model based on a fixed feed supply to achieve a SU value of 1.2 for crossbreeds ewes, such as the EF x Rn, producing 1.40 lambs per ewe mated.

Determining appropriate SU, and therefore the substitution rate, is an important issue when evaluating the introduction of a new breed. Alley (1998) interviewed four farmers who had either adopted (3) or evaluated (1) a new sheep breed. Surprisingly, in all cases a 1:1 substitution rate with the existing ewes was assumed in the planning analysis. A mitigating factor on one farm was a pasture development programme: it was assumed that the feed supply per sheep would increase if constant sheep numbers were maintained as the new breed was introduced. Parker (1998b) reviewed the SU system in light of new sheep breeds and farming systems. The availability of farm feed budgeting models, such as spreadsheets (Parker, 1993) and STOCKPOL, reduces the need for SU conversion factors because they allow the numbers of sheep per class that should be farmed to be derived directly from feed demand relative to the supply. These model outputs can also be incorporated in a financial budget to quantify the economic advantage of one breed versus other.

The transition from a Rn x Rn flock to a F1 crossbred EF x Rn took six years. Mating hoggets increased the rate of change by reducing the generation interval. In practice, a farmer might speed-up the transition by increasing the flock replacement rate (e.g. 30-35 % vs. 20 % per annum). This may not necessarily increase costs because more cull ewes are also sold, and if a heavier breed than the current sheep is being introduced, some capital sheep stock will also be available for sale. It would be worth exploring alternative transition options because this period often posses the most serious problems for farmers when adopting a new technology or farming system. These usually occur because of a lack of cash flow, but may also be caused by the significant change in management skill required to cope with the new technology (or breed) (Hawkins et al., 1989; Sherlock and Parker, 1998).

The calibration of STOCKPOL to the Tuapaka farm system was a significant task, despite the availability of a comprehensive farm data set. The model lacks flexibility for the user to modify equation parameters as, for example, can be done with the UDDER model for dairy farm systems (Larcombe 1991). The main adjustment to get the model to simulate the recorded levels of animal performance and monthly stock numbers at Tuapaka was to pasture growth rate data. The data available - positive growth rates and backward derivation estimates - were in a fact proxy for historical pasture production and subject to large errors. For example, both operator bias and the method of Ellenbank plate meter use (Earle and McGowan, 1979) can lead to significant errors in the estimation of the pasture covers from which positive growth rates are derived. Blanchard (1993) also experienced problems in calibrating STOCKPOL to a Wairarapa property where several years of pasture growth rate derived from cage cuts were available. Thus, one of the basic issues in using simulation models to evaluate alternative livestock policies for a case farm is the availability of reliable pasture growth rate data. In practice, most commercial farmers do not have this information and estimates based on district or regional research are used, or the model is used to estimate, by backward derivation for animal intake and performance records, the likely growth rates (as partially occurred in this study). Once the model is calibrated, it is reasonably straightforward to compare other policies against this base system. In summary, the case farm analysis suggests the farm's owner (Massey University) should carefully consider introducing East Friesian genetics to the Ronmey flock.

Chapter Five: Conclusions

The procedure for evaluating a new sheep breed in New Zealand (or in other countries) was developed by comparing the productivity and profitability of the current flock (Romney) with alternative sheep systems (either an East Friesian x Romney cross flock or a pure-breed East Friesian flock). The management strategy for introducing a new sheep breed to a case farm was developed by calibrating the STOCKPOL model to simulate the existing sheep and beef cattle policy. Then, pasture growth rate data were adjusted to sustain the recorded levels of animal production and to establish the basis against which an EF x Rn and EF x EF flock could be compared.

The biological feasibility of the farm system was obtained by adjusting ewe numbers taking into account replacement rate, live weight profiles and production levels of the EF x Rn and EF x EF breeds. After that, STOCKPOL outputs were analysed financially using an enterprise margin (EM) format in order to calculate the profitability of each sheep breed after adjusting for the cost of capital (CoC) of sheep wintered. The EF x EF flock was the preferred option for all risk preferences in terms of profitability.

Developing a sheep age structure model to simulate the transition to an EF x Rn crossbred flock was a useful tool to calculate sheep production and pasture consumption by age class. Higher lamb:ewe ratios of the EF sheep contributed to reduced pasture production. Pasture senescence and decay in the summer and autumn was higher under both the EF x Rn and the EF x EF sheep policies. Ways to prevent this need to be explored thought further modelling studies using the STOCKPOL and by evaluating the experience of the farmers who have adopted East Friesian sheep. STOCKPOL farm simulation model was a useful tool for evaluating the introduction of the East Friesian sheep on the case farm. The study confirmed the hypothesis: East Friesian sheep would improve production and profit on the hill country case farm.

In order to critically evaluate the method developed for this New Zealand case study in relation to the introduction of a new sheep breed in a Mexican farm, it is necessary to briefly review the sheep industry in Mexico.

A total sheep population (6,200,000) was reported on 1997. At the last census (1990) 421,800 production systems were recorded. In 1996, Mexico imported 41% of its total lamb consumption (49,612 tonnes). Approximately 95 % of sheep production is obtained from traditional sheep production systems (extensive systems) using mainly a native breed (Mexican criolla). This breed is derived from Spanish sheep breeds e.g. Merino, Churra, Lacha and Manchega , which has been mixed across time with many other breeds, e.g. Suffolk, Hampshire, Ramboullet, Romney Marsh, Pool Dorset, Corriedale and other. Sheep from traditional system are feed with native pastures (mostly without fertiliser and without a defined grazing system). The pasture species include Bouteloua gracilis, Bouteloua curtipendula, Hilaria mutica, Pennicetum clandestinum, Muehlenbergia macrocura, Brachypodium mexicanum, and others. The diversity of breeds, the lack of planned genetic programs and deficiencies in pasture management are the main reasons for the small size and low live weight of sheep in these production systems (40 kg average ewe live weight). The remaining sheep production systems (approx. 5%) in Mexico are intensive systems and produce lamb for laughter, using both crop feeding and grazing systems (using appropriate fertiliser policies and defined grazing systems). The main breeds used in these systems are Suffolk, Hampshire, Cheviot, and the Ramboullet. In order to improve sheep production from pasture in extensive systems in Mexico, it is necessary to introduce new technology for the grazing systems, improved pasture management practices, supporting pastoral technologies, and to improve the management skills of the farmers.

