Budget Analysis of Spring, Fall with Winter Clean-up, and High-fertility Fall Lambing Systems on a Simulated Fixed Forage Resource

By

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ABSTRACT

A successful business needs to generate enough cash to cover expenses, current debt, and family living expenses, pay interest on owned and borrowed capital, maintain productivity, and earn a reasonable return for the operator. Income from sheep production is generally only part of a total farm and nonfarm income. Thus options, opportunity costs, and decisions regarding the sheep production enterprise are not isolated; they affect other agricultural enterprises. Sheep production consistently returns profits to producers, which makes it an enticing agricultural enterprise. There are advantages in raising sheep in Virginia, such as abundant, high-quality forage, moderate climate, pasture improvement, and good access to markets with high demand for lamb. The disadvantages to sheep production are unavailable and inexperienced labor and operators, predators, and inconsistent market demand and supply. Sheep producers have the opportunity to choose which lambing system fits their existing operations and lifestyle. The use of economic analysis enables operator to make sound business management decisions.

To compare different lambing systems (spring, fall with winter clean-up, and high-fertility fall) in a systematic way, a simulation model was constructed with a fixed forage resource of 50 acres of pasture including typical Virginia mountain pasture plus various amounts of fescue for stockpiling. The simulation included a production calendar; nutritional requirements for ewes, lambs, and artificially reared triplets; growth rates for lambs; lambing distributions; forage growth; and enterprise budgets including income, costs, and returns. A economic analysis was performed for each lambing system with

average prices or with plus or minus one standard deviation for prices of corn, SBOM, and market lambs, and price differentials for market lambs across lambing seasons.

Comparisons of each lambing systems produced various results. In spring lambing, only 78 ewes could be maintained on the fixed forage resource, while the fall with winter clean-up and high-fertility fall lambing system each had 115 ewes. This result occurred because of limited forage in July and August and higher nutrient requirements for spring lambing in those months. The overall nutrient requirements were higher in the fall with winter clean-up and high-fertility fall lambing than in spring lambing as a result of the increased ewe and lamb numbers. Concentrate consumption by lambs was also greater for fall with winter clean-up and high-fertility fall lambing than for spring lambing because of the increased numbers of lambs. Because of the low number of ewes and lambs, spring system produced the most hay. Labor costs were highest in fall with winter clean-up lambing because of the two lambing seasons.

In the economic analysis system, each lambing was compared. With 10-year average prices for market lambs, corn, and SBOM, high-fertility fall lambing had the greatest income ($17,467), followed by fall with winter clean-up lambing ($14,695), and spring lambing ($10,358). This result occurred because high-fertility fall and fall with winter clean-up lambing had more lambs sold at higher market lambs prices than spring lambing. With 10-year average prices for market lambs, corn, and SBOM, high-fertility fall lambing had the highest cost ($7,935), followed by fall with winter clean-up lambing ($7,360), and spring lambing ($6,084). This was the result of increased ewe and lamb numbers in high-fertility fall and fall with winter clean-up lambing than spring lambing. High-fertility fall lambing had the greatest returns ($6,210), followed by fall with winter clean-up lambing ($4,025), and spring lambing ($2,028). On a fixed forage resource, increasing fertility in fall lambing clearly results in increased returns. In this model, forage availability controlled the number of ewes that a lambing system can have because of limited summer growth and had a major impact on profits. Conclusions of Tolman (1993) differed from those found within this thesis. On a per ewe basis, she found that spring lambing to yielded the highest returns whereas this thesis found that high-fertility fall lambing yielded the highest returns. A key difference between this study and that of Tolman (1993) was after weaning this thesis feed fall lambs stockpiled fescue and she feed fall lambs feed in dry lot.

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Table of Contents

List of Figures

List of Tables

Table 38. lambing distribution for ewes in fall lambing 92

Chapter 1. Introduction

Production of sheep generally contributes only a part of total farm and nonfarm income. As a consequence, many decisions regarding sheep production systems, are not isolated decisions. The production of sheep generally occurs on a fixed amount of land. One of the main objectives in a pastoral livestock production system is to achieve the full potential of the forage resource within a given environment and management scheme. The typical narrow profit margins for sheep production enterprises encourages efficient use of pasture. The characteristics of the land resource will affect the breed composition of the flock and the type of lambing system. However, many comparisons of breed types and lambing systems do not include the effect of a fixed land resource in their economic analysis.

Any change in production, such as reproductive efficiency, must be viewed in the context of the production system. Change does not occur in a vacuum; events have an interactive effect on other production traits. Thus an increase in number of lambs born will increase nutritional requirements of ewes and affect the forage resource and number of ewes per unit of land. Determination of the long term-value of any change in overall performance is achieved by analysis of production costs and revenues for the total system. Such an analysis may change perceptions by assigning economic values to production changes.

A simulation model was constructed to describe three lambing systems (fall with winter clean-up, fall high fertility without winter clean-up, and spring) with a fixed forage resource of pasture including various amounts of fescue for stockpiling and typical Virginia mountain pasture. For each system, a production calendar; nutrient requirements for ewes, lambs, and artificially raised triplets; growth rates for lambs and artificially raised triplets pre- and postweaning; and lambing distributions were simulated.

A forage spreadsheet was created to determine the number of sheep and acres of fescue and permanent pasture that would best suit the three different systems. The flock's nutritional requirements (ewes, ewe lambs, lambs, and artificially raised triplets), forage TDN for the year by months, and other feed (soybean, corn, milk replacer, creep feed, and pelleted lamb feed) were included in the spreadsheet. The spreadsheet determined the forage surplus or deficiencies, hay consumed, hay produced, and percent of animal requirements met through forage, hay, and concentrate on a per month basis.

Enterprise budgets were created for each system. Gross margins, calculated by subtracting variable costs (such as labor, feed, health costs, and shearing) from revenues (lambs, culled ewes, and wool), were compared to assess the economic efficiency of each system and the economic impact of different management decisions. Enterprise budgets were also used to calculate costs and returns on a per ewe basis for each of the three systems.

Chapter 2: Literature Review

Sheep Production in the United States

There are only 8 million sheep in the United States, compared to 127 million in China, 126 million in Australia, 51 million in Iran, and 49 million in New Zealand in 1992 (Taylor, 1995). Sheep production is small compared to other livestock enterprises such as cattle, hog, and poultry production. However, sheep are an important enterprise because there is a demand for lamb by certain ethnic groups in the United States. Sheep work well with other livestock such as beef cattle and horses. Multiple advantages exist in raising sheep; USDA Choice carcass can be produced on forage alone, sheep consume many pasture weeds, and sheep production returns a consistent profit to the producer.

The drop in sheep production has been dramatic over the past 50 years. The number of sheep in the United States reached a peak of 56 million in 1942 and has declined over time to 9 million in 1995 (figure 1) (FAO, 1958-1996; Ely, 1994; Purcell, 1995; Taylor, 1995; VA Ag. Stat., 1997).

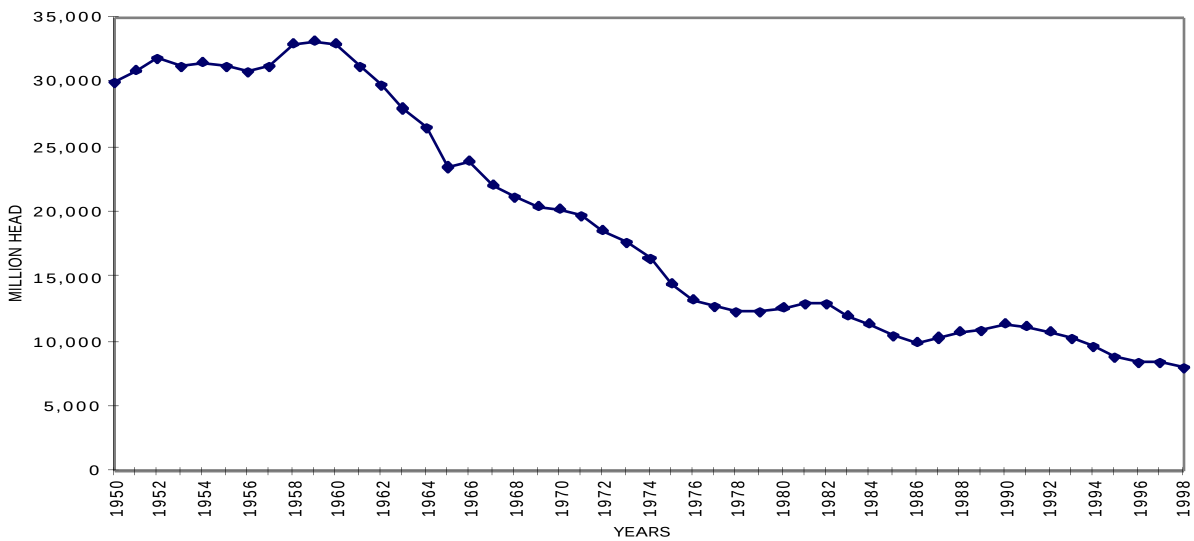

Figure 1. US sheep and lamb numbers from 1950 to 1988

Several states lead in sheep production. Texas (1.16 million), Wyoming (0.51 million), California (0.40 million), South Dakota (0.38 million), and Utah (0.34 million) have the largest numbers of ewes (Taylor, 1995). With most of the sheep concentrated in the west. Net cash returns for US sheep producers from 1972 to 1989 were found to be positive, but since 1962 per capita consumption of lamb and mutton has trended downward and is currently around 1.5 pounds (Shapouri, 1991).

Sheep Production in Virginia

Small flock sizes are typical in the eastern farm flock states. Virginia had around 80,000 sheep, which is down by 5% from 1996, and 1,400 sheep producers as of January 1, 1997 (VA Ag. Stat., 1996). These numbers represent a decline from 165,000 sheep and lambs and 2,800 farms in 1990. The record high of 510,000 sheep and lambs occurred in 1868 and the record low was in 1996. Virginia ranked 21st in numbers of sheep among all the states in 1997. The number of sheep has decreased over time, as demonstrated in figure 2 (VA Ag. Stat., 1972-1996).

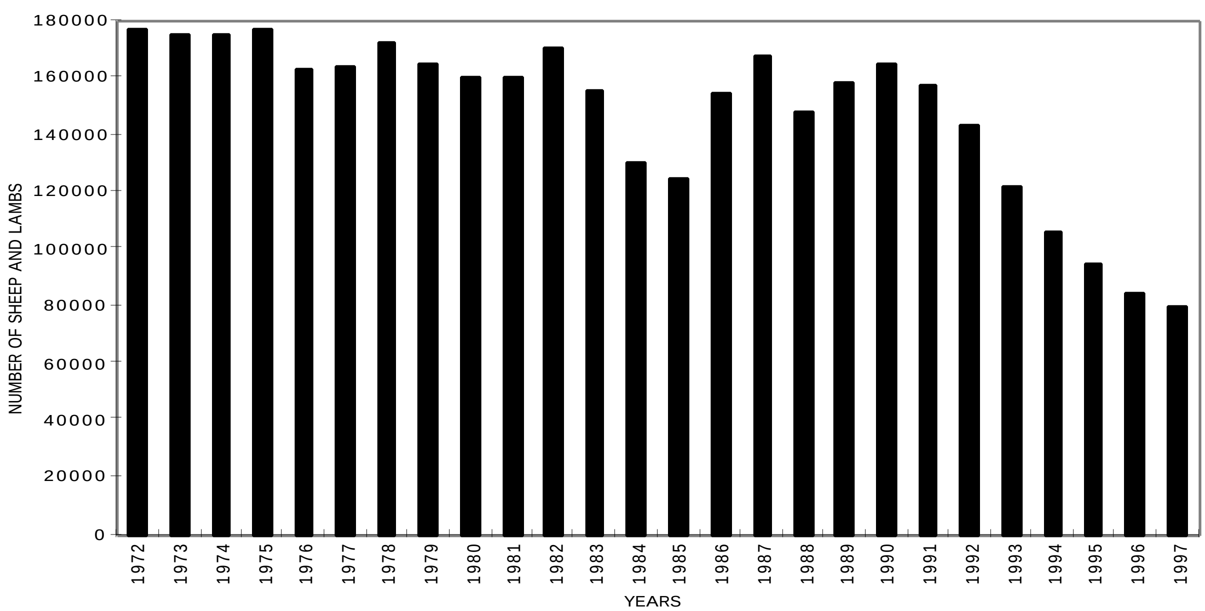

Figure 2. Virginia sheep and lamb numbers from 1972 to 1997

Since 1993, the number of sheep has been declining each year from 122,000 in 1993 to 80,000 in 1997 (VA Ag. Stat., 1996). The reasons for the decline in sheep numbers in Virginia, as well as the overall decline in United States sheep numbers, include such threats as predators, internal parasites, footrot, adverse weather, and a reduction in experienced shepherds.

Virginia has several characteristics that make sheep production attractive, including a moderate climate, large quantities of high quality forage, and close proximity to the Northeast, which is the largest consumer of lamb. Virginia is the largest producer of sheep in the Eastern United States (Umberger and Notter, 1987). The largest number of sheep in Virginia are in the North (32,500), West (19,400), and Southwest 19,000) (VA Ag. Stat., 1996). The five top sheep producing counties in 1997 are Rockingham (15,500), Augusta (7,900), Highland (7,500), Shenandoah (6,000), and Wythe (3,000). Since 1974, the counties with the most sheep have been Rockingham, Augusta, Highland, Shenandoah, Wythe, Tazewell, and Russell (figure 3) (VA Ag. Stat., 1972-1996).

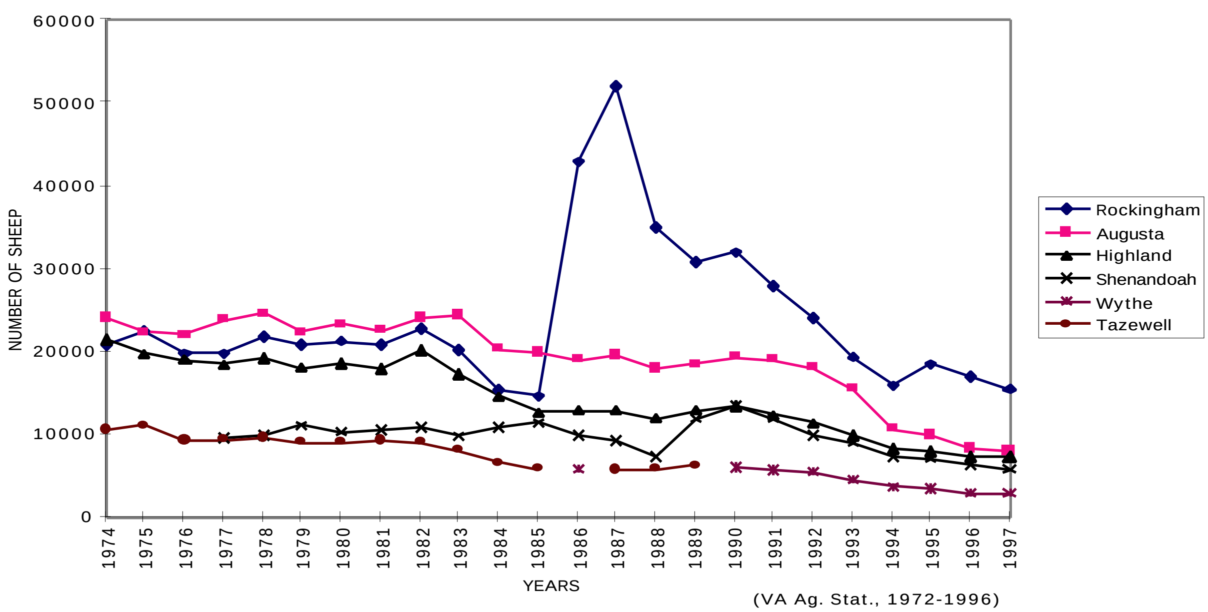

Figure 3. Top five sheep producing counties in Virginia from 1974 to 1997

Russell County dropped out of the top five in 1977 and Tazewell County dropped out in 1988. Augusta was the number one sheep producing county until 1986, when Rockingham County took its place. Rockingham County increased its sheep numbers dramatically from 14,000 in 1985 to 43,000 in 1986 because of the introduction of a lamb packing plant (Rocco Inc.) in the county. In January 1, 1986 there was an increase in sheep of 23% from the previous year (154,000 sheep) and a $7.50 increase in price per head ($67.00 per head) (VA Ag. Stat., 1985). The 10.4 million value of inventory had also increased 39% above the previous year as both value per head and size of inventory increased (VA Ag. Stat., 1985). This, along with the possibility of an increase in new sheep producers in the county, may have resulted in the large increase in numbers of sheep in Rockingham County.

In 1986, a survey was conducted to characterize the Virginia sheep industry (Umberger and Notter, 1987). The average flock size was 62 and the predominant sheep enterprise was a farm flock production system which produced lambs and wool. Producers used three types of lambing systems: winter lambing (39%), spring lambing (40%), and a combination of the two lambing systems (20%). Only a small number of sheep producers used fall, summer, or accelerated lambing programs. Most of the producers (46%) had been in the business of raising sheep for more than 15 years, while 36% had raised sheep for 6 years or less. This demonstrated the diversity of types of farmers in the sheep production business. Because of this variation in experiences of farmers, it is difficult to develop educational programs, create cooperatives, and deal with the myriad of issues and concerns of these different types of farmers. The largest proportion of farmers (32%) are over 55 years old. More than half of the producers had off-farm jobs and were part-time farmers. Sheep production in Virginia is generally a part-time business, which results in time and labor constraints on the production of sheep.

More than half of the producers planned to expand their flock in the next five years after the survey. Most sheep producers (87%) used crossbred ewes.

At the end of 1996, the value of all cattle, hogs and sheep in Virginia totaled $849 million. The cash receipts from these animals were $298 million; cattle accounted for 71% of total meat animal receipts. The cash receipts from sheep and lambs were $5.18 million, down by 3% from last year. The value of sheep and lambs on Virginia farms on January 1, 1997 was $6.60 million, up from the previous year by 7%. The average value per animal was $83.00, up by $9.00 from the previous year (VA Ag. Stat., 1996).

Market lamb prices in Virginia changed dramatically from 1988 to 1997, as shown in figure 4 (Tolman, 1993; VDACS, 1993-1996; VA Market News Service, 1997). It is difficult to draw a clear conclusion from the changes in the price of market lambs because there are many factors that effect the price of market lambs, such as grain prices, adverse weather, problems with internal parasites, predators, and footrot. From 1990 to 1992 the sheep industry had to deal with low (averages of $56.00) market lamb prices. In September and October of 1991, the price of lamb was $45.00/cwt. In 1993, prices for lambs in Virginia had increased over previous years and have continued to increase until July of 1997, when prices dropped.

As displayed in figure 5, the monthly average prices of market lambs in Virginia is affected primarily by the season of the year. The highest prices, which are a result of high demand for lamb and a reduced supply of lamb, are in spring. The prices are the lowest from August to November, because of the increased supply of lamb.

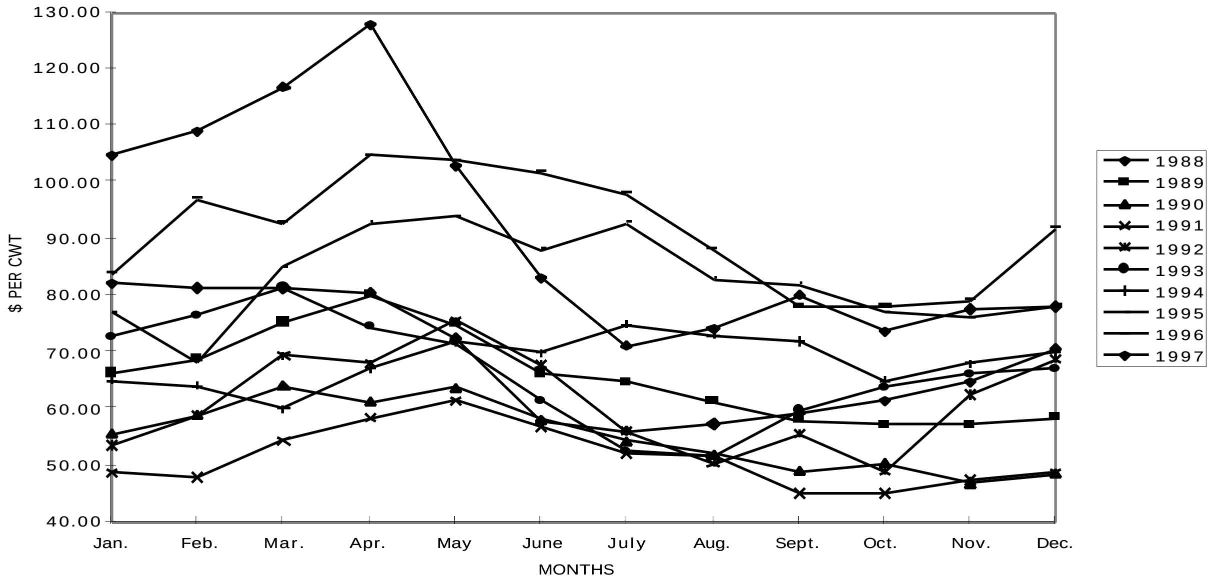

Figure 4. Virginia averages for slaughter lamb prices from 1988 to 1997

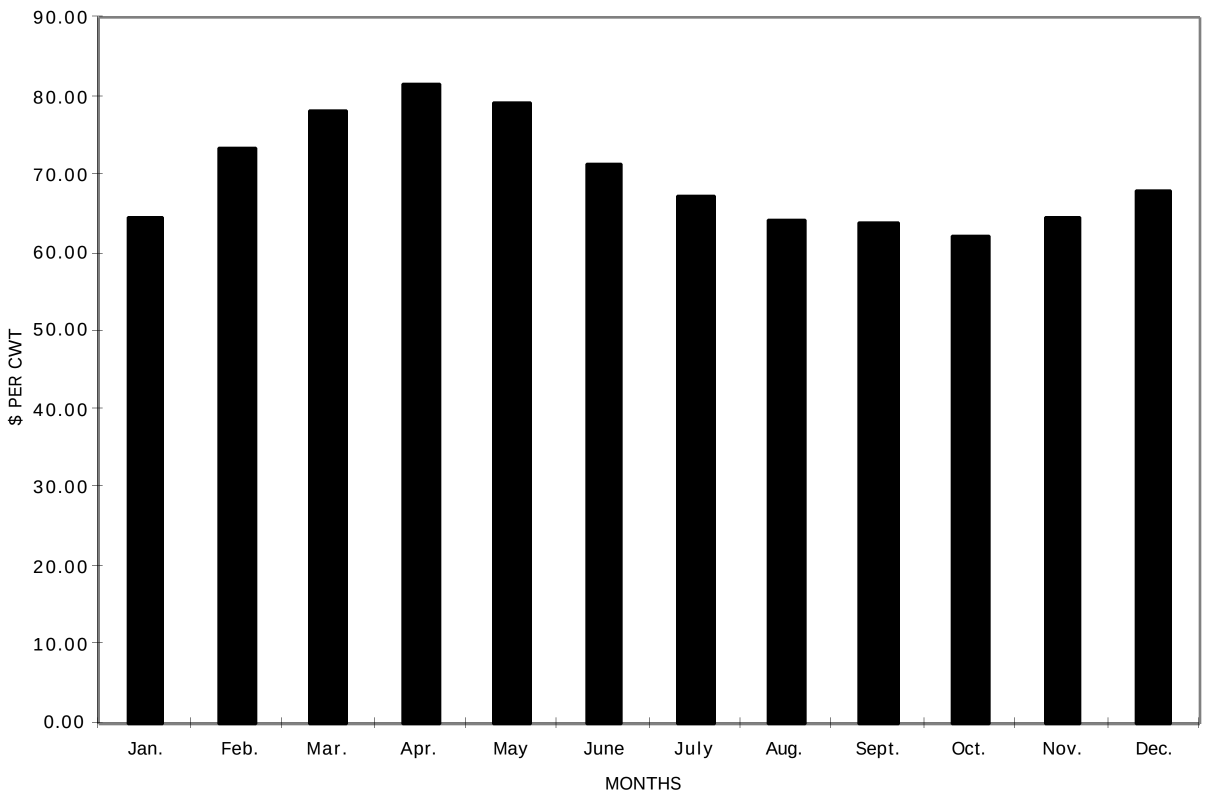

Figure 5. Monthly averages for Virginia slaughter lamb prices from 1988 to 1997

The yearly average prices for market lambs in Virginia from 1988 to 1997 were $68.86, $65.73, $55.23, $51.49, $61.28, $66.58, $68.42, $82.88, $91.50, and $91.67 per cwt, respectively (Figure 6) (Tolman, 1993; VDACS, 1993-1996; VA Market News Service, 1997). When the lamb prices were low, many sheep producers chose to get out of the sheep business or were forced out because of economics. The elimination of the National Wool Act had a negative effect on sheep producers. As a result, the numbers of sheep producers and sheep were reduced. This situation caused the prices of sheep to increase because of the economic pressure of supply and demand. Because of the reduced number of sheep producers, prices may continue to remain high for a period of time, but speculation on future markets is difficult. Because of the reduced supply of lamb being produced in the United States, countries such as Australia and New Zealand have increased lamb exports. This may affect the US profit picture in the long run.

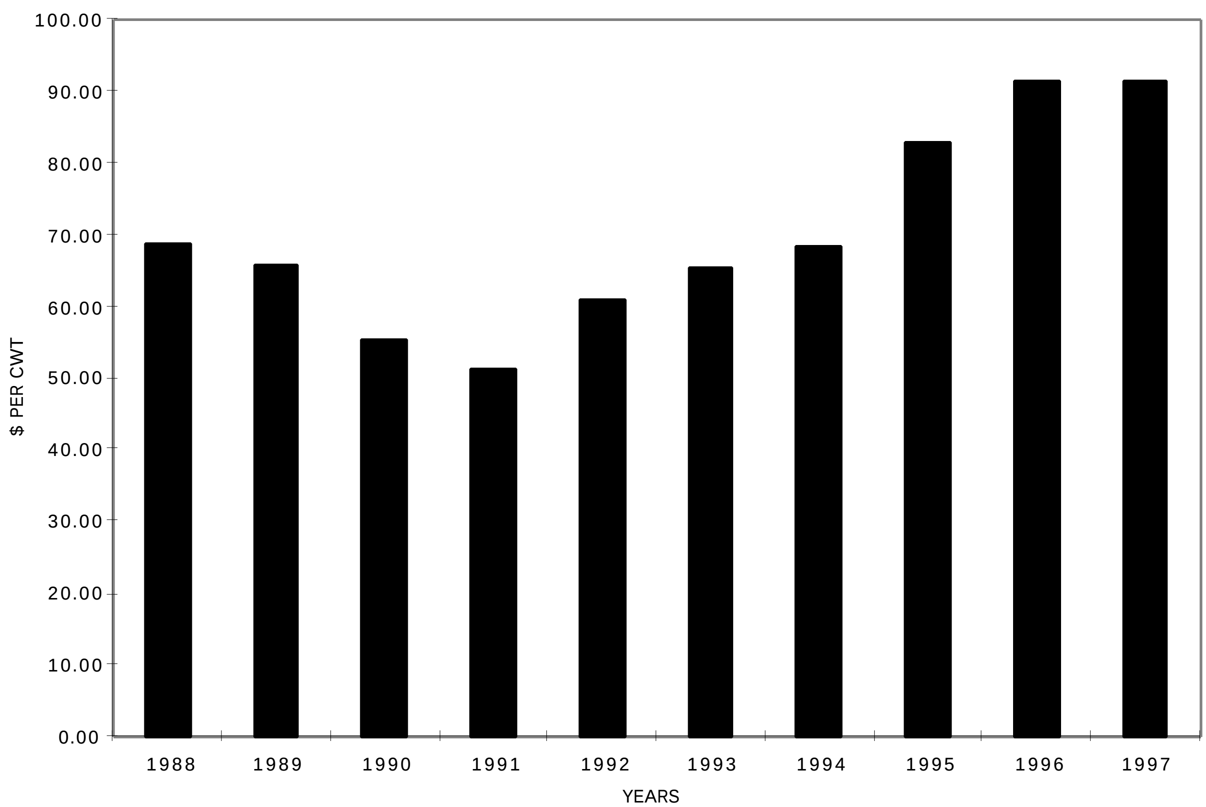

Figure 6. Yearly averages for Virginia slaughter lamb prices for 1988 to 1997

Forages

When considering any agricultural enterprise, an economic analysis of all aspects that affect the operation must be evaluated. A forage is defined as a herbaceous plant or plant part consumed by animals (generally, the term refers to such material as pasturage, hay, silage, and green chop in contrast to less digestible plant material known as roughage) (Tyner and Purcell, 1985). Forage needs to be seen as an economic commodity that should have a value attached to it, and should be used in a total systems approach. An economic analysis of forage must contain an understanding of the interrelationship between forages themselves, the animals that consume them, and the soil. An objective of the agricultural enterprise is being able to use a least-cost feed ration, which cannot be achieved without an understanding of the forages in the system. A principle that need to be analyzed when considering the economic of forage production is the relationship between forage outputs (pounds of dry matter per year) and inputs, (e.g., amount of fertilizer, seeding, and weed control) (Tyner and Purcell, 1985).

