OPTIMIZING FORAGE PROGRAMS
FOR OKLAHOMA BEEF
PRODUCTION

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Problem Statement

Cattle producers are facing many changes. Changes are results of the farm program phase-out and because of the shift from the family subsistence farm to the corporate contract farm. Livestock farming is no longer a subsistence way of life. Beef producers are looking for new production methods to increase returns. In the Southern states, winter wheat is often used in conjunction with cattle production to provide winter forage. However, the 1996 Farm Bill increased a producer's flexibility of using land in wheat for alternative uses. Wheat is an annual plant, meaning that the soil must be seeded every year. Therefore, the costs and returns of putting land into wheat production must be weighed against alternative uses of the land.

A major problem associated with many livestock operations is feed costs (Redmon 1996a; McGrann and Walter; Lalman, Gill, and Johnson). Except for the original purchase price of the livestock, feed costs are the largest expenditure in livestock production. Feed costs are greatest during low forage growth periods, such as winter or drought, because of the amount of supplemental feed needed to maintain proper nutrition for the cattle. Beef producers cannot control the market, but they can control and improve the management efficiency of their operations. How much potential exists for beef producers to lower feed costs through improved forage management, without trading-off needed nutrition?

Several alternatives to supplemental feeding are possible. The need for supplemental feeds, especially hay, are not likely to be eliminated through any pasture management program, but it may be possible to reduce the producers use of supplemental feeds. One alternative is using hay of a higher nutritive value. Hay production needs to be managed much like a cash crop. Proper hay management involves planning and preparing for different stages of cattle production. A good hay manager knows the soil's fertility, plans fertilizer applications well ahead of time, is aware of the stages of maturity of the growing hay and its nutritive value at each stage, and uses appropriate harvesting and storing practices.

Another alternative is allowing a forage to grow uninterrupted for at least one month. This practice is known as pasture stockpiling. Stockpiling can be a very effective feeding program if the forages are allowed to grow for periods without any grazing. Stockpiling works well with a rotational pasture program. Growing cool-season pastures is another option that can reduce supplemental regimens. Cool-season pastures can be significantly less expensive than feeding supplements alone, and can yield comparable animal performance. The use of cool-season pasture grazing must be carefully managed to keep from damaging the quantity and quality of the forage available. Such limited grazing "extends the quantity of forage produced in the cool-season pasture and requires less acreage to be established" (Redmon 1996a).

If nutritious forages are available for grazing during the winter, producers can rely on available forages instead of purchasing supplements. Grazing adequate nutritious forages can lower feeding costs by reducing the amount of purchased feed and by reducing the labor required to distribute the feed. The key is to plan for providing "enough" nutritious forages. Feed planning enables livestock producers to use feed resources efficiently and increase returns. The goal of this study is to develop a prototype mixed integer programming (MIP) model that will enable beef producers to identify the optimal combination of forages and beef cattle that maximizes returns to a given resource base. Funding for this research was provided by The Samuel Roberts Noble Foundation, Inc. together with the Oklahoma State University Agricultural Economics Department and a grant from the Southern Region Sustainable Agriculture Research and Education (SARE) Program. Extension specialists and other educators, in cooperation with producers, can use the model to enter farm resource information and then have the model solve for the optimal allocation of the farm's resources. The specialist and/or producer can make adjustments or changes to the prices and technical information as desired and quickly determine a farm plan maximizing returns to the farm's limited resources.

Objectives

Develop a prototype MIP model designed to identify the combination of forages and beef cattle to maximize returns to a given resource base to be used by extension specialists and other educators.

1. Develop a database summarizing Oklahoma forage data, specifying both quality–total digestible nutrient (TDN) and crude protein (CP)–and quantity–dry matter (DM) dimensions.

2. Estimate changes in quality and quantity of stockpiled forage over time.

3. Estimate cow-calf nutrient requirements measured in DM, TDN, and CP.

4. Estimate stocker nutrient requirements measured in DM, TDN, and CP.

Plan of Research

The most efficient way to lower winter feeding costs is with proper forage management. If cattle producers learn to efficiently manage their pastures, they can keep the cattle on grazed forage for longer periods of time and still maintain the needed nutritional requirements without excessive amounts of supplemental feed.

This research is devoted to helping producers increase returns by improving the efficiency of farm-level operations. This research project consists of 1) estimating monthly production (quantity and quality) of several forages, as well as cow-calf and stocker monthly nutritional requirements; 2) building a representative farm; and 3) linking all of this information in an MIP model. The MIP model solves for the optimal combination of forage and beef production given an available resource base. Also, the forage data collected are used in forage enterprise budgets. The forage data collected add another dimension to traditional forage enterprise budgets, and will facilitate links into cattle nutrition programs. An important aspect of this program is its extensive forage database of quantity and quality, which can be expanded and can be used in future research.

It is important for producers to treat their forages as individual enterprises of their operation, because forages are an extremely important input into a livestock operation. Currently, forage enterprise budgets contain production costs based on an animal unit month (AUM). Forage enterprise budgets could be more informative if they contained more dimensions of forage production. The forage enterprise budgets for this project break down forage production into measurements of monthly dry matter (DM), crude protein content (CP), energy content represented by total digestible nutrient (TDN), and the costs associated with that production. Much of the forage DM, CP, and TDN data for five Oklahoma forages are available from Oklahoma Experiment Station bulletins and reports and past forage nutrient studies. All of the forage nutritional information has been compiled into a forage database that is used for reference throughout this research, and is available for future research.

For the forage data to be worthwhile to a beef producer, the producer needs to know what the cattle nutrient requirements are. With this information, the cattle requirements can be better matched to the forage resources. The DM, CP, and TDN requirements per month for cow-calf and stocker enterprises are available from the *Nutrient Requirements of Beef Cattle* as developed by the National Research Council, Committee on Animal Nutrition.

Linking the information from the forage and livestock budgets in an MIP model allows for the MIP to solve for the optimal combination of forages and combination of beef production given a resource base. The mixed integer programming prototype model considers five major Oklahoma forages, but it does not consider any over-seeded combinations of forages. The model also does not allow for varying nitrogen levels. The model does allow grazing to compete with stockpiling. A cow-calf operation competes with a stocker operation, but the two operations can also be selected in conjunction.

This research project does not result in a 'final' product. The prototype MIP model reveals areas in need of further research and data. With additional data and modification, the prototype MIP model is capable of handling additional feed programs and livestock operations (e.g. ostrich). Also, adoption of computer technology is becoming an increasingly important issue. Ideally, this planning aid will be available through the Oklahoma Cooperative Extension Service and The Samuel Roberts Noble Foundation, Inc. Extension specialists and other educators can use it to help producers plan a management system suitable for their operations. As more and more producers begin to adopt computer technology for daily on-farm work, they may be able to individually adopt the planning aid.

CHAPTER II

LITERATURE REVIEW

Though percentages vary from farm to farm, feed costs are the greatest expenditure second to the original purchase price of the cattle. Feed costs range from 26-50% of total beef production expenditure, depending on farm location and type of operation (Redmon 1996a; McGrann and Walter; Lalman, Gill, and Johnson). In late 1997, feed costs ranged from \$.42 to \$.84 per day for a 1000 pound lactating cow, and ranged from \$.38 to \$.73 per day for a 1000 pound dry cow (Dunford). Feed costs vary directly with the price of hay.

Feed and Hay Management

According to Redmon (1996a), the four most common mistakes producers make in feeding their cattle include:

1) Use of hay that is low in nutritive value,

2) Feeding hay for an extended period of time,

3) Too much dependence on concentrate feeds,

4) Too little use of forages (stockpiled or growing) for winter feeding.

Neither Russell and Huhnke nor Redmon (1996a, 1996b) believe hay should be eliminated from feed programs, but do believe hay needs to be well managed to optimize its use. Russell and Huhnke discuss the basics of proper hay management. They emphasize the importance of proper hay storage, hay moisture levels, bale size, and bale density in reducing dry matter and digestible dry matter losses. Agronomists stress the fact that the basics of hay maintenance can be achieved and an optimal low-cost feed program attained with adequate planning. Planning involves knowing livestock maintenance required throughout the production cycle and knowing the nutrients available from alternative forages throughout different stages of forage growth/production, as well as the costs associated with forage production. To efficiently use forages, they must be budgeted according to expected daily growth (Lile and George). Informed decision making is crucial to any successful livestock operation.

Forage Versus Grain Feeding

Until recently, feedlots have fed grain based rations to accomplish a higher grade of meat. However, with improved pasturing techniques, feeding beef cattle at all stages of production on grass is becoming a more feasible option. According to Nickel's article in Beef Today, research shows that grass-fed beef is highly competitive with grain-fed beef in taste and grade. However, Griebenow, Martz, and Morrow's research found that grass-finished beef results in poor grade quality, and sometimes has a grassy flavor. They explain that the poor grade quality may be a result of poor forage selection and that the grassy flavor has only been detected by trained taste-test panelists. Griebenow, Martz, and Morrow discussed several studies that as a result of excreta remaining on the pasture from grazing livestock there is increased soil fertility and forage production. They concluded that a good combination of grass- and grain-feeding (grain-on-pasture) can overcome the problems of poor grade quality and grassy flavor, and is "more profitable than drylot feeding at all levels studied."

One concern producers have about shifting to a strictly grass-based feeding program is fear of adopting a new technology. Though most producers want to produce at a higher return, many are afraid of eliminating methods they already know and of learning and adjusting to new methods. Hanson, Taff, and Klair evaluated individual farms for the implications of shifting to grass-based feeding. They first developed whole-farm budgets to use in FINPACK, a financial analysis system developed at the University of Minnesota. The budgets show the effects of adopting a variety of grass-based feeding alternatives. The different alternatives were tested for plausibility on three study operations. The current farm management programs and alternatives were compared on an individual farm, as well as across farms. Hanson, Taff, and Klair conclude that, without an external income supplement, the current management practices result in higher incomes than the alternative grass-based feed systems. An important factor to consider in the Hanson, Taff, and Klair results is that Minnesota pasture, as opposed to Oklahoma pasture, competes with grain crop land. The majority of land in Oklahoma, the study site for the current project, is most suited for pasture, not grain production.

Animal Science and Agronomy Perspectives in Modeling

Forage management studies are usually done from the perspective of the animal scientist or the agronomist. Combining a forage production component as well as a livestock production component into one study is very complicated because of the array of factors involved in such a production system. Many animal science studies consider management practices or techniques that could be used given certain available resources and what effect those practices have on livestock. Such studies are usually designed around stocking rate decisions. A major complaint about most stocking rate models is their lack of dynamics. However, Torell, Lyon, and Godfrey developed a multi-period stocking rate model and compared it to a single-period stocking rate model. They concluded that the multi-period aspect had little effect on the results. Based on their conclusions, expected benefits from a multi-period model would be less than expected costs of building one.

Many agronomic studies have considered the management of one or a few specific forages. Emmick and Fox thoroughly describe the elements of production that an efficient manager should consider for planning a successful prescription grazing method on Virginia pastures. They discuss maintenance of forages as well as livestock stocking methods, and the tradeoffs to each in finding the optimal mix. They explain that the general pattern of forage production is fairly predictable and "grazing management is recognized as the single most important element in the efficient utilization of pasture."

Mattox discusses general management techniques for southern Oklahoma and northern Texas, emphasizing rotational grazing and grazing pressure. Grazing pressure is the practice of using rotational grazing to force livestock to harvest forages before it diminishes in quality. Mattox states that late spring to early summer and, also, early fall is typically the optimum grazing period to harvest summer forages during active forage growth. Grazing pressure requires more intensive livestock management, but more efficiently uses the available forages.

Rawlins addressed the problem of decision making under uncertainty in beef-forage production systems in eastern Oklahoma. Rawlins used MOTAD and Target-MOTAD models "to determine the risk efficient allocation of resources for a beef-forage producer." He attempted to identify the efficient beef-forage production system based on a static model that accounted for risk in variability of forage yields and cattle prices. His model was based on bi-monthly data collected from experiment stations in eastern Oklahoma and from the National Research Council (NRC). Rawlins found that efficient farm plans are sensitive to the risk criteria and the producer's degree of risk aversion.

Tarrant's study evaluated current and future wheat varieties based upon their profit potential. He compiled wheat, stocker, and cow-calf enterprise budgets into a variety of whole-farm budgets. Tarrant used two different budgeting methods for determining profitability: variable stocking density and constant stocking density. Tarrant also used a CERES-Wheat model to simulate daily growth of the wheat plants, so he could point out the necessity for awareness of jointing date (the growing point when the plant grows above the soil's surface) for wheat and winter wheat varieties. Returns from wheat as forage for beef and wheat for grain were estimated and summed to rank each cultivar. Tarrant justified using the sum of returns from the two different enterprises by explaining that "higher grain yielding cultivars were not among the highest forage yielding cultivars." Tarrant concluded that choosing a cultivar based on forage or grain yield seldom resulted in the greatest economic return, and instead, a producer interested in wheat for both forage and grain should choose a cultivar based upon returns.

Usually, producers know from experience when to fertilize and the number of times per year they must fertilize. However, producers usually do not know forage production or quality responses associated with alternative fertilization practices. This study will add a new dimension to forage enterprise budgets that will allow the planner to attribute forage production costs to different stages of forage growth and nutritional value. A computerized planning aid will allow beef producers to see and understand what resources are available and what kind of maintenance is required during different times of the year by having whole-farm information located in one place. A computerized planning aid is also beneficial because it allows the producer to make changes to any input information and quickly see the results of that change.

Optimizing forage combinations and forage use in a profitability framework depends on monetary values established for the forages. Forages are typically valued on quantity rather than quality (Undersander, Howard, Shaver). Forages can be valued by testing animal performance on various combinations of forages. However, animal performance tests are expensive and often impractical (Undersander, Howard, Shaver). Another alternative for valuing forages is determining the current price of dietary supplements which could substitute for the value of the forages. Tarrant valued wheat forage by the value of beef produced.

Current computerized farm planning aids typically do not entail as much information as is needed for whole farm planning. Few studies incorporate detailed agronomic, animal, and economic factors in a computerized decision aid. "There is a need for a simple method to combine forage yield and quality into a single term reflecting economic values and tradeoffs in either factor for use in extension and teaching" (Undersander, Howard, Shaver). This study seeks collaboration between animal scientists, agronomists, and production economists for the purpose of developing a computerized tool that can be used directly with livestock producers.

CHAPTER III

DATA

Forages

Forage data for this model consist of dry matter (DM), crude protein (CP), and total digestible nutrient (TDN) for some common Oklahoma pasture forages. The forages used in the model are winter wheat, bermuda, tall fescue, old world bluestem, and tall grass prairie.

Measurements of DM were not taken in the wheat quality tests, so the wheat data comes from two sources. Winter wheat forage quality data (Appendix 1) are from tests conducted over a period of three years, 1993-1995. Six varieties of wheat were tested: Karl, 2163, 2180, AgSeCo 7853, Longhorn, and Scout 66. Means across variety were used for this model. Also, the data were assigned to a month of production based on the sampling date month, and data of the same sampling month were averaged. Each wheat variety was sampled from four stocking rates on each sampling date. Because the stocking rate did not result in significant variations in wheat forage quality, means of data across stocking rates were used for this model. For these Wheat quality tests, TDN was not measured. However, in vivo organic matter digestibility/disappearance (In Vivo DOM) as a percent of total DM was tested. A one-to-one ratio is a generally accepted relationship between In Vivo DOM and TDN (Redmon 1998-99). The winter wheat forage data were collected by small samples from each plot. Since small samples do not result in accurate measures of yield, the quality data are not directly correlated to the yield measures used in this model. Three options of wheat production were used in this model (Appendix 2): dual purpose wheat, wheat for forage only, and wheat for grain only. The wheat forage data were reported in annual production.

For this model, the average annual production for six years was divided by a typical 110 days of grazing to estimate daily production. The estimated daily production was then multiplied by the number of grazing days in each month (20 days in November and 30 days each in December-February) to obtain monthly production estimates. Because of insufficient data for wheat for forage only, the forage estimates of the dual purpose wheat for November-February were used. To estimate March-May forage production, March production was assumed to be twice the estimated production in February, and April and May were assumed to be four times the estimated production in February. The grain yield estimates for dual purpose wheat and wheat for grain only were averages of six years of data.

Bermuda data were collected from several Oklahoma bermuda performance reports (Appendix 3). Bermuda was not tested for TDN, so it was calculated from Acid Detergent Fiber (ADF) using the National Research Council equation (NRC 1984):

(1) $$TDN = 88.9 - 0.779 * ADF$$

The bermuda data were collected from four Oklahoma Experiment Station sites: Haskell, Stillwater, Lane, and Chickasha. Also, three different varieties of bermuda were studied at each site: Hardie, Midland, and Tifton 44. The data are clipping data reported by cutting date over a period of three years, 1992-1994. The bermuda data were averaged across varieties and location. For this model, monthly production averages were needed. Therefore, the TDN and CP data were assigned to the month when cuttings were made. Averages were taken across cuttings in the same month. Because of differences in clipping dates and locations of the bermuda data, Natural Resources Conservation Service (NRCS) estimates of monthly percentages of annual growth (Appendix 4) were applied to expected annual bermuda yield to obtain monthly DM estimates. The expected annual bermuda yield was based on survey data (Appendix 5).

From the Oklahoma experiment stations in Haskell and Stillwater, data for bermuda as affected by varying nitrogen (N) rate were available (Appendix 6). The bermuda-N data were tested on Midland, Hardie, and Tifton 44 varieties for 1992 and 1993. Data means across variety and year were assigned to months based on cutting dates, and then means were taken across the two test sites.