In conclusion, only the intensive sheep production systems in Mexico would be suitable for using the model developed in this study. It could be modified to incorporate Mexican climatic and economic conditions and used to evaluate the introduction of heavier and more prolific sheep breeds. In the meanwhile, current Mexican extensive production systems remain unsuitable for this type of study.

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Appendix I. Gross margin and sensitivity of returns to wool and lamb price for the three sheep policies.

Gross Margins

Sheep

Rn x Rn

			total ($)	
	Lamb price (average)	no. lambs		
	19	1221	23,199	
	Culls price	no. culls		
	38	362	13,756	
	Wool price	kg wool		
	2.47	8408	20,768	57,723
	(Rams not included)			
Purchases				
	Ram price	no. rams		
	243	4	972	
	0	0	0	972
Expenses				
Animal health			4606	
Shearing			8010	
Supp Feed			1565	
				14181
			Gross margin	**42,570**

Sensitivity analysis

Rn x Rn

		$ / kg greasy (average)				
	42,570	1.75	2	2.25	**2.5**	2.75
	10	25,527	27,629	29,731	31,833	33,935
Lamb	13	29,190	31,292	33,394	35,496	37,598
	16	32,853	34,955	37,057	39,159	41,261
($ / head)	**19**	36,516	38,618	40,720	**42,822**	44,924
	22	40,179	42,281	44,383	46,485	48,587
	25	43,842	45,944	48,046	50,148	52,250
	28	47,505	49,607	51,709	53,811	55,913
min	max					
25,527	60,117					

EF x Rn

			total ($)	
	Lamb price (Average)	no. lambs		
	29.5	1394	41,123	
	Culls price	no. culls		
	38.5	246	9,471	
	Wool price	kg wool		
	2.47	6024	14,879	65,473
	(Rams not included)			
Purchases				
	Ram price	no. rams		
	600	3	1800	
	0	0	0	1800
Expenses				
Animal health			3137	
Shearing			5475	
Supp Feed			1451	
				10063
			Gross margin	**53,610**

EF x Rn

		$ / kg greasy (average)				
	53,610	1.75	2.00	2.25	**2.5**	2.75
	21	37,424	38,930	40,436	41,942	43,448
Lamb	24	41,606	43,112	44,618	46,124	47,630
	27	45,788	47,294	48,800	50,306	51,812
($ / head)	**29**	48,576	50,082	51,588	**53,094**	54,600
	33	54,152	55,658	57,164	58,670	60,176
	36	58,334	59,840	61,346	62,852	64,358
	39	62,516	64,022	65,528	67,034	68,540
min	max					
37,424	71,552					

EF x EF

	Lamb price (Average)	no. lambs	total ($)	
	36	1552	55,872	
	Culls price	no. culls		
	38.5	170	6.545	
	Wool price	kg wool		
	2.47	2793	6.899	69,316
	(Rams not included)			
Purchases				
	Ram price	no. rams		
	3500	2	7000	
	0	0	0	7000
Expenses				
Animal health			2169	
Shearing			3795	
Supp Feed			1284	
				7248
			Gross margin	**55,068**

EF x EF

		$ / kg greasy (average)				
	55,068	1.75	2.00	2.25	**2.5**	2.75
	27	39,089	39,787	40,485	41,184	41,882
Lamb	30	43,745	44,443	45,141	45,840	46,538
	33	48,401	49,099	49,797	50,496	51,194
($ / head)	**36**	53,057	53,755	54,453	**55,152**	55,850
	39	57,713	58,411	59,109	59,808	60,506
	42	62,369	63,067	63,765	64,464	65,162
	45	67,025	67,723	68,421	69,120	69,818
min		max				
	39,089	71,214				

Breeding cattle

Cattle	Average CWT*	Average price/kg	No. animals		total
	367	2.08	162		123,664
Expenses					
Animal health				2621	
Purchases				1421	
Supp feed				1935	
					5977
*include 1yr Heifr, !yr and 2yr Bulls					
				Gross margin	**117,687**

cattle

		($/kg CWT average)				
	117,687	1.8	1.9	2.0	**2.1**	2.2
	240	63,229	67,117	71,005	74,893	78,781
	280	74,764	79,300	83,836	88,372	92,908
	320	86,298	91,482	96,666	101,850	107,034
CWT	**360**	97,833	103,665	109,497	**115,329**	121,161
(kg)	400	109,367	115,847	122,327	128,807	135,287
	440	120,901	128,029	135,157	142,285	149,413
	480	132,436	140,212	147,988	155,764	163,540
min		max				
	63,229	179,092				