Development of a forage budget will assist in the development of a least-cost ration and evaluation of the forage as a economic commodity (Tyner and Purcell, 1985; Chamblee and Green, 1995). Many studies (e.g., Thomson and Bahhady, 1995a; Thomson and Bahhady, 1995b), pay little attention to permanent pasture, which makes it difficult to have an accurate and total farm budget. Using forages efficiently is important because feed cost are commonly 70 to 80% of the cost of growing or maintaining an animal (Luginbuhl et al., 1995; White and Wolf, 1995). Forages are an inexpensive way to feed animals because pasture provides feed at a cost of 1 to 2 cent/lb of total digestible nutrients (TDN), while hay cost are 4 to 6 cents/lb of TDN (White and Wolf, 1995). When compared to other harvested feeds, such as corn, wise use of forages is important in achieving a least-cost feed ration.

Forage Production

Virginia is in the region referred to as the "humid south", which is characterized by rainfall >1,250 mm/yr and a growing season of < 200 d (Chappell, 1993). A typical Virginia mountain pasture consists of a mixture of Kentucky bluegrass, orchardgrass, tall fescue, ladino clover and various weeds (White and Wolf, 1995). These grasses and legumes mentioned are all cool-season forages, with peak production in spring and fall. A mixture of grasses and legumes in a pasture is preferred over grass alone because of higher animal performance (Chamblee et al., 1995a). Typical TDN values for these forages are 69 to 72% for Kentucky bluegrass, 58 to 68% for orchardgrass, 59 to 70% for tall fescue, and 66 to 75% for ladino clover (Church and Pond, 1982; Church, 1986; SID, 1992; NRC, 1985). Annual yields of dry matter (DM) vary depending on proportions of forage species, precipitation, temperature, and other factors.

A Kentucky bluegrass and white clover mix will yield around 4,000 lb/DM/year, tall fescue with 100 pounds of nitrogen 1 year will yield 5,000 to 5,200 lb/DM/year, a ladino clover and tall fescue mixture will yield 5,500 to 6,500 lb/DM/year, and a ladino clover and orchardgrass mixture will yield 5,500 to 6,000 lb/DM/year as (figure 7) (USDA, 1988; Chamblee and Green, 1995). Around 60% of the annual DM production of most cool season grasses and legumes found in permanent pasture occurs in the spring during April, May and June (Umberger, 1996). Production declines drastically during July and August, but resumes in September and October.

Ladino clover is one of about 250 species of white clover, *Trifolium repens L.*, and is found in most parts of the United States (Carlson et al., 1985). White clover grows best under cool, moist conditions on well-drained fertile soil of a loamy or clay type with a pH of 6 to 7 (Chamblee et al., 1995b). White clover, a tetraploid, is a cool-season perennial legume with white flowers that is shallow rooted, rapidly growing, and frequently volunteer in pastures. In March to June, 50% of the total yield of white clover occurs (USDA, 1988; Chamblee et al., 1995a). Seasonal production of forages is seen in figure 8 and 9. The average annual yield of ladino clover is 3 to 4 tons per acre (Blaser et al., 1969; Chamblee et al., 1995b). Total DM yields of all forage species are affected by annual precipitation, percentage of that specific forage in the pasture, and weather conditions. The nutritive value of white clover is very high; DM is greater than 80% digestible and contains up to 25% crude protein (CP), and remains high in quality as the forage matures (Carlson et al., 1985; Chamblee et al., 1995a).

Kentucky bluegrass, *Poa pratensis L.*, a cool-season perennial grass, is present is throughout the United States, and is best adapted to mountain areas (Duell, 1985). In the mountain areas, bluegrass is the dominant grass found in old pastures. Bluegrass is adapted to a wide range of soils, but does best in well drained, productive soils with a pH of greater than 5 (Duell, 1985; Chamblee et al., 1995b). Seasonal production of this forage is seen in figure 8 and 9. The general period of growth is March 15 to November 1 with peak production during March to May and in September, with little growth in the summer months. The average annual yield of bluegrass is 2 to 3 tons per acre (Blaser et al., 1969; Chamblee et al., 1995b). This grass has narrow, soft, smooth leaves that form a dense sod because of the rhizomes (White and Wolf, 1995). The grass is short to medium height. The nutritive value of bluegrass is high; DM is 75 to 80% digestible, has 14 to 20% crude protein, and is very palatable (Chamblee et al., 1995b).

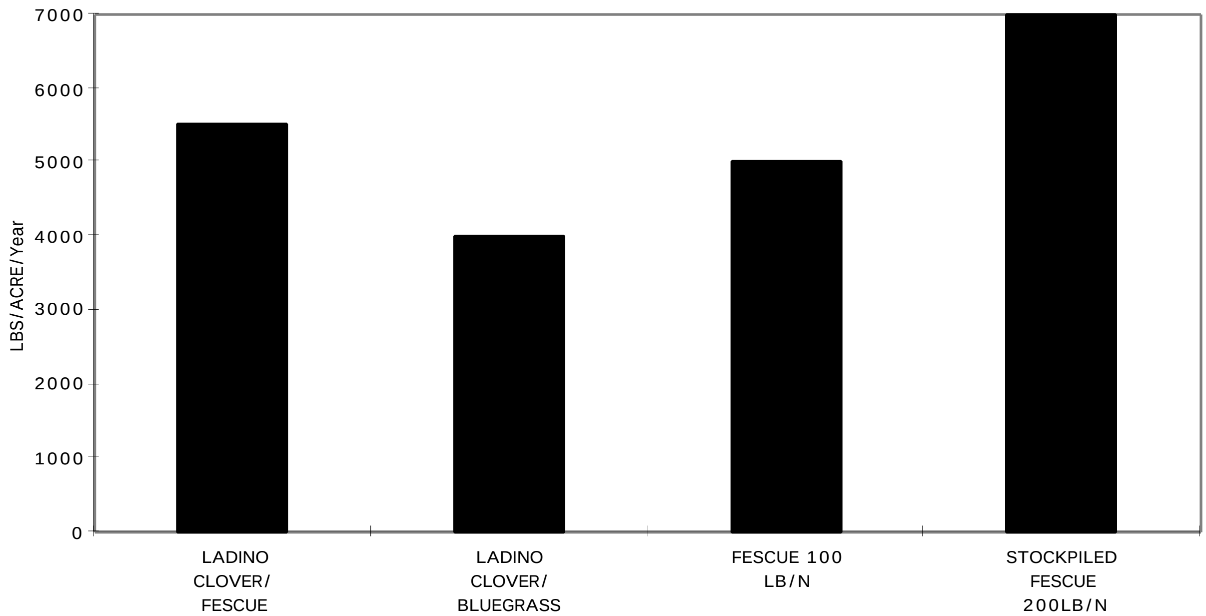

Figure 7. Annual dry matter of various forages

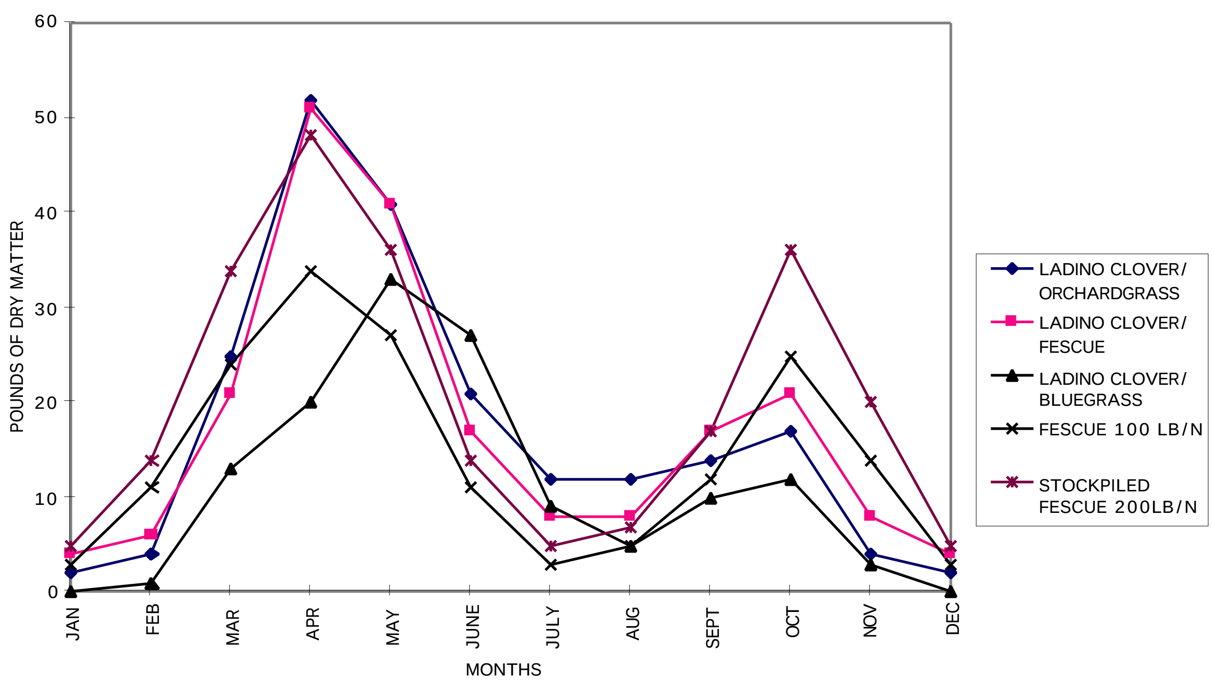

Figure 8. Seasonal production of various forages

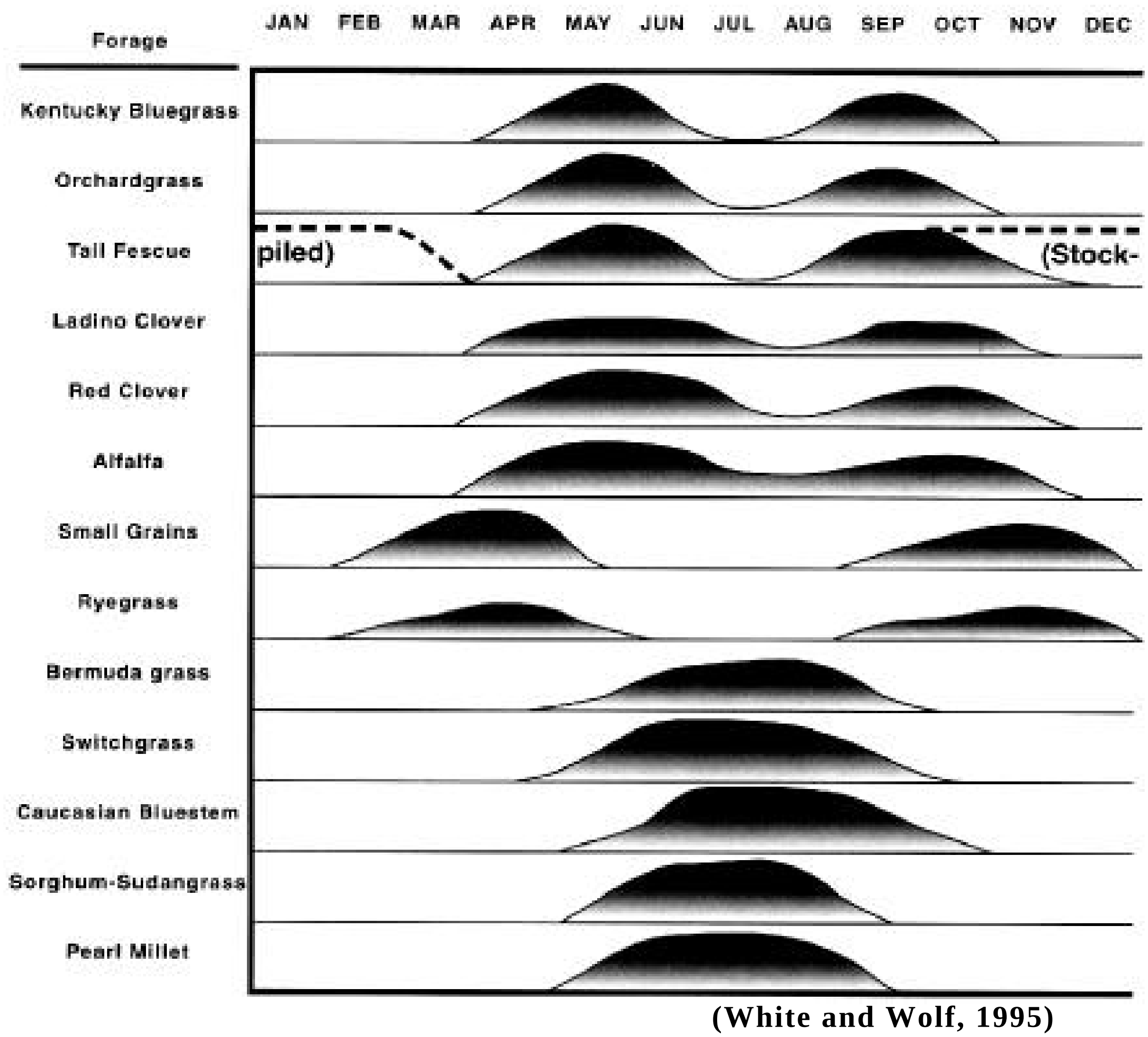

Figure 9. Seasonal growth of various forages

Orchardgrass, *Dactylis glomerata*, is a cool-season perennial grass that is found from Maine to the Gulf states and from the Atlantic Coast to the eastern Great Plains (Jung and Baker, 1985). It is well adapted to the mountain regions and requires medium to well drained soils (Chamblee et al., 1995b). Orchardgrass is more heat tolerant and drought resistant than timothy or Kentucky bluegrass, but less than tall fescue (Jung and Baker, 1985). The seasonal production of this forage is seen in figure 8 and 9. Orchardgrass grows from March to November, with is rapid growth in the spring, followed by a reduced growth in the summer, and finally moderate production in the fall. In March to June and in

September, 60% of the total production occurs, with an average annual yield of 3 to 5 tons per acre (Blaser et al., 1969; Chamblee et al., 1995b). Orchardgrass is also moderately winter hardy and shade tolerant. The plant grows tall and erect in a bunch-type grass without rhizomes and stolons (Chamblee et al., 1995b). Immature orchardgrass is of high quality (73 to 78% digestible and crude protein of 14 to 20%), but the quality decline as the plant becomes more mature with 58 to 65% digestibility at full bloom (Jung and Baker, 1985; Chamblee et al., 1995b).

Tall fescue, *Festuca arundianacea*, is a cool-season perennial grass that is grown from Florida to Canada. Tall Fescue grows in moist soils with a pH of 4.70 (Buckner, 1985). Tall Fescue can grow on thin soil, droughty slopes or poorly drained soils, and can handle close, continuous grazing (White and Wolf, 1995). The plant grows in semi-erect bunches with short rhizomes and numerous shiny, dark green, ribbed leaves (Buckner, 1985; Chamblee et al., 1995b). March , April, May, October, and November are the peak months of production. In the summer, unless there is ample moisture, cool temperatures and ample fertility, tall fescue will reduce its growth and sometimes go dormant (Buckner, 1985). The seasonal production of this forage is seen in figure 8 and 9. The range in annual yield for tall fescue is 3 to 5 tons per acre with a digestibility of 70 to 80% when immature, but the digestibility declines with maturity to 55 to 60% (Blaser et al., 1969; Chamblee et al., 1995b).

Stage of maturity of grasses and legumes will effect the palatability and total digestible nutrients (Blaser et al., 1986; Botkin et al., 1988). In orchardgrass, the CP is reduced as the plant matures from the leafy stage (33.90% CP), the boot stage (17.60% CP), the headed stage (10.10% CP), the full bloom stage (7.80% CP), and the seeding stage (6.10% CP) (Blaser et al., 1986). As the forage matures, digestibility decreases linearly as lignin increases, as seen in figure 10 (Ely, 1994). The digestibility of young, green leave is 70 to 80%, while brown leaves with mature seedheads are 30 to 40% digestibility (Mueller et al., 1995).

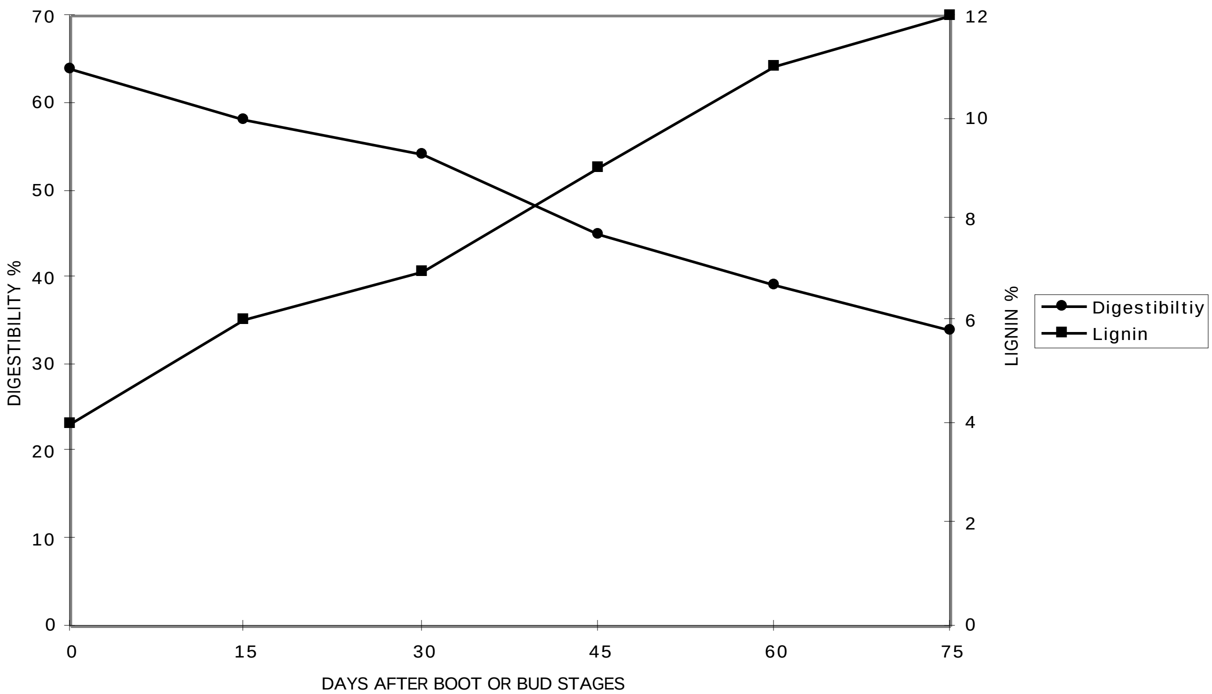

Figure 10. Changes in DM digestibility and lignin with advancing maturity of cool season grasses (boot) and legume forages (bud)

Pastures do not grow evenly throughout out the year. Year-around grazing is not attainable in most of Virginia; harvested hay, stockpiled forages, and concentrates thus need to be part of the diet of the sheep (White, 1996). If pastures are not grazed with proper stocking rates or harvested for hay, the surplus growth that is not consumed by the sheep will mature and seed out, causing reduced numbers of grass plants per acre and enabling weed and other undesirable plants to gain a competitive advantage (Umberger, 1996).

Sheep Grazing Behavior

Livestock have differing behavior as it relates to grazing, and a proper understanding of grazing behavior will enable the most efficient use of forages in an agricultural enterprise. Sheep are a ruminant (defined as a group of animals that chew their cud and characteristically have a four-compartment stomach) species of livestock, which enable them to use plants (grasses, legumes, weeds, herbs, and shrubs) as a major feed source (SID, 1992). Sheep will eat more browse than cattle but less than goats (Luginbuhl et al., 1995). The most efficient way to meet nutritional requirements of sheep is through grazing forages in permanent pasture. Forages make up around 75 to 90% of the total diet (Umberger, 1994). Up to 70% utilization of pasture by sheep is attained with proper pasture management (White, 1996). Sheep are efficient converter of forages to meat and fiber and are the only species able to produce a USDA choice carcass on forages alone (Umberger, 1994).

Sheep are efficient grazers and are capable of grazing on most types of terrain and in most kinds of weather, but prefer to graze hillsides and steep slopes (Botkin et al., 1988; Ely, 1994; Luginbuhl et al., 1995). Because of this preference to hillside terrain, it is difficult to manage forages and improve fertility of sheep pastures. There are approximately 1.5 million acres of steep pasture in Virginia (White, 1996). Ruminate animals will have their longest periods of grazing at sunrise and sunset. The length of these times are affected by season of the year, temperature, humidity, topography of the land, plant canopy, pasture availability , and social interaction of the animals (Pond et al., 1995).

One problem of sheep grazing pasture is that actual intake of feed is not known, which requires some assumptions of daily intake. The assumption can be made that sheep will meet their requirement through grazing when green growing grasses and legumes are in adequate supply, but supplementation is needed when the forage supply is sparse to ensure that the animals requirements are meet. Sheep prefer to consume forage that is leafy, vegetative, and at 2 to 6 inches tall, instead of taller mature forage containing lots of stems (Umberger, 1996). Pond et al. (1995) found that sheep graze 10 hours a day, which is more than beef cattle (9 hours a day), and less than horses (12 to 16 hours a day). Sheep have a daily number of bites and chews of around 34,000.

The stage of production of the animal dictates the quality and type of forage grazed. For example, lactating ewes and growing lambs should have access to the highest quality and most palatable forage, while ewes on a maintenance diet or non-lactating diet are placed on lower quality, more mature forage (Umberger, 1995). Sheep are more selective grazers than cattle; they take smaller bites, graze within 1/3 of an inch from the ground, and, because of their narrow muzzle, are able to select leaves within a plant (Luginbuhl et al., 1995; Pond et al., 1995).

Stocking Rate

Present and previous stocking rates affects forage production and composition. Stocking rate is defined as the number of animals grazed on an acre of pasture (SID, 1992). It is determined mathematically by taking the number of acres used for pasture grazing and hay production divided by the number of animals that will use the pasture. Stocking rate is impacted by several factors such as the type of production system (winter, spring, or fall lambing), grazing system (controlled, intensive, or continuous grazing systems), forages used (annuals, perennials, or warm or cool season grasses or legumes, or a combination of these), climate, soil fertility, and soil type (Umberger, 1994).

Stocking rate is also affected by the whether sheep graze alone or with other livestock species such as cattle. Stocking rate will affect the percentage of each forages species in a pasture. Abaye (1992) found that when sheep grazed alone, there was an increase of bluegrass (58%) and a decrease in white clover (6%) and weeds (36%). Forage quality is lower in pastures grazed with sheep alone, as compared to those grazed by cattle and sheep together (Abaye et al., 1994). Meat production per stock unit tends to decline as stocking rate increases, and wool production follows the same trend (Cacho et al., 1995). The stocking rate will affect the animals' performance by affecting the amount of forage available to each animal and limiting their choice of the most lush, green, and nutritious pasture components (Wilson and Macleod, 1991).

The type (growing lamb, replacement ewe, or ram), stage of production (lactating, gestation, or maintenance), lambing crop percentage, and body weigh of the animal will determine the quality and quantity of forage the animal can and will consume (Umberger, 1994). For example, predicted DM intakes (NRC, 1985) for a 154 lb ewe are 2.60 lb during maintenance, 4.00 lb during flushing, 3.10 lb during early gestation, 4.20 during the last 4 weeks of gestation, 5.50 lb during the first 8 weeks of lactating if suckling a twin lambs, and 4.20 lb during the last 6 weeks of lactating if suckling a single lamb. In contrast, an 88 lb replacement ewe lambs has a predicted DM intake that is the same for maintenance, flushing, and early gestation (2.60 lb, 4.00 lb, and 3.10 lb, respectively) but differs for the last 4 weeks of gestation (3.50 lb) and the first 8 weeks of lactating suckling a single lamb (NRC, 1985). The average DM intake as a percentage of body weight for a 154 lb ewe is 1.70, 2.00, and 4.00% for maintenance, gestation, and lactation, respectively (Umberger, 1994). Sheep consume 1.50, 2.00, 2.50% of their body weight in dry matter when grazing low, average, and highly digestibility forages, respectively (Umberger, 1994) These factors affect stocking rates.

Another factor that affects stocking rate is type of management. Investigating of past experiences on a specific farm will assist in establishing a benchmark for stocking rate. In many situations the stocking rate is in terms of animal units (AU). An AU is considered one mature non- lactating cow weighing 1,100 lb and fed at maintenance level, which represents the consumption of approximately 17.60 lb of DM per day (Umberger, 1994; Chamblee and Green, 1995). With this assumption, any animal may be represented as a certain fraction or multiple of the AU, based solely on its rate of forage intake per day. So a 154 lb ewe is .163 animal units (AU), or 6.10 animals per AU (Chamblee and Green, 1995). So, six ewes equal one AU. The AU for a ewe and her lambs is .30 (Umberger, 1994). In Virginia on a typical cool season permanent pasture, the stocking rate is 2 to 3 ewes per acre and this number can be increased to 5 to 6 if controlled or intensive grazing is used (Umberger, 1994).

Stockpiled Fescue

Winter is the time when forage growth slows or ceases entirely. Stockpiled fescue can be used to expand the grazing season. Stockpiled fescue reduces reliance on hay and concentrate feedstuffs in winter, because it may be grazed by sheep in November, December, and possibly January, if weather is good (poor weather degrades the quality and quantity of stockpiled fescue). Stockpiling fescue offers sheep producers an inexpensive feed source because it requires less labor, and machinery than harvested feed crops (White, 1994). The nutrient requirements of five gestating ewes can be met for around 120 days with one acre of stockpiled fescue (Umberger, 1994; White, 1996). Lactating ewes, growing lambs, and ewes in the last 4 weeks of gestation can also use stockpiled fescue to meet most of their nutritional requirements, but some supplementation with a protein and/or energy source, such as soybean meal and corn, is needed to fully meet the requirements of animals in these stages of production.

Tall fescue is a forage that is well suited for stockpiling because it responds well to late summer fertilization in August and maintains its quality throughout the winter grazing period of November and December (White, 1996). Stockpiled fescue can also be grazed in January, but the speed of deterioration depends on the weather. Fribourg and Bell (1984) found that large losses occurred if the stockpiled fescue was harvest in January alone. Tall fescue that is scheduled to be used as stockpiled winter feed can be managed as any other forage until August. In August, 75 to 100 pounds of nitrogen is applied to the field, and the forage is subsequently not grazed until November 15 (Chamblee and Green, 1995; White, 1996).

The amount of fertilizer applied to tall fescue will affect the yields and CP. With 0, 25, 50, 75, 100, 125, and 150 lb/acre of fertilizer, the tons of stockpiled fescue per acre with 12% moisture was 0.50, 0.90, 1.20, 1.60, 1.70, 1.90, and 2.00, respectively and the CP in the DM was 11.60, 12.30, 12.60, 13.90, 13.50, 14.60, and 15.30%, respectively (White, 1996). Gerrish et al. (1994) also found that the amount of fertilizer affect total DM yield. The maximum DM yields were 2800 lb/acre with 120 lb/acre of nitrogen fertilizer. Stockpiled fescue growth with alfalfa instead of fertilized with nitrogen had reduced yields, but gains of steers were higher than those of steers grazing fescue stockpiled with nitrogen fertilizer (Allen et al., 1992).

The seasonal DM yields of stockpiled fescue are represented in figures 8 and 9, with DM annual yield of 7,000 lb/DM (USDA, 1988; Chamblee and Green, 1995). With proper fertilization, tall fescue will produce the equivalent of 1.50 to 2 tons of hay per acre during the fall growing season (White, 1995). The TDN content of stockpiled fescue is 60 to 70%, depending on the month of the year (Chamblee and Green, 1995). Stockpiled fescue remain relatively high quality forage through December (Fribourg and Bell, 1984). CP decreased from .26 lb in July and .29 lb in September to .13 and .15 lb in December and January (Fribourg and Bell, 1984). CP in stockpiled fescue is generally 11 to 13% the CP of higher than average grass hay produced in Virginia (White, 1996). Gerrish et al. (1994) found that as nitrogen fertilizer was increased from 0 to 120 lb/acre, CP also increased.

Hay Production

Hay is defined as the aerial part of finer-stemmed forage crops stored in the dry form for animal feed (Cullison, 1979; Taylor, 1995). Harvested feeds such as hay are used during periods in which animal nutrient requirements cannot be met by grazing pasture alone. There is a great variation in the quality of hay, which is affected by stage of cutting, species composition, handling, and weather damage during harvesting. There is variation is palatability, nutrient content, and digestibility (Botkin et al., 1988).