The tall fescue data were obtained from a study that was supervised by Dr. Redmon, Dept. of Agronomy, Oklahoma State University (Appendix 7). Three plots were studied: "control" (no fertilizer and no grazing), "stockpiled" with 60 lb. N applied and late grazing, and "grazing" with 60 lb. N applied and immediate grazing. The data represent monthly (October 1995 through July1996) clipping means across several plots. Because of production scientists' concerns about measurements of fescue DM, NRCS estimates of monthly percentages of annual growth (Appendix 4) were applied to expected tall fescue annual yield to estimate monthly DM. The expected annual fescue yield was based on survey data (Appendix 5).

Old world bluestem quality data were taken along with native grass tests from the OSU plots in Stillwater, OK (Appendix 8). Expected average annual old world bluestem yield and the NRCS monthly estimates of percentage of total production for plains bluestem (Appendix 4) were used to calculate monthly DM. Expected annual old world bluestem yield was based on the average annual plains bluestem yield in Perkins, OK (Hodges and Bidwell) and survey data (Appendix 5).

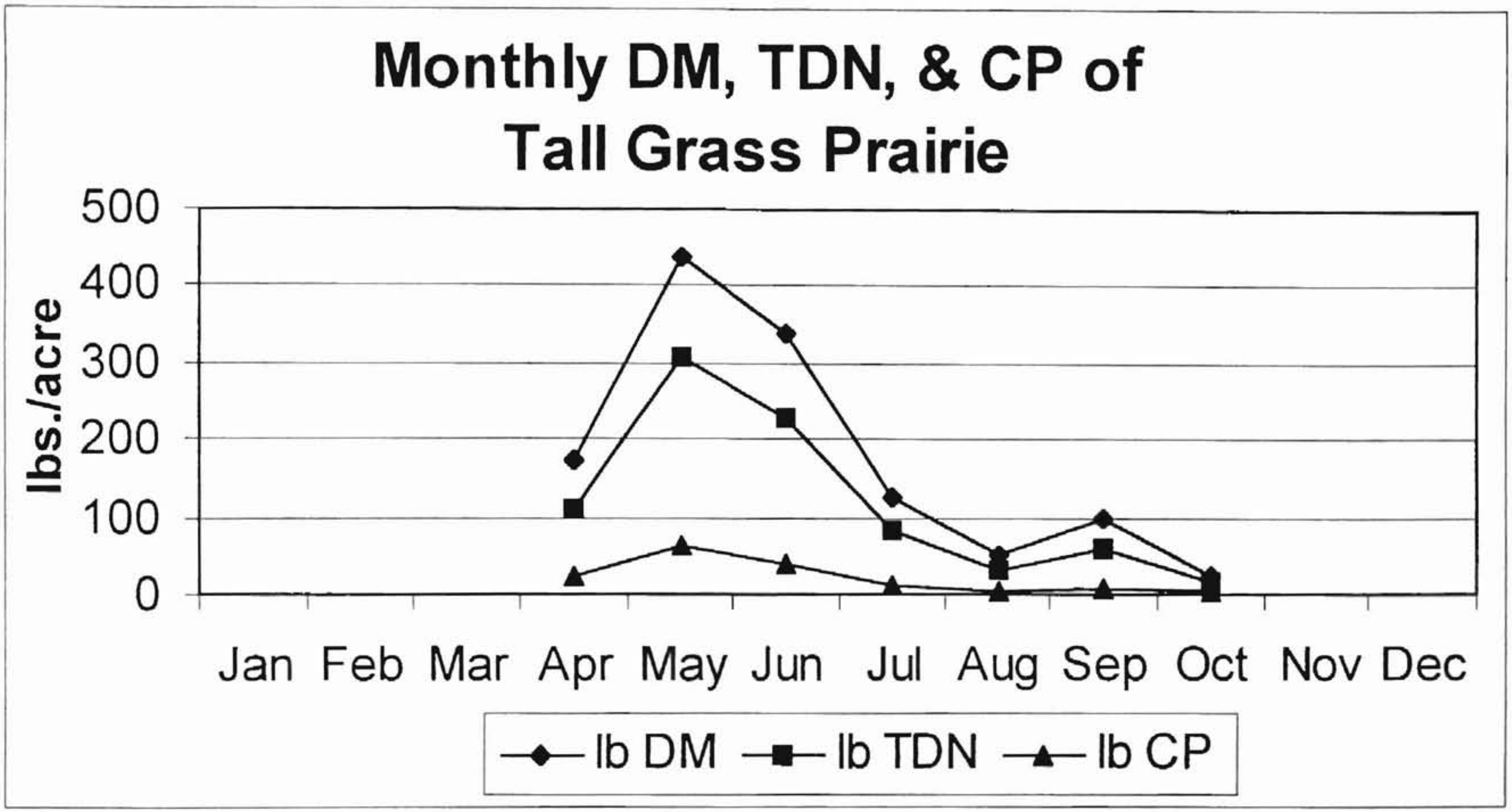
The tall grass prairie quality data were compiled from several studies on OSU plots in the Stillwater region (Appendix 9). The tall grass prairie was tested for in vitro dry matter disappearance/digestibility (IVDMD) as a percent of total DM consumed, which is the closest measure of TDN that resulted from the tall grass prairie studies. Because DM was not measured in the native grass tests, monthly DM was estimated by using expected annual tall grass prairie yield and the NRCS monthly estimates of percentage of total production for native grass (Appendix 4). Expected annual tall grass prairie yield was based on an OSU reported average annual yield of tall grass prairie (Redmon 1998-99) and survey data (Appendix 5). Figure 3.1 is a graph of the pounds of DM, TDN, and CP of tall grass prairie throughout the year. The graph is intended tas an example to help the reader visualize a forage's production curve.

This model does not represent a specific region in Oklahoma, so for the purposes of this model, all forage data estimates are assumed to be Oklahoma state averages. All monthly DM forage data is used in the model as a percent of estimated annual yield, and all TDN and CP forage data is used as a percent of estimated monthly DM yield.

Supplemental Feeds

A common supplemental feed used for cattle production in Oklahoma is 20% and 38 % range cubes. The percent value of the range cubes represents the CP content of that associated feed. The ingredients of the range cubes change according to price and

Figure 3.1. Monthly DM, TDN, and CP of Tall Grass Prairie



availability, and are mixed to obtain the desired CP percentage. TDN for the range cubes was calculated as an average of the typical main ingredients. Some of the typical ingredients used in range cubes were determined by personal contact with Stillwater Milling Co. The percent TDN content of each of the ingredients is taken from NRC 1996, and all of the typical ingredients were within a range of 75 to 88 percent TDN.

Animals

This model uses various cattle (cow-calf and stocker) enterprises to be optimized along with forage enterprises in seeking a profit-maximizing farm plan. The cow-calf activities are spring calving (March) and fall calving (October), which is typical for Oklahoma cow-calf operations. Stocker activities were selected from *Beef and Pasture Systems for Oklahoma, A Business Management Manual*, developed by Walker, Lusby, and McMurphy. The stocker activities include steers and heifers bought in November and sold in March, steers and heifers bought in November and sold in May, steers and heifers bought in May and sold in September.

The animals' nutrient requirements are available from the *Nutrient Requirements of Beef Cattle* as developed by the National Research Council, Committee on Animal Nutrition (NRC 1996). Instead of using predefined nutrient requirements, the model used prediction equations (NRC 1996) to calculate required TDN and CP per day for beef cows. For the purposes of this model, the nutrient requirement calculations are divided into three stages of production. Stage one represents beef cows for 180 days of lactation: the first 90 days after calving with lactation and the first 90 days of gestation with late lactation. Stage two represents beef cows in their middle third (90 days) of gestation. Stage three represents beef cows in their last third (90 days) of gestation. The daily net energy required for maintenance by beef cows in stage one of production is represented by equation 2:

(2) $$NE_l = (0.077 * BW^{0.75} * 1.2 * (0.8 + (BCS - 1) * 0.05)) + (Milk * 0.7178)$$

where:

NE_l = net energy for maintenance (Mcal/kg) + net energy for lactation (Mcal/kg); BW = body weight (kg); BCS = body condition score (1-9); $Milk$ = milk production (kg/d).

The daily metabolizable protein required for maintenance for beef cows in stage one is represented by equation 3:

(3) $$MP_l = (3.8 * BW^{0.75}) + (((Milk * 0.034) / 0.65) * 1000)$$

where:

MP_l = metabolizable protein for maintenance (g/d) + metabolizable protein for lactation (g/d).

The daily net energy required for maintenance by beef cows during stage two of production is represented by equation 4:

(4) $$NE_2 = (0.077 * BW^{0.75} * (0.8 + (BCS - 1) * 0.05)) + ((Calf * (0.576/0.13) * (0.05855 - (0.0000996 * 142)) * ((0.03233 - (0.0000275 * 142)) * 142)) / 1000)$$

where:

NE_2 = net energy for maintenance (Mcal/kg) + net energy for gestation (Mcal/kg); $Calf$ = expected calf birth weight (kg).

The daily metabolizable protein required for maintenance by beef cows in stage two is represented by equation 5:

$$(5) \qquad MP_2 = (3.8 * BW^{0.75}) + ((Calf * (.001669 - (0.00000211 * 142)) * ((0.0278 - (0.0000176 * 142)) * 142) * 6.25) / 0.65)$$

where:

MP_2 = metabolizable protein for maintenance (g/d) + metabolizable protein for gestation (g/d).

The daily net energy required for maintenance by beef cows in stage three of production is represented by equation 6:

$$(6) \qquad NE_3 = (0.077 * BW^{0.75} * (0.8 + (BCS - 1) * 0.05)) + ((Calf * (0.576/0.13) * (0.05855 - (0.0000996 * 253)) * ((0.03233 - (0.0000275 * 253)) * 253)) / 1000)$$

where:

NE_3 = net energy for maintenance (Mcal/kg) + net energy for gestation (Mcal/kg).

The daily metabolizable protein required for maintenance by beef cows in stage three of production is represented by equation 7:

$$(7) \qquad MP_3 = (3.8 * BW^{0.75}) + ((Calf * (.001669 - (0.00000211 * 253)) * ((0.0278 - (0.0000176 * 253)) * 253) * 6.25) / 0.65)$$

where:

MP_3 = metabolizable protein for maintenance (g/d) + metabolizable protein for gestation (g/d).

The daily net energy required for maintenance by stockers is represented by equation 8:

(8) $$NE_m = (.096 * BW)^{0.75} * 0.077$$

where:

NE_m = net energy for maintenance (Mcal/kg)

The daily net energy required for gain by stockers is represented by equation 9:

(9) $$NE_g = 0.0635 * (0.891 * ((.096 * BW) * (478 / (0.96 * \mathit{finished}\ BW)))^{0.75} * (0.956 * ADG)^{1.097}$$

where:

NE_g = net energy for gain (Mcal/kg); ADG = average daily gain (kg/d);

finished BW = expected finishing weight.

The daily metabolizable protein required for maintenance by stockers is represented by equation 10:

(10) $$MP_m = 3.8 * (.096 * BW)^{0.75}$$

where:

MP_m = metabolizable protein for maintenance(g/d).

The daily metabolizable protein required for gain by stockers is represented by equations 11 and 12 depending on the initial body weight of the stocker:

(11) $$MP_g\ [\mathrm{BW} \leq 300\ \mathrm{kg}] = (ADG * (268 - (29.4 * NE_g / ADG))) / (0.83 - ((0.891 * ((.096 * BW) * (478 / (0.96 * \mathit{finished}\ BW))) * 0.00114))$$

(12) $$MP_g\ [\mathrm{BW} > 300\ \mathrm{kg}] = (ADG * (268 - (29.4 * NE_g / ADG))) / 0.492$$

where:

MP_g = metabolizable protein for gain (g/d).

The animal nutrient requirements were in metric, while the forage data were reported in U.S. standard. For use with the forage data, the animal requirements of net energy (NE) and metabolizable protein (MP) were converted into pounds of TDN and CP using NRC equations. The daily TDN required for maintenance by any beef livestock is represented by equation 13:

(13) $$TDN_m = ME_m / 0.82 / 4.4 / 0.4536$$

where:

(14) $$NE_m = 1.37\, ME_m - 0.138\, ME_m^2 + 0.0105\, ME_m^3 - 1.12$$

TDN = total digestible nutrient (lb); NE_m = net energy for maintenance (Mcal/kg); ME = metabolizable energy (Mcal).

The daily TDN required for gain by any beef livestock is represented by equation 15:

(15) $$TDN_g = ME_g / 0.82 / 4.4 / 0.4536$$

where:

(16) $$NE_g = 1\ 42\, ME_g - 0.174\, ME_g^2 + 0.0122\, ME_g^3 - 1.65$$

NE_g = net energy for gain (Mcal/kg).

The daily crude protein required for a stocker, a lactating cow, and a cow in gestation are represented in equations 17, 18, and 18, respectively:

(17) $$CP \text{ for a stocker} = (MP_m + MP_g) / 0.67 / 454$$

(18) $$CP \text{ for a lactating cow} = (MP_m + MP_m \text{ Lactation}) / 0.67 / 454$$

(19) $$CP \text{ for a cow in gestation} = (MP_m + MP_m \text{ Gestation}) / 0.67 / 454$$

where:

CP = crude protein (lb).

The prediction equations result in the daily nutrient requirements, and the results are multiplied by the number of days in each month the animal will be on pasture to get the total requirement for each month. To help visualize a stocker's nutrient needs, the graph in Figure 3.2 represents the monthly nutrient requirements for a stocker steer from November to May. The nutrient prediction equations for stockers account for pre-specified start weight and ADG, which, in turn, determines the finish weight depending on the length of time the stocker is kept in the enterprise. The nutrient requirement values used in this model do not change in each month with increasing weight, because the equations calculate the average daily nutrient requirement for the entire period. Therefore, the lines representing the monthly nutrient requirements on the graph are flat. The minimum and maximum animal dry matter intake (DMI) is discussed in Chapter IV. Figure 3.3 represents the monthly nutrient requirements of a spring calving cow. The nutrient requirement calculations for cows are the average nutrient requirements for each stage of production. Therefore, the lines on the graph are flat in each stage of production.

Figure 3.2. Nutrient Requirements of a Stocker Steer from November to May

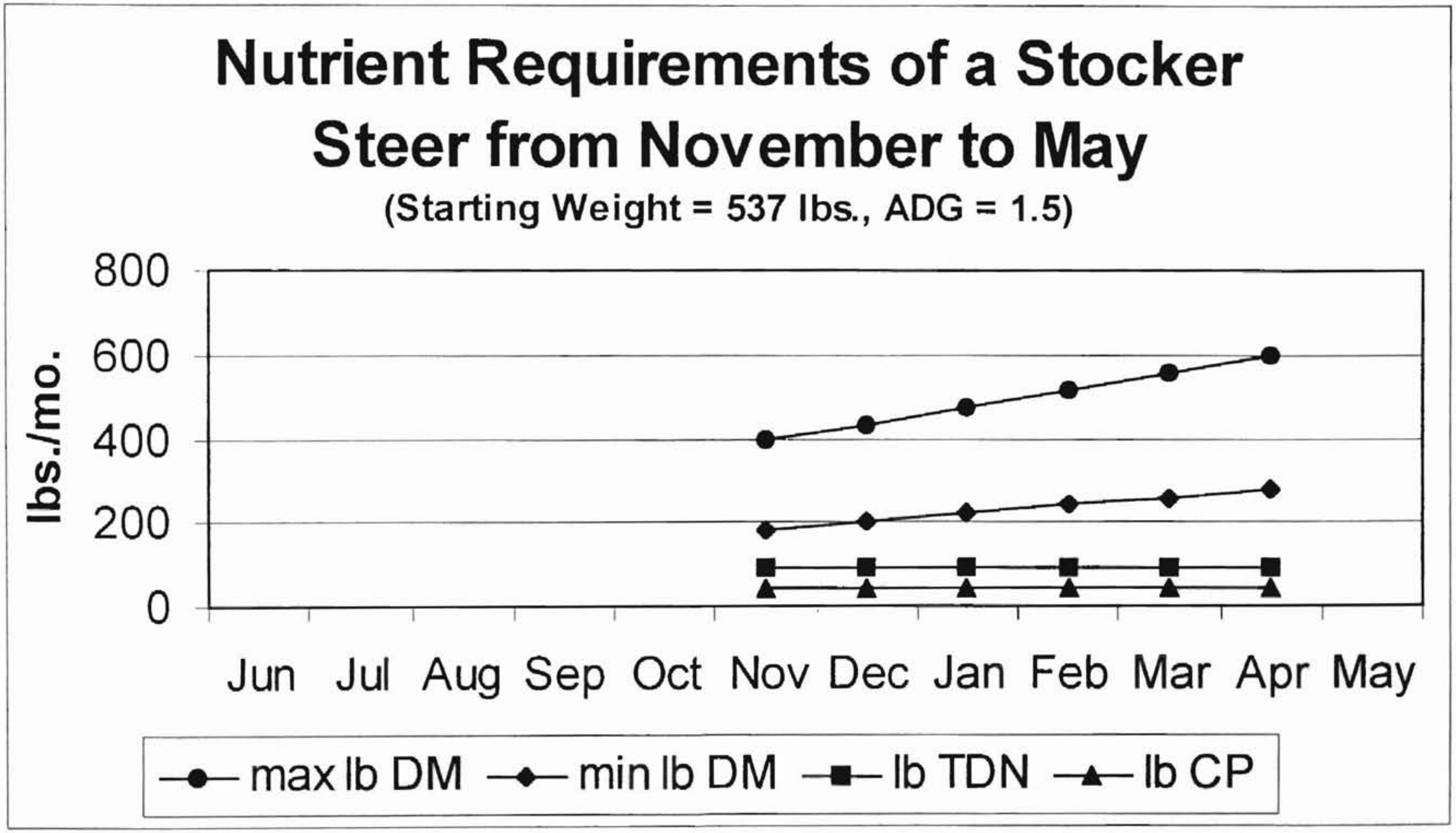
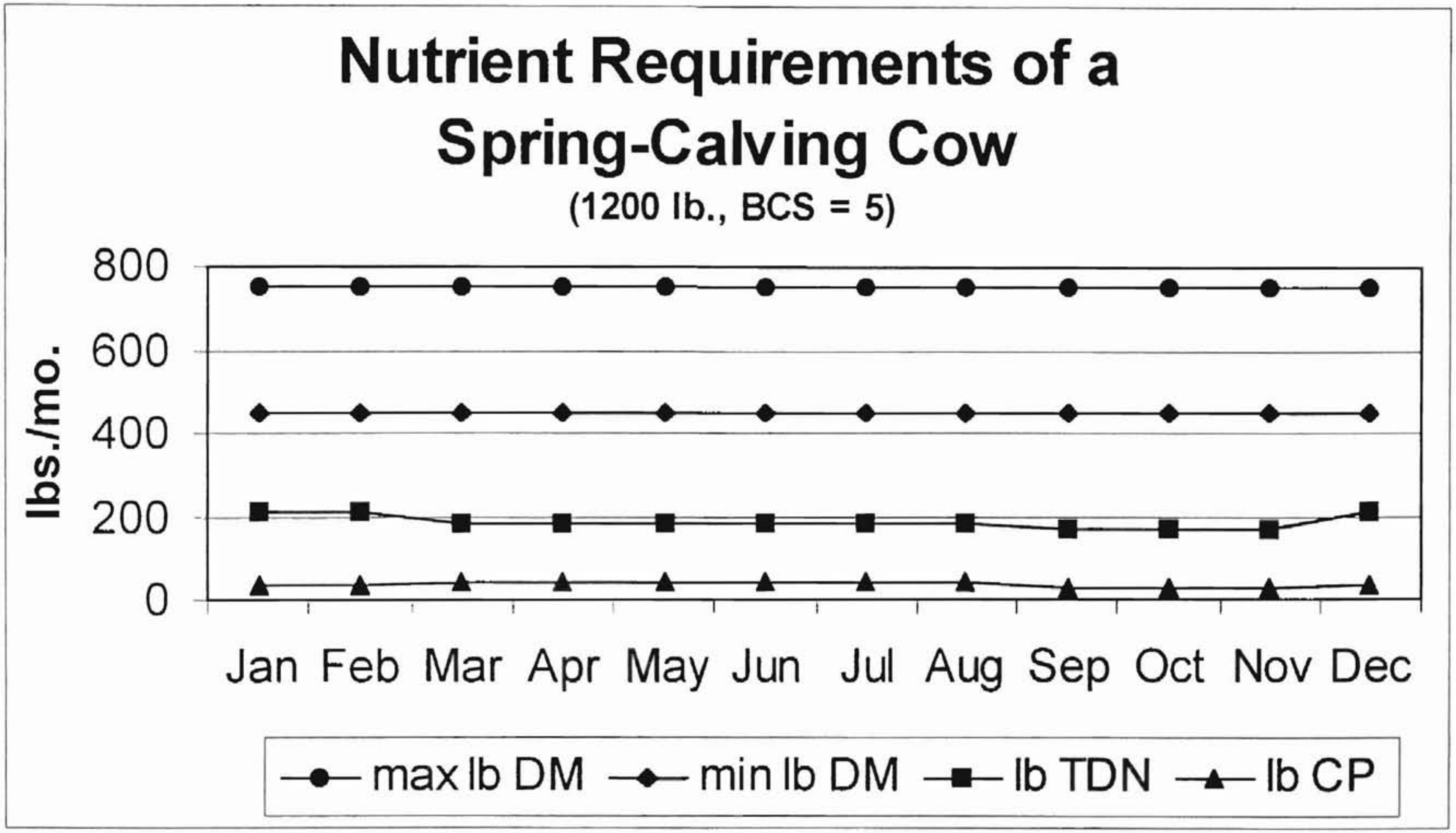