Appendix II. Risk analysis of the gross margin for the three sheep policies

Sheep Rn x Rn

Beta Distribution

	Sheep	Cattle			
alfa	3	3			
beta	3	3			
min	25,527	63,229			
max	60,117	179,092		less	
Sample	43,116	125,778		direct	Gross
			Net income	expenses =	margin
Iteration			Total		
1	44,914	138,139	183053	18736	164317
2	43,602	112,805	156407	18736	137671
3	30,927	151,004	181932	18736	163196
4	42,467	126,200	168667	18736	149931
5	45,672	131,599	177271	18736	158535
6	35,816	140,611	176427	18736	157691
7	44,820	94,617	139437	18736	120701
8	38,361	96,587	134948	18736	116212
9	40,345	147,823	188168	18736	169432
10	52,001	107,901	159902	18736	141166
11	48,066	144,329	192394	18736	173658
12	34,125	74,292	108417	18736	89681
13	52,470	138,528	190998	18736	172262
14	34,183	109,212	143394	18736	124658
15	49,034	94,262	143296	18736	124560
16	39,974	120,256	160230	18736	141494
17	29,495	94,926	124421	18736	105685
18	34,700	126,071	160772	18736	142036
19	42,125	101,575	143700	18736	124964
20	53,719	109,336	163055	18736	144319
21	54,268	126,080	180348	18736	161612
22	51,023	110,054	161077	18736	142341
23	37,434	129,290	166725	18736	147989
24	52,560	115,856	168416	18736	149680
25	39,178	102,047	141224	18736	122488
26	35,610	92,989	128599	18736	109863
27	35,157	146,568	181725	18736	162989
28	50,279	152,484	202763	18736	184027
29	49,776	107,260	157037	18736	138301
30	49,707	107,470	157177	18736	138441
32	42,290	147,349	189640	18736	170904
33	45,797	107,767	153564	18736	134828
34	46,512	99,979	146491	18736	127755
35	38,326	134,363	172688	18736	153952
36	41,838	167,027	208865	18736	190129
37	52,625	117,905	170530	18736	151794
38	39,149	92,184	131333	18736	112597
39	50,894	123,190	174083	18736	155347
40	54,338	108,778	163116	18736	144380
41	51,231	156,952	208183	18736	189447
42	39,756	104,569	144324	18736	125588
43	40,312	111,444	151756	18736	133020
44	35,191	130,707	165898	18736	147162
45	46,827	145,336	192163	18736	173427
46	36,368	109,210	145577	18736	126841
47	43,848	128,931	172779	18736	154043
48	51,384	147,244	198628	18736	179892
49	31,137	144,947	176084	18736	157348
50	47,099	116,961	164060	18736	145324
Average =	43,403	121,327	**164,729**	**18,736**	**145,993**

Sheep EF x Rn

Beta Distribution

	Sheep	Cattle			
alfa	3	3			
beta	3	3			
min	38,495	63,229			
max	72,623	179,092		less	
Sample	65,861	111,616		direct	Gross
			Net income	expenses =	margin
Iteration			Total		
1	56,915	103,726	160641	14733	145908
2	55,511	143,581	199092	14733	184359
3	49,052	105,514	154566	14733	139833
4	49,874	144,399	194273	14733	179540
5	40,151	129,515	169666	14733	154933
6	49,674	90,204	139877	14733	125144
7	42,805	120,333	163139	14733	148406
8	51,019	110,047	161066	14733	146333
9	51,606	132,754	184359	14733	169626
10	58,506	111,970	170476	14733	155743
11	52,751	132,881	185632	14733	170899
12	51,946	133,081	185027	14733	170294
13	55,729	133,579	189308	14733	174575
14	60,494	132,648	193142	14733	178409
15	46,730	153,075	199805	14733	185072
16	48,196	127,406	175603	14733	160870
17	59,034	132,258	191293	14733	176560
18	61,720	103,288	165008	14733	150275
19	50,804	133,128	183931	14733	169198
20	50,948	99,643	150591	14733	135858
21	53,326	116,019	169345	14733	154612
22	64,106	94,591	158697	14733	143964
23	60,961	120,698	181659	14733	166926
24	49,538	121,717	171254	14733	156521
25	45,742	127,622	173364	14733	158631
26	47,461	90,884	138346	14733	123613
27	50,107	150,575	200682	14733	185949
28	51,560	146,830	198390	14733	183657
29	62,736	130,530	193266	14733	178533
30	44,519	117,334	161853	14733	147120
32	50,295	111,698	161993	14733	147260
33	52,894	96,619	149513	14733	134780
34	60,145	134,573	194719	14733	179986
35	55,177	118,397	173574	14733	158841
36	49,060	122,924	171985	14733	157252
37	63,182	118,136	181318	14733	166585
38	63,469	134,213	197682	14733	182949
39	47,018	161,244	208261	14733	193528
40	44,540	104,017	148557	14733	133824
41	67,457	107,935	175392	14733	160659
42	56,722	95,802	152523	14733	137790
43	57,565	89,132	146696	14733	131963
44	55,055	95,853	150908	14733	136175
45	64,568	73,403	137971	14733	123238
46	50,784	140,044	190828	14733	176095
47	46,857	157,472	204329	14733	189596
48	53,005	74,343	127348	14733	112615
49	64,310	150,367	214677	14733	199944
50	68,666	122,002	190667	14733	175934
Average =	53,965	120,367	**174,333**	**14,733**	**159,600**