Moisture in green herbage may range from 65 to 85%, depending on forage species and maturity; harvested forages for hay usually have a moisture content of 15% or less (Church and Pond, 1982). The optimum time to harvest forages is the boot to early bloom stage for grasses and the late bud to early bloom stage for legumes (Mueller et al., 1995; Wahlberg, 1995). Harvest losses come from shattering, which is the loss of leaves (2 to 35%); leaching if the cut forage is rained on, causing loss of the more water soluble nutrients (5 to 14%); storing with too much moisture; and bleaching by exposure to sunlight, and reducing nutrients such as carotene (Cullison, 1979; Church, 1986; Ensminger, 1992). Haymaking losses can vary from 6% with artificial dehydration to 35% in rain-damaged field-cured hay (Church and Pond, 1982; Wahlberg, 1995). In good natural haymaking conditions, losses are 10 to 12%; in poor conditions, losses are 30 to 35% (Mueller et al., 1995).

Hay can be stored in various ways, such as in a solid or pole barn, outside under tarps with pallets to keep it off the ground, and outside exposed to the elements. DM losses from round bales stored outside range from 4 to 14% (Ensminger, 1992). Hay stored for 9 months at 36 degrees C with 18% moisture will have about 8.00% DM losses (Church, 1986). Hay stored inside a barn will have the lowest DM loses (about 5.50%); hay stored outside and covered will have losses DM increased to about 10.50%; and hay stored outside and uncovered will have the greatest DM losses (about 16.90%) (Harrigan and Rotz, 1992; Wahlberg, 1995). Belyea et al. (1985) found DM storage losses of large bales of 2.00% for inside, 6.00% for outside and covered, and 15.00% for outside and uncovered. Huhnke (1987) found DM losses ranging from 1.90% for covered bales stored outside on pallets, to over 13% for uncovered bales with direct contact to the ground. Collins et al. (1987) found DM losses of large round bales of 27.60% on the ground, 31.20% on gravel, 35.40% on tires, 26.00% on a rack, 12.30% on a rack with cover, and 2.30% in a barn. DM losses of stored hay for a 6 to 9 month period averaged 6.00% (Harrigan and Rotz, 1992).

Use of large round or small square bales will affect storage feeding losses. Round bales can be used to feed sheep with minimum waste if the proper equipment is used, such as round-bale feeders for sheep, although feeding losses were not measured for sheep. If animals have free access to hay such that they can stand or trample it, the losses will be up to 40 to 50%. If the hay is feed in a feeding rack, losses can be reduced to 5 to 10% (Anderson and Mader, 1985; Ensminger, 1992). Furthermore, species of animal will effect the feeding losses. Sheep are selective eaters and select the highest quality, most palatable material from the hay, which increases feeding losses. Belyea et al. (1985) found that the feeding losses with large round bales fed to dairy heifers were 12% for feeding inside a barn, 13 to 15% for feeding outside and covered, and 25% for feeding outside and uncovered. Feeding losses of cattle fed large round bales were 22.00% on the ground, 16.80% on gravel, 6.30% on tires or a rack, 1.50% on a rack with cover, and 1.20% in a barn. In Michigan, losses of hay fed to cattle were 9.90% inside a barn, 9.70% outside and covered, and 19.10% outside and uncovered (Harrigan and Rotz, 1992; Wahlberg, 1995).

The various forages found in Virginia's pastures are Kentucky bluegrass, orchardgrass, ladino clover, and tall fescue. In terms of nutrient composition, fescue hay is 46.00 to 60.80% TDN, 89.00 to 92.00% DM, and 9.50 to 10.00% CP; ladino clover hay is 51.00 to 59.00% TDN, 90.00% DM, and 16.90 to 21.00% CP; orchardgrass is 47.00 to 59.70% TDN, 89.00 to 91.00% DM, and 10.00 to 11.10% CP; and bluegrass hay is 50.00 to 54.00% TDN, 88.90 to 90.00% DM, and 11.00 to 15.60% CP (Cullison, 1979; Church, 1986; Botkin et al., 1988; Ensminger, 1992). The average quality of hay is 25 to 35% crude fiber and 45 to 55% TDN on as-fed basis (Ensminger, 1992). Maturity, handling, and weather all effect DM percentage, TDN, and CP.

Lactation Curve of the Ewes

Milk Production and the Lactation Curve

Milk production yields can be measured in a variety of way, such as weighing of the lambs before and after suckling, hand or machine milking methods following administration of oxytocin, and measuring body-water turnover (Geenty and Sykes, 1986). Breed of ewes, parity, and week of lactation all affect daily milk production. All of these methods have the possibility of estimation errors. It is thus not easy to determine which method gives the most accurate measurement of milk production. Doney et al. (1979) found that the highest daily milk yield in the first week of lactation was obtained when the method of oxytocin followed by machine milking was used on a group of Blackface ewes rearing single lambs. By the second week of lactation, there were no differences among testing methods. The high estimate in week 1 may be due to the lower intake of milk at this stage of lactation by small lambs that were not able to consume all the milk that was produced.

Keown et al. (1986), found that the first day of sampling may be during the peak and may overestimate production; this is why the shape of the lactation curve should be keep in mind. Also samples taken at the end of lactation often overestimate production because production is decreasing at a increasing rate. These are reasons for estimating lactation curves. Another reason for using lactation curves is seasonal effects, which can be minimized by the use of the curve. There are various applications of lactation curves, such as extension of incomplete records for use in genetic evaluation, formulation of rations, and greater understanding of the pattern of milk production. Knowledge of the shape of the lactation curve can be used for management decisions, such as culling, and economic evaluation of different management schemes (Sakul and Boylan, 1992; Groenewald et al., 1995). The first month of production accounts for 45 to 50% of the total milk yield of a 14 to 16 week lactation. Milk production decreases at a rate of .53 to .70 oz per day during the second and third months after peak production and .35 oz later in the cycle (Church, 1986).

Lactation curves can be described using various mathematical functions, such as Wood, Wood weighted, Jenkins, and Morant (Hohenboken et al., 1992). They found that the Wood equation was appropriate in the determination of milk production in beef cattle. Most researchers used the Wood equation in determination of lactation curves (Torres-Hernandez and Hohenboken, 1980b; Sakul and Boylan, 1992; Groenewald et al., 1995). Wohlt et al. (1981) found that daily milk yields in Dorset ewes decreased over time from 2.205 lb in the first month of lactation to 1.10 lb in the eight week of lactation. Wohlt et al. (1981) found that there are several factors that affect milk production. The age of the ewe affects milk production. Ewes will produce less during their first lactation than subsequent lactations (2.09 lb/d for 1.50 to 2.00, 2.09 lb/d for 2.10 to 4.00, and 2.16 lb/d 4.10 to 8.00 year old Dorset ewes), and increased milk production is correlated to the increased number of lambs suckling (2.09 lb/d from ewes with singles and 2.18 lb/d for ewes with twins).

Several studies measured daily milk production over the lactation period and found variation in daily milk production as a result of breed differences, the number of lambs suckling the ewe, and seasonal differences. Mean daily milk production, measured weekly over a 10-week period for Border Leicester x Scottish Blackface crossbred ewes suckling single lambs (6.17, 3.75, 4.41, 4.85, 3.97, 3.97, 3.75, 3.75, 3.53, and 4.19 lb/d) was lower overall than ewes suckling twins (6.84, 6.62, 6.17, 6.39, 4.85, 4.63, 4.19, 4.19, 3.53, and 3.75 lb/d) (Rhind et al., 1991). Torres-Hernandez and Hohenboken (1980b) study found similar results to those of Rhind et al. (1991). The milk production, measured weekly, over a 15-week period for crossbred ewes (North Country Cheviot, Dorset, Finnsheep, Romney, Suffolk and Columbia) suckling singles lambs was lower (.40, .43, .45, .44, .44, .43, .41, .40, .36, .33, .30, .29, .26, .23, and .17 gal/d) than ewes suckling twins (.43, .48, .51, .50, .49, .48, .46, .43, .40, .37, .34, .33, .30, .26, .22, and .22 gal/d). In another study, Torres-Hernandez and Hohenboken (1980a) fit lactation curves for crossbred ewes (North Country Cheviot, Dorset, Finnsheep, Romney, Suffolk, and Columbia) suckling singles and twin that lambs and found that the curves were essentially parallel during the lactation period, and that more milk was produced by the ewes nursing twins. The milk production, measured weekly, over 15-week period for ewes nursing singles was .41, .48, .48, .45, .42, .40, .36, .32, .29, .26, .24, .22, .18, and .16 gal/d, and for twins was .48, .53, .54, .50, .48, .44, .40, .37, .36, .33, .29, .26, .24, .21, and .18 gal/d.

Blackburn and Cartwright, (1987) reported average milk production, measured weekly, for a 10-week period of 1.10, .88, .66, .62, .60, .44, .35, .26, .26, and .31 lb/d. Groenewald et al. (1995) studied milk production of Merino ewes over 15-week of lactation. Daily yields, including both ewes suckling single or twin lambs, were 3.09, 3.75, 4.19, 3.97, 3.97, 3.51, 2.87, 2.65, 2.43, 2.21, 1.65, 1.54, 1.32, 1.21, and 1.10 lb/d. Sakul and Boylan (1992) presented lactation curves for purebred (Finnsheep, Dorset, Rambouillet, Romanov, Suffolk, and Targhee) and crossbred (various combinations of the before mentioned breeds) ewes that were higher than those of other studies. They found that Finnsheep x Rambouillet crosses produced .51 lb more milk per day than ewes sired by Dorset or Lincon rams. Breeds differed in total milk yields, with Suffolk (21.46 gal) having the highest producers. All breeds following a similar lactation curve, except Romanov, which produced milk at a relatively low level and a slower decline in milk production throughout lactation. The composition of the milk was not affected by age of ewe, lamb sibling status or sex of the lamb in Dorset ewes (Wohlt et al., 1981; Gallo and Davies, 1988).

Effect of Lamb Numbers on Milk Production

The number of lambs being suckled will affect milk production. Locerch et al. (1985) compared the lactation performance of Finnsheep crosses and Targhee ewes nursing twins and triplets. Ewes nursing triplets on day 42 of lactation produced 21% more milk/unit metabolic body weight, were 10% more efficient in converting feed to milk, and produced pounds of lamb per ewe. In another study, all ewes had triplets, but some ewes raised twins, while other raised triplets. Ewes nursing triplets produced 28% more milk/unit metabolic body weight and were 26% more efficient in converting feed to milk, which demonstrates that the increased mammary gland production is a result of the nursing stimulation from additional lambs (Locerch et al., 1985).

Doney et al. (1979) also found differences in milk production in single- and twin-reared lambs. The mean daily milk production for 6 weeks for Merino, Blackface, and East Friesland crossed ewes suckling singles and twins lambs was measured. Two methods, oxytocin and lamb-suckling, were used to measure milk production. Using the oxytocin method the following results were found; 5.16 lb for Merino ewes with singles, 3.88 lb for Merino ewes with twins, 6.13 lb for Blackface ewes with singles, 4.52 lb for Blackface ewes with twins, and 6.95 lb for East Friesland ewes with singles. Using the lamb-suckling method the following results were found; 5.14 lb for Merino ewes with single, 3.44 lb for Merino ewes with twins, 5.73 lb for Blackface ewes with singles, 4.32 lb for Blackfaced ewes with twins, and 7.19 lb for East Friesland ewes with twins.

Suffolk and Cambridge ewes produced more milk as a result of increased numbers of suckling lambs. Gallo and Davies (1988) found that ewes suckling triplets produced slightly more milk at 20 days (9.48 vs 9.04 lb/d), significantly more milk at 30 days (9.04 vs 8.16 lb/d), ingested similar amount of DM, but lost more body condition. From birth to 35 days, triplets grew faster than twins (12.67 vs 10.18 oz/d), but after 35 days, twins and triplets grew at similar rates, which are unexpected results. Rhind et al. (1991) likewise found that in Border Leicester x Scottish Blackface crossbred ewes, the mean daily milk production was lower in ewes suckling singles than in ewes suckling twins (4.26 vs 5.14 lb/d). The same results were found by Locerch et al. (1985) when adjusted milk production for 42 days of lactation was measured in two experiments. For ewes suckling twins, the result were 5.98 lb/d and for ewes suckling triplets, the results were 6.72 lb/d in experiment one. In experiment two, for ewes suckling twins, the results were 5.96 lb/d and for ewes suckling triplets, the results were 7.61 lb/d.

During lactation, Torres-Hernandez and Hohenboken (1980a) found that single lambs gained more weight than twin lambs, but the total gain was greater for twins.

Regression and correlation coefficients between preweaning weight gains and milk production for single lambs were larger for single lambs. Ewes with twins produced more milk, but less was available to each twin. Thus milk production is a limiting factor for preweaning weight gains in the twin, and the relationship between milk production and preweaning weight gains is expected to be lower for twin lambs, because twin lambs must rely on forages or concentrate feeds to met their nutritional requirements because milk alone is not enough.

Ewe and Ewe Lamb Production Requirements

Ewes Nutrition

Feeding costs make up more than half of the total cost of production, which causes sheep producers to rely on forages to meet most of the ewes nutritional requirements, and to supplement with grain and hay only to meet forage deficiencies (Rickett et al., 1990). Because of the problems in evaluation of amount and quality of forages, simulation models can be useful to gain information about grazing system and explore alternative grazing strategies (Cacho et al., 1995). There are various factors that must be considered when determining the ewes' nutritional needs, such as age, size, weight, body condition score, exercise, amount of confinement, stage of production, number of lambs, time of weaning, season of lambing, quality of feedstuffs, health of the ewe, and environmental conditions (SID, 1992). The two most critical stages of production for nutrition are late pregnancy and early lactation, if the ewe is to deliver large, strong, healthy lambs and producer enough milk for those lambs (Rickett et al., 1990).

Sheep are more efficient than cattle at utilization of forage. In Nevada, with a ration of 75% high quality alfalfa and 25% grain, cattle had a ratio of 19.85 lb of feed for 2.205 lb of gain and sheep had a ration of 13.23 to 15.41 lb of feed to 2.205 lb of gain (Terrill and Price, 1985). Forages are important to a fall lambing system because they can be used to meet nutritional requirements for ewes during late gestation and lactation. In spring lambing, there are large quantities of high-quality grass available for lactating ewe with high nutritional requirements and lambs that are just beginning to graze. Year-around grazing is not attainable in the mountains pastures of Virginia. Knowledge of the species present and of the relative proportions of those species in the pasture and of the maturity of the forage enables approximation of the nutrient content of the pasture.

The National Research Council (NRC, 1985) nutritional requirements for a 154 lb ewe is; 2.60 lb of DM and 1.50 lb of TDN for maintenance; 4.00 lb of DM and 2.30 lb of TDN for ewes in flushing; 3.10 lb of DM and 3.40 lb of TDN for nonlactating ewes in first 15 weeks of gestation; 4.00 lb of DM and 2.30 lb of TDN for ewes in the last 4 weeks of gestation with a lambing percent of 130 to 150 or ewes in the last 4 to 6 weeks of lactation suckling singles; 4.20 lb of DM and 2.80 lb of TDN for ewes in last 4 weeks of gestation with a lambing percent of 180 to 225; 5.50 lb of DM and 3.60 lb of TDN ewes in the first 6 to 8 weeks of lactation suckling singles or ewes in the last 4 to 6 weeks of lactation suckling twins; and 6.20 lb of DM and 4.00 lb of TDN for ewes in the first 8 to 6 weeks of lactation suckling twins. The NRC (1985) requirements are similar to the requirements published by the agricultural Research Council in England (CAB, 1980). The differences are that the sheep in England are smaller (88 to 165 lb), there is no consideration of frame size in the growing lamb in their requirements, and CAB has requirements for the milk fed lamb.

During maintenance and the first 15 weeks of lactation, the ewes requirements can be meet with low or medium quality forage alone (Luginbuhl et al., 1995). The only exception is 4 week before breeding flushing occurs, when 1.00 lb/d of corn can improve ovulation rate by 10 to 20% (Terrill and Price, 1985). During the last 4 weeks of gestation, only 1.00 lb/d of corn is fed, and all other requirements are meet with good-quality forages

(Goode and Crickenberger, 1984). During lactation, 1.00 lb/d of a 15% CP grain mix is fed to ewes with singles and 2.00 lb/d of a 15% CP grain mix is feed to ewes with twins; all other requirements are met with forages (Umberger, 1995). The rumen's limited capacity is the cause of supplementation of a forage diet during late gestation and early lactation. When fresh forage is not available for grazing, such as in the month of February, harvested forages in the form of hay can be used.

Scottish halfbred ewes crossed with Dorset Down rams nursing twin lambs on a low allowance herbage diet (1.05 oz DM/lb of live weight/d) produced less milk and lost more weight than ewes under the same situation on a high-allowance herbage diet (2.11 oz g DM/lb of live weight/d) (30.21 vs 37.04 lb, 35.72 vs 45.20 lb, 39.47 vs 53.36 lb, and 48.29 vs 67.03 lb at 6, 8, 10 and 14 weeks respectively; Gibb et al., 1981). The daily herbage organic matter intake was greater for ewes on high allowance (5.71 lb) than low allowance (3.84 lb).

In a simulation study, Levine et al (1978) found that Columbia ewes and lambs consumed 833.49 lb/yr in 1973 and 901.85 lb/yr in 1974 of DM from pasture and 460.85 lb/yr in 1973 and 443.21 lb/yr in 1974 of DM from supplemental feed. Suffolk ewes and lambs consumed 956.97 lb/yr in 1973, 1053.99 lb/yr in 1974 of DM from pasture, 529.20 lb/yr in 1973, and 502.74 lb/yr in 1974 of DM from supplemental feed.

Ewe Breeds and Characteristics

Use of Finnsheep crossbred ewes can increase reproductive performance in commercial sheep flocks. Tolman (1993) found that ewes with 1/4 Finnsheep breeding compared well to their purebred and crossbred counterparts in fertility and in many cases had increased fertility. One of the reasons for the increase in fertility is early sexual maturity of Finnsheep. Notter and Copenhaver (1980a) found that the increased production from adding 1/4 Finnsheep genetics to the ewe did not had a negative affect on longevity of the ewe, but the ewes in the study only nursed twin lambs; the other lambs born were fostered, which may have affected these result. Notter and Copenhaver (1980a) found during a 2 year study, the mean conception rates in 1/4 Finnsheep genetics was 90% in winter lambing system (breeding in August), 82% in a spring lambing system (breeding in November), and 48% in a fall lambing system (breeding in April). The pregnancy rate for 1/2 Suffolk, 1/4 Finnsheep, and 1/4 Rambouillet ewes 2 years old and older averaged 89.50% in a fall lambing system, 94.00% in a winter lambing system, and 85.70% in a spring lambing system (Notter and McClaugherty, 1991).

Prolificacy is a measure of reproductive efficiency expressed in number of lambs born per ewe lambing (SID, 1992). Tolman (1993) found that 1/4 Finnsheep genetics resulted in an increase in lambs born/ewe mated. Notter and McClaugherty (1991) found that the number of lambs born per year per ewe exposed was highest in ewes with 1/4 Finn genetics (1.83) and the spring lambing system (1.86) was higher than the winter (1.63) or fall (1.60) lambing systems. Dickerson (1970) states that the efficiency of meat production by sheep can be increased most efficiently by increasing the number of lambs marketed per ewe. Notter and Copenhaver (1980a) found that ewes with 1/4 Finnsheep genetics had a mean litter size of 1.93 in a winter lambing system, 2.13 in a spring lambing system, and 1.52 in a fall lambing system. Tolman (1993) stated that the mean number of lambs marketed per ewe exposed was 1.75 in a spring lambing system, 0.96 in a fall lambing system, and 1.34 in a winter lambing system.

Studies are contradictory on the issue of the effect of Finnsheep genetics on lamb survival. Some result demonstrate an increase in survival when Finnsheep genetics are added, where as others show a decrease in survival rates, and some show no difference (Tolman, 1993). Thirty-day survival for lambs was estimated to be 86.90% in a spring lambing system and 87.10% in a fall lambing system (Tolman, 1993). The average mortality was 5.40 for single lambs, 6.60 for twin lambs, and 14.00 for triplets. One would expect an increased mortality as the number of lambs born increases. Other studies found the mortality was 20% for triplets, 10% for twins, and 8% for single lambs (Notter and Copenhaver, 1980b; Cochran et al., 1984; Notter et al., 1991).

Ewe Lamb Nutrition and Characteristics

Chappell (1993) set the goal of raising replacement ewes on southern forages. Proper nutrition is essential to the ewe lamb. To be able to breed, ewe lambs must achieve around 88 lb or two-thirds of the ewe's projected mature weight before breeding. There are various factors that affect the development of ewe lambs, such as season of birth, age, nutrition, weight, breed, and environmental conditions. Nutrition is a factor that the sheep producer can use to encourage optimum growth resulting in early puberty. With quality pasture, the energy requirement to grow replacement lambs can be met and protein is not normally a limiting factor. Chappell (1993) found that the forages produced in the "humid south" will support the nutritional needs of replacement ewes, but some supplementation is needed during times when nutrition requirements are high, such as lactation and late gestation, and can not be met by forages alone.

The NRC (1985) nutritional requirements for a 88 lb ewe lamb is 3.10 lb DM and 1.80 TDN during nonlactating in the first 15 weeks of gestation; 3.50 lb of DM and 2.20 lb of TDN for ewes in the last 4 weeks of gestation with a lamb crop percent of 100 to 120; 4.60 lb of DM and 3.10 lb of TDN for a 110 lb ewe lambs in the first 6 to 8 weeks of lactation suckling singles; and 5.10 lb of DM and 3.50 lb of TDN for a 110 lb ewe in the first 6 to 8 weeks lactation suckling twins. These requirements are similar to the requirements by the Agricultural Research Council (ARC) in England (CAB, 1980).

The pregnancy rate for 1/2 Suffolk, 1/4 Finnsheep, and 1/4 Rambouillet ewe lambs averaged 50.7% in fall lambing, 87.4% in spring lambing system, and 87.4% in winter lambing (Notter and McClaugherty, 1991). Body weights for ewe lambs at breeding were lightest for the spring lambing system (141.78 lb) compared to fall or winter lambing (average of 161.19 lb). The average condition scores at breeding of the three-breed crossbred ewe lambs were 5.10 in spring lambing, 6.40 in fall lambing, and 6.60 in winter lambing.

Ewe lambs selected to be replacement ewes may have difficulty, depending on the lambing system, in reaching adequate size and most likely will not be at their peak of ovulation rate by the time of breeding (Botkin et al., 1988). In fall lambing, this is a major problem; in most ewe lambs are open after fall breeding and need to be put into a winter lambing system. Notter and McClaugherty (1991) found that seasonality of breeding is affected by age and ewe lambs tend to have shorter estrous seasons than older ewes. If replacement ewes are born in fall they will most likely not exhibit puberty until the following fall, so these lambs generally will not become a part of a fall lambing system for their second lambing at around 24 months of age (Notter, 1992).

Lamb Production Requirements

Before selecting a lamb feeding program, several factors should be considered, such as performance level desired, kind of lambs to be fed, feedstuffs, method of feeding, breed, and sex (male or female) (SID, 1992). After birth, the abosmasum is more developed than the rumen because it functions as the sole stomach in a nursing lamb (Church, 1986). The physiology of the stomach will change as the lamb starts to consume feed other than milk, such as forage, grain, or silage . Balancing rations to meet recommendations for growing lambs is a relatively simple process if harvested feeds are used, but is more complicated if grazing is involved. Growing lamb requirements fall into two categories; maintenance, which is what the lamb needs to stay alive and maintain body weight, and production requirements, which results in weight increase in growing lambs.

The maintenance requirement of lambs in Mcal/lb of body weight decreases as the animal get older. The net energy of maintenance (NE_m) of newborn lamb is 48.15 Mcal/lb, of a 1 to 2 month lamb is 48.15 Mcal/lb, of a 3 to 5 month lamb is 35.55 Mcal/lb, and of a 6 to 10 month lamb is 28.35 Mcal/lb (NRC, 1985; Church, 1986). Church (1986) states that there are two ways to determine production needs. One is by the factorial method (energy requirements for 3.51 oz gain equals the gross energy in 3.51 oz of corresponding weight gain divided by the efficiency of utilization of energy). The other is the global method (energy needs for 3.51 oz gain equals energy consumed by lambs that reach 3.51 oz gains). NRC and ARC tables for energy are set up using the factorial method, which implies that lambs all have growth potential corresponding to the values indicated in the tables. If growth rate is reduced, it is assumed to be solely the result of a drop in energy level. The protein or nitrogen requirement for maintenance is based on the amount of nitrogen needed to compensate for urinary losses (around .035 oz/d in a growing lambs) and the nitrogen needed for wool (.035 oz/d) (Church, 1986). Church states that the production requirements for growing lambs correspond to the amount of protein fixed, depending upon gain and diet.

Depending on age of the lamb and growth rates, gross energy goes from 1.58 to 2.03 Mcal/lb of gain between second and sixth weeks at a growth rate of 9.82 oz/d. During the first month of life, when live weight gains increases from 1.75 to 10.53 oz/d, the fixed energy per lb of gain increases (Church, 1986). The energy requirements of growing lambs/3.51 oz of gain and excluding maintenance requirements for 66 lb lamb at 7.01 oz/d of daily growth for NRC (1985) is 1.85 Mcal/lb NE on an empty body weight basis and 3.00 Mcal/lb ME for a diet with ME/GE = 0.60. For ARC a 66 lb lamb at 10.53

oz/d of daily growth rate is predicted to require 1.86 Mcal/lb NE on an empty body weight basis for NRC and 3.44 Mcal/lb ME for a diet with ME/GE = 0.60 (variations correspond to adjusted nutrition level) for ARC (CAB, 1980; NRC, 1975).

Growth rates of the lambs can be effected by the month of the year. During June to August, gains are reduced due to heat and poor quality forages (Goode and Crickenberger, 1984). Lamb gains maybe not equal through the grazing season, lambs gains are over 0.60 lb per day in the spring, but only around 0.30 lb per day in July and August, and 0.40 lb per day in the fall (Umberger, 1994).

Notter and Copenhaver (1980b) found no difference in preweaning gains of 1/4 Finnsheep crossed lambs and Suffolk x Rambouillet crossed lambs, but when the Finnsheep genetics was increased to 1/2 Finnsheep, the lambs grew more slowly. They also found that preweaning growth was significant affected by season of birth, sex and birth-rearing type. Males lambs grew 5% faster than female lambs, spring lambs grew faster than fall and winter lambs, and single lambs grew faster than twin- and triplet-reared lamb, with daily gains of 11.47, 9.86, and 9.26 oz/d respectively. Tolman (1993) found that 1/4 Finnsheep genetic resulted in a reductions in lamb growth, but use of 1/4 Finnsheep increased pounds of lamb weaned per ewe.

For the first three weeks of life, a lamb's nutritional requirements are meet with milk alone, but as the lamb gets older and milk production is reduced or if the lamb is a twin or triplet, forages is increased. The age of the lamb when it will consume forages depends on ewes' milk production and birth status. As lambs grow and age, their nutritional requirements increase but milk production of the ewe decreases, which results in lambs being forced to meet more of their nutritional requirements from other sources, such as forages. Church (1986) states that studies have shown that lambs with lower milk supplies will consume forages earlier than lambs with high milk supplies.

Lambs with reduced milk supplies, such as twins, will compensate by increasing roughage intake. A reduction of .035 oz of milk organic matter (OM) may be compensated by approximately .16 oz of grass OM (Church, 1986). As early as 2 to 3 weeks of age, lambs will begin consuming forages. The capacity is limited due to the limited DM intake of the digestive system. A preference for pure legumes or a mixture of grass and legumes over grass alone pasture exists and can allow greater DM intake and growth rates. Suckling lambs can gain 0.40 lb/d on orchardgrass pasture and 0.60 lb/d on a mixture of orchardgrass and Ladino clover (Luginbuhl et al., 1995)   Lambs can consume 2 to 4% of their body weight per day in DM (NRC, 1985).   Jordon and Wedin (1961) reported that non-weaned lambs grazing legume pasture with no supplementation gained about 0.40/d/head. Average daily gains were increased and the average lamb production per acre was more than doubled when lambs were fed grains as compared to lambs on pasture (Jordon and Wedin, 1961).