Figure 3.3. Nutrient Requirements of a Spring Calving Cow



CHAPTER IV

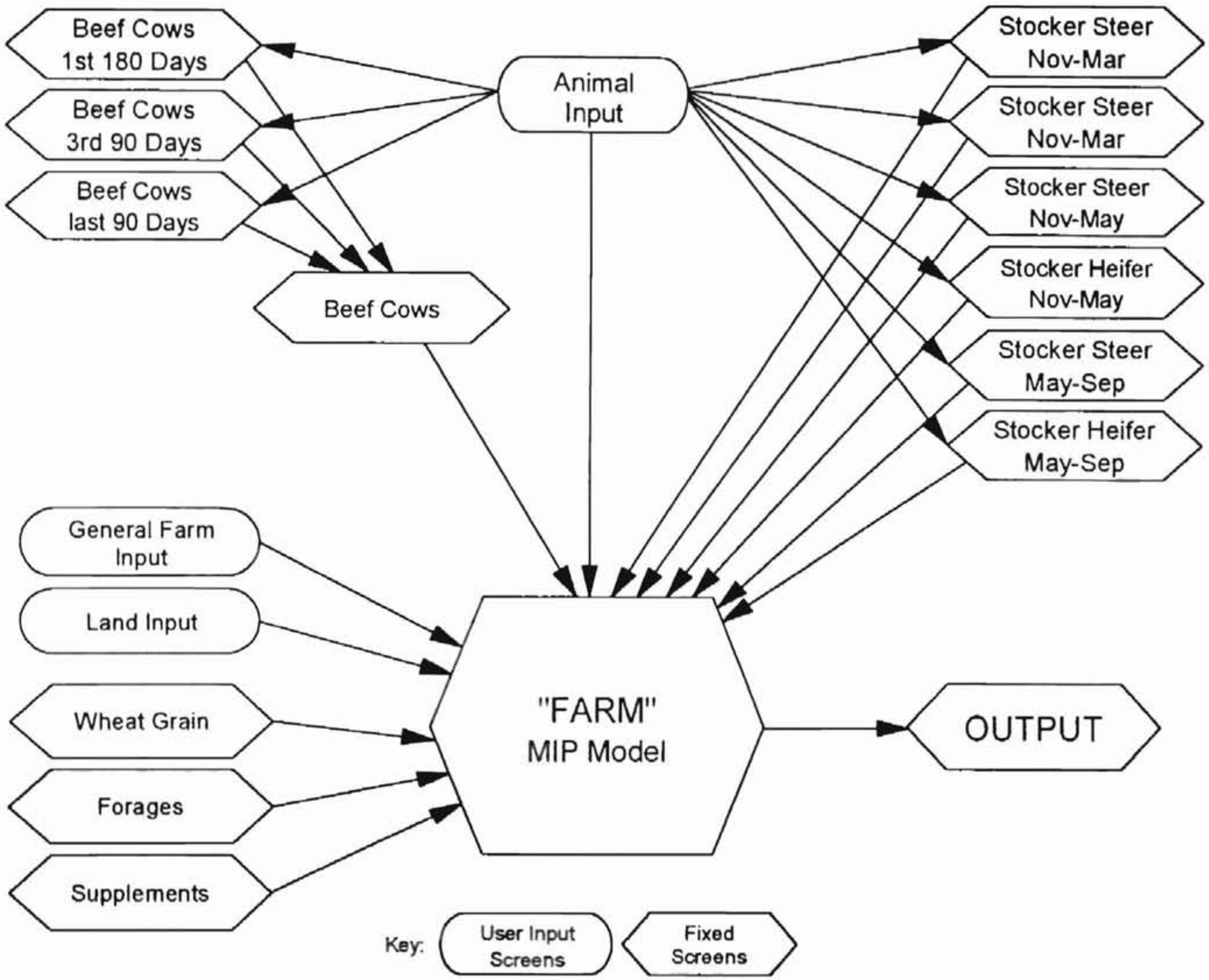
MODEL

The model uses a variety of information to determine the profit-maximizing combination of forage and beef cattle throughout a year. The model is made up of a mixed integer programming (MIP) tableau supplemented by calculations and input information that determine the information included in the MIP tableau.

The model was built in a common spreadsheet software, Microsoft Excel 97, so it would be more easily accessible to future users. Each Excel workbook is composed of multiple worksheets. Several worksheets are used to estimate production and consumption parameters to be used in the MIP model. Separation of production and consumption information and calculations allows for easier user access to coefficients used in the model. Hopefully, future research on individual components can be easily incorporated into the model. Figure 4.1 illustrates the flow of information between the many worksheets.

Information tailoring the model to a particular resource situation is entered in one of three user-input screens. The user-input screens discussed in the following sections are land and forage, livestock, and general whole farm information

Figure 4.1. Flow diagram of the worksheets within the program



Input for Land and Forages

Three categories of land can be used: cropland, improved pasture land, and native pasture land. Cropland is currently used for crops, but the model can permit cropland for use as improved pasture. Improved pasture land is former cropland or land with established non-native forages. Native pasture land is in forages native to a specific area and not needing establishment.

Land renting is an option for each of the three land categories. For land renting to possibly enter the profit-maximizing solution of the model, the user must identify a set amount of acreage for each land category that is known to be available for rent. The model decides whether to rent the entire block of acreage or none at all. The user enters the total number of acres operated in each of the three categories of land, number of acres to remain in a specific forage (used if the user does not want to change the established forages), and expected annual production per acre for each forage.

If the model chooses to stockpile a forage, the total amount of DM carry-over is expected to degrade each month. The user may change the percentage of each forage that can be transferred to the next month if the forage is not used in the current month. The actual percentage of monthly transfers of forages is unknown, so estimated default values are provided. The most common default value used is 90 percent, with 80 and 75 percent during the non-growing months of each forage.

The user may also change the percent animal harvest efficiency on each forage. The animal harvest efficiency is the percentage of a forage that is actually usable by the animal. Experts debate on the level of animal harvest efficiency, so the provided default values are based on expert opinion and how close to reality the results were in trial runs of the MIP software (Moseley, Lalman).

The user must also estimate the monthly labor hour requirements and the operating capital needed for each forage activity. For each land use activity, the user also needs to enter the total costs less labor and capital costs. Default estimates of monthly labor requirements, operating capital needed, and total remaining costs are based on Oklahoma State University Department of Agricultural Economics forage enterprise budgets.

Input for Livestock

The user can enter or use the default values for the average body weight (BW) of cows in the herd, average body condition score (BCS) for cows (NRC 1996), average cow milk production, average expected calf birth weight, expected percent calf crop, expected percent of replacement heifers, expected calf weaning weights, expected stocker starting weight, and desired stocker average daily gain (ADG).

The user must also enter the labor hours required and the operating capital needed for each livestock activity. For each livestock activity, the user also needs to enter the total costs less feed, labor, and capital costs. Default estimates of the labor requirements, operating capital needed, and total remaining costs are based on Oklahoma State University Department of Agricultural Economics livestock enterprise budgets.

Additional information needed from the user are buy and sell prices of cattle at different weights and in different months. Ten year average prices are provided as references, but the user can enter prices he/she feels most appropriate.

Calves from the cow-calf operation may either be sold or transferred into a stocker operation. Calves from spring calving cows are available as stockers on winter pasture, and calves from fall calving cows are available as stockers on summer pasture. In addition to transferring stockers from the cow-calf operations, stockers may be purchased.

General Input for the Whole Farm

The user must enter general farm information, such as starting operating capital, maximum capital that can be borrowed, annual percentage rate (APR) on the borrowed capital, monthly labor hours available from the owner/operator, and wage rate of potential hired labor. If labor is a limiting factor in any month, additional labor may be hired up to a user-specified limit.

Each of the user entry cells contain default values that can be easily changed. Many of the default values are also noted in the cells to the right of the user entry cells. This keeps default values from being lost as user values are changed. Some of the default values, such as expected annual forage production and harvest efficiency, are based on survey and expert opinion. All prices are based on actual prices. Default prices of supplemental range cubes were obtained from Stillwater Milling Co. in the summer of 1999. Default calf and stocker prices are ten year averages (1998-1997) of Oklahoma City prices. All labor hours required and capital default values are based on forage and livestock enterprise budgets. The entire model relies on the values specified in the input fields. All values within the MIP model are linked to the information in the input screens or linked to other calculations that reference the input information. As a result, users should not attempt to change values within the MIP model worksheet.

Other Worksheets

All of the data described in Chapter III is stored on worksheets within the Excel workbook. All of the forage data is stored in a forage database on one worksheet [Forages]. The wheat grain production data are kept on a separate worksheet [WhtGrain] from the forage data to avoid confusion from bushels of grain and pounds of forage. The animal nutrient requirement calculations are on a separate worksheet for each animal activity. Cow-calf daily nutrient requirements are calculated on separate worksheets for various stages of the reproductive cycle [Beef Cows 1st 180 days, Beef Cows 3rd 90 days, and Beef Cows last 90 days]. All of the cow-calf nutrient requirements are summarized on a separate worksheet [Beef Cows] for ease of calculating the monthly values based on the number of months since calving. The values for spring-calving and fall-calving are equal for each stage of production, but are adjusted for the time of year based on month of calving. Steer nutrient requirements are calculated separately from heifer nutrient requirements. Both steers and heifers are calculated separately for November to March, November to May, and May to September [StSteer Nov-Mar, StSteer Nov-May, StSteer May-Sep, StHeifer Nov-Mar, StHeifer Nov-May, StHeifer May-Sep], respectively. Using separate worksheets for each set of calculations facilitates the development and use of macros for converting the nutrient requirements from metric to U.S. Standard measurements.

Mixed Integer Programming Tableau

Mixed Integer Programming (MIP) goes a step beyond Linear Programming (LP), because some variables must result as integers. This model contains three binary variables, meaning each must result in either zero or one. The software used to solve a MIP model, Solver in this case, uses LP to solve the continuous model through several iterations of solving multiple equations simultaneously. Once the Linear Programming optimal solution (e.g. profit maximization) has been found, the branch and bound algorithm (Land and Doig) is used to decide the integer value of the variable. This model is intended to find the solution that maximizes returns to a farm's limited resources.

The MIP model contains a production activity and a set of monthly production balance rows for each forage. In any month, each forage can be used by the animals or, if unused, transferred to the next month for animal use in that month. Bermuda and tall grass prairie can also be cut for hay, if they are not used by the animals. Currently, the hay produced can only be sold, and is not available for consumption by the animals. Farm income may come from the sale of grain or sale of animals. All grain, hay, calves, and stockers are sold.

If the forage is used by the animals (i.e. eaten), DM flows out of the production rows and into a set of DM balance rows for the animals to "eat" from. One unit of forage must be produced for each unit required by the animals. If there were separate DM balance rows for each forage, then the model could better represent animal performance on an individual forage. However, the model could not solve for a "best" combination of forages, but would instead select one forage solely over another forage.

Two sets of DM balance rows are used, one containing the maximum DM that an animal can consume in each month and the other containing the minimum DM that an animal can consume in each month. For every pound of DM used by the animals, associated pounds of CP and TDN are also used.

An animal's dry matter intake (DMI) is a function of TDN concentration in the feed. Because the model is set up to select a forage or mixture of forages, a set TDN concentration is unknown before the model has been run. Therefore, to predict DMI of stockers, maximum consumption is set at three percent of the animal's body weight (BW) and minimum consumption at 1.4 percent of BW (NRC 1984). Prediction of DMI of cows was estimated based on realistic values. Therefore, maximum consumption of cows is set at 2.5 percent of BW and minimum consumption of cows is set at 1.5 percent of BW. Because of the maximum and minimum animal consumption values, two sets of DM balance rows were needed. The maximum consumption set of balance rows were set up as a greater than or equal to equation, while the minimum consumption set of balance rows were set up as less than or equal to equations The minimum and maximum balance rows require animals to "eat" an acceptable amount of DM. For example, a ration of all grain might have inadequate DM while a ration of all dry forages might require too much DM consumption for the level of TDN and CP obtained. If the CP or TDN is a limiting factor for the animal's nutrition in any month, supplemental 20% or 38% range cubes are purchased.

The MIP can be mathematically described as:

$$Max\ Z = \sum_{j} C_j X_j + \sum_{k} R_k L_k$$

where:

$C_j =$ income or costs of activity j

$X_j =$ level of activity j

$j =$ activities excluding land rental activities

$R_k =$ cost of renting land group k

$L_k =$ level of activity k; $L_k = 1$ if land group k is rented, and 0 otherwise

$k =$ land rental activities

subject to the constraints:

$$\sum_j a_{ij} X_j \leq b_i$$

$$\sum_j a_{tj} X_j + \sum_k a_{tk} L_k \leq b_t$$

$$X_j \geq 0 \qquad L_k = 0,1$$

where:

$a_{ij} =$ quantity of resource i required per unit of activity j

$a_{tj} =$ quantity of land type t required per unit of activity j

$a_{tk} =$ quantity of land type t per unit of activity k

$b_i =$ quantity of resource i

$b_t =$ quantity of land type t

$t =$ land types (cropland, improved pasture land, native pasture land)

Excel is packaged with a standard Solver, which is a program that solves simultaneous equations. The tableau for this model exceeds the limits for the standard Solver, so a larger version, Solver Premium Plus, was purchased from Frontline Systems.

Output

Another important worksheet to the user is the output worksheet. The output worksheet takes the results from the model and shows them in a more readable and understandable format. The output worksheet contains total acres owned, rented, transferred, and used. Starting acres and resulting used acres in each land category, as well as acres used for each forage or grain are listed. To help a user visualize the flow of forages from month to month, five tables are provided in the output revealing total pounds of each forage produced in each month, total pounds of each forage held to be carried-over to the next month, total pounds of each forage carried-over from the previous month, total pounds of each forage grazed in each month, and total pounds of each forage completely unused (not consumed or carried-over) in each month. The forage use tables help the user to detect when each forage is being used and how it is being used. The output worksheet also contains the total pounds of 20% and 38% range cubes purchased in each month. Total bushels of wheat grain produced and the sale price per bushel are listed in the output.