Sheep EF x EF

Beta Distribution

	Sheep	Cattle			
alfa	3	3			
beta	3	3			
min	45602.75	63229.4			
max	77728.25	179091.8		less	
Sample	56451.04	120690.5		direct	Gross
			Net income	expenses =	margin
Iteration			Total		
1	64953	114283	179237	12084	167153
2	46413	152918	199331	12084	187247
3	65729	169229	234957	12084	222873
4	58405	91408	149813	12084	137729
5	61824	140535	202359	12084	190275
6	64006	82420	146427	12084	134343
7	61813	161070	222884	12084	210800
8	59603	121226	180829	12084	168745
9	60684	80661	141345	12084	129261
10	62618	135995	198613	12084	186529
11	60478	111942	172419	12084	160335
12	56774	88225	144999	12084	132915
13	59273	134963	194236	12084	182152
14	57126	141268	198394	12084	186310
15	51535	86513	138048	12084	125964
16	51236	107162	158398	12084	146314
17	56110	73149	129259	12084	117175
18	51781	101142	152923	12084	140839
19	66167	106273	172441	12084	160357
20	58032	134301	192333	12084	180249
21	54496	126276	180772	12084	168688
22	61726	118066	179792	12084	167708
23	59014	143534	202548	12084	190464
24	61285	138777	200063	12084	187979
25	73074	138590	211664	12084	199580
26	65177	99465	164642	12084	152558
27	57287	115023	172310	12084	160226
28	58216	125098	183314	12084	171230
29	62658	127130	189787	12084	177703
30	51232	133060	184292	12084	172208
32	62383	114287	176670	12084	164586
33	64494	120165	184658	12084	172574
34	64745	118133	182878	12084	170794
35	56134	111078	167212	12084	155128
36	64189	111392	175580	12084	163496
37	58392	107070	165462	12084	153378
38	60186	81309	141495	12084	129411
39	61901	119273	181174	12084	169090
40	62868	161935	224803	12084	212719
41	54764	162387	217150	12084	205066
42	61459	144739	206199	12084	194115
43	60352	146872	207225	12084	195141
44	59831	103053	162884	12084	150800
45	60444	137209	197654	12084	185570
46	61573	146034	207607	12084	195523
47	62563	154563	217126	12084	205042
48	69878	103501	173379	12084	161295
49	50495	85717	136212	12084	124128
50	65438	118007	183445	12084	171361
Average =	60017	121356	**181372**	**12084**	**169288**

Appendix III. Frequency distribution and cumulative frequency (%) of the gross Margin for the three sheep policies.

			GM / ha			
Rn x Rn	EF x Rn	EF x EF	Rn x Rn	EF x Rn	EF x EF	
164,317	128,179	172,761	507	396	533	270
137,671	143,784	132,180	425	444	408	285
163,196	151,983	187,409	504	469	578	300
149,931	186,429	167,352	463	575	517	315
158,535	143,085	182,774	489	442	564	330
157,691	185,974	165,958	487	574	512	345
120,701	169,107	162,362	373	522	501	360
116,212	191,753	182,513	359	592	563	375
169,432	199,062	173,199	523	614	535	390
141,166	145,750	189,740	436	450	586	405
173,658	129,281	156,651	536	399	483	420
89,681	168,225	152,131	277	519	470	435
172,262	194,714	126,626	532	601	391	450
124,658	161,942	149,951	385	500	463	465
124,560	141,094	138,948	384	435	429	480
141,494	142,628	190,552	437	440	588	495
105,685	182,240	128,465	326	562	396	510
142,036	178,022	158,707	438	549	490	525
124,964	177,409	176,682	386	548	545	540
144,319	165,645	178,659	445	511	551	555
161,612	193,145	188,605	499	596	582	570
142,341	144,128	186,059	439	445	574	585
147,989	166,044	180,204	457	512	556	600
149,680	182,630	164,815	462	564	509	615
122,488	158,529	185,630	378	489	573	630
109,863	140,087	190,033	339	432	587	645
162,989	161,170	146,295	503	497	452	660
184,027	204,201	142,384	568	630	439	675
138,301	183,778	157,364	427	567	486	690
138,441	162,694	160,517	427	502	495	705
170,904	191,927	197,584	527	592	610	
134,828	176,186	161,204	416	544	498	
127,755	143,854	192,326	394	444	594	
153,952	148,571	136,379	475	459	421	
190,129	181,243	119,469	587	559	369	
151,794	119,630	208,867	468	369	645	
112,597	171,109	153,613	348	528	474	
155,347	115,270	137,523	479	356	424	
144,380	151,853	163,981	446	469	506	
189,447	122,770	174,699	585	379	539	
125,588	144,517	181,570	388	446	560	
133,020	181,710	164,100	411	561	506	
147,162	151,212	164,029	454	467	506	
173,427	159,515	136,318	535	492	421	
126,841	134,127	214,351	391	414	662	
154,043	182,726	177,990	475	564	549	
179,892	172,739	187,540	555	533	579	
157,348	121,185	202,826	486	374	626	
145,324	151,094	179,984	449	466	556	

Cumulative frequency (%)

GM range	Rn x Rn	EF x Rn	EF x EF
250	2%	0%	2%
320	8%	6%	14%
390	20%	24%	29%
460	39%	43%	43%
530	59%	59%	57%
600	78%	76%	69%
670	92%	92%	84%
740	98%	100%	98%
More	100%	100%	100%

Appendix IV. Procedure to obtain values for alternative decision criteria to select a sheep policy on the basis of the EM per hectare

Rn x Rn	/ha							
				$ / kg greasy (average)				
	72,624	1.75	2	2.25	**2.47**	2.75	3	3.25
	10	79	85	92	98	105	111	118
Lamb	13	90	97	103	110	116	123	129
	16	101	108	114	121	127	134	140
($ / head)	**19**	113	119	126	**132**	139	145	152
	22	124	130	137	143	150	156	163
	25	135	142	148	155	161	168	174
	28	147	153	160	166	173	179	186
	min	max						
		79	186					

EF x Rn	/ ha							
				$ / kg greasy (average)				
	53,610	1.75	2	2.25	**2.47**	2.75	3	3.25
	21	116	120	125	129	134	139	143
Lamb	24	128	133	138	142	147	152	156
	27	141	146	151	155	160	165	169
($ / head)	**29.5**	150	155	159	**164**	169	173	178
	33	167	172	176	181	186	190	195
	36	180	185	189	194	199	203	208
	39	193	198	202	207	212	216	221
		min	max					
			116	221				