NRC has no recommendations for milk-fed lambs, but ARC does.   The ME requirements of milk-fed males at 11.02 lb are .57 Kcal/d with live weight gains of 3.51 oz/d, .77 Kcal/d with live weight gains of 7.02 oz/d, and 1.00 Kcal/d with live weight gains of 10.52 oz/d. For 44 lb lambs, ME requirements are 1.48 Kcal/d with live weight gains of 3.51 oz/d, 1.87 Kcal/d with live weight gains of 7.20 oz/d, and 2.27 Kcal/d with live weight gains of 10.52 oz/d (CAB, 1980). The ME requirements of milk-fed lambs for females are at 11.02 lb are .55 Kcal/d with live weight gains of 3.51 oz/d, .77 Kcal/d with live weight gains of 7.02 oz/d, and 1.03 Kcal/d with live weight gains of 10.52 oz/d. For a at 44 lb lambs, ME requirements are 1.41 Kcal/d with live weight gains of 3.51 oz/d, 1.87 Kcal/d with live weight gains of 7.02 oz/d, 2.39 Kcal/d with live weight gains of 10.52 oz/d (CAB, 1980).

Weaned Lambs

In a traditional pasture management system, lambs are commonly weaned at 4 to 5 months of age, separated from the ewes, and allowed to graze the highest quality pastures (Botkin et al., 1988; Luginbuhl et al, 1995). Other studies suggest leaving the lambs on the ewe until they reach market weight (Goode and Crickenberger, 1984). Weight of the lambs should be taken at weaning because is can be used as a tool for selection. Total weight of lambs weaned is a true measure of production and can be used for culling and selecting replacement ewes. Many authors have shown that with age, the effect of feeding level decreases and that the composition of the gain and the body after weaning are independent of feed and energy supply (Church, 1986). The result is that whatever the growth weight, composition of gain is similar at given weight.

Many studies have demonstrated that the growth of lambs on forages is highly variable (Chappell, 1993). Weaned lambs should be on the highest quality pasture available. Botkin et al. (1988) found that by observing the lactation curve, early weaning may improve efficiency and, in the latter part of lactation, it is more efficient to provide high quality feed directly to the lambs rather than feeding the ewes. Programs that uses pasture are often more economical in cost per unit of gain than are fast finishing programs, even with slower rates of gain (Botkin et al., 1988). Rate of gain and feed per unit of grain improve as the ratio of concentrate to roughage increase. Chappell (1993) states that two factors play a role in the adjustment of the lambs after weaning; the ruminal microorganisms need to adjust to different feed and lambs must learn to graze.

Jordon and Marten (1968) found different gains between lambs weaned at 8 to 10 weeks of age and fed in dry lots, and unweaned, creep-fed lambs. Under grazing conditions, early weaned lambs gained less than unweaned lambs. Gibb et al., (1981) found that lambs weaned at 6 week from ewes on a low forage allowance grew slower than unweaned lambs, but not lambs weaned at 8 or 10 weeks of age. Notter and Copenhaver (1980a) found that 1/4 Finnsheep genetics did not have a negative affect on average daily gains when substituted for Rambouillet breeding, but did when substituted for Suffolk breeding. They also found an effect of sex and season on average daily gain. Males grew faster than females and fall and winter lambs grew faster than spring lambs (Notter and Copenhaver, 1980b).

Finishing Lambs

Lambs can be finished using a variety of diets. Forage diet can be used, but gains are less than with a higher energy diet. A typical finishing diet includes corn, soybean, and a high quality hay like alfalfa (SID, 1992). Lambs should be marketed at 110 to 125 lb (Umberger, 1995; Church, 1986). Notter et al. (1991) found that fall-born lambs on concentrate diets grew faster and were slaughtered at younger ages than winter born lambs grazed on alfalfa and ladino clover pastures and spring born lambs grazed on bluegrass and white clover pastures. Many lambs in the US and throughout the world are finished on a forage diet alone (Church, 1986); carcasses of grass fed lambs contained more protein and less fat and had a lower quality grades but higher yield grades, where as grain-fed lambs tended to be too fat.

Church (1986) found differing opinions on the protein requirement for lambs. NRC recommends 11% CP for a finishing lambs of unspecified age and expected gains of 7.02 to 8.77 oz/d. The ARC requirements are 11.20% CP for a 44 lb lamb with a daily gain of 3.51 oz/d, 11.70% CP for a 44 lb lamb with daily gain of 7.02 oz/d, 9.00% CP for a 66 lb lamb with a daily gain of 7.02 oz/d, 9.40% CP for 66 lb lamb with a daily gain of 7.02 oz/d, and 8.60% CP for a 88 lb lambs with a daily gain of 3.51, 7.02 or 10.52 oz/d (the ME of the diet is 60% of gross energy). The recommendations of the ARC are dependent upon growth rates, metabolizability of the diet, and optimum degradability of the diet (CAB, 1980). As lambs get older and become fatter, feed protein levels decrease. Umberger et al. (1986) stated that feedlot gains of lambs are .60 to .75 lb/d on a high energy diets, .25 to .30 lb/d on silage, and .10 to .30 lb/d on forages.

The ARC recommended energy levels are based on metabolizability of the diet and on expected gains and are expressed in ME (CAB, 1980). The ARC requirements for metabolizable energy of lambs for maintenance and growth (ME/GE of 0.60) are 1.96 Kcal/d (males), 1.84 Kcal (females), and 1.79 Kcal (castrated males) for 88 lb lambs with .11 lb/d of live weight gain (CAB, 1980). The NRC recommendations for energy concentration are 72% TDN, DE of 1.44 Mcal/lb, and ME of 1.13 Mcal/lb for 66 lb lambs; 76% TDN, DE of 1.48 Mcal/lb, and ME of 1.22 Mcal/lb for a 88 lb lamb; 77% TDN, DE of 1.53 Mcal/lb, and ME of 1.26 Mcal/lb for a 110 lb lamb (NRC, 1985). With diets of high roughage (low energy), the consumption of feed is restricted, there is a slower rate of passage, and gains are slower than with higher energy diets (Church, 1986).

Economic Analysis of Sheep Production

There are opportunities and limitations to the production of sheep. The opportunities are: production of a USDA choice carcass and wool primarily from forage, companion grazing with other livestock (horses and cattle), potential to produce two lamb crops per year, a high reproductive rate as compared to cattle or horses, quick return on investment, and choice of lambing season which provides management flexibility (Botkin et al., 1988). The limitations or disadvantages to sheep production are predation, poor product development, fluctuations in market lamb prices, seasonality of production, and higher labor costs than cattle. Resources need to be assessed, such as labor, feed, facilities, and investment capital (SID, 1992).

There are several key economic characteristic of sheep production including supply and demand relationship, price determination mechanisms, and marketing channels. Purcell (1995) states that lamb, like other meats, has a reduction in per capita consumption. The supply of lamb in the US has decreased and the problem of seasonality affects supply (SID, 1992). Profit levels can be increased by improving biological or economic efficiency (Gutierrez et al., 1991; Dickerson, 1996). The use of breeding objectives (defined as a necessary foundation for designing genetic evaluation procedures, selection practices, and integrated animal breeding programs) will enable a flock to achieve changes in production that will result in improved the profits (Harris and Neuman, 1994).

Van Tassell and Whipple (1994) examined the cyclical nature of the sheep industry and found that the cycle length for stock sheep numbers and lambs prices has decreased over time. The cycle length for stock sheep numbers is a 10-year cycle and for lamb prices is a 10-year cycle. The investigation of lamb prices included the seasonal pattern. They found that the nature of sheep cycles had been statistically changed over time because of major changes that occurred in the late 1940's to the early 1950's, and the late 1960's to early 1970's. The first change was in response to World War II, when wool prices were frozen, wool was restricted, synthetic fabrics were development, and fashion changed. The second change was in response to inflationary pressure, the oil embargo, and meat price controls.

Simulation Models

Various studies have used simulation models to investigate different aspects of sheep production, including economic evaluation of biological traits. The advantage of using this approach is the flexibility to change of the various inputs and detailed outcomes because of the number of factors that can be included. The problems in using modeling is that certain aspects of sheep production are difficult to quantify, such as labor and prices of inputs. Harris and Neuman (1994) found that the use of simulation models resulted in a detailed understanding of the common boundaries between breeding and production. They found that the choice of lambing season was affected by various factors, such as labor availability, cost and availability of feeds, facilities, cash flow, other agricultural enterprises on the farm, and market lamb prices. Levine et al. (1978) used a grazing simulated model to estimate ewe and lamb feed requirements. Thonney et al. (1979) used models to evaluate management alternatives; components of the model were costs associated with feed, labor, equipment, facilities, and interest on operating capital.

Economic Comparison of Biological Traits

There is a small number of studies that put economic values to comparisons of biological traits, such as prolificacy and growth. Ponzoni (1988) derived economic values for biological traits, but pointed out that the same product can be valued differently according to the items that are included as costs. Saoud and Hohenboken (1984) suggested that various factors, such environmental conditions and parasites, may affect breed types differently with in the same system and may cause problems when comparing production systems. Many studies exclude variable such as labor and stocking rates which may vary by breed and production level. This results in inaccurate economic values placed on various biological traits, and invalid conclusion in comparisons of different systems.

Biological efficiency can be indicated by pregnancy rate and lambing rate, percentage lamb crop weaned per ewe exposed, and economic efficiency that can be measured by cost of production per weight of live animal marketed, net return per ewe, net return to the ewe enterprise, and return on investment (Gutierrez et al. 1991). Factors that affect biological and economic efficiency include interrelationships between cost of production, ewe fertility, breeding soundness of ram, flock replacement rate, environment, labor quantity and quality, producers management skills, and market price. These can be analyzed by using a break-even approach where total receipts are equated to total costs for a given level of production.

The efficiency of a sheep operation can be measured by using gross margins and the return on working capital (Kilkenny and Read, 1974). The factors that affect gross margins for land are gross output per ewe, flock replacement costs, feed and forage costs, and stocking rate. Gross output per ewe is an important factor that directly affects gross margins of the flock and can be increased by increasing the number of lambs sold through changes in number of lambs born, barren ewes, prelambing ewe deaths, prenatal lamb deaths, and later lamb deaths. Tolman (1993) found that in various studies, variation among ewes in gross income was more important than variation in costs in the explanation of difference in net revenue among ewes. Parker (1986) states that the most important factor affecting profitability of sheep production is number of lambs marketed annually per ewe.

Saunderson and Vinke (1935) conducted a study to evaluate the economics of range sheep production in Montana. The areas that were investigated were topography, soils, and climate within Montana, the vegetation in the different regions of the state, the ownership of the land (private, public, or rented), the size of the ranches in terms of sheep numbers (1,000 to over 7,500 ewes), breeding practices, breeds of sheep, nutritional management, management practices, and health practices. Along with these investigations, three ranches were used as case studies to go into depth on these various issues. Useful standard budgets could not have been developed without these investigations into the various aspects that make up sheep production.

Tolman (1993) found that lambs marketed per ewe exposed was greatest in the spring at 1.75, followed by the winter with 1.34, and, lastly, the fall with 0.96 for 1/4 Finnsheep genetics. Increasing the number of lambs marketed per ewe will increase the efficiency of the ewes in the flock, resulting in increase farm profits. Levine et al. (1978) used a simulation model to investigate net return per ewe. They found returns per ewe above feed costs were $11.95 in 1973 and $2.11 in 1994 for Columbias and $13.18 in 1973 and $3.12 in 1974 for Suffolks. Net returns per ewe above feed, variable costs for labor, depreciation, and interest were $8.09 in 1973 and $-1.03 in 1974 for Columbias and $9.62 in 1973 and $0.46 in 1974 for Suffolks. The net return for land per acre was $38.32 in 1973 and $-4.87 in 1974 for Columbias and $38.95 in 1973 and $1.86 in 1974 for Suffolks.

Budgets

Warnock and Carkner (1995) developed budgets with costs and returns for sheep enterprises with lambing in February of 50- or 200-ewes for use in farm management decisions involving financing, profit planning, and marketing. In this study, operating assumptions were made on labor (by owner or operator only), price of hay ($75.00/ton), grazing costs ($2.50 per ewe per month), interest on investment and operating capital (10%), prices for all items needed is from the previous year (1994), and number of animals. Total return per ewe were $108.57 in the 200-ewe flock and $110.85 in the 50-ewe flock. Total costs per ewe were $87.75 in the 200-ewe flock and $92.43 in the 50-ewe flock. The break-even lamb price to cover total costs was basically the same for both systems (0.48 for the 200-ewe flock and 0.49 for the 50-ewe flock). Return to operator's labor, management, land, and risk per ewe was $20.82 for the 200-ewe flock and $18.43 for the 50-ewe flock.

Epplin et al. (1983) did a comparison of costs and return from sheep for alternative management systems, lambing times, and flock sizes. Several assumptions were made regarding lambing rates, rates of gain, and cost of lamb production. They found that the intensive-care systems required 30% more investment per ewe than easy-care system because of additional equipment needed. The intensive-care system produced 17% more pounds of lamb per ewe than the easy-care system. The winter lambing system generated 45% more lamb production per ewe than the fall lambing system. Operating costs (excluding feed and labor) were 3% more for the intensive-care system than for the easy-care system and were 6% more for the winter lambing system than for the fall lambing system. Total gross receipts per ewe were 16% greater for the intensive-care system than the easy-care system, and 35% greater for the winter lambing system than the fall lambing system. The smaller flock (25) fit the easy-care system better, while large flocks (500) fit the intensive-care system best, but for average size flock (150) the results were mixed. The intensive-care system suited the winter lambing system best while the fall and summer lamb systems were best suited to the easy-care system.

Budget Income Sources

A budget consists of cash income and cash expenses. Cash income is from the sale of livestock which include the feeder or market lambs, culled ewes and rams, and wool. Cash expenses are from the supplies that are needed to maintain and grow the livestock, which include feed, minerals and vitamins, health supplies, pasture costs, replacement ram costs, shearing costs, taxes, marketing and hauling costs, labor costs, facilities and fencing costs, and machinery costs.

Umberger and McKinnon (1995c) determined that the annual receipts per ewe (income) for a fall lambing system in Virginia were $110.00 for a 125% lamb crop, $124.00 for a 140% lamb crop, and $142.00 for a 160% lamb crop. Umberger and

McKinnon (1995b) determined that the annual receipts per ewe (income) for a winter lambing system in Virginia is $110.00 for a 125% lamb crop, $133.00 for a 150% lambs crop, and $156.00 for a 175% lamb crop. Umberger and McKinnon (1995a) determined that the annual receipts per ewe (income) for a spring lambing system in Virginia were $91.00 in a 120% lamb crop, $104.00 in a 140% lamb crop, $116.00 in a 160% lamb crop, and $129.00 in a 180% lamb crop. This demonstrates the seasonal differences in expenses per ewe. Tolman (1993) found total revenues per ewe with 1/4 Finnsheep genetic of $83.73 for a fall lambing system (total variable cost of $80.30), $115.35 for a winter lambing system (total variable costs of $94.24), and $111.90 for a spring lambing system (total variable costs of $72.00).

The value assigned to income sources, such as wool or lambs, is done in various way, Tolman (1993) found that some studies assigned current values, others used the previous year's prices, and others used averages over a several years. Thonney et al. (1979) found that within lambing season, net income increased as lambing percentage increased (125 to 175%). With increased number of lambs, the market weight decreased and feed, labor, and interest costs increased, but this did not reduce overall profits.

Lamb prices follow a seasonal pattern from year to year. Income is positively related to the price of lambs and a 1% increase in disposable income results in a .21% increase in the retail lamb price (SID, 1992). The seasonal pattern can be seen in figure 5, the yearly trends can be seen in figure 6, and prices from 1988 to 1997 by month can be seen in figure 4. The peak monthly prices for lambs occur in March to May, and the lowest prices are in September to November. The yearly averages prices for market lambs has increased from $55.00 per cwt to $97.00 in 1996. The monthly price of market lamb has increased since 1994.

Ewe replacement cost vary depending on the production system. Kilkenny and Read (1974) found that the average flock replacement costs were 34% of the direct (variable) costs. The number of replacement ewes varies from 13 to 20% (Thonney et al, 1979; Eracnbrack and Knight, 1989; Umberger, 1996). The average replacement cost for a ram is $350.00 and the average replacement cost for a ewe is generally 10% over market price (Umberger and McKinnon, 1995a; Umberger and McKinnon, 1995b; Umberger and McKinnon, 1995c; Virginia farm management budget, 1997). The replacement rate for a flock is 15 to 20% ((Umberger and McKinnon, 1995a; Umberger and McKinnon, 1995b; Umberger and McKinnon, 1995c).

Budget Expense Sources

Various studies determine the cost per ewe in different production system. A study was done in North Dakota to determine which factors influenced profitability. Seventy-seven producers were interviewed. The total annual cost per ewe was $48.42 ($40.07 were variable costs and $8.35 were fixed costs) (Brignone et al., 1977). Gerrish (1993) found that the gross margin per pound was larger with spring lambing than winter lambing. The break-even price for winter lambing is 79 cents/lb and for spring lambing is 44 cents/lb. The production costs (including land, ownership of ewe, and variable inputs) in total cost per ewe was greater in the winter lambing system with $149.30 as compared to $64.24 for the spring lambing system.

Umberger and McKinnon (1995c) determined that the annual cost per ewe for a fall lambing system in Virginia was $72.00 for a 125% lamb crop, $75.00 for a 140% lamb crop, and $79.00 for a 160% lamb crop. Umberger and McKinnon (1995b) determined that the annual cost per ewe for a winter lambing system in Virginia is $84.00 for a 125% lamb crop, $88.50 for a 150% lambs crop, and $95.00 for a 175% lamb crop. Umberger and McKinnon (1995c) determined that the annual cost per ewe for a spring lambing system in Virginia was $60.00 in a 120% lamb crop, $62.00 in a 140% lamb crop, $63.50 in a 160% lamb crop, and $65.00 in a 180% lamb crop. This demonstrates the seasonal and lambing crop differences in expenses per ewe.

There are inconsistencies in the way labor is accounted for in among economic evaluations. Labor is a continuous flow of inputs. Many studies do not include labor costs in their determinations of net profit. Alderfer (1995) found that Minnesota sheep farmers allocated more than half their labor to feed and grazing. The largest segment of farm employment in Virginia is self-employed owner-operators (54.2%), with 28% hired labor and 16.9% unpaid labor (VA Ag. Stat. 1995). Figure 11 displays the Virginia average farm wage rate from 1976 to 1997, which have increased over time from $2.20 in 1976 to $6.58 in 1997. The unpaid labor segment is large and difficult to evaluate in budget systems and is often overlooked or ignored. Shapouri (1991) studied sheep producers in 11 western states as assigned costs to unpaid labor; total cash receipts for unpaid labor (2.1/hr) from 1972 to 1989 went from $4.12 to $8.20.

Labor is used for feeding, care of ewe, lambing, care of newborns, and care of sheep on pasture. Labor is often measured in hours per ewe per year. Man-hours of labor represents the amount of work completed by one adult man in one hour. Shapouri (1991) found that labor was the highest at 3.44 hours per ewe per year in the Pacific regions and the lowest in Texas with 1.57 hours per ewe per year. The labor per year is affected by the production season in Virginia. The winter system requires an estimated 3.20 hours per ewe per year (figure 12), the fall system requires an estimated 3.05 hours per ewe per year (figure 13), and the spring system requires an estimated 3.30 hours per ewe per year (figure 14) (Gill et al., 1984).

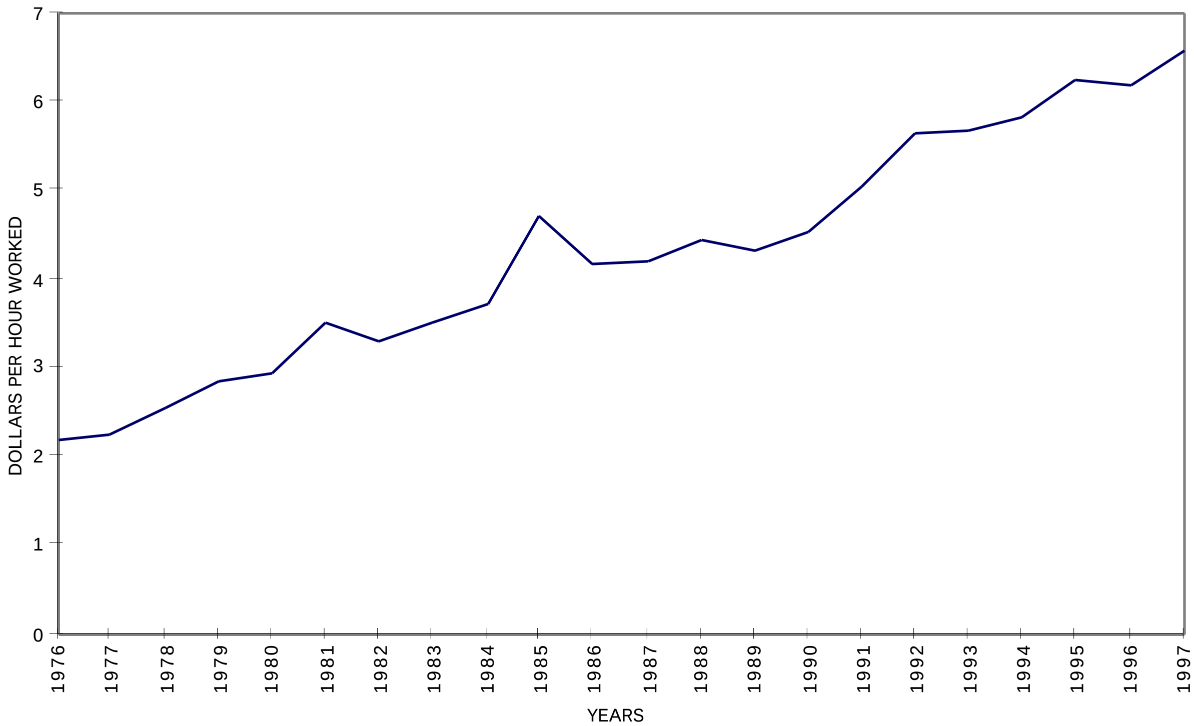

Figure 11. Virginia livestock farm wage rates from 1976 to 1997

The efficiency of labor depends not only on the skills and training of the labor force, but also on other factors, such as the size of the farm enterprise, and amount of mechanization. Because of this, it is unwise to make comparisons of labor efficiency on different types and sizes of farms. The type of operation will effect labor needs and efficiency. Brignone et al., (1977) found that the producers with the highest profits had the lowest man hours per ewe and that smaller sheep producers experienced a negative return for labor and management. Epplin et al. (1983) found that intensive care systems required 25% more labor per ewe than easy care systems. Thonney et al. (1979) found that the time of lambing and lambing percentages Affected labor requirements; as lambing percentages increased, so did labor requirements. Alderfer (1995) found that as the number of ewes increased, the number of minutes required per ewe decreased.

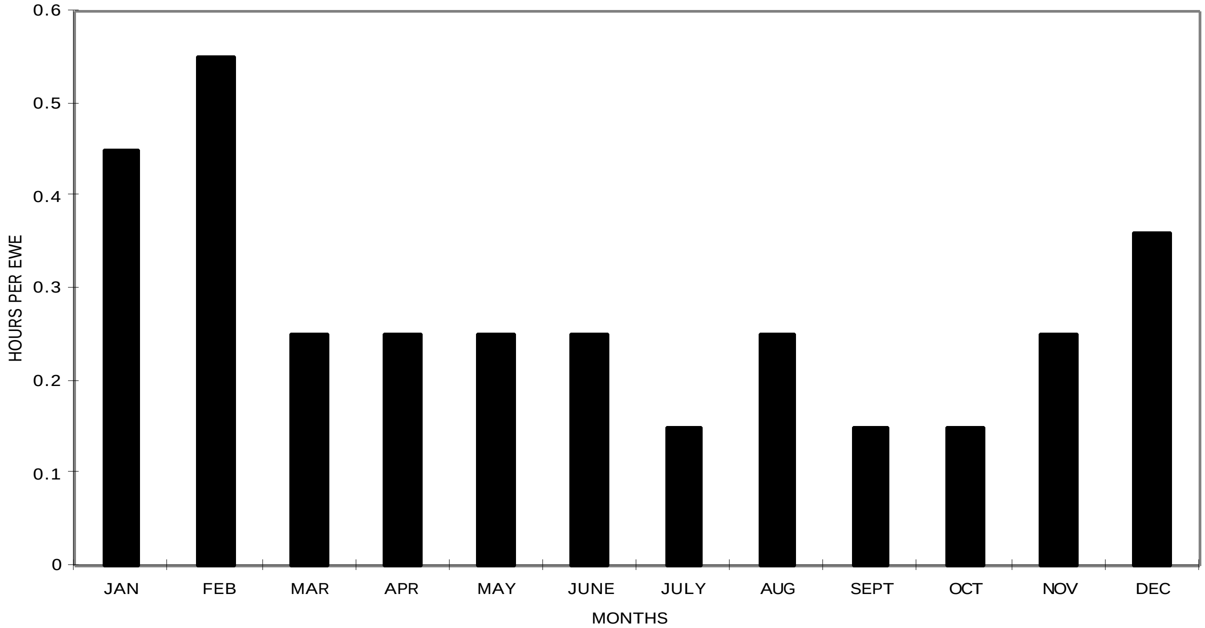

Figure 12. Hours required per ewe with a winter lambing schedule

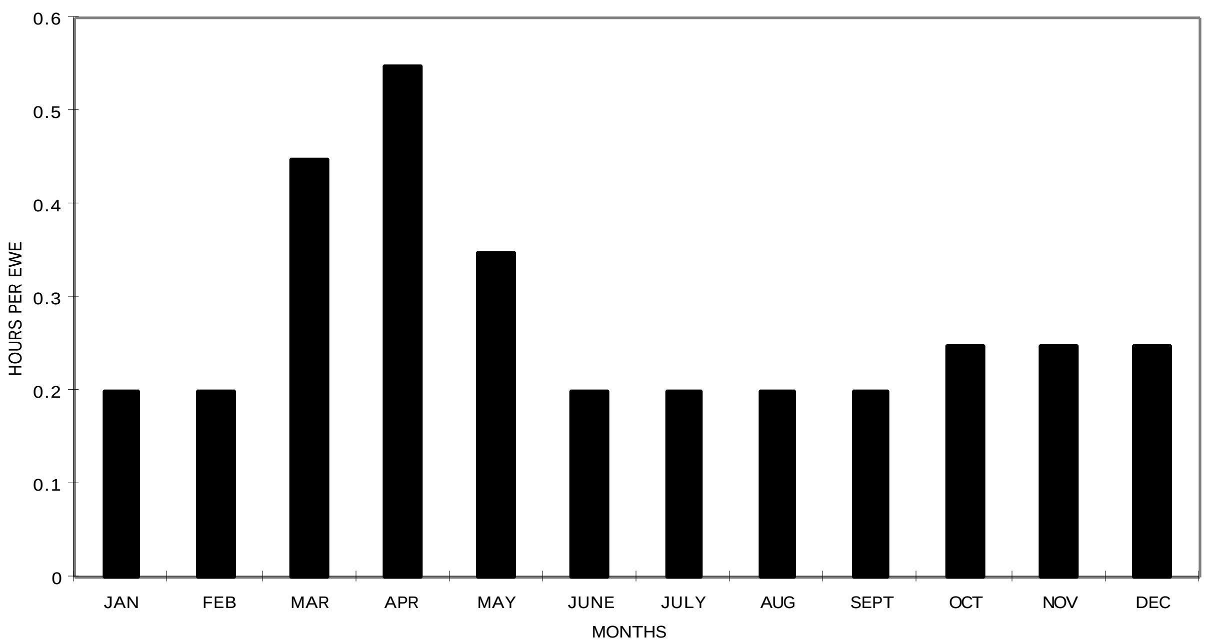

Figure 13. Estimated hours required per ewe with a fall lambing schedule

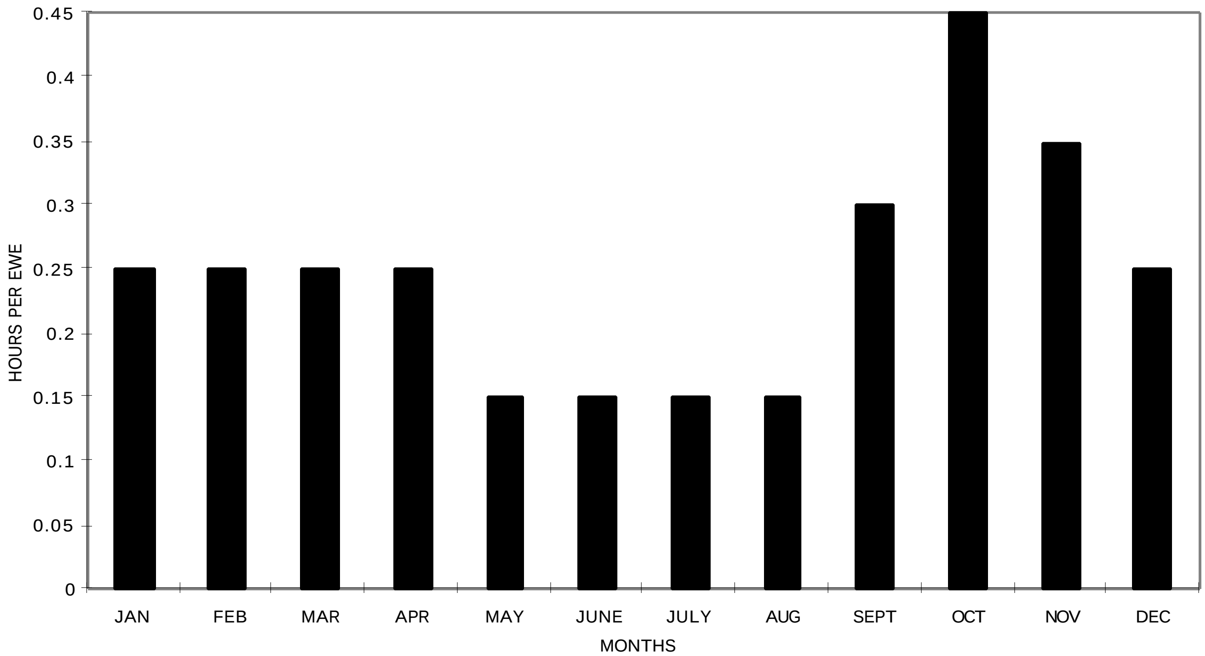

Figure 14. Estimated hours required per ewe with a spring lambing schedule

Feed and forage costs vary depending on the system used in a specific sheep operation. Brignone et al.(1977) found that 84% of the total variable cost were from feed, pasture and labor, and feed cost were found to be the most important factor affecting profitability . Warnock and Carkner (1995) also found that feed represents over 80% of the total annual cash operating costs in raising sheep. Kilkenny and Read (1974) found that feed and forage costs accounted for only 53% of the direct cost of production in Britain, which is considerably lower than in other studies. In the production of lambs, approximately 70% of the feed required to produce a lamb is consumed by the ewe, so it is important to keep annual ewe maintenance cost reduced by spreading it over more or larger lambs (Gutierrez et al. 1991).