The number of spring calving cows, fall calving cows, and stockers are contained on the output worksheet. For both spring calving and fall calving cows, the number of head of steer calves, heifer calves, and replacement heifers produced are listed. Also, the output contains the number head of steer and heifers calves that are sold and the number that are transferred into stockers in November and/or May. The output worksheet also reveals the number of head of stocker steers and heifers purchased in November or May, and the number of head sold in March, May, and September Stocker steer and heifer starting weights, finishing weights, and price per hundred weight (cwt) are listed to the right of the number of head purchased and sold The output contains a stocking density table that may help a user to better visualize when animals are entering and exiting the farm.

A labor table is provided in the output to show a user the number of owner/operator hours used, number of hired labor hours purchased, cost of hired labor per hour, and total cost of hired labor. Total operating capital, owned and borrowed, and net income before taxes is listed in the output.

CHAPTER V

RESULTS

Instead of choosing multiple sites across Oklahoma as a basis for several representative farms, the sensitivity of results to changes in constraints or assumptions are best demonstrated by using one representative farm. South central Oklahoma was selected as the base for the representative farms, because most Oklahoma forages are adapted to that area. Several farm scenarios with only minor differences are tested. All of the farm scenarios are derived from "Summary of Average Farms for Eight Regions of Oklahoma" (Kletke). The farm scenarios are only representative of the average size of a farm in south central Oklahoma.

Agricultural researchers debate about how much of a forage is actually usable by an animal (Moseley, Lalman). Researchers know that some forage is lost to trampling, so not all DM disappearance is attributable to animal consumption. No data exists to suggest how low or high the animal harvest efficiency is. To demonstrate the effects of the harvest efficiency on the optimal solution of the model, the large farm scenario is tested with adjustments to the harvest efficiency by a 5% decrease for all forages, a 10% decrease for all forages, and a 5% increase for all forages.

To demonstrate the effects of capital constraint, the large farm scenario is used with zero owned capital and $100,000 maximum borrowed capital. Also, to demonstrate the land rental activities, a medium size farm is used.

The input information remains constant for all of the farm scenarios, except for any demonstrative input changes as described above. The model is very sensitive to some of the input information, and the reader may better understand each scenario's results by knowing the initial operating input assumptions. Costs of production required for forages (Figure 5.1) and cost of production required for livestock (Figure 5.2) seem to be the most influential user-input entries that can not be seen later in this chapter in the figures from each of the farm scenarios.

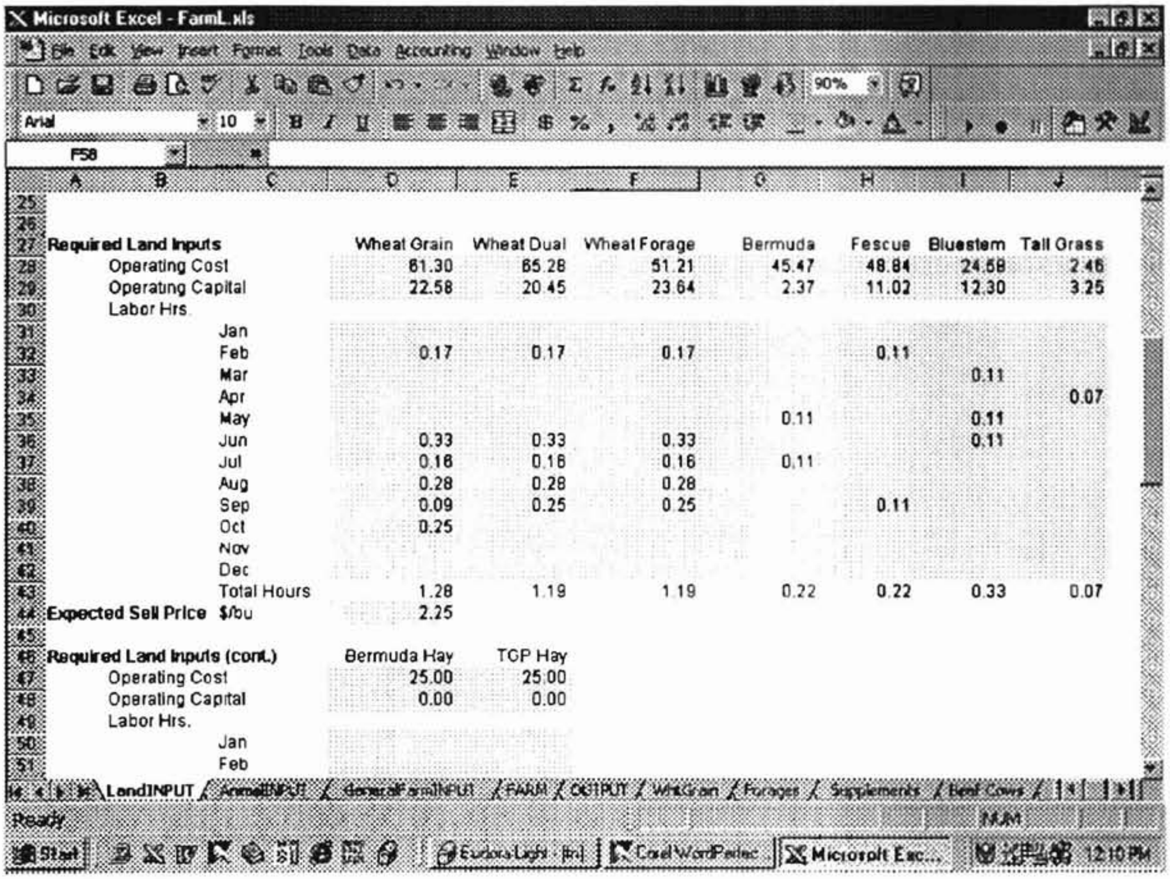
Simulated Farms

Large Farm

A large farm with pasture and non-irrigated cropland in south central Oklahoma has an estimated 675 acres in cropland and 1,376 acres in pasture. Since the model is designed for two categories of pasture land, twenty percent of the pasture land is assumed to be improved pasture land and the remaining eighty percent is assumed to be native pasture land. Therefore, the large farm (Farm L) scenario consists of 675 acres in cropland, 275 acres in improved pasture land, and 1,101 acres in native pasture land (Figure 5.3). A small ratio of improved pasture land to native pasture land is used because the model can transfer crop land into improved pasture land All land in Farm L is owned.

The MIP model selected a result for the Farm L scenario (Table 5.1) consisting of 254 acres in cropland, 697 acres in improved pasture land, and 1,101 acres in native pasture land. From the original 675 acres of cropland, 421 acres are transferred into improved pasture land. The acreage transfer increases improved pasture land from an original 275 acres to 697 acres All of the original 1,101 acres of native pasture land is

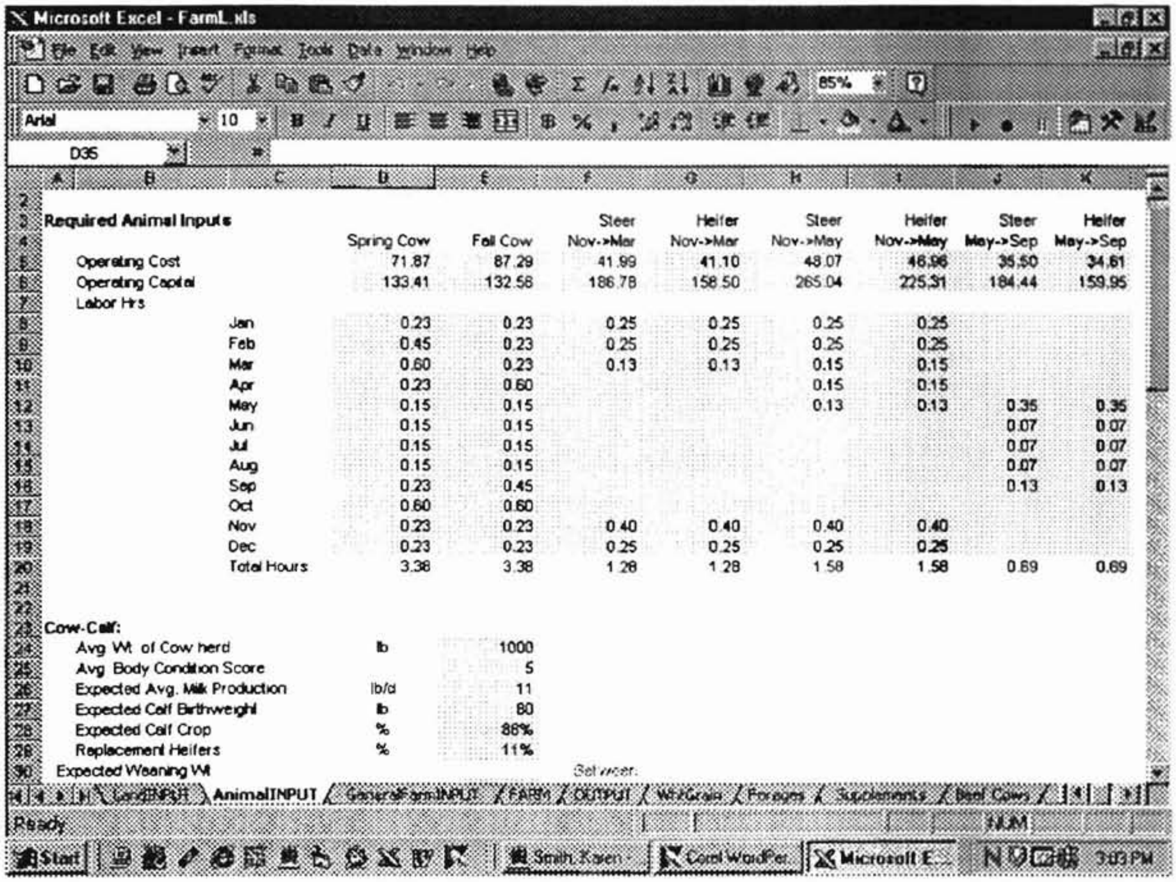
Figure 5.1. Partial input screen used for all farm scenarios: Required Land Inputs



Required Land Inputs		Wheat Grain	Wheat Dual	Wheat Forage	Bermuda	Fescue	Bluestem	Tall Grass
Operating Cost		61.30	65.28	51.21	45.47	48.84	24.58	2.46
Operating Capital		22.58	20.45	23.64	2.37	11.02	12.30	3.25
Labor Hrs.								
	Jan							
	Feb	0.17	0.17	0.17		0.11		
	Mar						0.11	
	Apr							0.07
	May				0.11		0.11	
	Jun	0.33	0.33	0.33			0.11	
	Jul	0.16	0.16	0.16	0.11			
	Aug	0.28	0.28	0.28				
	Sep	0.09	0.25	0.25		0.11		
	Oct	0.25						
	Nov							
	Dec							
	Total Hours	1.28	1.19	1.19	0.22	0.22	0.33	0.07
Expected Sell Price	$/bu	2.25						

Required Land Inputs (cont.)		Bermuda Hay	TGP Hay
Operating Cost		25.00	25.00
Operating Capital		0.00	0.00
Labor Hrs.			
	Jan		
	Feb		

Figure 5.2. Partial input screen used for all farm scenarios: Required Animal Inputs



Required Animal Inputs		Spring Cow	Fall Cow	Steer Nov->Mar	Heifer Nov->Mar	Steer Nov->May	Heifer Nov->May	Steer May->Sep	Heifer May->Sep
Operating Cost		71.87	87.29	41.99	41.10	48.07	46.96	35.50	34.61
Operating Capital		133.41	132.56	186.78	158.50	265.04	225.31	184.44	159.95
Labor Hrs									
	Jan	0.23	0.23	0.25	0.25	0.25	0.25		
	Feb	0.45	0.23	0.25	0.25	0.25	0.25		
	Mar	0.60	0.23	0.13	0.13	0.15	0.15		
	Apr	0.23	0.60			0.15	0.15		
	May	0.15	0.15			0.13	0.13	0.35	0.35
	Jun	0.15	0.15					0.07	0.07
	Jul	0.15	0.15					0.07	0.07
	Aug	0.15	0.15					0.07	0.07
	Sep	0.23	0.45					0.13	0.13
	Oct	0.60	0.60						
	Nov	0.23	0.23	0.40	0.40	0.40	0.40		
	Dec	0.23	0.23	0.25	0.25	0.25	0.25		
	Total Hours	3.38	3.38	1.28	1.28	1.58	1.58	0.69	0.69

Cow-Calf:		
Avg Wt. of Cow herd	lb	1000
Avg Body Condition Score		5
Expected Avg. Milk Production	lb/d	11
Expected Calf Birthweight	lb	80
Expected Calf Crop	%	88%
Replacement Heifers	%	11%
Expected Weaning Wt		

Figure 5.3. Partial input screen for Farm L: Starting acres

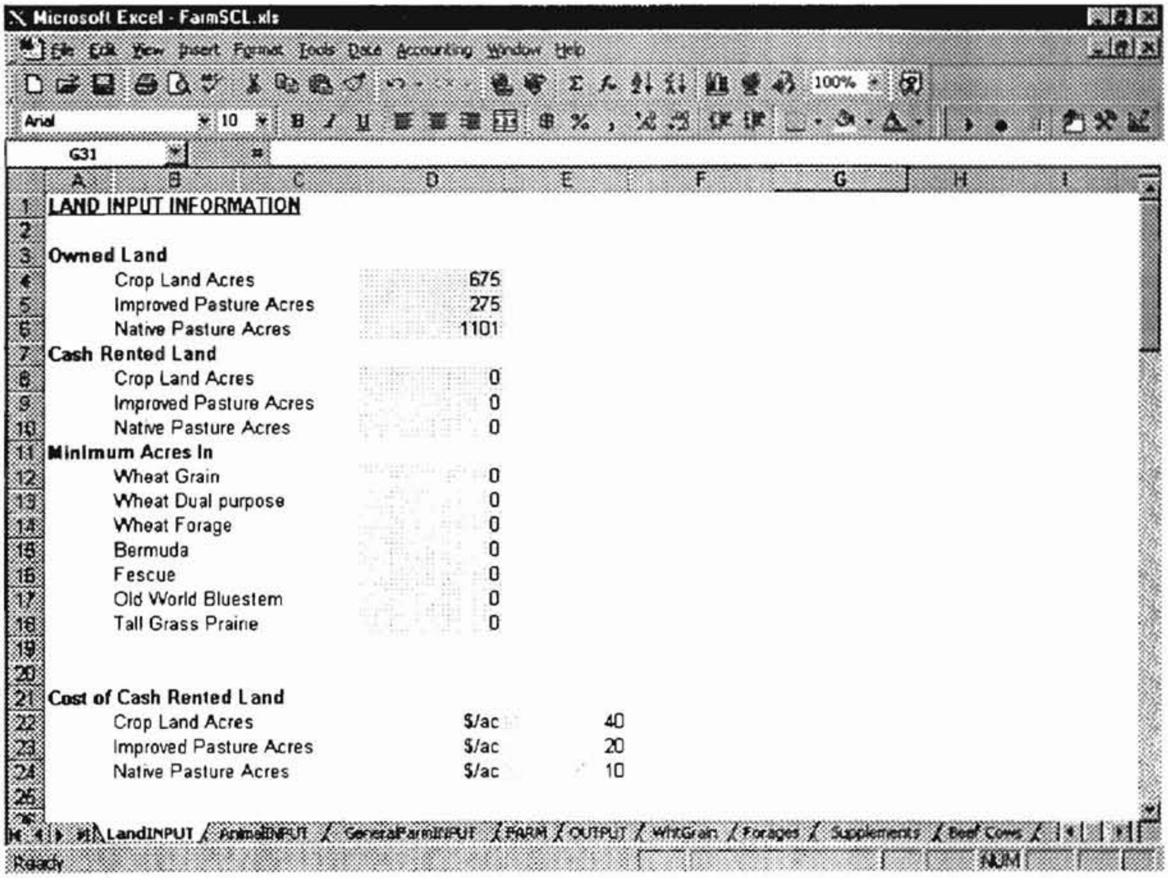


Table 5.1. Output of Farm L

	Owned	Rented	Transferred	Total Used
Total Acres	2,051	0		2,051
Acres In:				
Cropland	675	0	-421	**254**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				254
Improved Pasture Land	275	0	421	**697**
Bermuda				388
Fescue				308
Old World Bluestem				0
Native Pasture Land	1,101	0		**1,101**
Tall Grass Prairie				1,101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Production	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	63493	57348	114696	229392	229392	0	0	0	0	0	40963	63493
Bermuda	0	0	0	99408	248521	372781	248521	124260	124260	24852	0	0
Fescue	17265	43163	129489	189917	164019	69061	0	0	69061	86326	69061	25898
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	192640	481600	371520	137600	55040	110080	27520	0	0
Held for Carry-over	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	39357	0
Bermuda	0	0	0	99408	337988	443373	411037	264801	362581	337529	0	0
Fescue	251043	0	14793	203230	346926	381294	343165	308848	316139	370851	402827	388442
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	192640	654976	960998	1002499	957289	742247	479796	431817	175144
Carry-over from previous	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	0	39357
Bermuda	0	0	0	0	99408	337988	443373	411037	264801	362581	337529	0
Fescue	388442	251043	0	14793	203230	346926	381294	343165	308848	316139	370851	402827
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	175144	0	0	0	192640	654976	960998	1002499	957289	742247	479796	431817
Grazing/Consumption	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	63493	57348	114696	229392	229392	0	0	0	0	0	1606	98914
Bermuda	0	0	0	0	0	233597	236519	229392	0	13646	303776	0
Fescue	115819	269102	114696	0	0	0	0	0	0	0	0	0
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	140115	0	0	0	0	0	0	0	229392	215747	0	213491
Unused	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	0	3,936
Bermuda	0	0	0	0	9,941	33,799	44,337	41,104	26,480	36,258	33,753	0
Fescue	38,844	25,104	0	1,479	20,323	34,693	38,129	34,316	61,770	31,614	37,085	40,283
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	35,029	0	0	0	19,264	65,498	96,100	100,250	95,729	74,225	47,980	43,182

Table 5.1. Output of Farm L (continued)

Supplemental Feed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
Produce & Sale Hay	**tons**	**$/ton**	**Total $**									
Bermuda Hay - Jun	0	$60.00	$0.00									
Bermuda Hay - Jul	0	$60.00	$0.00									
Bermuda Hay - Aug	0	$60.00	$0.00									
Bermuda Hay - Sep	0	$60.00	$0.00									
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00									
Produce & Sale Grain	**bu.**	**sell $**	**Total $**									
	0	$2.25	$0.00									
Cow-Calf	**hd.**											
Spring Calving Cows	443											
Produce Steer Calves	195	==>	Sell Steer Calves in Nov.		195		Transfer Steer Calves to Stocker in Nov				0	
Produce Heifer Calves	146	==>	Sell Heifer Calves in Nov		0		Transfer Heifer Calves to Stocker in Nov.				146	
Produce Repl. Heifers	49											
Fall Calving Cows	66											
Produce Steer Calves	29	==>	Sell Steer Calves in May		29		Transfer Steer Calves to Stocker in May				0	
Produce Heifer Calves	22	==>	Sell Heifer Calves in May		22		Transfer Heifer Calves to Stocker in May				0	
Produce Repl. Heifers	7											
Stockers	**hd.**	**wt.**	**$/cwt**									
Buy Steers in Nov	0	437	$92.97									
Buy Heifers in Nov	282	422	$80.40									
Buy Steers in May	0	420	$96.94									
Buy Heifers in May	0	415	$84.16									
Sell Nov Steers in Mar	0	617	$82.68									
Sell Nov Heifers in Mar	429	578	$81.12									
Sell Nov Steers in May	0	707	$76.92									
Sell Nov Heifers in May	0	656	$75.15									
Sell May Steers in Sep	0	600	$80.57									
Sell May Heifers in Sep	0	571	$76.97									
Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd.	851	851	812	812	900	900	900	900	900	958	851	851
Ac. / Hd.	2.41	2.41	2.53	2.53	2.28	2.28	2.28	2.28	2.28	2.14	2.41	2.41
Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs	222	336	336	217	119	160	160	147	227	306	286	222
Hired hrs.	0	63	1	0	0	0	0	0	0	0	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$407.24	$4.43	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Capital												
Owned/Retained Capital	$100,000.00											
Borrowed Capital	$50,000.00	9.00%										
Total	$150,000.00											
Net Returns Before Taxes	$84,181.23											

used. All of the cropland is used for wheat for forage only, so no grain is produced. No range cubes are purchased. No hay is produced.