EF x EF	/ ha							
				$ / kg greasy (average)				
	55,068	1.75	2	2.25	**2.47**	2.75	3	3.25
	27	121	123	125	127	129	131	134
Lamb	30	135	137	139	141	144	146	148
	33	149	152	154	156	158	160	162
($ / head)	**36**	164	166	168	**170**	172	175	177
	39	178	180	182	185	187	189	191
	42	192	195	197	199	201	203	205
	45	207	209	211	213	215	218	220
	Min	Max						
		121	220					

Appendix V. Transition effects of changing from the Rn x Rn flock due to the introduction of the EF x EF and EF x RN rams

0.001	35.9%		25 Sep 1998		28 Dec 1998		1 May 1999					25 Sep 1999		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	851	43	808	279	529	26	26	477	0.86	841	EF x Rn	446	226,689
5.0%	5.0%	1-2	341					17	17	307	1.17	477	Rn x Rn	526	172,191
5.0%	5.0%	2-3	306					15	15	275	1.17	307	Rn x Rn	526	154,518
5.0%	5.0%	3-4	287					14	14	258	1.17	275	Rn x Rn	526	144,924
5.0%	5.0%	4-5	274					14	14	247	1.17	258	Rn x Rn	526	138,359
5.0%		5-6	248	12	236							247	Rn x Rn	526	32,612
		Total	2307		Ewes 0-5	296			60	1087					869,293
					Lambs	1114									
										% Lambing	Hoggets	86%			
											Ewes	117%			

Total Dry Matter Eaten										
	Total		869,293	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2683	869,292	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			(1)							

0.001	71.3%		25 Sep 1999		28 Dec 1999		1 May 2000					25 Sep 2000		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	841	42	799	589	210	10	10	189	0.86	841	EF x Rn	446	89,855
5.0%	5.0%	1-2	477					24	24	429	1.48	189	EF x Rn	666	304,658
5.0%	5.0%	2-3	307					15	15	276	1.17	429	Rn x Rn	526	154,972
5.0%	5.0%	3-4	275					14	14	248	1.17	276	Rn x Rn	526	139,066
5.0%	5.0%	4-5	258					13	13	232	1.17	248	Rn x Rn	526	130,431
5.0%		5-6	247	12	234							232	Rn x Rn	526	32,428
		Total	2405		Ewes 0-5	300			66	1185					851,411
					Lambs	1398									
										% Lambing	Hoggets	86%			
											Ewes	128%			

Total Dry Matter Eaten										
	Total		851,411	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2628	851,493	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			82							

0.001	57.2%		25 Sep 2000		28 Dec 2000		1 May 2001					25 Sep 2001		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	841	42	799	464	335	17	17	302	0.86	817	EF x Rn	446	143,471
5.0%	5.0%	1-2	189					9	9	170	1.48	302	EF x Rn	666	120,761
5.0%	5.0%	2-3	429					21	21	386	1.48	170	EF x Rn	666	274,192
5.0%	5.0%	3-4	276					14	14	249	1.17	386	Rn x Rn	526	139,475
5.0%	5.0%	4-5	248					12	12	223	1.17	249	Rn x Rn	526	125,159
5.0%		5-6	232	12	221							223	Rn x Rn	526	30,570
		Total	2215		Ewes 0-5	278			57	1028					833,629
					Lambs	1280									
										% Lambing	Hoggets	86%			
											Ewes	134%			

Total Dry Matter Eaten										
	Total		833,629	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2573	833,694	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			65							

0.001	64.4%		25 Sep 2001		28 Dec 2001		1 May 2002					25 Sep 2002		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	817	41	776	513	263	13	13	237	0.86	804	EF x Rn	446	112,675
5.0%	5.0%	1-2	302					15	15	271	1.48	237	EF x Rn	666	192,818
5.0%	5.0%	2-3	170					8	8	153	1.48	271	EF x Rn	666	108,685
5.0%	5.0%	3-4	386					19	19	347	1.48	153	EF x Rn	666	246,773
5.0%	5.0%	4-5	249					12	12	224	1.17	347	Rn x Rn	526	125,528
5.0%		5-6	223	11	212							224	Rn x Rn	526	29,334
		Total	2146		Ewes 0-5	267			55	996					815,812
					Lambs	1302									
										% Lambing	Hoggets	86%			
											Ewes	141%			

Total Dry Matter Eaten				1998	1999	2000	2001	2002	2003	2004
	Total		815,812							
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2518	815,896	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			84							

0.001	60.8%		25 Sep 2002		28 Dec 2002		1 May 2003					25 Sep 2003		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	804	40	764	475	289	14	14	260	0.86	784	EF x Rn	446	123,761
5.0%	5.0%	1-2	237					12	12	213	1.48	260	EF x Rn	666	151,429
5.0%	5.0%	2-3	271					14	14	244	1.48	213	EF x Rn	666	173,536
5.0%	5.0%	3-4	153					8	8	138	1.48	244	EF x Rn	666	97,816
5.0%	5.0%	4-5	347					17	17	313	1.48	138	EF x Rn	666	222,096
5.0%		5-6	224	11	213							313	Rn x Rn	526	29,421
		Total	2036		Ewes 0-5	263			50	908					798,059
					Lambs	1253									
										% Lambing	Hoggets	86%			
											Ewes	148%			

Total Dry Matter Eaten				1998	1999	2000	2001	2002	2003	2004
	Total		798,059							
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2463	798,097	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			38							

0.001	43.6%		25 Sep 2003		28 Dec 2003		1 May 2004					25 Sep 2004		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	784	39	744	321	424	21	21	381	0.86	734	EF x Rn	446	181,381
5.0%	5.0%	1-2	260					13	13	234	1.48	381	EF x Rn	666	166,328
5.0%	5.0%	2-3	213					11	11	192	1.48	234	EF x Rn	666	136,286
5.0%	5.0%	3-4	244					12	12	220	1.48	192	EF x Rn	666	156,182
5.0%	5.0%	4-5	138					7	7	124	1.48	220	EF x Rn	666	88,034
5.0%		5-6	313	16	297							124	EF x Rn	666	52,054
		Total	1952		Ewes 0-5	340			43	770					780,266
					Lambs	1086									
										% Lambing	Hoggets	86%			
											Ewes	148%			