Thonney et al. (1979) estimated feed cost through simulation models by estimating digestible energy requirements for different stages of production and prices of different feeds. They found that the profitability in different lambing season was influenced by feed costs. Saoud and Hohenboken (1984) estimated feeds cost by using ME requirements based on ewe weights and productivity. Barr et al. (1968) investigated effect of lambing season and found net income per ewe exposed was 77% less in fall lambing systems than spring lambing systems, even with higher numbers of lambs marketed, because of high grain consumption in the fall lambing system (201 lb of grain in fall and 68 lb of grain in spring).

Cacho et al. (1995) developed a farm management model of sheep grazing systems, with the objective of implementing a simple pasture production model that interacts with grazing animals and also takes into consideration the seasonal changes in forage production. They considered reproductive performance, including conception rates and liveweight changes for multiple ovulations, animal death rates, stocking rate, growth of lambs, and number of lambs when investigating a pasture production system.

Umberger et al. (1986) created a budget for feeding lambs where total receipts per lambs were $84.12 and total expenses per lamb were $80.54, so profit per lambs was $3.58 and the break-even price was $0.67/lb. Warnock and Carkner (1995) in Central Washington developed budgets and found that total feed costs per ewe were $64.20 in a flock of 200 ewes and $65.68 for a flock of 50 ewes. Tolman (1993) found that stockpiled fescue had a total cost per acre of $34.30 and a cost per ewe at a stocking rate of 5.7 ewes per acre of $6.02. She found that a perennial grass and legume pasture cost $12.05 per acre and the cost per head depended on the stage of production of the ewe. The estimated costs per acre were established by Neuman et al. (1995) at $146.29 for tall fescue, $153.25 for orchardgrass, $159.97 for ladino and orchardgrass or tall fescue.

Because of the small size and geographical disbursement of sheep farms, transportation is becoming an increasingly important factor. The result is an increased transportation cost for the production of sheep. This has also resulted in an increased marketing options, such as public marketing, graded sales, electronic marketing, and direct marketing for sheep producers, which may affect prices of lambs.

Chapter 3: Materials and Methods

Ewe Performance

The simulation model represented a sheep farm in the mountains of Virginia, with 50 ac of permanent and tall fescue pasture. Acreages of permanent pasture and tall fescue were determined by the needs of the three lambing systems. The forage species in the permanent pasture were tall fescue, Kentucky bluegrass, orchardgrass, ladino clover, and white clover (Chappell, 1993; Umberger, 1994; White and Wolf, 1995). Three lambing systems were investigated: spring, fall with winter clean-up, and high-fertility fall (without winter clean-up). The high-fertility fall lambing assumes ewes and ewe lambs producing at a high fertility rate. Production calendars for each lambing season are shown in table 1. Fall lambing ewes were not flushed with grain because the quality of forage was high enough to flush the ewes. Winter clean-up ewes were not flushed because only a proportion of the ewes exposed in August were expected to be open. After the winter clean-up ewe's lambs were weaned, the ewes rejoined the fall lambing system ewes on March 18.

All three lambing system were assumed to use 1/2 Dorset, 1/4 Finnsheep and 1/4 Rambouillet ewes (Al-Shorepy and Notter, 1996) crossed with Suffolk rams. The average weight of the ewes was assumed to be 154 lb, and the average weight of ewe lambs at breeding was assumed to be 88 lb (Notter and McClaugherty, 1991). A mean body condition score of 6 on a 9-point scale was assumed for all lambing systems (Notter and McClaugherty, 1991). The replacement rate for ewes was 20%/yr (Umberger, 1995).

In spring lambing, there was a 51-d breeding season. Seventy percent of the adult ewes were bred in the first cycle, 18% were bred in the second cycle, and 6% were bred in the third cycle. Total fertility of adult ewes was 94% (Notter and Copenhaver, 1980a; Tolman, 1993). For ewe lambs in spring lambing, 30% were bred in the first cycle, 30%

were bred in the second cycle, and 13% were bred in the third cycle. The total fertility rate was 73% for ewe lambs (Notter and Copenhaver, 1980a; Tolman, 1993). Prolificacy (lambs born per 100 ewes lambing) in spring lambing was assumed to average 226% for ewes and 125% for ewe lambs. Proportions of ewes and ewe lambs with single, twin, and triplet births are shown in table 2.

TABLE 1. PRODUCTION CALENDARS FOR EACH LAMBING SEASON

	Lambing season		
Stage of production	Spring	Fall	Winter
Flushing	Sept. 17 to Oct. 14	No flushing	No flushing
Breeding	Oct. 15 to Nov. 20	Apr. 1 to May 21	Aug. 1 to Aug. 31
Early gestation	Nov. 21 to Feb. 11	May 22 to Aug. 12[a]	Sept. 1 to Nov. 30
Last 4 wks of gestation	Feb. 12 to Mar. 11	Aug. 13 to Sept. 9	Dec. 1 to Dec. 31
Early lactation	Mar. 12 to May 31	Sept. 10 to Nov. 30	Jan. 1 to Mar. 14
Late lactation	June 6 to July 31	Dec. 1 to Dec. 31	No late lactation
Maintenance	Aug. 1 to Sept. 16	Jan. 1 to Mar. 31	Mar. 15 to Mar. 17[b]

[a] Nonpregnant ewes move to winter lambing schedule on August 1
[b] Winter ewes return to the fall lambing schedule on March 18

Fall lambing also used a 51-d breeding season. Table 3 shows fertility and prolificacy of ewes in fall lambing (Notter and Copenhaver, 1980a; Tolman, 1993). The winter clean-up lambing used a 31-d breeding season. Prolificacy in fall lambing with winter clean-up was assumed to average 170% for ewes and 100% for ewe lambs in fall lambing. Prolificacy in high-fertility fall lambing was assumed to average 200% for ewes and 129% for ewe lambs. The increased prolificacy in the high-fertility fall lambing was due to genetic selection for a period of 9 years. Table 4 shows fertility and prolificacy of ewes in winter lambing (Notter and Copenhaver, 1980a; Tolman, 1993). Prolificacy was assumed to average 198% for ewes and 133% for ewe lambs in winter lambing.

TABLE 2. FERTILITY AND PROLIFICACY IN SPRING LAMBING

Item	Ewes	Ewe lambs
Fertility (%):		
Cycle 1	70	30
Cycle 2	18	30
Cycle 3	6	13
Overall	94	73
Prolificacy:		
% Singles	0	75
% Twins	74	25
% Triplets	26	0

TABLE 3. FERTILITY AND PROLIFICACY IN FALL LAMBING

	Ewes		Ewe lambs	
Item	Normal fertility	High fertility	Normal fertility	High fertility
Fertility (%):				
Cycle 1	55	70	0	30
Cycle 2	13	18	5	30
Cycle 3	2	6	10	13
Overall	70	94	15	75
Prolificacy:				
% Singles	50	16	100	71
% Twins	30	68	0	29
% Triplets	20	16	0	0

Nutritional requirements for ewes in each stage of production were assumed to be the same in all three systems, except during lambing, the last 4 weeks of gestation, and lactation, when numbers of single and twin lambs affected requirements. Ewes were assumed to suckle no more than two lambs. Surplus lambs were assumed to be artificially reared. Also, fall and winter clean-up ewes were not flushed. Table 5 shows daily nutrient requirements per ewe for the different stages of production (NRC, 1985). Winter clean-up ewes went directly from early lactation to maintenance and spent no time in late lactation before returning to the fall lambing system.

TABLE 4. FERTILITY AND PROLIFICACY IN WINTER LAMBING

Item	Ewes	Ewe lambs
Fertility (%):		
Cycle 1	50	30
Cycle 2	25	30
Overall	75	60
Prolificacy:		
% Singles	33	67
% Twins	38	33
% Triplets	29	0

TABLE 5. DAILY TDN REQUIREMENTS OF EWES

	TDN, lb	
Stage of production	Ewes	Ewe lambs
Flushing	2.30	2.30
Early gestation	1.70	1.80
Last 4 wks of gestation:		
Twins	2.80	2.30
Single	2.30	2.20
Early lactation:		
Twins	4.00	3.50
Singles	3.60	3.10
Late lactation:		
Twins	3.60	3.60
Single	2.30	2.30
Maintenance	1.50	1.50

Forage Production

A forage budget were developed which contained monthly DM and TDN production for tall fescue and permanent pasture, pasture utilization values, and acres of permanent pasture and tall fescue. Permanent pasture was assumed to contain 38.8% bluegrass and white clover, 22.4% ladino clover and tall fescue, and 38.3% ladino clover and orchardgrass (Chamblee et al., 1995a; White and Wolf, 1995). Tall fescue pasture was stockpiled for winter grazing. Pasture utilization by sheep was assumed to be 70% (White, 1996). From March to July, a 2-week lag between daily DM growth and consumption of the forage was assumed (Chamblee et al., 1995a). Permanent pasture received 100 lb of nitrogen fertilizer in a split application of 60 lb in February and 40 lb in August (USDA, 1988; Chamblee et al., 1995a). Carryover losses of DM and TDN when forage from permanent pasture was not consumed in the month in which it was produced were assumed to be 20% between April and May, 15% between June and July and between July and August, and 5% between September and October. Carryover tall fescue losses were assumed to be 20% between April and May and 10, 15 and 20% for stockpiled fescue consumed in November, December, and January, respectively (Fribourg and Bell, 1984).

Assumed DM production per acre per month for different forages are shown in table 6 (USDA, 1988; Chamblee and Green, 1995). Total DM production per year of the various forages were, 3,722 lb/acre/year for bluegrass and white clover, 6,037 lb/acre/year for ladino clover and tall fescue, and 6,041 lb/acre/year for ladino clover and orchardgrass. The annual DM production for the composite permanent pasture was 5,150 lb/acre/year. Sheep did not begin grazing permanent pasture in spring until April 1 because they would damage any limited growth present in January, February, and March.

The TDN production per acre per month for the different forages are shown in table 7 (Blaser et al., 1969; Buckner, 1985; Carlson et al., 1985; Duell, 1985; Jung and Baker, 1985; USDA, 1988; Chamblee et al., 1995b; Chamblee and Green, 1995; Wolf and White, 1995). The TDN content of DM was 69 to 72% for bluegrass, 58 to 68% for orchardgrass, 59 to 70% for tall fescue, and 66 to 75% for ladino clover (Church and Pond, 1982; NRC, 1985; Church, 1986; SID, 1992). The TDN production per year of the various forages was 6835 lb/acre/year of bluegrass and white clover, 6037 lb/acre/year of ladino clover and tall fescue, and 6041 lb/acre/year of ladino clover and orchardgrass. The TDN annual total was 3543 lb/acre/year for permanent pasture of various percentages of various forages.

TABLE 6. MONTHLY DM PRODUCTION OF VARIOUS FORAGES

	Forages (lb of DM) available for sheep consumption			
Month	BG/WC[a]	LC/ F[b]	LC/OG[c]	Composite pasture[d]
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	570	1410	1440	1096
May	837	1457	1457	1226
June	900	870	930	905
July	558	403	527	511
August	248	372	558	397
September	240	510	420	370
October	279	651	527	459
November	90	240	120	135
December	0	124	62	52

[a] bluegrass and white clover
[b] ladino clover and tall fescue
[c] ladino clover and orchardgrass
[d] Composite pasture consists of 38.8% bluegrass and white clover, 22.4% ladino clover and tall fescue, and 38.8% ladino clover and orchardgrass

TABLE 7. MONTHLY TDN PRODUCTION OF VARIOUS FORAGES

Month pasture[d]	Forages (lb of TDN) available for sheep consumption BG/WC[a]	LC/ F[b]	LC/OG[c]	Composite
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	411	1015	1036	789
May	620	104	1049	883
June	621	601	642	625
July	363	262	343	332
August	153	231	347	246
September	146	316	261	229
October	184	443	359	310
November	61	167	85	94
December	0	88	44	37

[a] bluegrass and white clover
[b] ladino clover and tall fescue
[c] ladino clover and orchardgrass
[d] Composite pasture consists of 38.8% bluegrass and white clover, 22.4% ladino clover and tall fescue, and 38.8% ladino clover and orchardgrass

The DM and TDN production per acre per month for tall fescue are shown in table 8 (Blaser et al., 1969; Buckner, 1985; USDA, 1988; Chamblee and Green, 1995; Chamblee et al., 1995b; White, 1995). Tall fescue was grazed from April 1 to July 31 and then stockpiled from August 1 to November 15. Animals grazed stockpiled fescue from November 15 until January 31 or until it was used up. Tall fescue had 200 lb of nitrogen fertilizer added in a split application of 120 lb in February and 80 lb in August. Total DM production was 6,410 lb/acre/ year and total TDN production was 4,285 lb/acre/year. Total production of stockpiled tall fescue from August to January was 2,756 lb of DM and 1,778 lb of TDN.

TABLE 8. MONTHLY DM AND TDN PRODUCTION OF TALL FESCUE

	Tall Fescue (lb/ac) available for sheep consumption	
	DM	TDN
Month	Monthly	Monthly
January	699	419
February	0	0
March	0	0
April	1230	834
May	1302	911
June	750	495
July	372	267
August	0	0
September	0	0
October	0	0
November	1013	668
December	1046	691

Hay was harvested when nutritional requirements of the sheep flock were met and there was sufficient unused forage to justify production of hay. During harvesting of hay, 10% of DM was assumed lost because of leaf shattering and other harvesting losses (Church and Pond, 1982; Mueller et al., 1995; Wahlberg, 1995). Losses of 6% occurred during hay storage; in this simulation model, the hay was assumed stored in a barn (Church, 1986; Collins et al., 1987; Ensminger, 1992; Harrigan and Rotz, 1992; Huhnke, 1987; Wahlberg, 1995). A 10% hay loss occurred during feeding (Anderson and Mader, 1985; Belyea et al., 1985; Ensminger, 1992; Harrigan and Rotz, 1992; Wahlberg, 1995). Total losses in hay were thus 26% of total DM.

Concentrates, such as corn and soybean oil meal (SBOM), were fed to ewes when forages or hay did not meet their nutritional requirements. Concentrate requirements are shown in table 9 (Church and Pond, 1982; Church, 1986; Umberger, 1995). The TDN for corn was assumed to be 89% of DM and the TDN for SBOM was assumed to be 81% of

DM (Church and Pond, 1982; Church, 1986). Sheep during early lactation were assumed fed a concentrate supplement of corn and SBOM that was 15% CP.

TABLE 9. REQUIREMENTS (LB/HD/D)FOR CORN AND SBOM FOR EWES IN DIFFERENT LAMBING SYSTEMS

	Stages of production and supplementation					
	Flushing	Last 4 wks of gestation	Early lactation			
			Nursing singles		Nursing twins	
Lambing System	Corn	Corn	Corn	SBOM	Corn	SBOM
Spring:						
(Dates)						
(9/17 - 10/14)(14d)	1.00					
(2/12 - 3/11)(28d)		1.00				
(3/12 - 4/30)(81d)			.80	.20	1.60	.40
Fall:						
(8/13 - 9/9)(28d)		1.00				
Winter:						
(12/1 - 12/31)(31d)		1.00				
(1/1 - 3/15) (74d)			.80	.20	1.60	.40

Lamb Growth

Birth weights were 7.06 lb, 8.16 lb for twin lambs, and 9.79 lb for single lambs and were derived from Notter and Copenhaver (1980b) and from records of Polypay flocks in the National Sheep Improvement Program, (D. R. Notter, unpublished data) for triplets lambs. Death losses were assumed to be, 20% for triplets, 10% for twins, and 8% for singles (Notter and Copenhaver, 1980b; Cochran et al., 1984; Notter et al., 1991). All death losses were assumed to occur at or shortly after birth. Lamb production calendar for the lambing systems is shown in table 10.

TABLE 10. LAMB PRODUCTION CALENDAR FOR EACH LAMBING SEASON

	Lambing seasons		
Item	Spring	Fall	Winter
Born	3/12 to 5/1	9/10 to 10/29	1/1 to 1/31
Weaned	7/31	12/31	3/15
Sold	8/31 to 12/31	2/28 to 4/30	5/31 to 6/30

A lactation curve for 120 d of lactation was created for ewes suckling single and twin lambs (figure 15); (Torres-Hernandez and Hohenboken, 1980b; Blackburn and Cartwright, 1987; Rhind et al., 1991), and used to predict growth rates of suckling lambs. Ewes suckling twin lambs produced an average of 25% more milk than ewes suckling single lambs

Spring lambs were born between March 12 and May 1, fall lambs were born between September 10 and October 29, and winter lambs were born between January 1 and January 31. For spring and winter lambs, growth rates were derived from Notter and McClaugherty (1991b). For fall lambs, growth rates were obtained from growth of lambs managed on fescue with no creep feed (D. R. Notter, unpublished data). The TDN for maintenance and gain required for single and twin lambs was calculated based on expected growth rates and predicted energy densities of gain (CAB, 1980). Energy density (ED) of gain was calculated for lambs of medium to large frame size and averaged across ewe and wether lambs (CAB, 1980). Lambs were categorized during lactation into age period of 1 to 17, 18 to 34, 35 to 60, 61 to 90, and 91 to 120d. Mean growth rates and nutrient requirements for singles and twins were simulated for each interval. The TDN requirements for the lambs during lactation were assumed met with milk, creep feed and/or forage, depending upon the lambing season.

To predict growth rates and nutrient requirements of young suckling lambs, both ARC and NRC recommendations were used (CAB, 1980; NRC, 1984). Nutrients from milk were assumed to first be used to meet maintenance requirements of the lambs; excess nutrients from milk were then used for gain. Gross energy of ewe's milk was assumed to be .480 Mcal/lb (CAB, 1980). The digestibility of milk gross energy at maintenance was 95% (CAB, 1980). The efficiency of ME use from milk for maintenance(k_m) was 85% (CAB, 1980). The predicted NE requirement for maintenance of milk-fed lambs was .35(W/1.05) ** .75 (CAB. 1980). This equation was used for lambs that were less than 35d old. The predicted NE for maintenance for the ruminant lambs was .251(W/1.08) **. 75 (CAB, 1980). This equation was used for lambs that were more than 60d old. For lambs between 35 and 60d of age, NE for maintenance was predicted as the average of values for milk-fed and ruminant lambs. By 90d, the available milk did not meet the lambs' maintenance requirements, so forage or creep feed were used to meet the requirements. The digestibilities of different forages are shown in table 11. The ME requirement from forage or creep feed was calculated as NE/km, TDN requirements were calculated as ME/15.06 (assuming a constant 1.62 Mcal of ME/lb TDN), and DM requirements were calculated as TDN divided by the digestibility of forage DM.

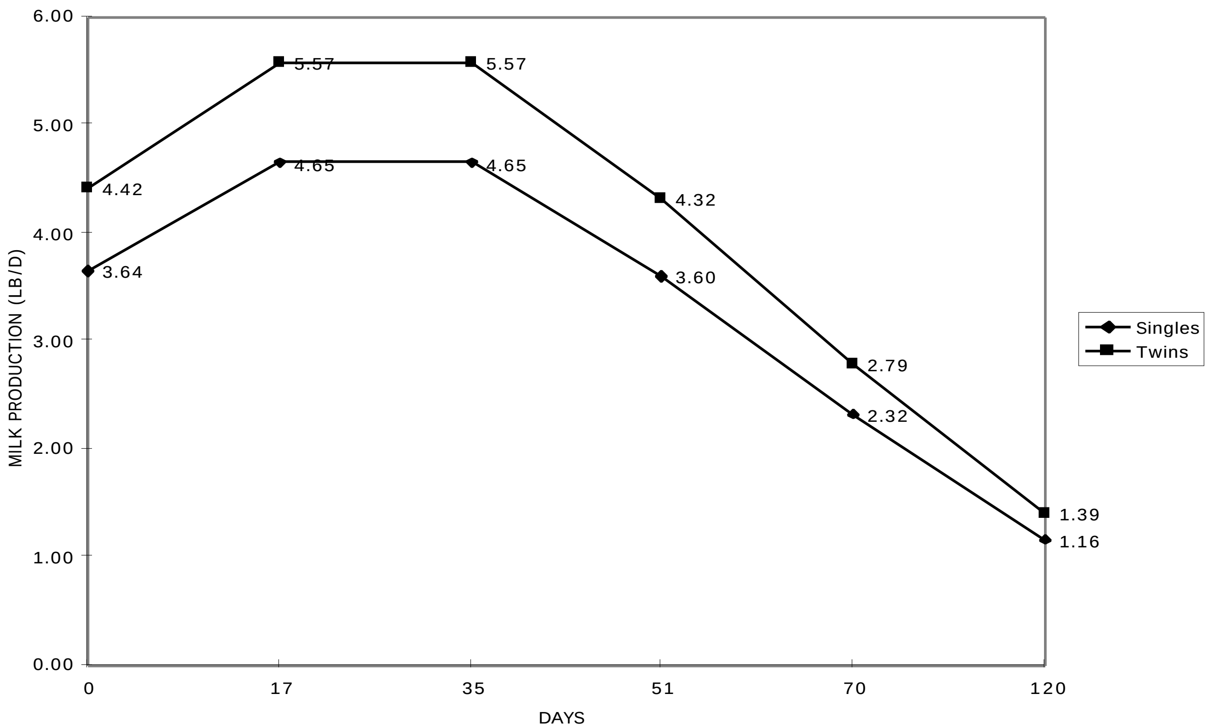

Figure 15. Lactation curve for ewes suckling single and twin lambs

The energy density of lamb gain was first calculated for twins lambs as an average of values for ewes and wether lambs and adjusted for frame size. The equation for milk-fed lambs (less than 35/d old) was ED = (4.635 + .405W) * .925, where .925 was used to adjusted to a larger frame size than that typical of lambs described by ARC (CAB, 1980; NRC, 1984). The predicted ED of ruminant lambs (over 60/d old) was ED = (3.250 + .385W) * .925. At 35 to 60d, the ED of gain was an average of milk-fed and ruminant values. For single lambs, the ED was assumed to be proportional to their increased body weight relative to twin lambs of the same age: ED = [(single wt.)/(twin wt.)] * (twin ED). This adjustment allowed for a higher energy density at the same body weight in the more rapidly growing single lambs.

Growth rates of the single and twin lambs were set assuming the body weight of singles was 25% greater than that of twins at 60/d. Between 60 and 90d, singles were assumed to gain 10% faster than twins. Between 91 to 120/d, gains of single and twins were basically the same, but the twin and single lambs consumed different amounts because of differences in maintenance requirements and ED.

Requirements for gain (Mcal/d) was calculated as the product of gain (lb/d) and energy density (Mcal/lb). Milk NE above that required for maintenance was first used to meet NE requirements for gain assuming a digestibility of milk GE for gain of 93% and an efficiency of milk ME for gain (k_f) of .70. Additional requirements for gain were then assumed met from forage or creep feed using k_f values in table 11. The ME required gain from forage or creep feed was than converted to TDN assuming 1.64 Mcal ME/lb TDN and then to DM using values in table 11 (NRC, 1984).

Twin lambs were assumed to began consuming forage or creep feed between 18 to 34/d of age, but single lambs did not begin forage until between 35 to 60/d of age. The forage DM that the lambs consumed was assumed to be 65% digestible DM, except during late summer (July and August) where forage DM was assumed to be 61% digestible (Church, 1986; Chamblee and Green, 1995). Figures 16, 17, and 18 show predicted growth curves for spring, fall, and winter lambs.

Before weaning, lambs were further categorized into three birth groups: early lambs, middle lambs, and late lambs (only early and late for winter lambing). The ADG during lactation for each lambing systems for single and twin lambs is shown in table 12. The lambs' nutrient requirements were met with milk and forages in spring and fall lambings and with milk and creep feed in winter clean-up lambing. The TDN consumed during lactation for each lambing systems for single and twin lambs is shown in table 13.