The livestock for Farm L includes 443 spring-calving cows, 66 fall-calving cows, and 429 stockers. With an 88% calf crop and 11% replacement heifers, Farm L produces 195 spring steer calves, 146 spring heifer calves, 49 spring replacement heifers, 29 fall steer calves, 22 fall heifer calves, and seven fall replacement heifers. All 195 spring steer calves are sold in November, and all 146 spring heifer calves are transferred into a stocker operation. All 29 fall steer calves and 22 fall heifer calves are sold in May. Along with the 146 spring heifer calves transferred into a stocker operation in November, an additional 282 stocker heifers are purchased. A total of 429 stocker heifers are sold in March. No stocker steers are raised

Farm L uses the maximum amount of available owner/operator labor hours in February and March. 63 additional labor hours are hired in February and only one labor hours is hired in March. Maximum owned capital of $100,000 and maximum borrowed capital of $50,000 is used. Farm L results in a $84,181.23 net return to family resources before taxes.

Large Farm with a 5% Decrease in Harvest Efficiency

The base Farm L scenario discussed above uses harvest efficiencies of 50% of wheat for forage only, 40% of Bermuda, 40% of Fescue, 30% of Old World Bluestem, and 25% of Tall Grass Prairie (Figure 5.4). For the large farm with a 5% decrease in harvest efficiency (Farm L-5), Farm L starting acreage base is used and all harvest efficiencies are decreased to 45% of wheat for forage only, 35% of Bermuda, 35% of Fescue, 25% of Old World Bluestem, and 20% of Tall Grass Prairie (Figure 5.5).

Figure 5.4. Partial input screen for Farm L: Harvest efficiencies

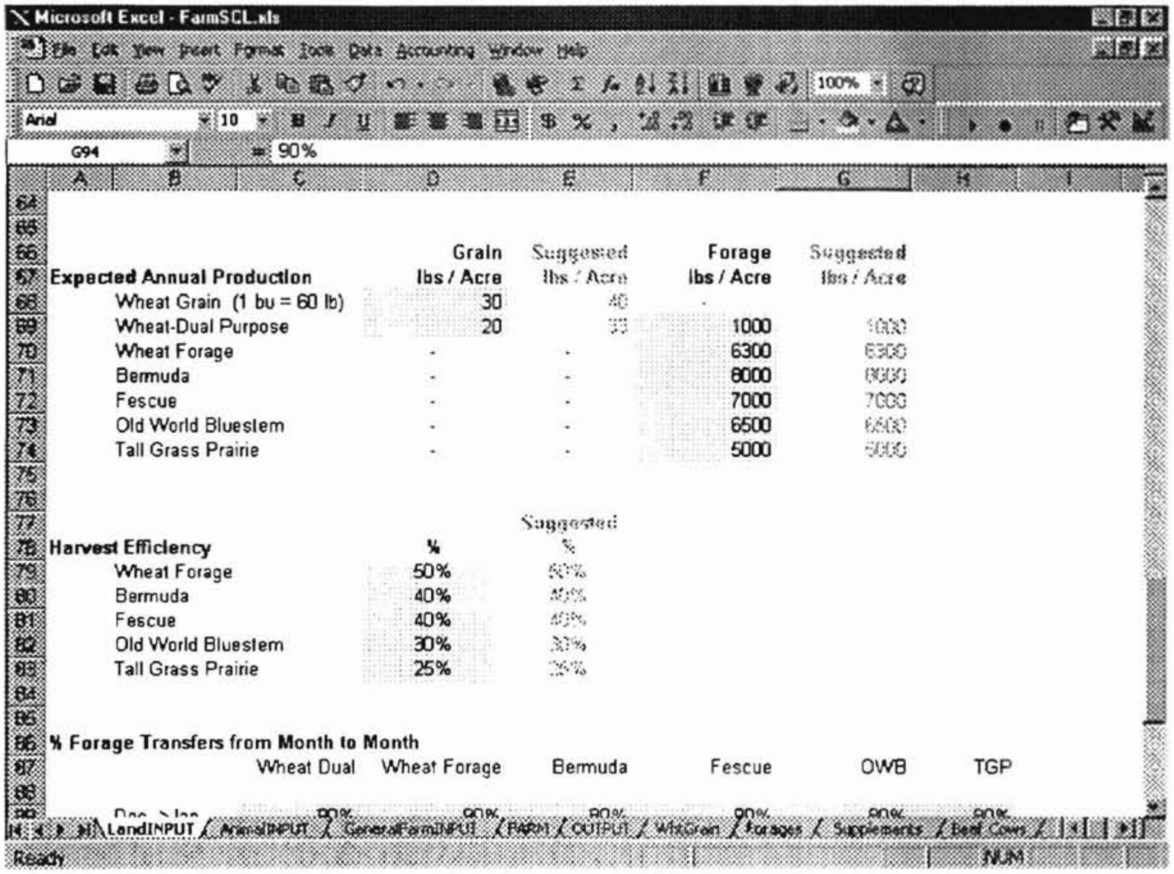
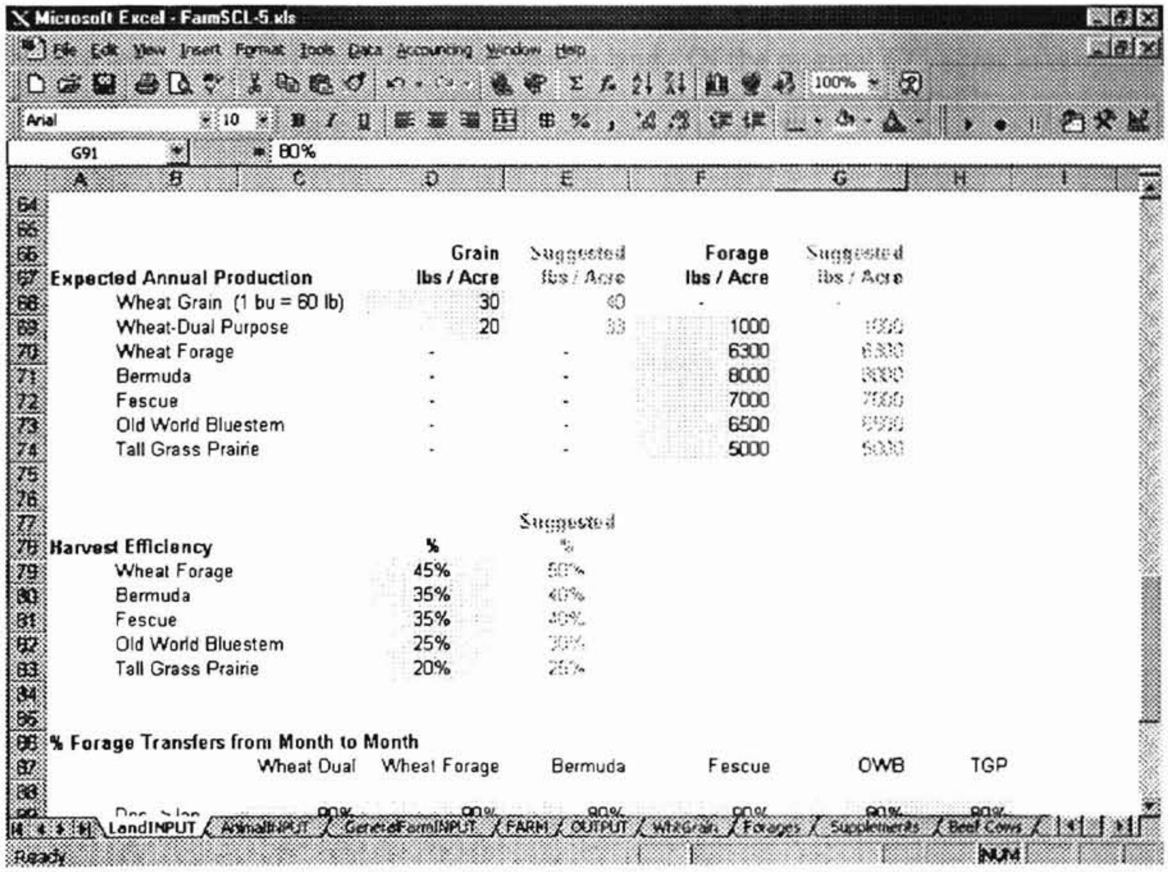


Figure 5.5. Partial input screen for Farm L-5: Harvest efficiencies



	Grain lbs / Acre	Suggested lbs / Acre	Forage lbs / Acre	Suggested lbs / Acre
Expected Annual Production				
Wheat Grain (1 bu = 60 lb)	30	40	-	-
Wheat-Dual Purpose	20	33	1000	1000
Wheat Forage	-	-	6300	6300
Bermuda	-	-	8000	8000
Fescue	-	-	7000	7500
Old World Bluestem	-	-	6500	6500
Tall Grass Prairie	-	-	5000	5000

Harvest Efficiency	%	Suggested %
Wheat Forage	45%	50%
Bermuda	35%	40%
Fescue	35%	40%
Old World Bluestem	25%	30%
Tall Grass Prairie	20%	25%

% Forage Transfers from Month to Month

	Wheat Dual	Wheat Forage	Bermuda	Fescue	OWB	TGP

Farm L-5 results (Table 5.2) include 217 acres in cropland, 733 acres in improved pasture land, and 1,101 acres in native pasture land. Of the original 675 acres in cropland, 458 acres are transferred for use as improved pasture land. The acreage transfer from cropland increases improved pasture land from an original 275 acres to 733 acres. All of the original 1,101 acres of native pasture land are used. All of the crop land acres are used for wheat for forage only, so no grain is produced. No range cubes are purchased. No hay is produced.

The Farm L-5 results reveal that the selected forage base is optimally used with 393 spring calving cows, no fall calving cows, and 527 stockers. With an 88% calf crop and 11% replacement heifers, Farm L-5 produces 173 spring steer calves, 130 spring heifer calves, and 43 replacement heifers. All of the steer calves are sold in November, and all of the heifer calves are transferred into a stocker operation in November. Along with the 130 heifer calves that are transferred into a stocker operation, an additional 398 stocker heifers are purchased. All 527 stocker heifers that are purchased or transferred into the stocker operation in November, are sold in March. No stocker steers are raised.

Farm L-5 uses the maximum available owner/operator labor hours in February, and 53 labor hours are hired. All owned capital of $100,000 and all borrowed capital of $50,000 is used. Farm L-5 results with $69,423.17 net return to family resources before taxes.

Large Farm with a 10% Decrease in Harvest Efficiency

For the large farm with a 10% decrease in harvest efficiency (Farm L-10) scenario, the harvest efficiencies are decreased 10% on all forages from the original values used in Farm L. Farm L starting acreage base is used and the harvest efficiencies are decreased to

Table 5.2. Output of Farm L-5

	Owned	Rented	Transferred	Total Used
Total Acres	2,051	0		2,051
Acres In:				
Cropland	675	0	-458	**217**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				217
Improved Pasture Land	275	0	458	**733**
Bermuda				341
Fescue				392
Old World Bluestem				0
Native Pasture Land	1,101	0		**1,101**
Tall Grass Prairie				1,101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Production	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	48930	44194	88389	176778	176778	0	0	0	0	0	31567	48930
Bermuda	0	0	0	76388	190971	286457	190971	95486	95486	19097	0	0
Fescue	19210	48026	144078	211315	182499	76842	0	0	76842	96052	76842	28816
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	154112	385280	297216	110080	44032	88064	22016	0	0
Held for Carry-over	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	21267	0
Bermuda	0	0	0	76388	259721	390457	349741	226902	299698	288825	0	0
Fescue	226596	0	55689	261435	417790	452853	407567	366811	370290	429313	463224	381433
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	154112	523981	698147	738412	708603	549028	339364	305427	128357
Carry-over from previous	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	0	21267
Bermuda	0	0	0	0	76388	259721	390457	349741	226902	299698	288825	0
Fescue	381433	226596	0	55689	261435	417790	452853	407567	366811	370290	429313	463224
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	128357	0	0	0	154112	523981	698147	738412	708603	549028	339364	305427
Grazing/Consumption	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	48930	44194	88389	176778	176778	0	0	0	0	0	10301	68069
Bermuda	0	0	0	0	0	129748	192641	183350	0	0	259942	0
Fescue	135904	251962	88389	0	0	0	0	0	0	0	0	64284
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	102685	0	0	0	0	70652	0	0	176778	176778	0	146528
Unused	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	0	2,127
Bermuda	0	0	0	0	7,639	25,972	39,046	34,974	22,690	29,970	28,882	0
Fescue	38,143	22,660	0	5,569	26,143	41,779	45,285	40,757	73,362	37,029	42,931	46,322
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	25,671	0	0	0	15,411	52,398	69,815	73,841	70,860	54,903	33,936	30,543

Table 5.2. Output of Farm L-5 (continued)

Supplemental Feed	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
Produce & Sale Hay	**tons**	**$/ton**	**Total $**									
Bermuda Hay - Jun	0	$60.00	$0.00									
Bermuda Hay - Jul	0	$60.00	$0.00									
Bermuda Hay - Aug	0	$60.00	$0.00									
Bermuda Hay - Sep	0	$60.00	$0.00									
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00									
Produce & Sale Grain	**bu.**	**sell $**	**Total $**									
	0	$2.25	$0.00									
Cow-Calf	**hd.**											
Spring Calving Cows	393											
Produce Steer Calves	173	==>	Sell Steer Calves in Nov.		173	Transfer Steer Calves to Stocker in Nov.					0	
Produce Heifer Calves	130	==>	Sell Heifer Calves in Nov		0	Transfer Heifer Calves to Stocker in Nov.					130	
Produce Repl. Heifers	43											
Fall Calving Cows	0											
Produce Steer Calves	0	==>	Sell Steer Calves in May		0	Transfer Steer Calves to Stocker in May					0	
Produce Heifer Calves	0	==>	Sell Heifer Calves in May		0	Transfer Heifer Calves to Stocker in May					0	
Produce Repl. Heifers	0											
Stockers	**hd.**	**wt.**	**$/cwt**									
Buy Steers in Nov	0	437	$92.97									
Buy Heifers in Nov	398	422	$80.40									
Buy Steers in May	0	420	$96.94									
Buy Heifers in May	0	415	$84.16									
Sell Nov Steers in Mar	0	617	$82.68									
Sell Nov Heifers in Mar	527	578	$81.12									
Sell Nov Steers in May	0	707	$76.92									
Sell Nov Heifers in May	0	656	$75.15									
Sell May Steers in Sep	0	600	$80.57									
Sell May Heifers in Sep	0	571	$76.97									
Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd.	791	791	609	609	739	739	739	739	739	739	791	791
Ac / Hd	2.59	2.59	3.37	3.37	2.78	2.78	2.78	2.78	2.78	2.78	2.59	2.59
Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs.	220	336	304	165	96	131	131	120	186	236	299	220
Hired hrs.	0	53	0	0	0	0	0	0	0	0	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$342.23	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Capital												
Owned/Retained Capital	$100,000.00											
Borrowed Capital	$50,000.00	9.00%										
Total	$150,000.00											
Net Returns Before Taxes	$69,423.17											

40% of wheat for forage only, 30% of Bermuda, 30% of Fescue, 20% of Old World Bluestem, and 15% of Tall Grass Prairie (Figure 5.6).