Total Dry Matter Eaten				1998	1999	2000	2001	2002	2003	2004
	Total		780,266							
Total DM eaten (Stockpol)				2683	2628	2573	2518	2463	2408	2409
	324	2408	780,298	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess										
			32							

0.001	63.9%		25 Sep 2004		28 Dec 2004		1 May 2005					25 Sep 2005		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	734	37	697	456	240	12	12	216	0.86	777	EF x Rn	446	102,965
5.0%	5.0%	1-2	381					19	19	343	1.48	216	EF x Rn	666	243,767
5.0%	5.0%	2-3	234					12	12	211	1.48	343	EF x Rn	666	149,695
5.0%	5.0%	3-4	192					10	10	173	1.48	211	EF x Rn	666	122,658
5.0%	5.0%	4-5	220					11	11	198	1.48	173	EF x Rn	666	140,564
5.0%		5-6	124	6	118							198	EF x Rn	666	20,633
		Total	1885		Ewes 0-5	169			51	924					780,282
					Lambs	1165									
										% Lambing	Hoggets	86%			
											Ewes	148%			

Total Dry Matter Eaten									
	Total	780,282	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2628	2573	2518	2463	2408	2408
324	2408	780,298	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess									
		16							

0.001	53.8%		25 Sep 2005		28 Dec 2005		1 May 2006					25 Sep 2006		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Animal	Total of the
5.0%	5.0%	0-1	777	39	738	401	337	17	17	304	0.86	759	EF x Rn	446	144,400
5.0%	5.0%	1-2	216					11	11	195	1.48	304	EF x Rn	666	138,380
5.0%	5.0%	2-3	343					17	17	309	1.48	195	EF x Rn	666	219,390
5.0%	5.0%	3-4	211					11	11	190	1.48	309	EF x Rn	666	134,726
5.0%	5.0%	4-5	173					9	9	155	1.48	190	EF x Rn	666	110,392
5.0%		5-6	198	10	188							155	EF x Rn	666	32,945
		Total	1918		Ewes 0-5	235			47	849					780,232
					Lambs	1156									
										% Lambing	Hoggets	86%			
											Ewes	148%			

Total Dry Matter Eaten									
	Total	780,232	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2628	2573	2518	2463	2408	2408
324	2408	780,298	869,292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess									
		66							

Appendix VI. Transition effects on the gross margin of changing from a Rn x Rn to an EF x Rn flock through the introduction of EF xEF and EF x Rn rams

Flock growth	1998	1999	2000	2001	2002	2003	2004
Age Class							
0-1	851	841	841	817	804	784	734
1-2	341	477	189	301	237	260	381
2-3	306	307	429	170	271	213	234
3-4	287	275	276	386	153	244	192
4-5	274	258	248	249	347	138	220
5-6	248	247	232	223	224	313	124
Total	2307	2405	2215	2146	2036	1952	1885
Total DM eaten	869292	851,493	833,694	815,896	798,097	780,298	780,298
Deficit or Execess	-1	82	65	84	38	32	16
Wool production							
0-1	1413	1396	1396	1356	1334	1301	1218
1-2	1064	1706	676	1079	849	931	1364
2-3	955	958	1535	610	971	764	838
3-4	895	859	862	1381	549	874	687
4-5	855	806	773	776	1243	494	787
5-6	774	769	725	696	698	1119	444
Total	5955	6494	5968	5898	5644	5482	5338
Wool income							
0-1	3581	3539	3540	3438	3383	3298	3087
1-2	2564	4111	1630	2600	2045	2243	3288
2-3	2301	2308	3700	1469	2340	1841	2019
3-4	2158	2071	2077	3329	1322	2106	1657
4-5	2060	1942	1864	1869	2996	1190	1896
5-6	1865	1854	1748	1677	1682	2696	1071
Total	14529	15825	14558	14383	13769	13374	13017
Sheep sales (n)							
0-1	1114	1398	1280	1302	1253	1086	1165
5-6	296	300	278	267	263	340	169
Total	1410	1698	1558	1569	1516	1426	1334
Sale income.							
0-1	39870	50727	46243	47148	45322	39036	42179
5-6	11248	11400	10564	10146	9994	12920	6422
Ram sales	4000	0	0	0	0	0	0
Total	55118	62127	56807	57294	55316	51956	48601

Expenses							
Shearing / SU							
0-1	2017	1993	1994	1936	1905	1857	1739
1-2	808	1129	448	714	562	616	903
2-3	725	727	1016	404	643	506	555
3-4	680	653	655	914	363	579	455
4-5	649	612	587	589	823	327	521
5-6	588	584	551	529	530	741	294
Total	5468	5699	5251	5086	4826	4625	4466
An. Health / SU							
0-1	1157	1144	1144	1111	1093	1066	998
1-2	464	648	257	410	322	354	518
2-3	416	417	583	232	369	290	318
3-4	390	375	376	525	208	332	261
4-5	373	351	337	338	472	188	299
5-6	337	335	316	303	304	425	169
Total	3138	3270	3013	2919	2769	2654	2563
Supp. Feed							
0-1	536	530	530	515	506	494	462
1-2	215	300	119	190	149	164	240
2-3	193	193	270	107	171	134	147
3-4	181	174	174	243	97	154	121
4-5	173	163	156	157	219	87	138
5-6	156	155	146	141	141	197	78
Total	1453	1515	1396	1352	1283	1229	1187
Rams purchas	10	5	3	3	3	4	1
Net cost rams ($)	19,413	1,831	1,149	1,057	1,190	1,612	488
Gross margin	40175	65637	60556	61262	59016	55209	52914
Rams required	10	12	11	11	10	11	9
EF x EF	10	7	5	3	1	0	0
EF x Rn	0	5	6	7	9	11	9

Relation ram:ewe 1:150

Replacements EF x Rn rams 24%

Replacements of the EF x EF r: ls in direct relotion with the introduction of the EF x Rn rams (ratio 1:150)

Appendix VII. Age structure effects during a six year period on the Rn x Rn flock.