TABLE 11. CHARACTERISTICS OF FEEDS

Type of feed	Digestibility of DM, %	Efficiency of ME use for Maintenance (k_m)	Gain (k_f)
Early summer forage	65	.533	.422
Late summer forage	61	.678	.396
Fescue	65	.533	.422
Creep and dry lot feed	85	.680	.536
Milk	93[g] to 95[m]	.850	.700

[g] % digestibility of DM of milk for gain
[m] % digestibility of DM of milk for maintenance

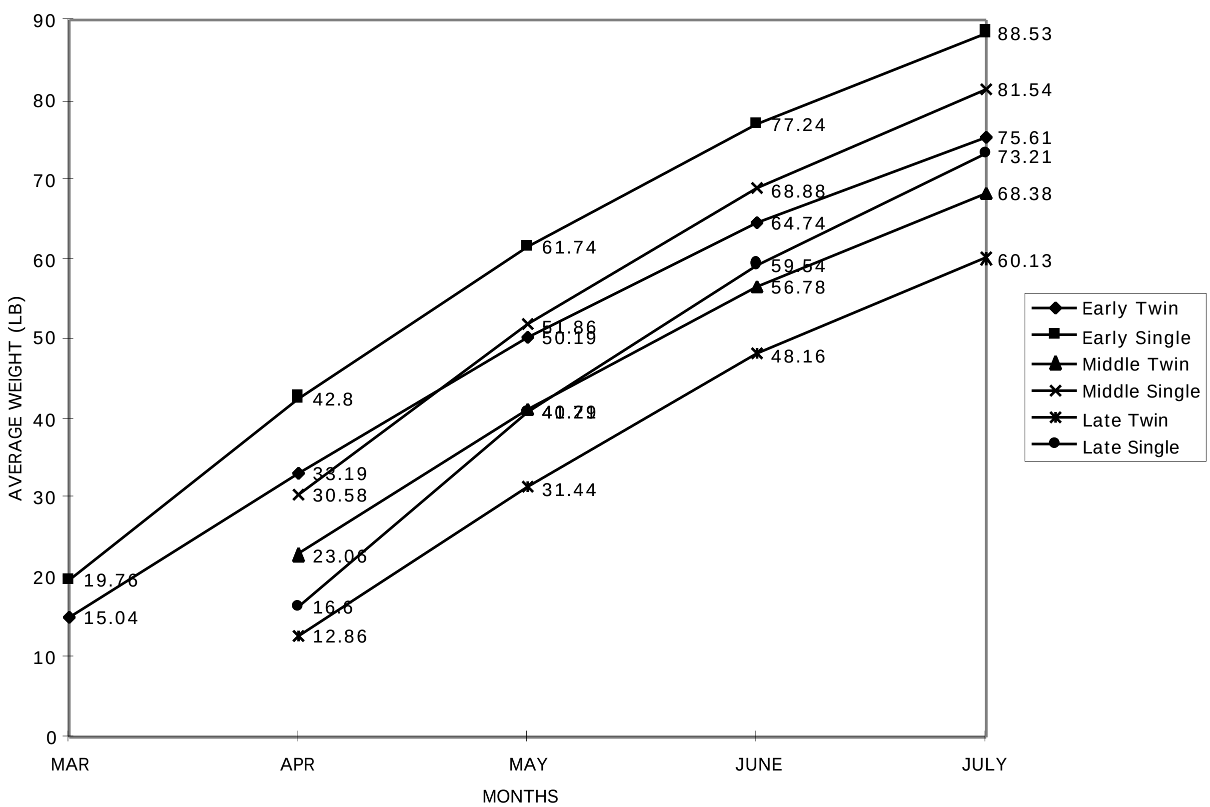

Figure 16. Growth curve for single and twin spring lambs

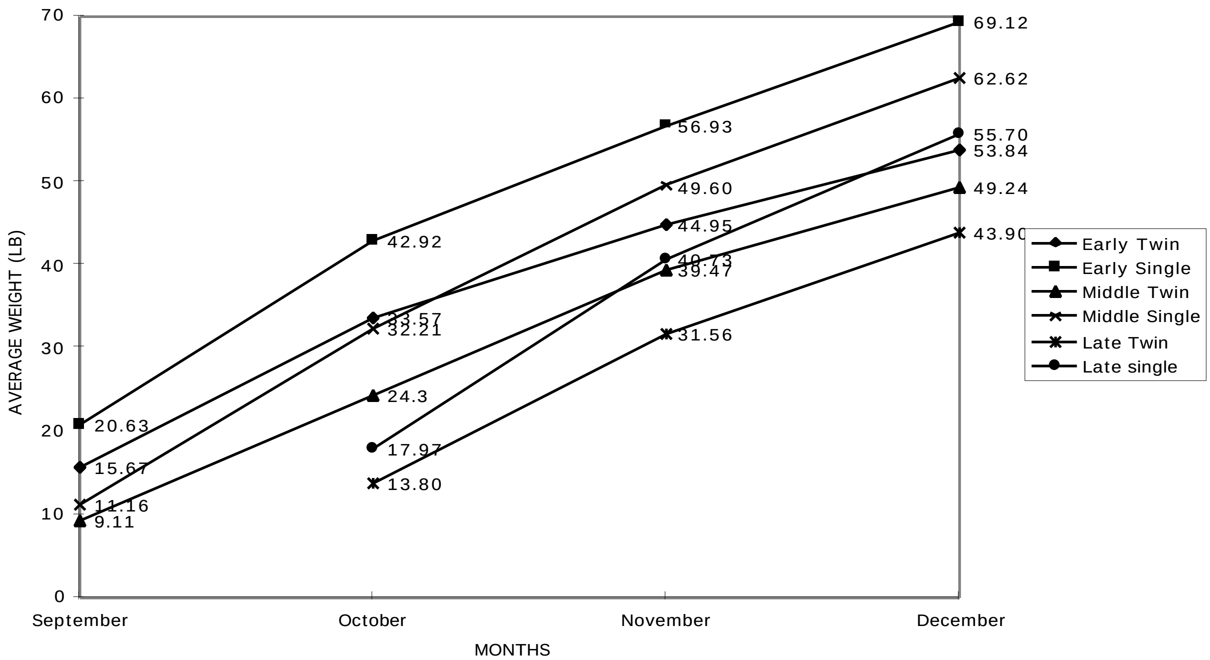

Figure 17. Growth curve for single and twin fall lambs

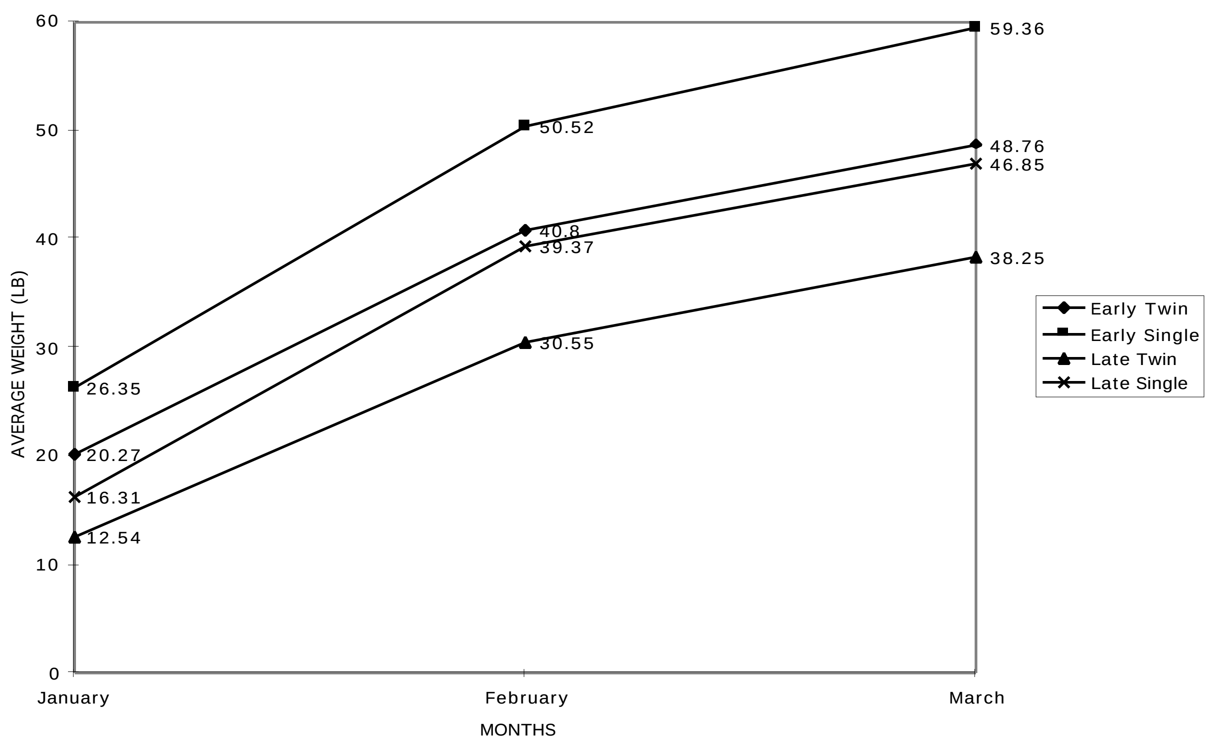

Figure 18. Growth curve for single and twin winter lambs

TABLE 12. PREDICTED ADG FOR NURSING LAMBS IN EACH LAMBING SYSTEM

Age and type of birth	ADG (lb) Spring (3/12-7/31)	Fall (9/10-12/31)	Winter clean-up (1/1-3/14)
1 to 17 d twin	.626	.630	.625
1 to 17 d single	.908	.900	.906
18 to 34 d twin	.609	.610	.640
18 to 34 d single	.767	.770	.776
35 to 60 d twin	.573	.500	.700
35 to 60 d single	.648	.520	.770
61 to 90 d twin	.507	.350	.730
61 to 90 d single	.551	.410	.770
91 to 120 d twin	.452	.360	
91 to 120 d_single	.465	.380	

TABLE 13. PREDICTED DAILY TDN INTAKE FOR NURSING LAMBS IN EACH LAMBING SYSTEM

Age and type of birth	TDN (lb) Spring (3/12-7/31)	Fall (9/10-12/31)	Winter Clean-up (1/1-3/14)
1 to 17 twin	.000	.000	.000
1 to 17 single	.000	.000	.000
18 to 34 twin	.077	.077	.099
18 to 34 single	.000	.000	.000
35 to 60 twin	.265	.385	.660
35 to 60 single	.298	.143	.496
61 to 90 twin	.860	.430	1.450
61 to 90 single	.772	.375	1.110
91 to 120 twin	1.350	.882	
91 to 120_single	1.440	.992	

When ewes had triples and all survived, one of the lambs was assumed to be removed from the ewe and artificially raised. The artificially reared lambs consumed .93 lb/d of milk replacer per day for birth to 30/d (Umberger, 1996). The spring triplets were also assumed to consume concentrate feed that was 85% digestible from 31 to 75/d and to graze summer forage which was 61% digestible from 76 to 150/d. The fall triplets consumed feed that was 85% digestible from 31 to 120/d. The winter triplets consumed feed that was 85% digestible from 31 to 75/d. Artificially raised lambs were commingled with other weaned lambs on July 31 for spring lambs, December 31 for fall lambs, and March 15 for winter lambs. Table 14 shows predicted growth rates and nutrient requirements for artificially raised lambs in each lambing systems. Figures 19 shows growth curves for artificially raised lambs born in spring. Figure 20 shows growth curves for artificially raised lambs born in fall and winter, which were the same.

TABLE 14. PREDICTED GROWTH RATES AND NUTRIENT REQUIREMENTS FOR ARTIFICIALLY RAISED LAMB IN EACH LAMBING SYSTEM

Lambing system Age of lamb(d)	TDN, lb/d	ADG, lb/d	Final Weight, lb
Spring:			
1 to 30 d	.93	.50	22.10
31 to 75 d	1.14	.50	44.70
76 to 120 d	.88	.19	53.20
121 to 150 d	1.03	.21	61.00
Fall:			
1 to 30 d	.93	.50	22.10
31 to 75 d	1.14	.50	44.70
76 to 120 d	1.51	.62	72.40
Winter:			
1 to 30 d	.93	.50	22.10
31 to 75 d	1.14	.50	44.70

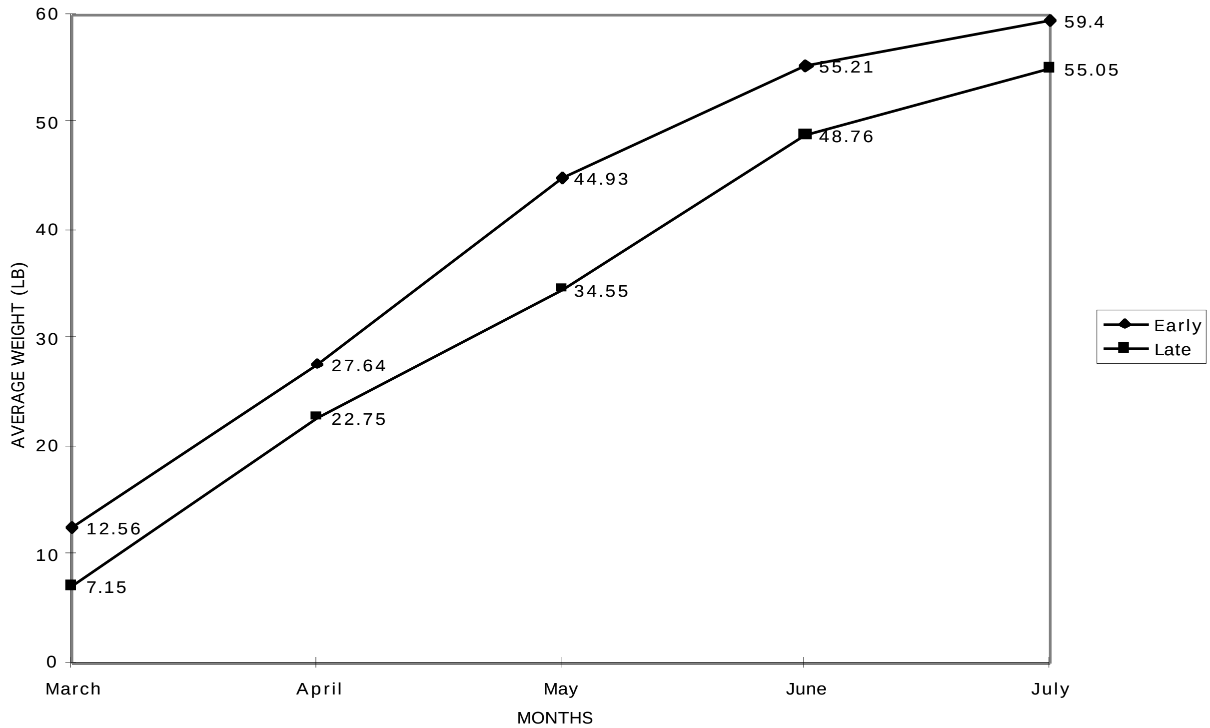

Figure 19. Growth curve for artificially raised spring lambs

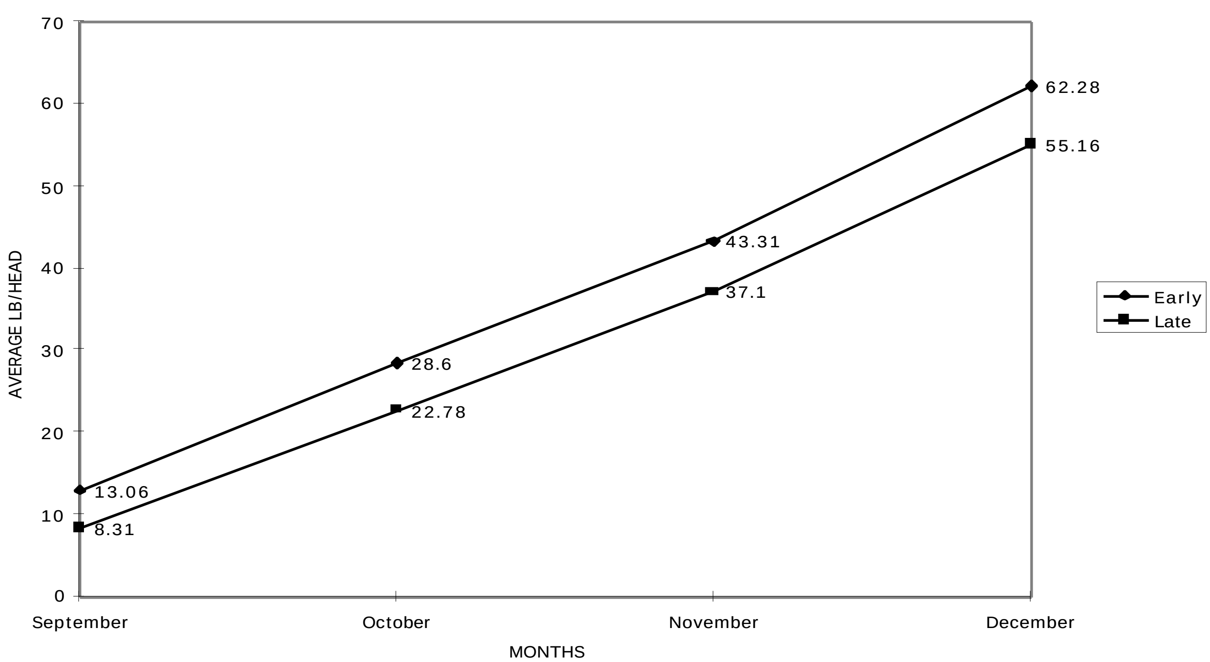

Figure 20. Growth curve for artificially raised fall and winter lambs

After weaning, lambs were combined and managed as one group in each system. Lambs born in spring were weaned on July 31. After weaning, lamb nutrient requirements were assumed met with forage (permanent pasture) from August 1 to August 31 and with a lamb finishing ration (complete pellet protein feed which contains 14 to 20% protein from linseed, cottonseed, or soybean oil meal and corn) from September 1 until marketing (Umberger et al., 1986). Lambs born in fall lambing were weaned on December 31 and lambs born in winter were weaned on March 15. After weaning, nutrient requirements for fall and winter lambs were assumed met with a lamb finishing ration until marketing. The ADG for spring lambs after weaning were .221 lb/d for August and then .551 lb/d until marketing. The ADG for fall lambs after weaning were .68 lb/d. The ADG for winter lambs after weaning were .750 lb/d. The daily TDN requirements for weaned lambs for each lambing system is shown in table 15.

TABLE 15. DAILY TDN REQUIREMENTS FOR WEANED LAMBS IN EACH LAMBING SYSTEM

Month	Daily TDN requirement of each lambing seasons, lb/d		
	Spring	Fall	Winter
January		1.83	
February		2.23	
March		2.58	1.64
April		2.89	2.01
May			2.50
June			3.13
August	1.31		
September	1.91		
October	2.14		
November	2.35		
December	2.52		

Marketing Lambs

At the time the lambs were assumed to enter drylot, lamb weights were assumed to have a normal distribution with coefficient of variation of 17%. Normal distribution theory was then used to identify the proportion of the lambs that were expected to exceed 110 lb in body weight. These lambs were assumed sold; mean weights of sold lambs was predicted from normal distribution theory. Means and standard deviations of body weights of remaining lambs were likewise predicted. Means and standard deviations of remaining lambs at the end of the next month were then predicted from means and standard deviations of body weight at the start of the month and from means and standard deviations of monthly gains. Gain was assumed to have a coefficient of variation of 20% and to be independent of initial body weight. Body weight and proportions sold were updated monthly until all lambs were sold. When lambs were sold, the remaining lambs were assumed to be smaller framed or to have a higher proportion of female lambs, and so were predicted to fatten faster. Thus, there was proportional increase in ED of .015 for each 10% of lambs marketed. Percentages of lambs sold in each month for each lambing system are shown in table 16.

TABLE 16. PERCENTAGES OF LAMBS SOLD AT THE END OF EACH MONTH IN EACH LAMBING SYSTEM

	Percentage sold (%)			
Month	Spring	Fall	Winter	Fall (high fertility)
January		0		0
February		22.4		11.7
March		52.3	0	52.7
April		25.3	0	35.6
May			41.5	
June			58.50	
August	5.4			
September	17.1			
October	30.2			
November	32.6			
December	14.7			

Budgets

Enterprise budgets were developed for each lambing system. Sources of revenue included lambs, cull ewes, cull rams, and wool. Nine years of lamb prices (1988 to 1997) were used to determine monthly average prices as shown in table 17 (Tolman, 1993; VDACS, 1993-1996; VA Market News Service, 1997). To reflect the number of lambs sold in each month, an averages lamb price was calculated for each system. Weighted averages were $64.18 for spring lambing, $76.78 for the fall and winter lambing, and $78.39 for high-fertility fall lambing.

TABLE 17. MONTHLY AVERAGE PRICES OF MARKET LAMBS

Months	Average price of lambs, $/cwt
January	$64.56
February	$73.14
March	$78.09
April	$81.61
May	$79.29
June	$71.17
July	$67.29
August	$64.24
September	$63.24
October	$62.07
November	$64.07
December	$68.02

Price differentials between lambs born in different systems were $10.86 for fall with winter clean-up vs spring, $14.21 for high- fertility fall vs spring, and $3.36 for high-fertility fall vs fall with winter clean-up. Price differentials were also calculated for each of the years used to determine average prices. The standard deviations (σ) across years of the price differential were $6.41 for fall with winter clean-up vs spring, $10.88 for high-fertility fall vs spring, and $7.53 for high-fertility fall vs fall with winter clean-up. Comparisons among systems were made at the mean and at ± 1 σ price differentials as shown in table 18.

TABLE 18. COMPARING DIFFERENT LAMBING SYSTEM WITH +1 AND -1 STANDARD DEVIATION FROM THE MEAN OF MARKET LAMB PRICES

		Lamb price, $/cwt			
			Comparison system		
Base system	Comparison system	Average for base system	Average - 1 σ	Average	Average + 1 σ
Spring	Fall w/ winter clean-up	64.68	70.37	76.78	83.19
Spring	High-fertility fall	64.18	67.51	78.39	89.27
Fall with winter clean-up	High-fertility fall	76.78	70.86	78.39	85.92

The price for cull ewes was $30.00 per 150 lb ewe and the price for culled rams was $30.00 per 200 lb ram (Umberger and McKinnon, 1995a; Umberger and McKinnon, 1995b; Umberger and McKinnon, 1995c; VA Farm Management Livestock Enterprise Budget, 1997). The price for wool was $0.60/lb, and the average ewe produced 6.50 lb/hd (Umberger and McKinnon, 1995a; Umberger and McKinnon, 1995b; Umberger and McKinnon, 1995c; VA Farm Management Livestock Enterprise Budget, 1997).

Costs included feed, salt and minerals, health products, shearing, hauling, marketing, labor, Virginia checkoff program, bedding, building and fence repair, utilities, machinery costs and miscellaneous costs. The 10-yr average price of corn was $2.56/bu from 1987 to 1997, with a standard deviation of $0.52 (CRB, 1997). The 10-yr average price of SBOM was $208.35/ton with a standard deviation of $32.48 (CRB, 1997). Table 19 has various costs for items in the enterprise budget (Umberger and McKinnon, 1995a; Umberger and McKinnon, 1995b; Umberger and McKinnon, 1995c; VA Farm Management Livestock Enterprise Budget, 1997).

TABLE 19. COSTS OF ITEMS IN THE ENTERPRISE BUDGET

Item	Cost	Unit of measurement
Salt and minerals	$ 21.50	CWT
Pelleted protein supplement	$350.00	Ton
Shearing	$ 2.50	Head
Hay	$ 70.00	Ton
Hauling	$ 1.55	Head
Marketing	$ 1.85	Head
VA checkoff program	$ .50	Head
Utilities	$ .90	Head
Machinery	$ 1.78	Head
Milk replacer	$ 33.30	25 lb Bag
Replacement ram	$350.00	Head
Building and fence repairs	$ 2.00	Head
Harvest costs	$ 19.75	Ton
Miscellaneous (including taxes)	$ 2.00	Head

Drylot feed that was fed to lambs was assumed to consist of 15% pelleted protein supplement and 85% corn with a TDN of 78% and 88% DM, respectively. Creep feed was assumed to consist of 77% corn and 23% SBOM, with 16% CP on a as-fed-basis. A grinding fee of $20.00 per ton was assumed for the creep feed. The hay that was produced was assumed to be 87% DM and 88% TDN. There were comparison made at $\pm$ standard deviations for feed costs.

Costs for health products were $4.27/hd for ewes and $3.18/hd for ewe lambs in spring and fall system (VA Farm Management Livestock Enterprise Budget, 1997; American Livestock supply, 1998; Sheepman Supply Co., 1998). There were no health costs for winter lambing ewes and ewe lambs. Costs for health products for lambs were $5.64/hd in spring lambing, $3.69 in fall lambing, and $0.36/hd in winter lambing (VA Farm Management Livestock Enterprise Budget, 1997; American Livestock supply, 1998; Sheepman Supply Co., 1998). The low cost of lambs in winter lambing was due to no dewormer used. Lambs born in spring had higher health costs than lambs born in fall or winter because they required more dewormings.

Labor was valued at $6.58/hr (Gill et al., 1984; VA. Ag. Stat. 1996). In spring lambing, 3.30 hr/ewe/year of labor were needed, which resulted in total labor costs of $21.75/ewe/year. In fall lambing with the clean-up winter lambing, 2.95 hr/ewe/year of labor was needed for the fall system and an additional 1.23 hr/ewe of labor was needed for the clean-up winter system from November 1 to March 15, for a total of 4.18 hr/ewe/year and for a total system cost of $27.50/ewe/year In high-fertility fall lambing, 2.95 hr/ewe/year of labor were needed, which resulted in total labor costs of $19.44/ewe/year. Fall lambing required less labor than spring lambing because of fewer dewormings for fall lambs and because in fall lambing as compared to spring and winter, the farmer does not need to feed the ewes because use of harvested feeds in not required for lactation ewes in September, October, and November.

In fall lambing, 200 lb of nitrogen (N) per year was applied the 14 acres of fescue (120 lb in February and 80 lb in August) at a cost of .10¢/lb for 10-10-10, $200 per acre (2000 lb of 10-10-10 per acre) (USDA, 1988; Chamblee and Green, 1995; Southern States, 1998). For the 36 acres of permanent pasture in the fall lambing system, 100 lb of N per year was added (60 lb in February and 40 lb in August) at a cost of .10¢/lb for 10-10-10, or $100 per acre (1000 lb of 10-10-10 per acre) (USDA, 1988; Chamblee and Green, 1995; Southern States, 1998). Lime was added every 3 years at 2 tons per acre for a cost of $14.03 per acre ($21.05 per ton of lime) (USDA, 1998). Total fertilizer and lime costs for each of the two fall lambing systems was $314 per year. In spring lambing, 100 lb of N per year was added to 50 acres of permanent pasture at a cost of .10¢ for 10-10-10 for a cost of $100 per acre (1000 lb of 10-10-10 per acre) (USDA, 1988; Chamblee and Green, 1995; Southern States, 1998). The lime requirements were the same as in fall lambing. The total fertilizer and lime cost for spring lambing was $114 per year. The fertilizer and lime costs included a $4.80 per acre spreading fee.

Annual debt service was calculated for each lambing systems for the enterprise budgets. The spring lambing consisted of 78 ewes and 2 rams and fall lambing consisted of 115 ewes and 3 rams. The value of ewes were calculated by using 150% of $69.73, the 10-year average of the 110 lb market lambs prices. The interest were calculated at 10% and the length of the loan was 5 years.

Chapter 4: Results and Discussion

Spring Lambing System

Lambing Calendar

The simulated 50-acre farm could support 78 ewes (62 adult ewes and 16 ewe lambs) and their lambs in the spring lambing system. The dates of the various stages of production were shown in table 1 and the nutrient requirements for individual ewes were shown in table 5. The nutrient requirements for the simulated flock for each stage of production are shown in table 20.

TABLE 20. NUTRIENT REQUIREMENTS FOR EWES FOR SPRING LAMBING

Stages of production	Number of ewes	TDN/d, lb	TDN/days, lb
Flushing	78	179.4	5023/28d
Breeding	78	134.2	4965/37d
Nonlactation	78	134.2	11138/83d
Last 4 wks of gestation	78	209.5	5866/28d
Early lactation:			
March	78	251.0	5020/20d
April	78	271.8	8153/30d
May	70[a]	270.4	8382/31d
Late lactation	70	240.3	14658/61d
Maintenance	70	105.0	4935/47d

[a] 8 ewes (4 adult ewes and 4 ewe lambs) were cull on May 1

In spring lambing, 58 adult ewes and 12 ewe lambs lambed, producing 148 lambs (table 21 and 22) Of these, 22 lambs died, leaving a total of 126 lambs to be marketed. Six triplet lambs were artificially raised on milk replacer, creep feed and forage. One ewe lambed but raised no lamb. At the end of lambing on May 1, four open ewes and four open ewe lambs were culled.

TABLE 21. LAMBING DISTRIBUTION FOR EWES IN SPRING LAMBING

Cycle	Birth type	Ewes	Number of lambs			
			Born	Die	Artificially reared	Suckled
1	Triplets	11	33	7	4	22
1	Twins	32	64	7	0	57
1	Singles	0	0	0	0	0
2	Triplets	4	12	2	2	8
2	Twins	8	16	2	0	14
2	Singles	0	0	0	0	0
3	Triplets	0	0	0	0	0
3	Twins	3	6	0	0	6
3	Singles	0	0	0	0	0
Totals		58	131	18	6	107

TABLE 22. LAMBING DISTRIBUTION FOR EWE LAMBS IN SPRING LAMBING

Cycle	Birth type	Ewe lambs	Number of lambs		
			Born	Die	Suckled
1	Triplets	0	0	0	0
1	Twins	1	2	1	1
1	Singles	3	3	1	2
2	Triplets	0	0	0	0
2	Twins	1	2	0	2
2	Singles	4	4	0	4
3	Triplets	0	0	0	0
3	Twins	1	2	0	2
3	Singles	2	2	0	2
Total		12	15	2	13

Nutrient Requirements and Growth of Lambs

Growth curves of spring born lambs were shown in figure 16, average daily gains of single and twin lambs were shown in table 12, and predicted daily TDN for suckling lambs in spring lambing was shown in table 13. Table 23 shows the prediction of growth rates of young suckling twin lambs in spring lambing and table 24 shows the prediction of growth rates of young suckling single lambs in spring lambing. Values shown in table 23 and 24 are for lambs consuming a forage of 65% digestible DM before July 1.

TABLE 23. PREDICTION OF GROWTH OF YOUNG SUCKLING TWIN LAMBS IN SPRING LAMBING

	Days of age of lambs				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb/d	2.21	2.78	2.11	1.63	.99
Initial weight, lb/d	8.16	18.80	29.10	44.00	59.20
Gain (milk), lb/d	.63	.55	.21	.03	0.00
Gain (forage), lb/d	0.00	.06	.37	.49	.45
Total gain, lb/d	.63	.61	.58	.51	.45
TDN, lb/d	0.00	.08	.56	.86	1.35
Final weight, lb	18.80	29.10	44.00	59.20	72.70

TABLE 24. PREDICTION OF GROWTH OF YOUNG SUCKLING SINGLE LAMBING IN SPRING LAMBING

	Days of age of lambs, lb				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb/d	3.64	4.41	3.53	2.73	1.68
Initial weight, lb/d	9.79	25.20	38.30	55.00	71.51
Gain (milk), lb/d	.91	.77	.49	.20	0.00
Gain (forage), lb/d	0.00	0.00	.15	.35	.46
Total gain, lb/d	.91	.77	.65	.55	.46
TDN, lb/d	0.00	0.00	.30	.77	1.44
Final weight, lb	25.20	38.20	55.00	71.51	85.40

Predicted growth rates of suckling lambs in July were based upon a forage with 61% digestible dry matter. Predicted of growth rates of young suckling twin and single lambs in July in spring lambing are shown in tables 25 and 26, respectively.