Farm L-10 results (Table 5.3) with 187 acres in cropland, 763 acres in improved pasture land, and 1,101 acres in native pasture land. Of the original 675 acres of cropland, 488 acres are transferred for use as improved pasture land, increasing the improved pasture land from an original 275 acres to 763 acres. All of the original 1,101 acres of native pasture land are used. All of the cropland acres are used for wheat for forage only, so no grain was produced. No range cubes are purchased. No hay is produced.

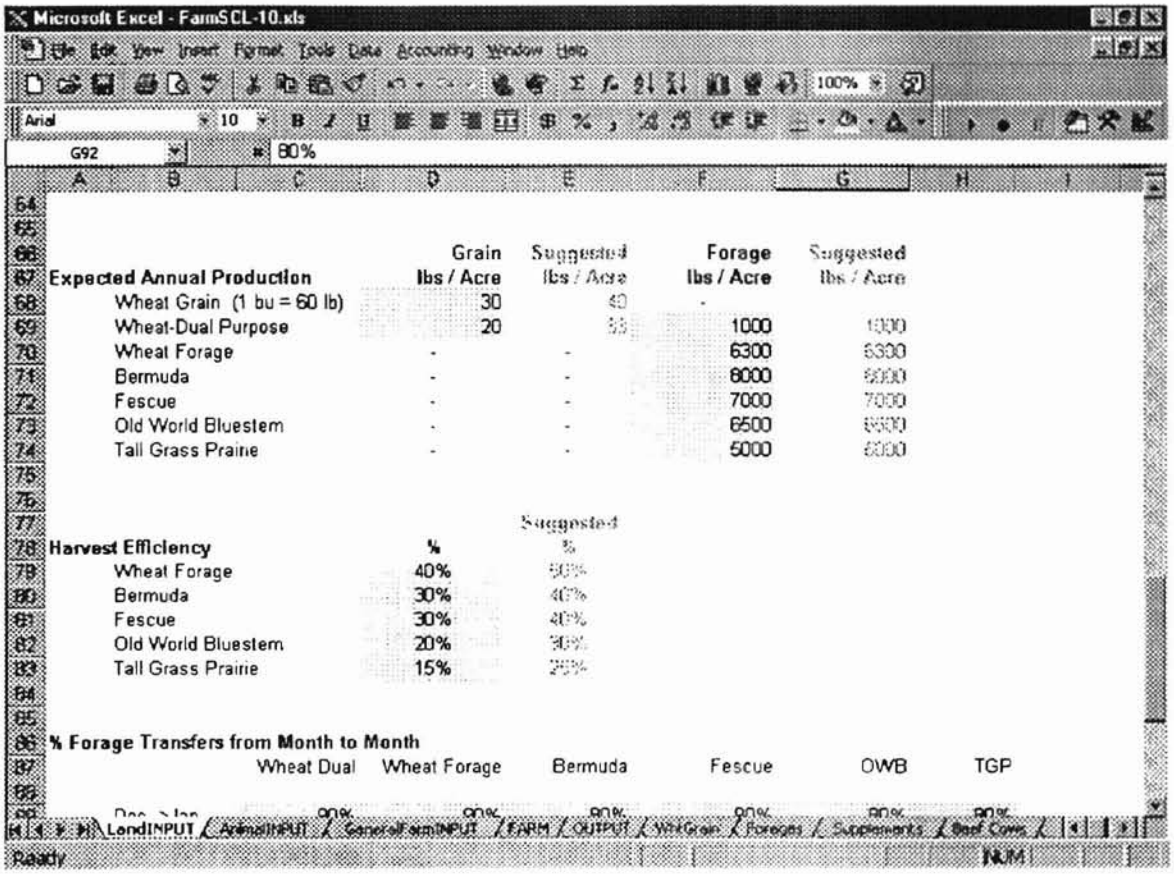
Farm L-10 results reveal that the selected forage base is optimally used with 289 spring calving cows, no fall calving cows, and 615 stockers. With an 88% calf crop and 11% replacement heifers, Farm L-10 produces 127 spring steer calves, 95 spring heifer calves, and 32 spring replacement heifers. All 127 steer calves are sold in November, and all 95 heifer calves are transferred to stockers in November In addition to the transferred heifer calves, 461 stocker heifers are purchased in November. All 556 stocker heifers that enter in November are sold in March. Also, 58 stocker heifers are purchased in May, and all are sold in September. No stocker steers are produced.

Farm L-10 uses all of the available owner/operator labor hours in February, and 18 labor hours are hired All owned capital of $100,000 and all borrowed capital of $50,000 is used. Farm L-10 results in $54,135.97 net return to family resources before taxes.

Large Farm with a 5% Increase in Harvest Efficiency

For the large farm with a 5% increase in harvest efficiency (Farm L+5) scenario, the harvest efficiencies are increased 5% on all forages from the original values used in Farm L. Farm L starting acreage base is used and the harvest efficiencies are increased to

Figure 5.6. Partial input screen for Farm L-10: Harvest efficiencies



	Grain lbs / Acre	Suggested lbs / Acre	Forage lbs / Acre	Suggested lbs / Acre
Expected Annual Production				
Wheat Grain (1 bu = 60 lb)	30	40	-	
Wheat-Dual Purpose	20	35	1000	1000
Wheat Forage	-	-	6300	6300
Bermuda	-	-	8000	6000
Fescue	-	-	7000	7000
Old World Bluestem	-	-	6500	6500
Tall Grass Prairie	-	-	5000	6000

Harvest Efficiency	%	Suggested %
Wheat Forage	40%	50%
Bermuda	30%	40%
Fescue	30%	40%
Old World Bluestem	20%	30%
Tall Grass Prairie	15%	25%

% Forage Transfers from Month to Month

Wheat Dual	Wheat Forage	Bermuda	Fescue	OWB	TGP

Table 5.3. Output of Farm L-10

	Owned	Rented	Transferred	Total Used
Total Acres	2,051	0		2,051
Acres In:				
Cropland	675	0	-488	**187**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				187
Improved Pasture Land	275	0	488	**763**
Bermuda				279
Fescue				484
Old World Bluestem				0
Native Pasture Land	1,101	0		**1,101**
Tall Grass Prairie				1,101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Production												
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	37409	33789	67578	135156	135156	0	0	0	0	0	24135	37409
Bermuda	0	0	0	53557	133893	200839	133893	66946	66946	13389	0	0
Fescue	20349	50872	152617	223838	193314	81396	0	0	81396	101744	81396	30523
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	115584	288960	222912	82560	33024	66048	16512	0	0
Held for Carry-over												
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	0	0	5290	0	0	0	0	0	0	663	0
Bermuda	0	0	0	53557	182094	364724	304181	190365	238275	227836	0	0
Fescue	190240	0	90328	305133	467934	502536	452283	407054	407039	468079	502667	355650
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	115584	392986	403114	445363	433850	326647	180628	162565	73947
Carry-over from previous												
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	0	0	0	0	5290	0	0	0	0	0	0	663
Bermuda	0	0	0	0	53557	182094	364724	304181	190365	238275	227836	0
Fescue	355650	190240	0	90328	305133	467934	502536	452283	407054	407039	468079	502667
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	73947	0	0	0	115584	392986	403114	445363	433850	326647	180628	162565
Grazing/Consumption												
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	37409	33789	67578	129867	139917	0	0	0	0	0	23472	38006
Bermuda	0	0	0	0	0	0	157963	150345	0	0	205053	0
Fescue	150193	222088	62288	0	0	0	0	0	0	0	0	127274
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	59157	0	0	0	0	173485	0	0	129867	129867	0	72362
Unused												
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	0	0	0	0	529	0	0	0	0	0	0	66
Bermuda	0	0	0	0	5,356	18,209	36,472	30,418	19,036	23,827	22,784	0
Fescue	35,565	19,024	0	9,033	30,513	46,793	50,254	45,228	81,411	40,704	46,808	50,267
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	14,789	0	0	0	11,558	39,299	40,311	44,536	43,385	32,665	18,063	16,256

Table 5.3. Output of Farm L-10 (continued)

Supplemental Feed	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
Produce & Sale Hay	**tons**	**$/ton**	**Total $**									
Bermuda Hay - Jun	0	$60.00	$0.00									
Bermuda Hay - Jul	0	$60.00	$0.00									
Bermuda Hay - Aug	0	$60.00	$0.00									
Bermuda Hay - Sep	0	$60.00	$0.00									
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00									
Produce & Sale Grain	**bu.**	**sell $**	**Total $**									
	0	$2.25	$0.00									
Cow-Calf	**hd.**											
Spring Calving Cows	289											
Produce Steer Calves	127	==>	Sell Steer Calves in Nov		127		Transfer Steer Calves to Stocker in Nov.				0	
Produce Heifer Calves	95	==>	Sell Heifer Calves in Nov		0		Transfer Heifer Calves to Stocker in Nov.				95	
Produce Repl. Heifers	32											
Fall Calving Cows	0											
Produce Steer Calves	0	==>	Sell Steer Calves in May		0		Transfer Steer Calves to Stocker in May				0	
Produce Heifer Calves	0	==>	Sell Heifer Calves in May		0		Transfer Heifer Calves to Stocker in May				0	
Produce Repl. Heifers	0											
Stockers	**hd.**	**wt.**	**$/cwt**									
Buy Steers in Nov	0	437	$92.97									
Buy Heifers in Nov	461	422	$80.40									
Buy Steers in May	0	420	$96.94									
Buy Heifers in May	58	415	$84.16									
Sell Nov Steers in Mar	0	617	$82.68									
Sell Nov Heifers in Mar	557	578	$81.12									
Sell Nov Steers in May	0	707	$76.92									
Sell Nov Heifers in May	0	656	$75.15									
Sell May Steers in Sep	0	600	$80.57									
Sell May Heifers in Sep	58	571	$76.97									
Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd.	750	750	447	447	600	600	600	600	600	543	750	750
Ac. / Hd.	2.73	2.73	4.59	4.59	3.42	3.42	3.42	3.42	3.42	3.78	2.73	2.73
Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs.	204	336	246	142	94	109	108	100	172	173	288	204
Hired hrs.	0	18	0	0	0	0	0	0	0	0	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$117.45	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Capital												
Owned/Retained Capital	$100,000.00											
Borrowed Capital	$50,000.00	9.00%										
Total	$150,000.00											
Net Returns Before Taxes	$54,135.97											

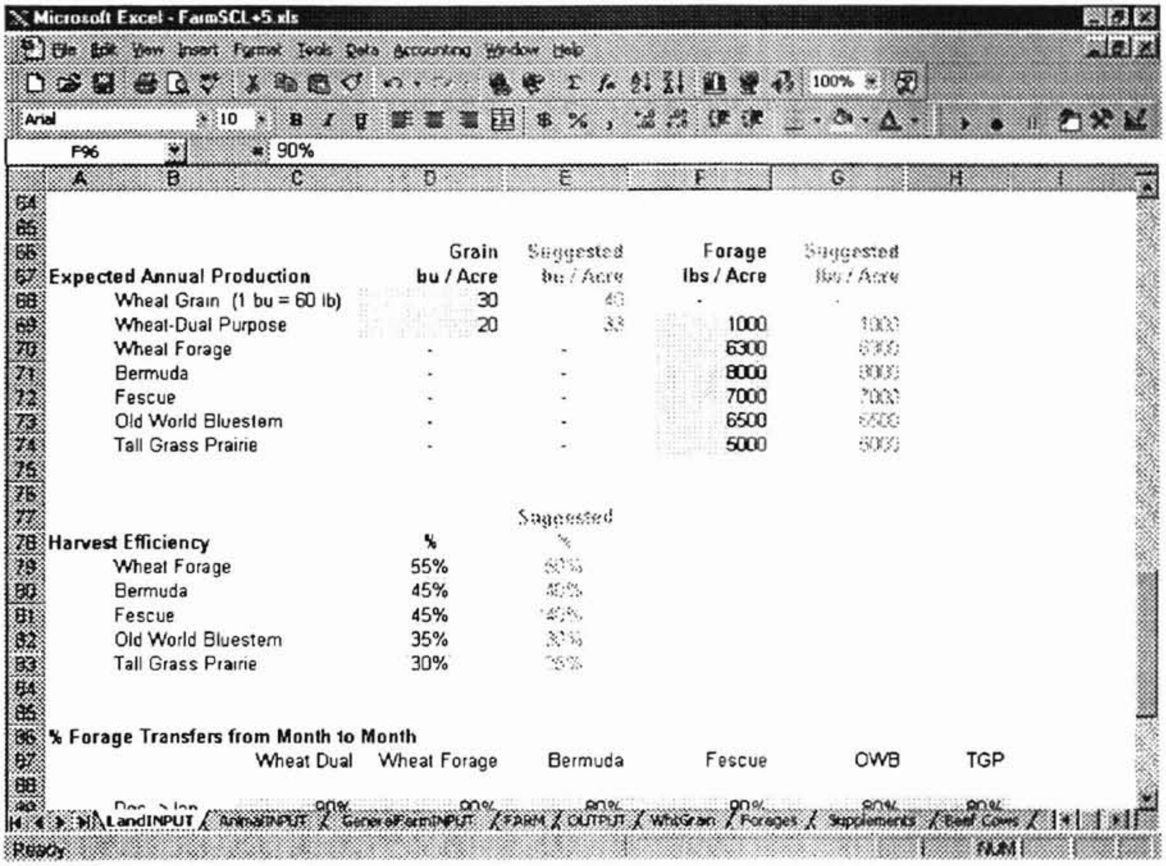
55% of wheat for forage only, 45% of Bermuda, 45% of Fescue, 35% of Old World Bluestem, and 30% of Tall Grass Prairie (Figure 5.7).

Farm L+5 results (Table 5.4) with 281 acres in cropland, 669 acres in improved pasture land, and 1,101 acres in native pasture land. Of the original 675 acres of cropland, 394 acres are transferred to improved pasture land. The land transfer increases improved pasture land from an original 275 acres to 669 acres. All of the original 1,101 acres of native pasture land are used. All of the 281 acres used for cropland are used for wheat for forage only, so no grain is produced. No range cubes are purchased. No hay is produced.

Farm L+5 results reveals that the selected forage base is optimally used with 522 spring calving cows, 99 fall calving cows, and 330 stockers. With an 88% calf crop and 11% replacement heifers, Farm L+5 produces 230 spring steer calves, 172 spring heifer calves, 57 spring replacement heifers, 43 fall steer calves, 33 fall heifer calves, and 11 fall replacement heifers. All 230 spring steers calves are sold in November, and all 172 spring heifer calves are transferred to stockers in November. All 43 fall steers calves and 33 fall heifer calves are sold in May. In addition to the spring heifer calves transferred into a stocker operation in November, 158 stocker heifers are purchased. All 330 stocker heifers that enter in November are sold in March. No stocker steers are produced.

Farm L+5 uses the maximum available owner/operator labor hours in February, March, and October. An additional 84 labor hours in February, 43 labor hours in March, and 37 labor hours in October are hired. The maximum owned capital of $100,000 and maximum borrowed capital of $50,000 is reached. Farm L+5 results with $97,614.78 net return to family resources before taxes.

Figure 5.7. Partial input screen for Farm L+5: Harvest efficiencies



Microsoft Excel - FarmSCL+5.xls

F96 = 90%

Expected Annual Production	Grain bu / Acre	Suggested bu / Acre	Forage lbs / Acre	Suggested lbs / Acre
Wheat Grain (1 bu = 60 lb)	30	40	-	-
Wheat-Dual Purpose	20	33	1000	1000
Wheat Forage	-	-	6300	6300
Bermuda	-	-	8000	8000
Fescue	-	-	7000	7000
Old World Bluestem	-	-	6500	6500
Tall Grass Prairie	-	-	5000	5000

Harvest Efficiency	%	Suggested %
Wheat Forage	55%	60%
Bermuda	45%	45%
Fescue	45%	40%
Old World Bluestem	35%	30%
Tall Grass Prairie	30%	25%

% Forage Transfers from Month to Month

	Wheat Dual	Wheat Forage	Bermuda	Fescue	OWB	TGP
Dec -> Jan	90%	90%	80%	90%	80%	80%

LandINPUT / AnimalINPUT / GeneralFarmINPUT / FARM / OUTPUT / WhtGrain / Forages / Supplements / Beef Cows

Table 5.4. Output of Farm L+5

	Owned	Rented	Transferred	Total Used
Total Acres	2,051	0		2,051
Acres In:				
Cropland	675	0	-394	**281**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				281
Improved Pasture Land	275	0	394	**669**
Bermuda				374
Fescue				296
Old World Bluestem				0
Native Pasture Land	1,101	0		**1,101**
Tall Grass Prairie				1,101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Production	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	77351	69866	139731	279462	279462	0	0	0	0	0	49904	77351
Bermuda	0	0	0	107605	269012	403519	269012	134506	134506	26901	0	0
Fescue	18631	46577	139731	204939	176993	74523	0	0	74523	93154	74523	27946
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	231168	577920	445824	165120	66048	132096	33024	0	0
Held for Carry-over	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	0	0	0	0	0	0	0	0	0	49904	24851
Bermuda	0	0	0	107605	365857	453328	392457	240085	350583	342426	0	0
Fescue	264198	0	0	204939	361438	399817	359835	323852	333605	393398	428582	413670
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	231168	785971	1153198	1202998	1116917	857859	525635	443262	152948
Carry-over from previous	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	24851	0	0	0	0	0	0	0	0	0	0	49904
Bermuda	0	0	0	0	107605	365857	453328	392457	240085	350583	342426	0
Fescue	413670	264198	0	0	204939	361438	399817	359835	323852	333605	393398	428582
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	152948	0	0	0	231168	785971	1153198	1202998	1116917	857859	525635	443262
Grazing/Consumption	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	99717	69866	139731	279462	279462	0	0	0	0	0	0	97414
Bermuda	0	0	0	0	0	279462	284551	247633	0	0	308183	0
Fescue	126736	284355	139731	0	0	0	0	0	0	0	0	0
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	122358	0	0	0	0	0	0	31829	279462	279462	29810	245988
Unused	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	2,485	0	0	0	0	0	0	0	0	0	0	4,990
Bermuda	0	0	0	0	10,760	36,586	45,333	39,246	24,008	35,058	34,243	0
Fescue	41,367	26,420	0	0	20,494	36,144	39,982	35,984	64,770	33,360	39,340	42,858
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	30,590	0	0	0	23,117	78,597	115,320	120,300	111,692	85,786	52,564	44,326