0.001	25.1%		25 Sep 1998		28 Dec 1998		1 May 1999					25 Sep 1999		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	851	43	808	182	626	31	31	564	0	636	Rn x Rn	377	226,652
5.0%	5.0%	1-2	341					17	17	307	1.17	564	Rn x Rn	526	172,191
5.0%	5.0%	2-3	306					15	15	275	1.17	307	Rn x Rn	526	154,518
5.0%	5.0%	3-4	287					14	14	258	1.17	275	Rn x Rn	526	144,924
5.0%	5.0%	4-5	274					14	14	247	1.17	258	Rn x Rn	526	138,359
5.0%		5-6	248	12	236							247	Rn x Rn	526	32,612
		Total	2307		Ewes 0-5	296			60	1087					869,256
					Lambs	1022									

% Lambing	Hoggets	0%
	Ewes	117%

Total Dry Matter Eaten									
Total		869,256	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		36							

0.001	42.3%		25 Sep 1999		28 Dec 1999		1 May 2000					25 Sep 2000		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	636	32	604	251	353	18	18	318	0	739	Rn x Rn	377	127,762
5.0%	5.0%	1-2	564					28	28	507	1.17	318	Rn x Rn	526	284,608
5.0%	5.0%	2-3	307					15	15	276	1.17	507	Rn x Rn	526	154,972
5.0%	5.0%	3-4	275					14	14	248	1.17	276	Rn x Rn	526	139,066
5.0%	5.0%	4-5	258					13	13	232	1.17	248	Rn x Rn	526	130,431
5.0%		5-6	247	12	234							232	Rn x Rn	526	32,428
		Total	2287		Ewes 0-5	304			70	1264					869,267
					Lambs	873									

% Lambing	Hoggets	0%
	Ewes	117%

Total Dry Matter Eaten									
Total		869,267	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		25							

0.001	39.1%		25 Sep 2000		28 Dec 2000		1 May 2001					25 Sep 2001		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	739	37	702	267	435	22	22	392	0	710	Rn x Rn	377	157,492
5.0%	5.0%	1-2	318					16	16	286	1.17	392	Rn x Rn	526	160,431
5.0%	5.0%	2-3	507					25	25	457	1.17	286	Rn x Rn	526	256,147
5.0%	5.0%	3-4	276					14	14	249	1.17	457	Rn x Rn	526	139,475
5.0%	5.0%	4-5	248					12	12	223	1.17	249	Rn x Rn	526	125,159
5.0%		5-6	232	12	221							223	Rn x Rn	526	30,570
		Total	2321		Ewes 0-5	288			67	1214					869,275
					Lambs	991									

% Lambing	Hoggets	0%
	Ewes	117%

Total Dry Matter Eaten									
Total		869,275	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		17							

0.001	42.6%		25 Sep 2001		28 Dec 2001		1 May 2002					25 Sep 2002		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	710	36	675	283	392	20	20	352	0	728	Rn x Rn	377	141,712
5.0%	5.0%	1-2	392					20	20	352	1.17	352	Rn x Rn	526	197,764
5.0%	5.0%	2-3	286					14	14	257	1.17	352	Rn x Rn	526	144,388
5.0%	5.0%	3-4	457					23	23	411	1.17	257	Rn x Rn	526	230,533
5.0%	5.0%	4-5	249					12	12	224	1.17	411	Rn x Rn	526	125,528
5.0%		5-6	223	11	212							224	Rn x Rn	526	29,334
		Total	2316		Ewes 0-5	281			69	1244					869,258
					Lambs	978									
										% Lambing	Hoggets	0%			
											Ewes	117%			

Total Dry Matter Eaten									
Total		869,258	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		34							

0.001	42.2%		25 Sep 2002		28 Dec 2002		1 May 2003					25 Sep 2003		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	728	36	692	287	405	20	20	364	0	723	Rn x Rn	377	146,504
5.0%	5.0%	1-2	352					18	18	317	1.17	364	Rn x Rn	526	177,949
5.0%	5.0%	2-3	352					18	18	317	1.17	317	Rn x Rn	526	177,987
5.0%	5.0%	3-4	257					13	13	232	1.17	317	Rn x Rn	526	129,949
5.0%	5.0%	4-5	411					21	21	370	1.17	232	Rn x Rn	526	207,479
5.0%		5-6	224	11	213							370	Rn x Rn	526	29,421
		Total	2325		Ewes 0-5	281			69	1236					869,289
					Lambs	999									
										% Lambing	Hoggets	0%			
											Ewes	117%			

Total Dry Matter Eaten									
Total		869,289	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		3							

0.001	22.6%		25 Sep 2003		28 Dec 2003		1 May 2004					25 Sep 2004		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	723	36	687	136	551	28	28	496	0	648	Rn x Rn	377	199,416
5.0%	5.0%	1-2	364					18	18	328	1.17	496	Rn x Rn	526	183,965
5.0%	5.0%	2-3	317					16	16	285	1.17	328	Rn x Rn	526	160,154
5.0%	5.0%	3-4	317					16	16	286	1.17	285	Rn x Rn	526	160,189
5.0%	5.0%	4-5	232					12	12	208	1.17	286	Rn x Rn	526	116,954
5.0%		5-6	370	18	351							208	Rn x Rn	526	48,628
		Total	2323		Ewes 0-5	413			62	1107					869,305
					Lambs	850									
										% Lambing	Hoggets	0%			
											Ewes	117%			