TABLE 25. PREDICTION OF GROWTH OF YOUNG SUCKLING TWIN LAMBS IN JULY IN SPRING LAMBING

Item	Early twins	Middle twins	Late twins
Milk intake, lb/d	.73	1.08	1.46
Initial weight, lb/d	58.12	56.76	48.16
Gain, lb/d	.35	.37	.39
TDN, lb/d	1.28	1.07	.81
Final weight, lb	75.40	68.20	60.00

TABLE 26. PREDICTION OF GROWTH OF YOUNG SUCKLING SINGLE LAMBS IN JULY IN SPRING LAMBING

Item	Early single	Middle single	Late single
Milk intake, lb/d	1.21	1.83	2.43
Initial weight, lb/d	77.24	68.88	59.54
Gain, lb/d	.36	.41	.44
TDN, lb/d	1.38	1.15	.78
Final weight, lb	88.30	81.30	73.00

Growth rates of weaned spring lambs were calculated from August 1 through December 31. In August, TDN requirements were meet by forages containing 61% digestible dry matter. A finishing diet with a 85% digestible dry matter was fed from

September 1 through December 31. Predicted growth of weaned lambs in spring lambing is shown in table 27. The total number of lambs was 126: 6 were sold in August at a weight of 118 lb, 22 were sold in September at a weight of 119 lb, 38 were sold in October at a weight of 120 lb, 41 were sold in November at a weight of 120 lb, and 19 were sold in December at a weight of 121 lb.

TABLE 27. PREDICTION OF GROWTH OF WEANED LAMBS IN SPRING LAMBING

Months	Number of lambs	Starting wt, lb	TDN lb/hd/d	Final weight of lambs not sold, lb
August	126	73.53	1.31	80.20
September	120	78.37	1.91	94.70
October	98	89.58	2.14	106.40
November	60	98.14	2.35	114.40
December	19	104.20	4.08	

Artificially Raised Triplet Lambs

Within the spring lambing system, 15 ewes had triplets; nine died, which left 6 lambs to be artificially raised. The growth curve for spring born, artificially raised lambs was shown in table 19. The TDN requirements of these 6 lambs are shown table 28. A total of was 167.40 lb of milk, 307.80 lb of TDN from grain, and 284.30 lb of TDN of forage were consumed.

TABLE 28. TDN REQUIREMENTS FOR 6 SPRING BORN, ARTIFICIALLY RAISED LAMBS

	TDN, lb		
Month	Milk, lb	Grain	Forage
March	41	0	0
April	115	51	0
May	12	194	3
June	0	63	110
July	0	0	172

Nutritional Budget

A nutritional budget was developed for spring lambing which consisted of grazed and harvested (hay) forages, concentrates (corn, SBOM, creep feed, and pelleted protein mix), and milk replacer. Nutrient requirements (table 29) do not include the TDN that the suckling lambs consumed from milk. Small amounts of pasture growth occurred in January, February, and March, but the sheep did not utilize spring pastures until April 1. The spring lambing used only permanent pasture; no use of fescue was assumed. Ewes numbers were controlled by availability of forage to met animal's nutritional requirements during July and August.

Concentrate need for ewes and lambs were met with corn, SBOM, creep feed, and a pelleted protein mix. Percentages of the ewe's total nutritional requirements that were met with concentrates were 0.00% in January, 19.65% in February, 26.29% in March, 7.58% in April, 0.00% in May through August, 7.53% in September, 7.36% in October, and 0.00% in November and December. Percentage of the lambs' total nutritional requirements that were met with concentrates were 0.00% in January through August, and 100% in September through December. Percentages of the artificially raised triplets' total nutritional requirements that were met through concentrates were 30.60% in April, 98.72% in May, 36.62% in June, and 0.00% for all other months. Total concentrate needs for sheep in spring lambing is shown are table 30. In August, the suckled and artificially reared lambs were combined into one groups.

TABLE 29. AVAILABLE FORAGE AND ANIMAL REQUIREMENTS IN SPRING LAMBING

	TDN, lb			
Months	Available forage	Ewes' requirements	Suckled lambs requirements[a]	Artificially raised lambs requirements[a]
January	0	4160	0	0
February	0	5038	0	0
March	0	7325	1	41
April	27605	8153	261	165
May	46786	8382	1458	209
June	11361	7209	3342	173
July	12265	7449	4438	172
August	8722	3255	5125	0
September	8292	4192	6866	0
October	10839	4793	6498	0
November	3287	4026	4227	0
December	1280	4160	1487	0

[a] suckled and artificially reared lambs were combined on August 1

In some months there was a surplus of forages that would be carried over to the next month or harvested as hay. In some months there was a deficiency of forage and animal's requirements would be met with harvested hay. Forage surpluses and deficiencies per month in spring lambing are shown in table 31. Hay produced and harvested in spring lambing is shown table 32. The hay produced contained 53,062 lb/TDN/year. Hay consumed by the sheep 16,721 lb/TDN/year, leaving a surplus of 36,341 lb/TDN/year of hay that was sold.

TABLE 30. CONCENTRATE NEEDS FOR SHEEP IN SPRING LAMBING

	TDN, lb			
Months	Ewes	Lambs	Artificial raised lambs	Total
January	0	0	0	0
February	1034	0	0	1034
March	1886	0	0	1886
April	669	0	51	720
May	0	0	194	194
June	0	0	63	63
July	0	0	0	0
August	0	0	0	0
September	852	6866	0	7718
October	852	6498	0	7350
November	0	4227	0	4227
December	0	1487	0	1487

TABLE 31. FORAGE SURPLUS OR DEFICIENCIES IN SPRING LAMBING

	TDN, LB	
Months	Surplus	Deficiency
January	0	4159
February	0	4229
March	0	4716
April	19870	0
May	36927	0
June	685	0
July	139	0
August	343	0
September	4698	0
October	6613	0
November	0	738
December	0	2879
Totals	69275	16721

TABLE 32. HAY HARVESTED AND HAY USED FOR SPRING LAMBING

	TDN, lb	
Months	Hay Produced	Hay Needed
January	0	4159
February	0	4229
March	0	4716
April	0	0
May	40620	0
June	0	0
July	0	0
August	0	0
September	5168	0
October	7274	0
November	0	738
December	0	2879
Total	53062	16721

Enterprise Budget

In spring lambing, three enterprise budgets were created. The first budget was calculated with 10-year average prices for market lambs and concentrate feeds (table 33). Returns were calculated with labor included or excluded. The second budget was by increasing prices for corn and SBOM by one standard deviation, to $3.08/bu and $240.83/ton, respectively. The third budget was calculated by decreasing corn and SBOM by one standard deviation. The income, expenses, and returns for the three budgets for the flock are shown in table 34. The income, expenses, and returns for the three budgets on a per basis are shown in table 35. Harvest and seed cost were only assigned for the hay that was consumed by the sheep.

TABLE 33. ENTERPRISE BUDGET FOR SPRING LAMBING WITH 10 YEAR AVERAGE PRICES FOR MARKET LAMBS, CORN, & SBOM

ITEM	SOLD		UNIT	PRICE	QUANTITY	TOTAL
CASH INCOME						
LAMBS IN AUG	6 @	1.18	CWT	$64.24	7.08	$454.82
LAMBS IN SEPT	22	1.19	CWT	$63.24	26.18	$1,655.62
LAMBS IN OCT	38 @	1.20	CWT	$62.07	45.60	$2,830.39
LAMBS IN NOV	41	1.20	CWT	$64.07	49.20	$3,152.24
LAMBS IN DEC	19	1.21	CWT	$68.02	22.99	$1,563.78
CULL EWES	8.0 @	1.50	CWT	$30.00	12.00	$360.00
CULL RAM	0.5 @	2.00	CWT	$30.00	0.94	$28.08
WOOL	6.5 #	/HD.	LBS	$0.60	522.21	$313.33
				TOTAL CASH INCOME		$10,358.26
CASH EXPENSES						
				PRICE	QUANTITY	TOTAL
HAY HARVEST & RESEEDING			TON	$20.22	9.41	$190.27
SHELLED CORN			BU	$2.56	162.00	$414.72
SBOM			BU	$208.35	0.72	$150.22
DRYLOT FEED			TON		15.75	$2049.68
MILK REPLACER			LB	$1.33	167.00	$222.11
CREEP FEED			TON	$138.32	0.18	$20.73
FERT. & LIME			LB			$354.00
VET MED	EWE		HEAD	$4.27	62.00	$264.74
VET MED	EWE LAMB		HEAD	$3.18	16.00	$50.88
VET MED	LAMB		HEAD	$5.64	126.00	$710.64
SALT & MINERAL			CWT	$21.50	15.40	$331.15
MISCELLANEOUS			HEAD	$2.00	78.00	$156.00
REPLACEMENT RAM			HEAD	$350.00	0.47	$163.80
SHEARING			HEAD	$2.00	80.34	$160.68
HAUL SHEEP			HEAD	$1.55	134.47	$208.43
MARKET SHEEP			HEAD	$1.85	134.47	$248.77
VIRGINIA CHECKOFF			HEAD	$0.50	66.00	$33.00
BLDG. & FENCE REPAIR			HEAD	$2.00	78.00	$156.00
UTILITIES			EWE	$0.90	78.00	$70.20
MACHINERY, NON-CROP			EWE	$1.78	78.00	$138.84
				TOTAL CASH EXPENSES		$6098.47
RETURN TO EQUITY, MANAGEMENT, AND OPER. LABOR						**$4,259.80**
LABOR	3.30 HR/EWE		EWE	$21.75	78.00	$1,696.50
RETURN TO EQUITY AND MANAGEMENT						**$2,563.30**
ANNUAL DEBT PAYMENTS						$2,215.90
RETURN TO EQUITY AND MANAGEMENT						**$347.40**

TABLE 34. INCOME, EXPENSES, AND RETURNS FROM SPRING LAMBING ENTERPRISE BUDGET FOR THE FLOCK

		Dollars	
Budget	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	10,358	7,795	347
Average of market lamb corn, & SBOM prices & excluding labor	10,358	6,098	2,044
Average of market lamb prices, +1 σ for corn & SBOM including labor	10,358	8,320	(178)
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	10,358	6,624	1,519
Average of market lamb prices, -1 σ for corn & SBOM including labor	10,358	7,270	873
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	10,358	5,574	2,570

There were 8.36 tons of hay consumed by the sheep. There were 18.17 tons of hay that were not used in the spring lambing system. The harvest cost was $358.86 and the value of the hay sold at $70.00 per ton was $913.04 (Farm Management, 1988 and 1998).

TABLE 35. INCOME EXPENSES, AND RETURNS FROM SPRING LAMBING ENTERPRISE BUDGETS ON A PER EWE BASIS

		Dollars	
Budgets	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	132.79	99.93	4.45
Average of market lamb corn, & SBOM prices & excluding labor	132.79	78.18	26.21
Average of market lamb prices, +1 σ for corn & SBOM including labor	132.79	106.67	(2.28)
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	132.79	84.92	19.47
Average of market lamb prices, -1 σ for corn & SBOM including labor	132.79	93.21	11.19
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	132.79	71.46	32.95

Chapter 5: Results and Discussion

Fall and Winter Clean-up Lambing Systems

Lambing Calendar for Fall and Winter Lambing

In fall lambing with winter clean-up, the simulated 50 acres supported 115 ewes (92 adult ewes and 23 ewe lambs). The fall and winter lambing calendar was shown in table 1, and nutrient requirements for individual ewes were shown in table 4. The TDN consumption by the flock in each stage of production is shown in table 36 for fall lambing and table 37 for winter clean-up lambing. For the winter clean-up lambing, nutrient requirements during breeding were allocated to fall lambing. Lambs were weaned early, so there was also no late lactation production stage.

TABLE 36. NUTRIENT REQUIREMENTS FOR EWES FOR FALL LAMBING

Stages of production	Number of ewes	TDN/d, lb	TDN/days, lb
Breeding	115	197	10088/51d
Early gestation	115	197	16417/83d
Last 4 wks of gestation	115	284	7986/28d
Early lactation:			
September	115	314	6591/21d
October	115	353	10949/31d
November[a]	68	256	7668/30d
Late lactation	68	198	5838/31d
Maintenance	68	102	9180/90d

[a] 47 ewes are moved into a winter lambing system on November 1

TABLE 37. NUTRIENT REQUIREMENTS FOR EWES FOR WINTER CLEAN-UP LAMBING

Stages of production	Number of ewes	TDN/d, lb	TDN/days, lb
Early gestation	47	82	2454/30d
Last 4 wks of gestation	47	117	3599/31d
Early lactation:			
January	47	136	4205/31d
February[a]	33	119	3326/28d
March	33	119	1663/14d
Maintenance	33	50	148/3d

[a] 14 ewes are culled on February 1

In fall lambing 64 adult ewes and 4 ewe lambs lambed, producing 112 lambs (table 38 and 39). Of these 15 lambs died, leaving a total of 98 lambs to be marketed. Five triplet lambs were artificially raised on milk replacer and creep feed. Three ewes lambed but raised no lambs. In winter clean-up lambing, 21 adult ewes and 12 ewe lambs lambed, producing 57 lambs (table 40 and 41) Of these 9 lambs died, leaving a total of 48 lambs to be marketed. Two triplet lambs were artificially raised on milk replacer and creep feed. One ewe and one ewe lamb lambed but raised no lambs.

TABLE 38. LAMBING DISTRIBUTION FOR EWES IN FALL LAMBING

			Number of lambs			
Cycle	Birth type	Ewes	Born	Died	Artificially reared	Suckled
1	Triplets	11	33	7	4	22
1	Twins	14	28	3	0	25
1	Singles	25	25	2	0	23
2	Triplets	2	6	1	1	4
2	Twins	3	9	1	0	8
2	Singles	7	7	1	0	6
3	Triplets	0	0	0	0	0
3	Twins	2	4	0	0	4
3	Singles	0	0	0	0	0

TABLE 39. LAMBING DISTRIBUTION FOR EWE LAMBS IN FALL LAMBING

			Number of Lambs			
Cycle	Birth type	Ewe lambs	Born	Die	Artificially reared	Suckled
1	Triplets	0	0	0	0	0
1	Twins	0	0	0	0	0
1	Singles	0	0	0	0	0
2	Triplets	0	0	0	0	0
2	Twins	0	0	0	0	0
2	Singles	2	2	0	0	2
3	Triplets	0	0	0	0	0
3	Twins	0	0	0	0	0
3	Singles	2	2	0	0	2

TABLE 40. LAMBING DISTRIBUTION FOR EWES IN WINTER CLEAN-UP LAMBING

			Number of lambs			
Cycle	Birth type	Ewes	Born	Die	Artificially reared	Suckled
1	Triplets	4	12	3	1	8
1	Twins	5	10	1	0	9
1	Singles	5	5	1	0	4
2	Triplets	2	6	1	1	4
2	Twins	3	6	1	0	5
2	Singles	2	2	0	0	2

TABLE 41. LAMBING DISTRIBUTION FOR EWE LAMBS IN WINTER CLEAN-UP LAMBING

			Number of lambs			
Cycle	Birth type	Ewe lambs	Born	Die	Artificially reared	Suckled
1	Triplets	0	0	0	0	0
1	Twins	3	6	1	0	5
1	Singles	3	3	0	0	3
2	Triplets	0	0	0	0	0
2	Twins	1	2	2	0	0
2	Singles	5	5	1	0	4

Nutrient Requirements and Growth of Lambs

Lambs gains in fall on fescue were less than those in spring on pastures. Figures 17 and 18 showed growth curves for fall and winter lambs, respectively. Tables 42, 43, 44, and 45 show the predicted growth of young suckling lambs in fall and winter, respectively.

TABLE 42. PREDICTION OF GROWTH OF YOUNG SUCKLING TWIN LAMBS IN FALL LAMBING

	Days of age of lambs				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb	2.21	2.78	2.11	1.63	.99
Initial weight, lb/d	8.16	18.80	29.10	40.40	48.80
Gain (milk), lb/d	.63	.55	.20	.08	0.00
Gain (forage), lb/d	0.00	.06	.24	.27	.36
Total gain, lb/d	.63	.61	.44	.35	.36
TDN, lb/d	0.00	.08	.27	.43	.88
Final weight, lb	18.80	29.10	40.40	48.80	59.70

TABLE 43. PREDICTION OF GROWTH OF YOUNG SUCKLING SINGLE LAMBS IN FALL LAMBING

	Days of age of lambs				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb/d	3.64	4.41	3.53	2.73	1.68
Initial weight, lb/d	9.79	25.20	38.30	51.60	63.80
Gain (milk), lb/d	.91	.77	.20	.23	0.00
Gain (forage), lb/d	0.00	0.00	.04	.18	.38
Total gain, lb/d	.91	.77	.52	.41	.38
TDN, lb/d	0.00	0.00	.14	.38	1.00
Final weight, lb	25.20	38.20	51.60	63.80	75.30

TABLE 44. PREDICTION OF GROWTH OF YOUNG SUCKLING TWIN LAMBS IN WINTER CLEAN-UP LAMBING

	Days of age of lambs			
Item	1-17/d	18-34/d	35-60/d	61-90/d
Milk intake, lb/d	2.21	2.78	2.11	1.63
Initial weight, lb/d	8.16	18.80	29.60	47.90
Gain (milk), lb/d	.63	.54	.18	0.00
Gain (creep), lb/d	0.00	.10	.53	.77
Total gain, lb/d	.63	.64	.70	.77
TDN, lb/d	0.00	.10	.66	1.15
Final weight, lb	18.80	29.60	47.90	69.70

TABLE 45. PREDICTION OF GROWTH OF YOUNG SUCKLING SINGLE LAMBS IN WINTER CLEAN-UP LAMBING

	Days of age of lambs			
Item	1-17/d	18-34/d	35-60/d	61-90/d
Milk intake, lb/d	3.64	4.41	3.53	2.73
Initial weight, lb/d	9.79	25.20	38.30	58.20
Gain (milk), lb/d	.91	.77	.41	.08
Gain (creep), lb/d	0.00	0.00	.36	.69
Total gain, lb/d	.91	.77	.77	.77
TDN, lb/d	0.00	0.00	.56	1.11
Final weight, lb	25.20	38.20	58.20	81.30

Predictions of growth of weaned lambs in fall and winter lambing are shown in tables 46 and 47, respectively. The total number of lambs in fall lambing was 98: 21 were sold at the end of February at a weight of 118.5 lb, 51 were sold at the end of March at a weight of 121.1 lb, and 26 were sold at the end of April at a weight of 122.4 lb. The number of lambs in winter clean up was 48: 19 were sold at the end of May at a weight of 112.0 lb, and 29 were sold at the end of June at a weight of 120.7 lb.

TABLE 46. PREDICTION OF GROWTH OF WEANED LAMBS IN FALL LAMBING

Months	Number of lambs	Starting wt, lb	lb/hd/d	Final weight of lambs not sold, lb
January	98	58.96	1.83	80.00
February	98	80.15	2.39	93.73
March	77	93.73	2.58	102.16
April	26	114.92	2.89	

TABLE 47. PREDICTION OF GROWTH OF WEANED LAMBS IN WINTER CLEAN-UP LAMBING

Months	Number of lambs	Starting wt, lb	lb/hd/d	Final weight of lambs not sold, lb
March	48	49.35	1.54	61.20
April	48	61.34	2.01	83.60
May	48	83.83	2.50	98.17
June	29	98.17	3.13	

Artificially Raised Triplet Lambs

Within the fall lambing system, 13 ewes had triplets; eight of the triplets died, which left 5 lambs to be artificially raised. The total TDN requirements and amount of milk replacer for these 5 lambs are shown in table 48. The 5 artificially raised triplets joined the other lambs on January 1. The total milk consumed was 139.3 lb and the total TDN from creep feed was 459.4 lb.

TABLE 48. TDN REQUIREMENTS FOR 5 FALL BORN ARTIFICIALLY RAISED LAMBS

Month	Milk, lb	TDN, lb Creep feed
September	44.73	0.00
October	94.53	60.82
November	0.00	175.50
December	0.00	223.00

Within the winter clean-up lambing system, 6 ewes had triplets; four of the triplets died, which left 2 lambs to be artificially raised. The TDN requirements and amount of milk replacer for the 2 artificially raised lambs are shown in table 49. The 2 artificially raised triplets joined the other lambs on March 15. The total milk consumed was 57.0 lb and the total TDN from creep feed was 65.6 lb.

TABLE 49. TDN REQUIREMENTS FOR 2 WINTER CLEAN-UP BORN ARTIFICIALLY RAISED LAMBS

		TDN, lb
Month	Milk, lb	Creep feed
January	26.97	0.00
February	30.00	29.64
March	2.79	33.20

Nutritional Budget for the Fall and Winter Clean-up Lambing Systems

A nutritional budget was developed for fall and winter lambing, which consisted of grazed and harvested (hay) forages, concentrates (corn, soybean, creep feed, and pelleted protein mix) and milk replacer. Available forage and animals' forage requirements for fall and winter are shown in tables 50 and 51, respectively, and do not include the TDN that the suckling lambs consumed from milk. Small amounts of pasture growth occurred in January, February, and March, but the sheep did not utilize spring pasture until April 1. The fall lambing with winter clean-up lambing used 36 acres of permanent pasture and 14 acres of tall fescue. Ewe numbers were controlled by the availability of forage to meet the animal's nutritional requirements during July and August.

Concentrate needs for ewes, ewe lambs, and lambs were met with corn, SBOM, creep feed, and a pelleted protein mix. Percentages of total nutritional requirements that were met through concentrates were 8.66% in January, 0.00% in February through August, 36.92% in September, 14.82% in October, 0.00% in November, and 0.00% in December for ewes and ewe lambs. Percentages of the lambs' total nutritional requirements that were meet through concentrates were 100% in January through April and 0.00% in May through December for lambs. Percentages of the artificially raised triplets' total nutritional requirements that were meet through concentrates were 0.00% in September, 39.15% in October, and 100% in November and December in fall lambing. Percentages of the artificially raised triplets' total nutritional requirements that were met through concentrates were 0.00% in January, 49.70% in February, 92.24% in March, and 0.00 for all other months in winter clean-up lambing. The concentrates needs for sheep in fall lambing are shown in table 52 and in winter clean-up lambing are shown in table 53. In fall lambing, the lambs were combined into one group on January 1 and in winter clean-up lambing, the lambs were combined into one group on March 15.

TABLE 50. AVAILABLE FORAGE AND ANIMAL REQUIREMENTS IN FALL LAMBING

	TDN, lb			
Month	Forage	Ewes	Lambs	Artificially raised lambs
January	2297	2135	0	0
February	0	2856	0	0
March	0	3162	0	0
April	28072	5934	0	0
May	31173	6132	0	0
June	13031	5969	0	0
July	10599	6167	0	0
August	6195	6103	0	0
September	5761	9212	1	0
October	7804	11052	56	0
November	7952	7670	841	0
December	10492	_6155	1638	0

TABLE 51. AVAILABLE FORAGE AND ANIMAL REQUIREMENTS IN WINTER CLEAN-UP LAMBING

	TDN, lb			
Month	Forage	Ewes	Lambs	Artificially raised lambs
January	2297	3126	0	0
February	0	3326	0	0
March	0	1812	0	0
April	20694	0	0	0
May	31173	0	0	0
June	13031	0	0	0
July	10598	0	0	0
August	6195	0	0	0
September	5761	0	0	0
October	7804	0	0	0
November	7952	2453	0	0
December	10492	_3599	0	0

TABLE 52. CONCENTRATE NEEDS FOR SHEEP IN FALL LAMBING

	TDN, lb			
Months	Ewes	Lambs	Artificially raised lambs	Total
January	0	5560	0	5560
February	0	6556	0	6556
March	0	6159	0	6159
April	0	2254	0	2254
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	1704	0	0	1704
September	807	0	0	807
October	0	0	61	61
November	0	0	176	176
December	0	0	223	223

TABLE 53. CONCENTRATE NEEDS FOR SHEEP IN WINTER CLEAN-UP LAMBING

		TDN, lb		
Months	Ewes	Lambs	Artificially raised lambs	Total
January	1026	11	30	1066
February	0	336	33	370
March	0	1687	0	1687
April	0	2894	0	2894
May	0	3720	0	3720
June	0	2723	0	2723
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0

In some months there was a surplus of forages that would be carried over to the next month or harvested. In some months there was a deficiency of forages and animals requirements would be met with harvested hay. The forage surpluses and deficiencies per month in fall and winter lambing are shown in table 54. Hay produced and harvested in fall and winter lambing are shown in table 55. The hay produced contained 49,204 lb of TDN. Hay consumed by the sheep totaled 11,909 lb of TDN, leaving a surplus of 37,295 lb/yr of TDN from hay that was sold.

TABLE 54. FORAGE SURPLUS OR DEFICIENCIES IN FALL AND WINTER CLEAN-UP LAMBING

	TDN, lb	
Month	Surplus	Deficiency
January	161	0
February	0	2856
March	0	3162
April	22138	0
May	25041	0
June	7062	0
July	4414	0
August	92	0
September	0	2643
October	0	3247
November	282	0
December	82	0
Total	59180	11909

TABLE 55. HAY HARVESTED AND HAY USED FOR FALL AND WINTER CLEAN-UP LAMBING

	TDN, lb	
Month	Hay Produced	Hay Needed
January	0	0
February	0	2856
March	0	3162
April	9016	0
May	27545	0
June	7769	0
July	4874	0
August	0	0
September	0	2644
October	0	3247
November	0	0
December	0	0
Total	49204	11909

Enterprise Budget

In fall with a winter clean-up lambing, five enterprise budgets were created. The first budget was calculated with 10-year average prices for market lambs, corn, and SBOM as seen in table 56. The second budget was calculated with 10-year average prices for market lambs, +1 standard deviation for corn (52¢), and +1 standard deviation for SBOM ($32.48). The third budget was calculated with 10-year average prices for market lambs, -1 standard deviation for corn, and -1 standard deviation for SBOM. The fourth budget was calculated with 10-year average prices for corn and SBOM and with +1 standard deviation for the market lamb price differential between spring and fall with winter clean up lambing systems. The fifth budget was calculated with 10-year average prices for corn and SBOM and with -1 standard deviation for the market lamb price differential between spring and fall with winter clean up lambing systems. The income, expenses, and returns for the five budgets for the flock are shown in table 57. The income, expenses, and returns for the five budgets on a per ewe are shown in table 58. Table 59 shows the comparisons of different lambing systems with $\pm$ standard deviation from the mean of market lamb prices as shown in table 18. The hay harvest and reseeding cost in the five budgets were only calculated for the hay that was consumed by the sheep.

There were 5.96 tons of hay consumed by the sheep. There was 18.65 tons of hay that was not used in fall with winter clean-up lambing. It had a harvest cost of $368.34 and the value of hay sold at $70.00 per ton was $937.16 (Farm Management, 1988 and 1998).