Table 5.4. Output of Farm L+5 (continued)

Supplemental Feed	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
Produce & Sale Hay	**tons**	**$/ton**	**Total $**									
Bermuda Hay - Jun	0	$60.00	$0.00									
Bermuda Hay - Jul	0	$60.00	$0.00									
Bermuda Hay - Aug	0	$60.00	$0.00									
Bermuda Hay - Sep	0	$60.00	$0.00									
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00									
Produce & Sale Grain	**bu.**	**sell $**	**Total $**									
	0	$2.25	$0.00									
Cow-Calf	**hd.**											
Spring Calving Cows	522											
Produce Steer Calves	230	==>	Sell Steer Calves in Nov		230		Transfer Steer Calves to Stocker in Nov.				0	
Produce Heifer Calves	172	==>	Sell Heifer Calves in Nov		0		Transfer Heifer Calves to Stocker in Nov.				172	
Produce Repl. Heifers	57											
Fall Calving Cows	99											
Produce Steer Calves	43	==>	Sell Steer Calves in May		43		Transfer Steer Calves to Stocker in May				0	
Produce Heifer Calves	33	==>	Sell Heifer Calves in May		33		Transfer Heifer Calves to Stocker in May				0	
Produce Repl. Heifers	11											
Stockers	**hd.**	**wt.**	**$/cwt**									
Buy Steers in Nov	0	437	$92.97									
Buy Heifers in Nov	158	422	$80.40									
Buy Steers in May	0	420	$96.94									
Buy Heifers in May	0	415	$84.16									
Sell Nov Steers in Mar	0	617	$82.68									
Sell Nov Heifers in Mar	330	578	$81.12									
Sell Nov Steers in May	0	707	$76.92									
Sell Nov Heifers in May	0	656	$75.15									
Sell May Steers in Sep	0	600	$80.57									
Sell May Heifers in Sep	0	571	$76.97									
Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd	866	866	995	995	1081	1081	1081	1081	1081	1168	866	866
Ac / Hd.	2.37	2.37	2.06	2.06	1.90	1.90	1.90	1.90	1.90	1.76	2.37	2.37
Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs.	222	336	336	254	134	186	179	172	265	336	272	222
Hired hrs.	0	84	43	0	0	0	0	0	0	37	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$546.61	$276.55	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$238.00	$0.00	$0.00
Capital												
Owned/Retained Capital	$100,000.00											
Borrowed Capital	$50,000.00	9.00%										
Total	$150,000.00											
Net Returns Before Taxes	$97,614.78											

Large Farm with a Capital Constraint

Farm L uses a maximum owned capital of $100,000 and maximum borrowed capital $50,000 (Figure 5.8). The large farm with a decreased capital constraint (Farm L-Cap) uses the base Farm L starting acreage and harvest efficiencies, but has zero owned capital and $100,000 maximum borrowed capital (Figure 5.9).

The Farm L-Cap scenario results (Table 5.5) with 301 acres in cropland, 649 acres in improved pasture land, and 1,101 acres in Native pasture land Of the original 675 acres in cropland, 374 are transferred into improved pasture land. The transfer of acreage increases improved pasture land from an original 275 to 649. All of the original 1,101 acres of native pasture is used. All 301 acres of cropland are used for wheat for forage only, so no grain is produced. No range cubes are purchased. No hay is produced.

The Farm L-Cap results reveal that the selected forage base is optimally used with 524 spring-calving cows, 82 fall-calving cows, and 26 stockers. With an 88% calf-crop and 11% replacement heifers, Farm L-Cap produces 230 spring steer calves, 173 spring heifer calves, 58 spring replacement heifers, 36 fall steer calves, 27 fall heifer calves, and 9 fall replacement heifers. All 230 spring steer calves and 147 of the 173 spring heifer calves are sold in November. The remaining 26 spring heifer calves are transferred into a stocker operation. All 36 fall steer calves and 27 fall heifer calves are sold in May. As the only stockers, the 26 spring heifer calves transferred to stocker heifers are sold in March. No stocker steers are produced.

Farm L-Cap uses the maximum available owner/operator labor hours in February and October An additional 11 labor hours in February and 27 labor hours in October are

Figure 5.8. Partial Input Screen for Farm L: Capital

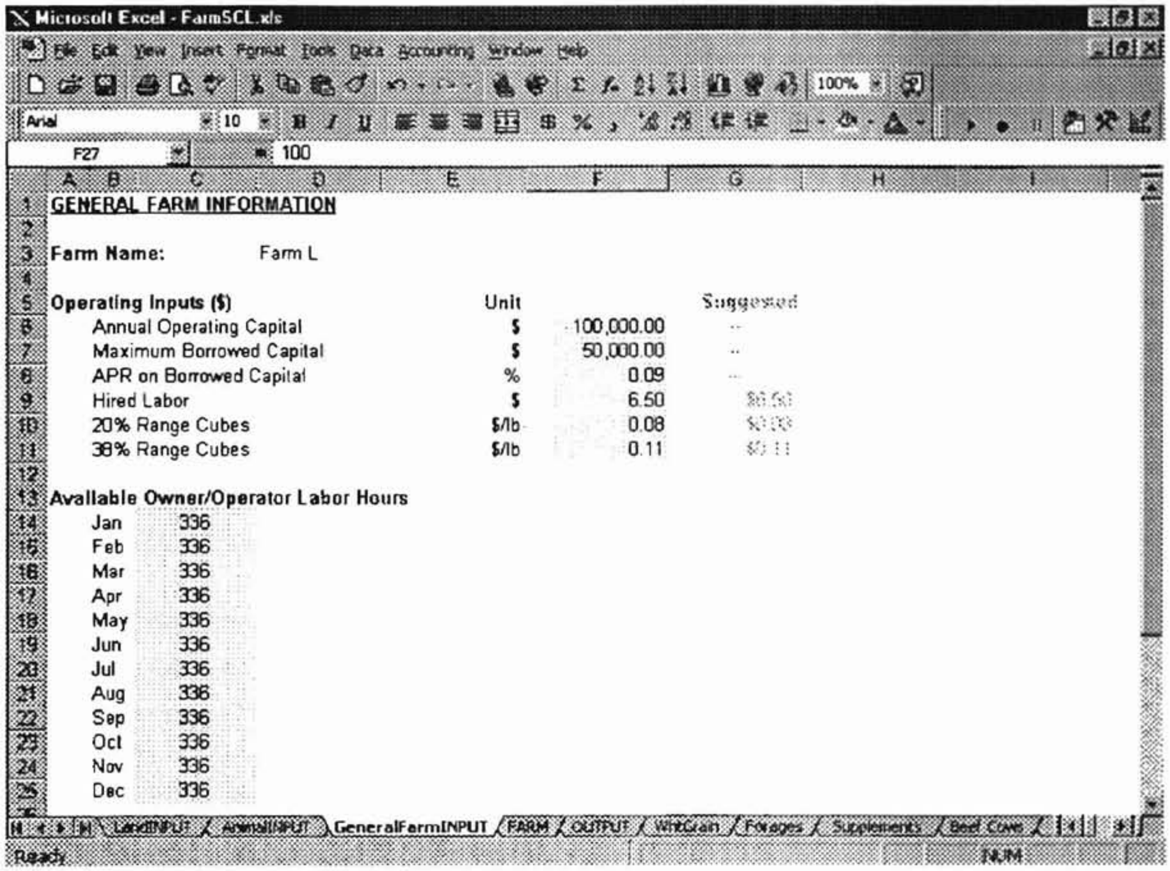


Figure 5.9. Partial Input Screen for Farm L-Cap: Capital

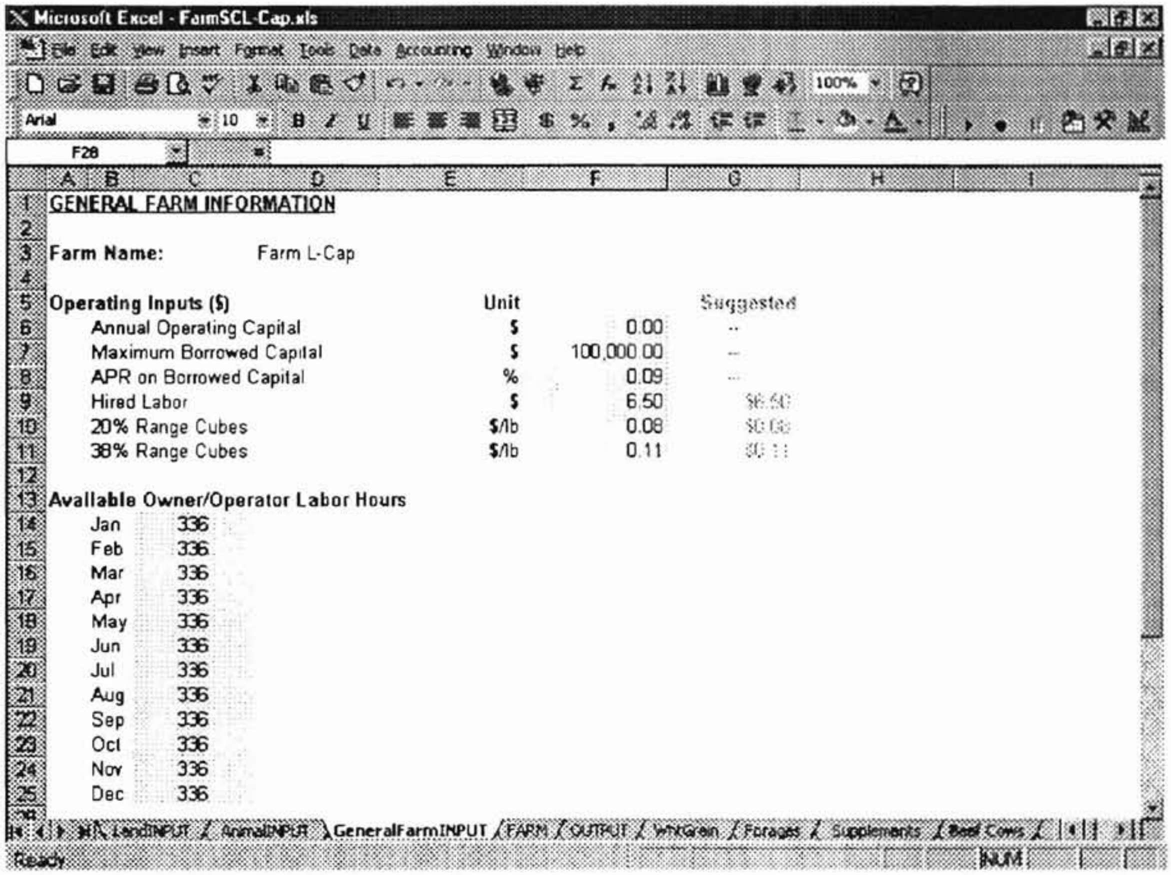


Table 5.5. Output of Farm L-Cap

	Owned	Rented	Transferred	Total Used
Total Acres	2,051	0		2,051
Acres In:				
Cropland	675	0	-374	**301**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				301
Improved Pasture Land	275	0	374	**649**
Bermuda				325
Fescue				324
Old World Bluestem				0
Native Pasture Land	1,101	0		**1,101**
Tall Grass Prairie				1,101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Production												
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	75394	68098	136196	272391	272391	0	0	0	0	0	48641	75394
Bermuda	0	0	0	83152	207880	311819	207880	103940	103940	20788	0	0
Fescue	18159	45399	136196	199754	172514	72638	0	0	72638	90797	72638	27239
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	192640	481600	371520	137600	55040	110080	27520	0	0
Held for Carry-over												
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	134034	0	0	0	0	0	0	0	0	0	48641	65156
Bermuda	0	0	0	83152	282716	417816	303606	104794	198254	114917	0	0
Fescue	49100	0	0	199754	352293	262562	236306	212676	242778	309297	351005	343144
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	192640	654976	960998	1002499	957289	699249	468752	248271	0
Carry-over from previous												
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	65156	134034	0	0	0	0	0	0	0	0	0	48641
Bermuda	0	0	0	0	83152	282716	417816	303606	104794	198254	114917	0
Fescue	343144	49100	0	0	199754	352293	262562	236306	212676	242778	309297	351005
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	0	192640	654976	960998	1002499	957289	699249	468752	248271
Grazing/Consumption												
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	188729	136196	272391	272391	0	0	0	0	0	0	54016
Bermuda	0	0	0	0	0	148448	280308	272391	0	84300	103426	0
Fescue	277889	89589	136196	0	0	127139	0	0	0	0	0	0
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	0	0	0	0	0	272391	188092	173605	223444
Unused												
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	6,516	13,403	0	0	0	0	0	0	0	0	0	4,864
Bermuda	0	0	0	0	8,315	28,272	41,782	30,361	10,479	19,825	11,492	0
Fescue	34,314	4,910	0	0	19,975	35,229	26,256	23,631	42,535	24,278	30,930	35,101
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	0	19,264	65,498	96,100	100,250	95,729	69,925	46,875	24,827

Table 5.5. Output of Farm L-Cap (continued)

Supplemental Feed	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
Produce & Sale Hay	**tons**	**$/ton**	**Total $**									
Bermuda Hay - Jun	0	$60.00	$0.00									
Bermuda Hay - Jul	0	$60.00	$0.00									
Bermuda Hay - Aug	0	$60.00	$0.00									
Bermuda Hay - Sep	0	$60.00	$0.00									
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00									
Produce & Sale Grain	**bu.**	**sell $**	**Total $**									
	0	$2.25	$0.00									
Cow-Calf	**hd.**											
Spring Calving Cows	524											
Produce Steer Calves	230	==>	Sell Steer Calves in Nov		230		Transfer Steer Calves to Stocker in Nov.				0	
Produce Heifer Calves	173	==>	Sell Heifer Calves in Nov		147		Transfer Heifer Calves to Stocker in Nov.				26	
Produce Repl. Heifers	58											
Fall Calving Cows	82											
Produce Steer Calves	36	==>	Sell Steer Calves in May		36		Transfer Steer Calves to Stocker in May				0	
Produce Heifer Calves	27	==>	Sell Heifer Calves in May		27		Transfer Heifer Calves to Stocker in May				0	
Produce Repl. Heifers	9											
Stockers	**hd.**	**wt.**	**$/cwt**									
Buy Steers in Nov	0	437	$92.97									
Buy Heifers in Nov	0	422	$80.40									
Buy Steers in May	0	420	$96.94									
Buy Heifers in May	0	415	$84.16									
Sell Nov Steers in Mar	0	617	$82.68									
Sell Nov Heifers in Mar	26	578	$81.12									
Sell Nov Steers in May	0	707	$76.92									
Sell Nov Heifers in May	0	656	$75.15									
Sell May Steers in Sep	0	600	$80.57									
Sell May Heifers in Sep	0	571	$76.97									
Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd.	677	677	1112	1112	1066	1066	1066	1066	1066	1138	677	677
Ac. / Hd	3.03	3.03	1.84	1.84	1.92	1.92	1.92	1.92	1.92	1.80	3.03	3.03
Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs	143	336	336	244	127	190	175	175	265	336	147	143
Hired hrs.	0	11	0	0	0	0	0	0	0	27	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$74.36	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$176.72	$0.00	$0.00
Capital												
Owned/Retained Capital	$0.00											
Borrowed Capital	$100,000.00	9.00%										
Total	$100,000.00											
Net Returns Before Taxes	$66,353.31											

hired. No owned capital is available for use, but all $100,000 maximum borrowed capital is used. Farm L-Cap results with $66,353.31 net return to family resources before taxes.

Medium Farm with Land Renting

A medium farm with pasture and non-irrigated crop land in south central Oklahoma has an estimated 163 acres in crop land and 210 acres in pasture land. Twenty percent of the pasture land is assumed as improved pasture land, and the remaining eighty percent is assumed as native pasture land. Therefore, the medium farm with land renting (Farm M+R) scenario consists of 163 acres in cropland, 42 acres in improved pasture land, and 168 acres in native pasture land (Figure 5.8), all of which was owned. Also, Farm M+R allows for renting 160 acres of cropland and 80 acres of native pasture land.

The Farm M+R scenario uses (Table 5.10) a total of 109 acres of cropland, 256 acres of improved pasture land, and 248 acres of native pasture land. Of the original 163 acres in cropland plus 160 acres of rented cropland, 214 acres are transferred for use as improved pasture land. The transfer of cropland acreage increases improved pasture land from an original 42 acres to 256 acres. All of the original 168 acres of native pasture land plus 80 acres of rented native pasture land are used. All of the 109 acres used for cropland are for wheat for forage only, so no grain is produced No range cubes are purchased. No hay is produced.