Total Dry Matter Eaten									
Total		869,305	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		(13)							

0.001	39.2%		25 Sep 2004		28 Dec 2004		1 May 2005					25 Sep 2005		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	648	32	615	235	380	19	19	342	0	734	Rn x Rn	377	137,593
5.0%	5.0%	1-2	496					25	25	446	1.17	342	Rn x Rn	526	250,407
5.0%	5.0%	2-3	328					16	16	295	1.17	446	Rn x Rn	526	165,568
5.0%	5.0%	3-4	285					14	14	257	1.17	295	Rn x Rn	526	144,139
5.0%	5.0%	4-5	286					14	14	257	1.17	257	Rn x Rn	526	144,170
5.0%		5-6	208	10	198							257	Rn x Rn	526	27,411
		Total	2251		Ewes 0-5	268			70	1255					869,288
					Lambs	870									
										% Lambing	Hoggets	0%			
											Ewes	117%			

Total Dry Matter Eaten									
Total		869,288	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		4							

Rn x Rn

0.001	38.3%		25 Sep 2005		28 Dec 2005		1 May 2006					25 Sep 2006		Requirements for Dry M	
Mortality rate	Culling rate	Age Class		Dead		Culled		Dead	Culled		Litter size			Per Anima	Total of the /
5.0%	5.0%	0-1	734	37	698	259	438	22	22	394	0	706	Rn x Rn	377	158,597
5.0%	5.0%	1-2	342					17	17	308	1.17	394	Rn x Rn	526	172,776
5.0%	5.0%	2-3	446					22	22	402	1.17	308	Rn x Rn	526	225,366
5.0%	5.0%	3-4	295					15	15	266	1.17	402	Rn x Rn	526	149,012
5.0%	5.0%	4-5	257					13	13	231	1.17	266	Rn x Rn	526	129,725
5.0%		5-6	257	13	244							231	Rn x Rn	526	33,790
		Total	2332		Ewes 0-5	311			67	1206					869,265
					Lambs	979									
										% Lambing	Hoggets	0%			
											Ewes	117%			

Total Dry Matter Eaten									
Total		869,265	1998	1999	2000	2001	2002	2003	2004
Total DM eaten (Stockpol)			2683	2683	2683	2683	2683	2683	2683
324	2683	869,292	869,292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess									
		27							

Appendix VIII. Effects on gross margin during a 6 year period on the Rn x Rn sheep enterprise

Flock growth	1998	1999	2000	2001	2002	2003	2004
Age Class							
0-1	851	636	739	710	728	723	648
1-2	341	564	318	392	352	364	496
2-3	306	307	507	286	352	317	328
3-4	287	275	276	457	257	317	285
4-5	274	258	248	249	411	232	286
5-6	248	247	232	223	224	370	208
Total	2307	2287	2321	2316	2325	2323	2251
Total DM eaten	869292	869,292	869,292	869,292	869,292	869,292	869,292
Deficit or Execess	36	25	17	34	3	-13	4
Wool production							
0-1	3098	2315	2691	2585	2650	2632	2358
1-2	1241	2052	1156	1426	1283	1326	1805
2-3	1114	1117	1846	1041	1283	1154	1193
3-4	1045	1002	1005	1662	937	1155	1039
4-5	997	940	902	905	1496	843	1039
5-6	903	898	846	812	814	1346	759
Total	8397	8324	8448	8430	8462	8456	8193
Wool income							
0-1	7853	5869	6822	6554	6718	6671	5977
1-2	2991	4944	2787	3436	3091	3196	4350
2-3	2684	2692	4450	2508	3092	2782	2876
3-4	2518	2416	2423	4005	2258	2783	2504
4-5	2404	2266	2174	2181	3604	2032	2505
5-6	2176	2163	2039	1957	1963	3244	1829
Total	20625	20350	20696	20641	20726	20708	20041
Culled Nos.							
0-1	1021	873	991	978	999	851	869
5-6	296	304	288	281	281	413	268
Total	1317	1177	1279	1259	1280	1264	1137
Culled income.							
0-1	26678	24114	27128	27039	27582	22033	23797
5-6	11248	11552	10944	10678	10678	15694	10184
Total	37926	35666	38072	37717	38260	37727	33981

Expenses							
Shearing / SU							
0-1	1841	1376	1599	1536	1575	1564	1401
1-2	1490	2463	1388	1711	1540	1592	2167
2-3	1337	1341	2217	1250	1540	1386	1433
3-4	1254	1203	1207	1995	1125	1386	1247
4-5	1197	1129	1083	1086	1796	1012	1248
5-6	1084	1078	1016	975	978	1616	911
Total	8204	8590	8510	8554	8553	8556	8407
An. Health / SU							
0-1	1057	790	919	882	904	898	805
1-2	856	1415	797	983	885	914	1245
2-3	768	770	1273	718	885	796	823
3-4	720	691	693	1146	646	796	716
4-5	688	648	622	624	1031	581	717
5-6	622	619	583	560	562	928	523
Total	4712	4934	4888	4913	4913	4915	4829
Supp. Feed							
0-1	358	268	311	299	306	304	273
1-2	290	479	270	333	300	310	422
2-3	260	261	431	243	300	270	279
3-4	244	234	235	388	219	270	243
4-5	233	220	211	211	349	197	243
5-6	211	210	198	190	190	314	177
Total	1596	1671	1655	1664	1664	1664	1635
Rams purchas	2	4	2	3	3	3	3
Net cost rams ($)	566	882	530	654	610	626	627
Gross Margin	43,474	39,940	43,184	42,573	43,247	42,673	38,524

Rams required	10	11	11	11	11	11	11

Relation ram:ewe 1:150

Replacements Rn x Rn rams = 24%