TABLE 56. ENTERPRISE BUDGET FOR FALL WITH WINTER CLEAN-UP LAMBING WITH 10 YEAR AVERAGE PRICES FOR MARKET LAMBS, CORN, & SBOM

ITEM	SOLD		UNIT	PRICE	QUANTITY	TOTAL
CASH INCOME						
LAMBS IN FEB	21 @	1.19	CWT	$73.14	24.99	$1,827.77
LAMBS IN MAR	51	1.21	CWT	$78.09	61.71	$4,818.93
LAMBS IN APR	26 @	1.23	CWT	$81.61	31.98	$2,609.89
CULL EWES	0.0 @	1.50	CWT	$30.00	0.00	$0.00
CULL RAM	0.7 @	2.00	CWT	$30.00	1.38	$41.40
WOOL	6.5 #	/HD.	LBS	$0.60	769.93	$461.96
WINTER INCOME						$4,935.17
				TOTAL CASH INCOME		$14,695.12
CASH EXPENSES						
				PRICE	QUANTITY	TOTAL
HAY HARVEST & RESEEDING			TON	$20.22	6.69	$135.27
SHELLED CORN			BU	$2.56	58.00	$148.48
SBOM			BU	$208.35	0.00	$0.00
DRYLOT FEED			TON		13.36	$1,739.36
MILK REPLACER			LB	$1.33	167.00	$222.11
CREEP FEED			TON		0.27	$37.38
FERT. & LIME			LB			$554.00
VET MED	EWE		HEAD	$4.27	92.00	$392.84
VET MED	EWE LAMB		HEAD	$3.18	23.00	$73.14
VET MED	LAMB		HEAD	$3.69	98.00	$361.62
SALT & MINERAL			CWT	$21.50	22.45	$482.68
MISCELLANEOUS			HEAD	$2.00	115.00	$230.00
REPLACEMENT RAM			HEAD	$350.00	0.69	$241.50
SHEARING			HEAD	$2.00	118.45	$236.90
HAUL SHEEP			HEAD	$1.55	98.69	$152.97
MARKET SHEEP			HEAD	$1.85	98.69	$182.58
VIRGINIA CHECKOFF			HEAD	$0.50	98.00	$49.00
BLDG. & FENCE REPAIR			HEAD	$2.00	115.00	$230.00
UTILITIES			EWE	$0.90	115.00	$103.50
MACHINERY, NON-CROP			EWE	$1.78	115.00	$204.70
LABOR	2.95 HR/EWE		EWE	$19.44	115.00	$2,235.60
WINTER EXPENSES						$2,009.90
				TOTAL CASH EXPENSES		$10,023.34
ANNUAL DEBT PAYMENTS						$3,267.45
RETURN TO EQUITY, MANAGEMENT AND OPER. LABOR						**$1403.00**

TABLE 57. INCOME, EXPENSES, AND RETURNS FROM FALL WITH WINTER CLEAN-UP LAMBING ENTERPRISE BUDGETS FOR THE FLOCK

	Dollars		
Budget	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	14,695	10,024	1,403
Average of market lamb corn, & SBOM prices & excluding labor	14,695	7,408	4,019
Average of market lamb prices, +1 σ for corn & SBOM including labor	14,695	10,645	782
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	14,695	8,029	3,398
Average of market lamb prices, -1 σ for corn & SBOM including labor	14,695	9,403	2,024
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	14,695	6,787	4,640

TABLE 58. INCOME, EXPENSES, AND RETURNS FROM FALL WITH WINTER CLEAN-UP LAMBING ENTERPRISE BUDGETS ON A PER EWE BASIS

	Dollars		
Budget	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	127.78	87.17	12.20
Average of market lamb corn, & SBOM prices & excluding labor	127.78	64.42	34.95
Average of market lamb prices, +1 σ for corn & SBOM including labor	127.78	92.57	6.80
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	127.78	69.82	29.55
Average of market lamb prices, -1 σ for corn & SBOM including labor	127.78	81.77	17.60
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	127.78	59.02	40.35

TABLE 59. COMPARISONS OF SPRING AND FALL WITH WINTER CLEAN-UP LAMBING SYSTEMS ENTERPRISE BUDGETS

	Dollars		
Budget	Income	Expenses	Returns
Flock:			
Spring vs fall & winter lambing with +1 σ for lamb prices including labor[a]	15,827	10,574	2,535
Spring vs fall & winter lambing with +1 σ for lamb prices excluding labor[a]	15,827	7955	5,151
Spring vs fall & winter lambing with -1 σ for lamb prices including labor[a]	13,563	10,574	271
Spring vs fall & winter lambing with -1 σ for lamb prices excluding labor[a]	13,563	7955	2,887
Per ewe:			
Spring vs fall & winter lambing with +1 σ for lamb prices including labor[a]	137.63	91.94	22.04
Spring vs fall & winter lambing with +1 σ for lamb prices excluding labor[a]	137.63	69.17	44.79
Spring vs fall & winter lambing with -1 σ for lamb prices including labor[a]	117.94	91.95	2.56
Spring vs fall & winter lambing with -1 σ for lamb prices excluding labor[a]	117.94	69.17	25.10

[a]10 year average for corn and SBOM

Chapter 6: Results and Discussion

High-fertility Fall Lambing System

Lambing Calendar

In high-fertility fall lambing, the simulated 50 acres supported the same number of ewes, 115, as the fall lambing with winter clean-up lambing. The same number of ewes were maintained because ewe numbers were defined by the number of ewes that could be supported by the forage resource in July and August. The high-fertility lambing system calendar was were shown in table 1 and nutrient requirements for the individual ewes were shown in table 4. The TDN consumption for nutrient requirements of ewes in the flock in each stage of production is shown in table 60.

TABLE 60. NUTRIENT REQUIREMENTS FOR EWES FOR HIGH-FERTILITY FALL LAMBING

Stages of production	Number of ewes	TDN/d, lb	TDN/days, lb
Breeding	115	198	10088/51d
Early gestation	115	198	16417/83d
Last 4 wks of gestation	115	301	8439/28d
Early lactation:			
September	115	344	7221/21d
October	115	277	8582/31d
November	104[a]	364	10913/30d
Late lactation	104	341	10559/31d
Maintenance	104	156	14040/90d

[a] 11 ewes were culled on November 1

In high-fertility fall lambing, 87 adult ewes and 17 ewe lambs lambed, producing 196 lambs (table 61 and 62). Of these, 23 lambs died, leaving a total of 174 lambs to be marketed. Six triplet lambs were artificially raised on milk replacer and creep feed.

TABLE 61. LAMBING DISTRIBUTION FOR EWES IN HIGH-FERTILITY FALL LAMBING

			Number of lambs			
Cycle	Birth type	Ewes	Born	Died	Artificially reared	Suckled
1	Triplets	10	30	6	4	20
1	Twins	44	88	9	0	79
1	Singles	10	10	1	0	9
2	Triplets	3	9	2	1	6
2	Twins	11	22	2	0	20
2	Singles	3	3	0	0	3
3	Triplets	1	3	0	1	2
3	Twins	4	8	1	0	7
3	Singles	1	1	0	0	1

TABLE 62. LAMBING DISTRIBUTION FOR EWE LAMBS IN HIGH-FERTILITY FALL LAMBING

			Number of lambs			
Cycle	Birth type	Ewe lambs	Born	Died	Artificially reared	Suckled
1	Triplets	0	0	0	0	0
1	Twins	2	4	1	0	3
1	Singles	5	5	1	0	4
2	Triplets	0	0	0	0	0
2	Twins	2	4	0	0	4
2	Singles	5	5	0	0	5
3	Triplets	0	0	0	0	0
3	Twins	1	2	0	0	2
3	Singles	2	2	0	0	2

Nutrient Requirements and Growth Rates for Lambs

Growth curves of high-fertility fall born lambs were shown in figure 17. Average daily gains of single and twin lambs were shown in table 11. Predicted TDN for suckling lambs in high-fertility fall lambing was shown in table 12. Tables 63 and 64 show the predicted growth lambs in high-fertility fall lambing.

TABLE 63. PREDICTION OF GROWTH OF YOUNG SUCKLING TWIN LAMBS IN HIGH-FERTILITY FALL LAMBING

	Days of age of lambs				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb/d	2.21	2.78	2.11	1.63	.99
Initial weight, lb/d	8.16	18.80	29.10	41.20	48.80
Gain (milk), lb/d	.63	.55	.22	.77	0.00
Gain (forage), lb/d	0.00	.06	.38	.27	.36
Total gain, lb/d	.63	.61	.49	.35	.36
TDN, lb/d	0.00	.08	.39	.43	.88
Final weight, lb	18.80	29.10	41.20	48.80	59.70

Predicted growth weaned lambs in high-fertility fall lambing is shown in table 65. The total number of lambs was 173. Of these, 21 were sold at the end February at a weight of 117 lb, 91 were sold at the end March at a weight of 121 lb, and 61 were sold at the end April at a weight of 122 lb.

TABLE 64. PREDICTION OF GROWTH OF YOUNG SUCKLING SINGLE LAMBING IN HIGH-FERTILITY FALL LAMBING

	Days of age of lambs, lb				
Item	1-17/d	18-34/d	35-60/d	61-90/d	91-120/d
Milk intake, lb/d	3.64	4.41	3.53	2.73	1.68
Initial weight, lb/d	9.79	25.20	38.30	53.30	63.80
Gain (milk), lb/d	.91	.77	.47	.23	0.00
Gain (forage), lb/d	0.00	0.00	.12	.18	.38
Total gain, lb/d	.91	.77	.52	.41	.38
TDN	0.00	0.00	.22	.38	1.00
Final weight, lb/d	25.20	38.20	53.30	63.80	75.30

TABLE 65. PREDICTION OF GROWTH OF WEANED LAMBS IN HIGH-FERTILITY FALL LAMBING

Months	Number of lambs	Starting wt, lb	lb/hd/d	Final weight of lambs not sold, lb
January	173	54.44	1.74	75.50
February	173	75.50	2.31	91.82
March	152	91.82	2.51	101.9
April	61	101.90	2.86	

Artificially Raised Triplet Lambs

Within the high-fertility lambing system, 14 ewes had triplets; eight of the triplets died, which left 6 lambs to be artificially raised. The TDN requirements of these 6 lambs are shown table 66. No forage was consumed by these lambs. The 6 artificially raised triplets joined the other lambs on December 31. The total milk consumed was 139.26 lb, which was less than the amount consumed in spring lambing, and the total TDN from grain consumed was 459.36 lb, which was higher than the amount consumed in spring lambing.

TABLE 66. TDN REQUIREMENTS FOR 6 HIGH-FERTILITY FALL BORN ARTIFICIALLY RAISED LAMBS

Month	Milk, lb	TDN from concentrates, lb
September	44.73	0.00
October	94.53	60.82
November	0.00	175.53
December	0.00	223.02

Nutritional Budget

A nutritional budget was developed for high-fertility fall lambing which consisted of grazed and harvested (hay) forages, concentrates (corn, SBOM, creep feed, and pelleted protein mix), and milk replacer. Available forage and animals nutrient requirements are shown in table 67, and do not include the TDN that the suckling lambs consumed from milk. Sheep did not utilize spring pastures until April 1. The high-fertility fall lambing system used 38 acres of permanent pasture and 12 acres of fescue. Ewe numbers were controlled by availability of forage to met animals' nutrient requirements during July and August.

Concentrate need for ewes, ewe lambs, and market lambs were met with corn, SBOM and a pelleted protein mix. Percentages of the ewes' total nutritional requirements that were met with concentrates were 20.97% in August, 8.12% in September, and 0.00% in all other months. Percentage of the lambs' total nutritional requirements that were met through concentrates was 100% in January through April and 0.00% in all other months. Percentages of the artificially raised triplets' total nutritional requirements that were met through concentrates was 61% in October, 100% in November and December, and 0.00% for all other months. Concentrate needs for sheep in high-fertility fall lambing are shown in table 68. In January, artificially reared lambs were combined into one group with the suckled lambs.

Forage surpluses and deficiencies per month in high-fertility fall lambing are shown table 69. Hay produced and harvested in high-fertility fall lambing are shown table 70. The hay produced contained 40,044 lb/yr of TDN. Hay consumed by the sheep accounted for 21,840 lb/yr of TDN, leaving a surplus of 18,204 lb/yr of TDN of hay that was sold.

TABLE 67. AVAILABLE FORAGE AND ANIMAL REQUIREMENTS IN HIGH-FERTILITY FALL LAMBING

	Available	TDN required, lb for:		
Month	Forage TDN	Ewes	Lambs	Artificially raised lambs
January	0	4836	0	0
February	0	4368	0	0
March	0	4836	0	0
April	28005	5934	0	0
May	31132	6132	0	0
June	12792	5969	0	0
July	10746	6168	0	0
August	6539	6424	0	0
September	6081	9129	3	0
October	8238	8582	118	0
November	11010	10913	1609	0
December	7296	10559	2856	0

TABLE 68. CONCENTRATE NEEDS FOR SHEEP IN HIGH-FERTILITY FALL LAMBING

	TDN, lb			
Month	Ewes	Lambs	Artificially raised lambs	Total
January	0	9332	0	9332
February	0	11159	0	11159
March	0	18927	0	18927
April	0	5234	0	5234
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	1704	0	0	1704
October	807	0	61	983
November	0	0	176	176
December	0	0	233	233

TABLE 69. FORAGE SURPLUSES OR DEFICIENCIES IN HIGH-FERTILITY FALL LAMBING

	TDN, lb	
Months	Surplus	Deficiency
January	0	4836
February	0	4368
March	0	4836
April	22071	0
May	25001	0
June	6825	0
July	4578	0
August	115	0
September	0	3048
October	0	354
November	90	0
December	0	4398
Totals	58679	21840

TABLE 70. HAY HARVESTED AND HAY USED FOR HIGH-FERTILITY FALL LAMBING

	TDN, lb	
Months	Hay Produced	Hay Needed
January	0	4836
February	0	4368
March	0	4836
April	0	0
May	27500	0
June	7507	0
July	5037	0
August	0	0
September	0	3048
October	0	354
November	0	0
December	0	4398
Total	40044	21840

Enterprise Budget

In high-fertility fall lambing, seven enterprise budgets were created. The first budget was calculated with 10-year average prices for market lambs, corn, and SBOM (table 71). The second budget was calculated with 10-year average prices for market lambs, +1 standard deviation for corn (52¢), and +1 standard deviation for SBOM ($32.48). The third budget was calculated with 10-year average prices for market lambs, -1 standard deviation for corn, and -1 standard deviation for SBOM. The fourth and fifth budgets were calculated with 10-year average prices for corn and SBOM and plus or minus 1 standard deviation for market lamb price differentials between spring and high-fertility fall lambing. The sixth and sevenths budgets were calculated with 10-year average prices for corn and SBOM and plus and minus 1 standard deviation for market lamb price differentials between fall with winter clean-up and high-fertility fall lambing. Income, expenses, and returns for the seven budgets for the flock are shown in table 72. Income, expenses, and returns for the seven budgets on a per ewe basis are shown in table 73. Table 74 shows the comparisons of different lambing systems with ± standard deviation from the mean of market lamb prices as shown in table 18. The hay harvest and reseeding costs in the seven budgets were only calculated for the hay that was consumed by the sheep in the high-fertility fall lambing system.

There were 10.92 tons of hay consumed by the sheep. There was 9.10 tons of hay that was not used in fall with winter clean-up lambing. The harvest cost was $179.76 and the value of hay sold at $70.00 per ton was $457.24 (Farm Management, 1988 and 1998).

TABLE 71. ENTERPRISE BUDGET FOR HIGH-FERTILITY FALL LAMBING WITH 10 YEAR AVERAGE PRICES FOR MARKET LAMBS, CORN, & SBOM

ITEM	SOLD		UNIT	PRICE	QUANTITY	TOTAL
CASH INCOME						
LAMBS IN FEB	21 @	1.17	CWT	$73.14	24.57	$1,797.05
LAMBS IN MAR	91	1.21	CWT	$78.09	110.11	$8,598.49
LAMBS IN APR	61 @	1.22	CWT	$81.61	74.42	$6,073.42
CULL EWES	11.0 @	1.50	CWT	$30.00	16.50	$495.00
CULL RAM	0.7 @	2.00	CWT	$30.00	1.38	$41.40
WOOL	6.5 #	/HD.	LBS	$0.60	769.93	$461.96
				TOTAL CASH INCOME		$17,467.31
CASH EXPENSES						
				PRICE	QUANTITY	TOTAL
HARVEST & SEED			TON	$20.22	12.27	$248.10
SHELLED CORN			BU	$2.56	58.00	$148.48
SBOM			BU	$208.35	0.00	$0.00
DRYLOT FEED			TON		24.43	$3,184.50
MILK REPLACER			LB	$1.33	167.00	$222.11
CREEP FEED			TON		0.32	$43.15
FERT. & LIME			LB			$554.00
VET MED	EWE		HEAD	$4.27	92.00	$392.84
VET MED	EWE LAMB		HEAD	$3.18	23.00	$73.14
VET MED	LAMB		HEAD	$3.69	173.00	$638.37
SALT & MINERAL			CWT	$21.50	22.77	$489.51
MISCELLANEOUS			HEAD	$2.00	115.00	$230.00
REPLACEMENT RAM			HEAD	$350.00	0.69	$241.50
SHEARING			HEAD	$2.00	118.45	$236.90
HAUL SHEEP			HEAD	$1.55	184.69	$286.27
MARKET SHEEP			HEAD	$1.85	184.69	$341.68
VIRGINIA CHECKOFF			HEAD	$0.50	173.00	$86.50
BLDG. & FENCE REPAIR			HEAD	$2.00	115.00	$230.00
UTILITIES			EWE	$0.90	115.00	$103.50
MACHINERY, NON-CROP			EWE	$1.78	115.00	$204.70
				TOTAL CASH EXPENSES		$7,955.25
RETURN TO EQUITY, MANAGEMENT, AND OPER. LABOR						**$9,512.07**
LABOR	2.95 HR/EWE		EWE	$19.44	115.00	$2,235.60
RETURN TO EQUITY AND MANAGEMENT						**$7,276.47**
ANNUAL DEBT PAYMENTS						$3,268.45
RETURN TO EQUITY AND MANAGEMENT						**$4,008.01**

TABLE 72. INCOME, EXPENSES, AND RETURNS FROM HIGH-FERTILITY FALL LAMBING ENTERPRISE BUDGETS FOR THE FLOCK

	Dollars		
Budget	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	17,467	10,191	4,008
Average of market lamb corn, & SBOM prices & excluding labor	17,467	7,955	6,244
Average of market lamb prices, +1 σ for corn & SBOM including labor	17,467	10,870	3,329
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	17,467	8,634	5,565
Average of market lamb prices, -1 σ for corn & SBOM including labor	17,467	9,511	4,688
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	17,467	7,275	6,924

TABLE 73. INCOME, EXPENSES, AND RETURNS FROM HIGH-FERTILITY FALL LAMBING ENTERPRISE BUDGETS ON A PER EWE BASIS

	Dollars		
Budget	Income	Expenses	Returns
Average of market lamb corn, & SBOM prices & including labor	151.89	88.62	34.85
Average of market lamb corn, & SBOM prices & excluding labor	151.89	69.17	54.30
Average of market lamb prices, +1 σ for corn & SBOM including labor	151.89	94.52	28.95
Average of market lamb prices, +1 σ for corn & SBOM excluding labor	151.89	75.08	48.39
Average of market lamb prices, -1 σ for corn & SBOM including labor	151.89	82.70	40.77
Average of market lamb prices, -1 σ for corn & SBOM excluding labor	151.89	63.26	60.21

TABLE 74. COMPARISONS OF EACH OF THE LAMBING SYSTEMS ENTERPRISE BUDGETS

	Dollars		
Budget	Income	Expenses	Returns
Flock:			
Spring vs high-fertility fall lambing with +1 σ for lamb prices including labor[a]	19,742	10,191	6,283
Spring vs high-fertility fall lambing with -1 σ for lamb prices including labor[a]	15,192	10,191	1,733
Fall & winter vs high fert. fall lambing with +1 σ for lamb prices including labor[a]	19,042	10,191	5,583
Fall & winter vs high fert. fall lambing with -1 σ for lamb prices including labor[a]	15,893	10,191	2,434
Per ewe:			
Spring vs high-fertility fall lambing with +1 σ for lamb prices including labor[a]	171.67	88.62	54.63
Spring vs high-fertility fall lambing with -1 σ for lamb prices including labor[a]	132.10	88.62	15.07
Fall & winter vs high fert. fall lambing with +1 σ for lamb prices including labor[a]	165.58	88.62	48.55
Fall & winter vs high fert. fall lambing with -1 σ for lamb prices including labor[a]	138.20	88.62	21.17

[a]10 year average for corn and SBOM

Chapter 7: Conclusions and Implications

Three lambing systems on a fixed forage resource were compared. For each system, a production calendar, nutrient requirements for ewe and lambs, forage production, hay production, amount of milk replacer and concentrate feed consumed, fertility, death losses, lamb growth rates, lactation curves, and enterprise budgets were generated. Table 75 shows some of the key differences in the three lambing systems. In table 75, the item lambs weight at weaning only contains fall lambing weights in the column fall with winter. In the winter clean-up lambing, single lambs weighted 82 lb at weaning and twin lambs weighted 70 lb. Fall artificially raised lambs were on milk replacer and creep feed for 120 days, while spring artificially raised lambs were on milk replacer, creep feed, and forage for 150 days.

TABLE 75. KEY DIFFERENCES IN THE THREE LAMBING SYSTEMS

	Lambing systems		
Item	Spring	Fall with winter	High-fertility fall
Ewe numbers	78	115	115
Lamb numbers	126	146	173
Nutrient Requirements, lb:			
Ewes	68141	90113	86258
Lambs	33702	34180	42138
Artificially raised triplets	760	721	704
Forage produced, lb of TDN	130403	123376	121832
Hay produced, lb of TDN	53062	49205	40044
Hay used, lb of TDN	16721	11909	21840
Hay sold, lb of TDN	36341	37295	18204
Labor costs	$1697	$3166	$2236

The spring lambing produced the most forage (lb of TDN), using only permanent pasture. The fall with winter clean-up and high-fertility fall lambings used a combination of fescue and permanent pasture, but the total yield of forage TDN was lower than for spring lambing. Because of the limited forage in July and August, spring lambing could only support 78 ewes. Fall with winter clean-up and high-fertility fall lambing systems were able to support more ewes in July and August due to lower nutritional requirements for the flock during those months. The result is production of more lambs from more ewes in the fall with winter clean-up and high-fertility fall lambing systems in than spring lambing. As expected, because the number of lambs is largest in high-fertility fall lambing, lambs in this system consumed the most concentrate feed, followed by the fall with winter clean-up and spring lambings. The high-fertility fall lambing had the highest demand for hay, followed by spring and fall with winter clean-up lambings. The lambing systems that sold the most hay were fall with winter clean-up and spring, which sold about the same amount. The high-fertility fall system sold the least hay. Labor costs were greatest for fall with winter clean-up lambing because of the two lambing seasons, followed by high-fertility fall and spring lambings. Fall lambing had the lowest per ewe labor costs, but with the large number of ewes in fall compared to spring lambing, total labor costs were greater for the flock in fall lambing.

Enterprise budgets were completed on the three lambing systems. Sensitivity analysis to corn and SBOM prices with 10-year average market lamb prices, were computed. The enterprise budgets were calculated both with and without labor costs included in the expenses. The sensitivity analysis to market lamb price differentials between seasons, as shown in table 18, were calculated with average corn and SBOM prices and compared for the various lambing systems (table 76).

TABLE 76. RETURNS FROM ENTERPRISE BUDGETS FOR LAMBING SYSTEMS WITH VARIOUS MARKET LAMB PRICES

	Returns for lambing systems, $[a]		
Budget[b]	Spring fall with winter	Spring high-fertility fall	Fall with winter high-fertility fall
Base with average prices	347	347	1403
Target with average prices	1403	4008	4008
Target with +1 σ price differential	2535	6283	5583
Target with -1 σ price differential	271	1733	2434

[a] First system is the base system and the second system is the target system

[b] Prices based upon average prices or with ± σ for price differential between target and base system

In spring lambing, income on the enterprise budget with average market lamb prices was $10,358, which was lower than fall with winter clean-up ($14,695) and high-fertility fall ($17,467) lambing. Expenses were 75% of income in spring lambing, 72% of the income in fall lambing with winter clean-up, and 58% of income in high-fertility fall lambing. In spring lambing comparison of the price differentials for market lamb prices, the high-fertility fall lambing had the greatest returns. High-fertility fall lambing also had the greatest returns in the enterprise budgets for all corn and SBOM prices. This result could be due to the use of stockpiled fescue, high lambs prices, large numbers of lambs to sell, and more efficient use of the forage resource. The forage resource was a limiting factor in spring lambing. Even with the sale of hay added to the total revenue in the three lambing systems, the high-fertility fall lambing still had the greatest returns. The net sale from hay was $913.04 for spring lambing, $937.16 for fall with winter clean-up lambing, and $457.24 for high-fertility fall lambing. The sheep in spring lambing consumed more hay than fall with winter clean-up lambing (8.38 tons vs 5.96 tons).

Conclusions of Tolman (1993) differed from those found within this thesis. Tolman found that on a per ewe basis, the spring lambing system was more profitable than the fall system with a winter clean-up. Even with increased fertility in the fall, she still concluded that the spring lambing system yielded higher returns. These conclusions were calculated without using stockpiled fescue and with or without feeding lambs on millet during the summer. The results in this thesis were calculated on a flock basis, and the number of ewes was dependent on the forage resource. Tolman calculated enterprise budgets on a per ewe basis and for a 100-ewe flock as shown in table 77. The fall with 196% lamb crop in table 77 has winter clean-up lambing included in it. Tolman did not calculate results for fall lambing alone. To compare the results in the thesis to Tolman's, the enterprise budgets were calculated on a per ewe basis as shown in table 78. The budget results used do not include labor costs, because she did not include them in her results. When labor is included into the costs, the returns for each lambing system were reduced.

TABLE 77. ENTERPRISE BUDGETS ON A PER EWE BASIS

		Lambing systems, $	
Item	Spring	Fall with winter	Fall with 196% lamb crop
Income	115	116	
Expenses	77	94	
Returns	38	21	38

In the comparison of results from Tolman (1993) and the results of this thesis, the costs, income, and returns were compared. The performance level of the ewes in each system in this thesis were essentially the same as her performance levels.

In spring lambing on a per ewe basis, Tolman's (1993) forage costs were higher than the forage costs in this thesis ($12.04 vs $6.98) and costs were even highest when millet was added. Her concentrate feed costs were lower than the feed costs in this thesis ($23.06 vs $31.39). Her non-feed costs were slightly higher than the non-feed costs in this thesis ($36.90 vs $34.53). Overall, the costs for spring lambing in her budgets were somewhat lower than the costs in this thesis ($72.00 vs $73.00).

In fall with winter clean-up lambing on a per ewe basis, Tolman's (1993) forage costs were higher than the forage costs in this thesis ($13.18 vs $5.69). Her feed costs were lower than the feed costs in this thesis ($34.36 vs $45.09). Her non-feed costs were the same as the non-feed costs in this thesis ($33.52 vs $33.33). Overall, the costs in Tolman's costs were slightly lower for fall lambing with winter clean-up than the costs in this thesis ($81.00 vs $84.10). The high-fertility fall lambing could not be compared to Tolman's (1993) results because she does not show the costs of that system.

The income in each lambing system enterprise budget was higher ($12.00 to $18.00) on a per ewe basis than Tolman's (1993) incomes. This could be a result of the increased price of market lambs from 1994 to 1997; she used market lamb prices from 1988 to 1993. Costs per ewe in this thesis were $5.00 higher in spring lambing and $3.00 lower in fall with winter clean-up lambing per ewe than her costs. Returns per ewe in this thesis were $12.00 lower in spring lambing, $14 higher in fall with winter clean-up lambing, and $16.00 higher in high-fertility fall lambing than her returns.

TABLE 78. ENTERPRISE BUDGETS ON A PER EWE BASIS FOR THREE LAMBING SYSTEMS

	Lambing system, $		
Item	Spring	Fall with winter	High-fertility fall
Income:			
Average costs	133	128	152
+1 σ corn & SBOM	133	128	152
-1 σ corn & SBOM	133	128	152
+1 σ market lamb[a]		138	
-1 σ market lamb[a]		118	
+1 σ market lamb[b]			172
-1 σ market lamb[b]			132
Expenses:			
Average costs	78	64	69
+1 σ corn & SBOM	85	70	75
-1 σ corn & SBOM	72	59	63
+1 σ market lamb[a]		69	
-1 σ market lamb[a]		69	
+1 σ market lamb[b]			69
-1 σ market lamb[b]			69
Returns:			
Average costs	26	35	54
+1 σ corn & SBOM	20	30	48
-1 σ corn & SBOM	33	40	60
+1 σ market lamb[a]		45	
-1 σ market lamb[a]		25	
+1 σ market lamb[b]			73
-1 σ market lamb[b]			35

[a] spring vs fall with winter lambing
b spring vs high-fertility fall lambing
Labor cost were not included

The implications of these results shows that if one can increase fertility in fall lambing and remove the winter clean-up lambing, the high-fertility fall lambing yielded the greatest returns. One concern with this system is getting ewe lambs bred, which is difficult in a fall lambing system. The spring lambing ewe numbers could be increased if hay, summer annual grasses, or other feeds would be fed in July and August when forage growth is low. There was excess hay in all three lambing systems, which could be sold or consumed by some other class of livestock, such as stocker steers.

The issue of available labor and labor flow for sheep production systems is important due to the part-time nature of sheep production. This is another aspect which favors fall lambing. Spring lambing is in direct competition with other agricultural enterprises, such as cattle or tobacco. Fall lambing utilizes labor which is generally needed less for other agricultural enterprises.

Forage production can be a driving force in sheep production. It has been demonstrated in this thesis as a limiting factor in the number of ewes on a fixed resource of land. The limited growth in the summer (July and August) can be a controlling factor in the number of ewes a specific piece of land can support. One could choose to relieve this constraint by feeding ewes other feedstuff, such as summer annuals or hay during that time. The uses of stockpiled fescue resulted in a cheap feed source for ewes and lambs in fall lambing systems. Stockpiled fescue contribute to the not add spring lambing system.

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Vita

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