Farm M+R results reveal that the selected forage base is optimally used with 56 spring calving cows, no fall calving cows, and 762 stockers With 88% calf crop and 11% replacement heifers, Farm M+R produces 24 spring steer calves, 18 spring heifer calves, and six replacement heifers. All 24 steer calves are sold in November, and all 18 heifer calves are transferred into a stocker operation in November. In addition to the heifer

Figure 5.10. Partial input screen for Farm M+R: Starting acres

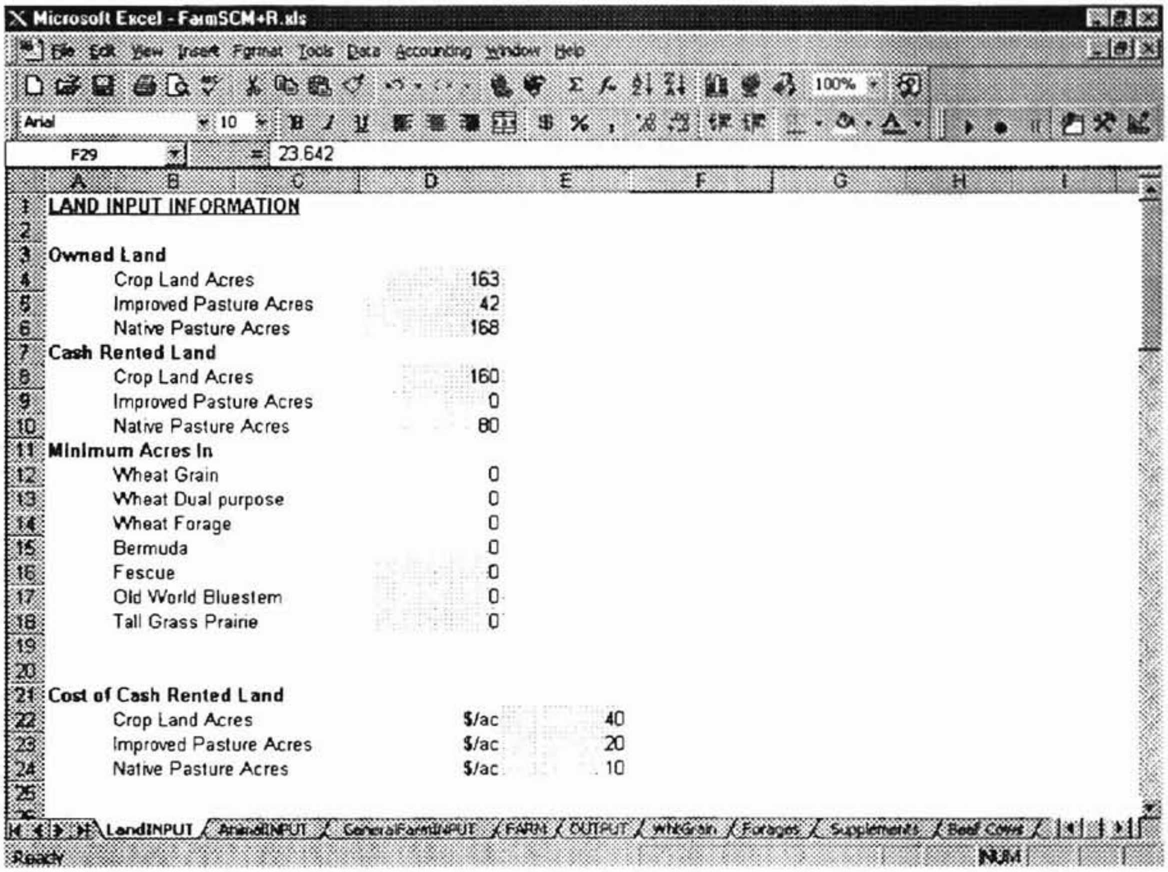


Table 5.6. Output of Farm M+R

	Owned	Rented	Transferred	Total Used
Total Acres	373	240		613
Acres In:				
Cropland	163	160	-214	**109**
Wheat Grain				0
Wheat-Dual Purpose				0
Wheat Forage				109
Improved Pasture Land	42	0	214	**256**
Bermuda				126
Fescue				130
Old World Bluestem				0
Native Pasture Land	168	80		**248**
Tall Grass Prairie				248

Total Production	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	27263	24625	49249	98499	98499	0	0	0	0	0	17589	27263
Bermuda	0	0	0	32258	80645	120968	80645	40323	40323	8065	0	0
Fescue	7286	18215	54645	80146	69217	29144	0	0	29144	36430	29144	10929
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	43400	108500	83700	31000	12400	24800	6200	0	0

Held for Carry-over	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	0	0	0	11396	0	0	0	0	0	0	0	0
Bermuda	0	0	0	32258	109678	219678	121294	0	40323	44355	0	0
Fescue	57361	0	20717	98792	158129	171460	154314	138883	140250	162655	153658	110153
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	0	0	0	43400	147560	44009	70608	75947	68162	42556	38300	16391

Carry-over from previous	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat-Dual Purpose	0	0	0									0
Wheat Forage	0	0	0	0	11396	0	0	0	0	0	0	0
Bermuda	0	0	0	0	32258	109678	219678	121294	0	40323	44355	0
Fescue	110153	57361	0	20717	98792	158129	171460	154314	138883	140250	162655	153658
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	16391	0	0	0	43400	147560	44009	70608	75947	68162	42556	38300

Grazing/Consumption	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat-Dual Purpose	0	0									0	0
Wheat Forage	27263	24625	49249	87103	108755	0	0	0	0	0	17589	27263
Bermuda	0	0	0	0	0	0	157062	149487	0	0	39919	0
Fescue	49062	69840	33927	0	0	0	0	0	0	0	21876	39068
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	13112	0	0	0	0	172495	0	0	24990	24990	0	18080

Unused	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat-Dual Purpose	0	0	0	0	0	0	0	0	0	0	0	0
Wheat Forage	0	0	0	0	1,140	0	0	0	0	0	0	0
Bermuda	0	0	0	0	3,226	10,968	21,968	12,129	0	4,032	4,435	0
Fescue	11,015	5,736	0	2,072	9,879	15,813	17,146	15,431	27,777	14,025	16,266	15,366
Old World Bluestem	0	0	0	0	0	0	0	0	0	0	0	0
Tall Grass Prairie	3,278	0	0	0	4,340	14,756	4,401	7,061	7,595	6,816	4,256	3,830

Table 5.6. Output of Farm M+R (continued)

Supplemental Feed	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
20% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0	0	0	0	0	0	0

Produce & Sale Hay	**tons**	**$/ton**	**Total $**
Bermuda Hay - Jun	0	$60.00	$0.00
Bermuda Hay - Jul	0	$60.00	$0.00
Bermuda Hay - Aug	0	$60.00	$0.00
Bermuda Hay - Sep	0	$60.00	$0.00
Tall Grass Prairie Hay - Jun	0	$50.00	$0.00

Produce & Sale Grain	**bu.**	**sell $**	**Total $**
	0	$2.25	$0.00

Cow-Calf	**hd.**					
Spring Calving Cows	56					
Produce Steer Calves	24	==>	Sell Steer Calves in Nov	24	Transfer Steer Calves to Stocker in Nov.	0
Produce Heifer Calves	18	==>	Sell Heifer Calves in Nov	0	Transfer Heifer Calves to Stocker in Nov.	18
Produce Repl. Heifers	6					
Fall Calving Cows	0					
Produce Steer Calves	0	==>	Sell Steer Calves in May	0	Transfer Steer Calves to Stocker in May	0
Produce Heifer Calves	0	==>	Sell Heifer Calves in May	0	Transfer Heifer Calves to Stocker in May	0
Produce Repl. Heifers	0					

Stockers	**hd.**	**wt.**	**$/cwt**
Buy Steers in Nov	0	437	$92.97
Buy Heifers in Nov	289	422	$80.40
Buy Steers in May	0	420	$96.94
Buy Heifers in May	455	415	$84.16
Sell Nov Steers in Mar	0	617	$82.68
Sell Nov Heifers in Mar	67	578	$81.12
Sell Nov Steers in May	0	707	$76.92
Sell Nov Heifers in May	240	656	$75.15
Sell May Steers in Sep	0	600	$80.57
Sell May Heifers in Sep	455	571	$76.97

Stocking Density	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total Farm Hd	344	344	326	326	560	560	560	560	560	104	344	344
Ac. / Hd	1.78	1.78	1.88	1.88	1.10	1.10	1.10	1.10	1.10	5.87	1.78	1.78

Labor	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Owner hrs.	89	135	78	66	213	76	71	71	113	33	135	89
Hired hrs.	0	0	0	0	0	0	0	0	0	0	0	0
$/hired hr.	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50	$6.50
Total Hired $	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

Capital		
Owned/Retained Capital	$100,000.00	
Borrowed Capital	$50,000.00	9.00%
Total	$150,000.00	

Net Returns Before Taxes	$36,547.04

calves transferred into a stocker operation, 289 stocker heifers are purchased in November. Of the total 307 stocker heifers that enter in November, 67 are sold in March and the remaining 240 are sold in May. Also, 455 stocker heifers are purchased in May, and all are sold in September. No stocker steers are produced.

Farm M+R did not approach the maximum levels of available owner labor hours, so no hired labor is required. Maximum owned capital of $100,000 and maximum borrowed capital $50,000 are used. Farm M+R results with $36,547.04 net return to family resources before taxes.

Summary of Results

A summary of the results is provided in Table 5.7 for easy comparison across the farm scenarios. Testing the same farm with various levels of harvest efficiency reveals that as the harvest efficiency decreases, the cow-calf operation size decreases, the stocker operation size increases, and returns decrease. As harvest efficiency increases on the same farm, stocking density decreases and available labor becomes more constraining. Constraining the capital limits the ability to purchase stockers, so the cow-calf operation size increases. The animal mix is very sensitive to capital. All farm scenario solutions were restrained by capital

Every farm scenario results with stocker heifers and no stocker steers. Also, in every farm scenario, all of the spring heifer calves are transferred to stockers while all of the spring steer calves, fall steer calves, and fall heifer calves are sold. Based on Oklahoma City ten year average prices for beef cattle, heifer calves sell for approximately $12.00/cwt less than steer calves in November, while stocker heifers sell for no more than $4.00/cwt less than stocker steers in March and May. It is probable that the nutrient

Table 5.7. Summary of the Farm Scenario Results

	Farm L	Farm L-5	Farm L-10	Farm L+5	Farm L-Cap	Farm M+R
Total Acres	**2,051**	**2,051**	**2,051**	**2,051**	**2,051**	**613**
Owned	2,051	2,051	2,051	2,051	2,051	373
Rented	0	0	0	0	0	240
Acres in:						
Cropland	**254**	**217**	**187**	**281**	**301**	**109**
Wheat Grain	0	0	0	0	0	0
Wheat-Dual Purpose	0	0	0	0	0	0
Wheat Forage	254	217	187	281	301	109
Transfer Cropland to Improved	**421**	**458**	**488**	**394**	**374**	**214**
Improved Pasture Land	**697**	**733**	**763**	**669**	**649**	**256**
Bermuda	388	341	279	374	325	126
Fescue	308	392	484	296	324	130
Old World Bluestem	0	0	0	0	0	0
Native Pasture Land	**1,101**	**1,101**	**1,101**	**1,101**	**1,101**	**248**
Tall Grass Prairie	1,101	1,101	1,101	1,101	1,101	248
Supplemental Feed (lbs.)						
20% Range Cubes	0	0	0	0	0	0
38% Range Cubes	0	0	0	0	0	0
Produce Hay (tons)						
Bermuda Hay - Jun	0	0	0	0	0	0
TGP Hay - Jun	0	0	0	0	0	0
Produce Grain (bu.)						
Wheat	0	0	0	0	0	0
Cow-Calf (hd.)						
Spring Calving Cows	**443**	393	289	**522**	**524**	**56**
Produce Steer Calves	195	173	127	230	230	24
Produce Heifer Calves	146	130	95	172	173	18
Produce Repl. Heifers	49	43	32	57	58	6
Fall Calving Cows	**66**	0	0	**99**	**82**	0
Produce Steer Calves	29	0	0	43	36	0
Produce Heifer Calves	22	0	0	33	27	0
Produce Repl. Heifers	7	0	0	11	9	0
Stockers (hd.)						
Buy Steers in Nov	0	0	0	0	0	0
Buy Heifers in Nov	**282**	**398**	**461**	**158**	0	**289**
Buy Steers in May	0	0	0	0	0	0
Buy Heifers in May	0	0	**58**	0	0	**455**
Sell Nov Steers in Mar	0	0	0	0	0	0
Sell Nov Heifers in Mar	**429**	**527**	**557**	**330**	**26**	**67**
Sell Nov Steers in May	0	0	0	0	0	0
Sell Nov Heifers in May	0	0	0	0	0	**240**
Sell May Steers in Sep	0	0	0	0	0	0
Sell May Heifers in Sep	0	0	**58**	0	0	**455**
Labor (hrs.)						
Owner hrs.	2,738	2,445	2,175	2,914	2,616	1,170
Hired hrs.	63	53	18	163	39	0
Capital ($)						
Owned/Retained Capital	$100,000.00	$100,000.00	$100,000.00	$100,000.00	$0.00	$100,000.00
Borrowed Cap. @ 9% Int.	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$100,000.00	$50,000.00
Total	$150,000.00	$150,000.00	$150,000.00	$150,000.00	$100,000.00	$150,000.00
Net Returns Before Taxes	$84,181.23	$69,423.17	$54,135.97	$97,614.78	$66,353.31	$36,547.04

requirements for winter stocker heifers are low enough for the November buy prices and March and May sell prices, even with lower prices for stocker heifers than for stocker steers, that winter stocker heifers were more profitable. Again, it is probable that the spring heifer calves were more valuable being kept as stockers in November than being sold as calves, given the input livestock prices, operating costs, and labor requirements.

As can be seen in the output for each of the farm scenarios (Table 5.1-5.6), the model suggests lower stocking densities (fewer acres per head) than are seen in the real world. This is most likely a function of presumed actual forage production and the harvest efficiency. Most agronomic tests reveal the amount of forage in a pasture, but researchers debate the amount that is actually usable by an animal. This model may provide some insight into the debate by allowing researchers to test their theories on forage dry matter (DM) availability and usability. Also, the model is designed to select the optimal mix of pasture and beef animal With optimal management and environmental conditions, the suggested stocking densities may be accurate. If capital had been increased, even heavier stocking rates (lower stocking density) would have resulted by purchasing range cubes to compensate for the lack of DM.

Limitations of the Model

Assumptions of Mixed Integer Programming

The mixed integer programming (MIP) model is a profit maximization model, so the objective function is maximized. Several of the constraints have a nonzero right hand side coefficient for the model's one year time period. Though the constraining factors and potential activities existing on a farm are infinite, this model contains 170 constraints and

207 activities. The user may change any input information before running the program, but the values in the MIP tableau that are derived from the input information are constant while Solver is running. Therefore, the C_j, a_{ij}, b_i, R_k, L_k, and b_t coefficients are known constants within the model. All of the resources and most of the activities can be used in fractional units, but three of the activities are set as binary. The three land renting activities are binary, because a block of land is rented or no land is rented. The model does not choose a fraction of the block of land to rent. Though, for example, no two acres of land are identical, the model assumes that all units of a resource are identical. No interaction between activities exists in the model, so the total output of all activities is equal to the sum of individual outputs of each activity. The costs, returns, and resource requirements for each activity remain constant per unit of activity regardless of the level of the activity selected by the model.

Limitations Specific to this Model

The forage data for this model do not allow for production variability as affected by nitrogen rates. For some forages, little data are available to reveal the effects of nitrogen rates on production. The forage data for this model were collected from various sites in Oklahoma, but not enough data were available from any one site to insert a region specific component into the model. Some of the forage data came from research that measured acid detergent fiber (ADF), and total digestible nutrient (TDN) was calculated from ADF. Though calculating TDN from ADF is generally accepted, ADF is not characteristic of true digestibility (Lalman 1999).

Any hay produced can only be sold. Hay is not available for consumption by the animal, because hay quality data are not available that reveals the effects of time and storage practice on degradation.

The model assumes the livestock can be moved among the various forages from month to month without additional cost. It does not account for grazing practice (continuous, rotational, or strip grazing).

As can be observed in Figure 2, the animal nutrient requirement equations calculate the average daily requirements for brood cows based on the stage of production (e.g. early gestation with late lactation). The nutrient requirement equations for stockers do not adjust for increasing weight, but represent the average daily requirements (Figure 3) based on starting weight, ADG, and days until finish. Animal dry matter intake (DMI) is a function of the energy (TDN) concentration of the feed. This model is designed to select an optimal mix of forages. Therefore, the TDN concentration is not known prior to running the model. This model contains an estimated minimum and maximum consumption values, and the model must maintain consumption within those limits.

This model is too large for the standard Solver that is packaged with Excel, so the model requires additional software. Solver Premium Plus, marketed by Frontline Systems, is used for this model.

CHAPTER VI

CONCLUSIONS

Conclusions

To increase returns, producers must optimize their production given certain constraints. Some constraints producers face are land availability, available forage resources, and precipitation. In beef production, feed costs are the greatest expense next to the original purchase price of the cattle (Redmon 1996a; McGrann and Walter; Lalman, Gill, and Johnson). Feed costs can often be reduced if producers are attentive to their available forage resources.

Incorporating cool season forages into a forage maintenance program can extend the availability of nutritional forages further into the winter. Typically, producers use native forages, possibly because they think that establishing a new forage will cost too much or will require too much labor. However, the benefits of using an optimal mix of forage can outweigh the costs of establishing a new forage. Some forage enterprise budgets prorate establishment costs over a five year period. Those budgets can be used in this model. An optimal forage mix may allow producers to maintain more livestock on the same amount of land.

A producer should not adopt new forages or new forage management techniques without planning and preparation. Developing a broader complement of forage enterprise budgets, containing quantity, quality, and economic dimensions, will allow beef producers to better determine the optimal use of their land. A forage enterprise budget shows forage production and the costs associated with maintaining that production throughout any period of time. By maintaining monthly enterprise budgets for an entire year and including the nutritional value of the forage for each month, a producer can see when the forage is most productive. Knowing when labor and capital needs to be allocated to a forage helps a producer plan and prepare. Planning helps keep overhead costs down, allows an operation to run smoothly, and helps an operator anticipate problems. Compiling detailed forage enterprise budgets along with income-providing (e.g. cow-calf, stockers, and grain) enterprise budgets into one whole farm budget will help a producer to design a production system that best fits the producers goals.

Producers are becoming increasingly aware of how important it is to keep track of when and where expenditures and income are incurred. It is crucial that universities and agricultural extension continue to provide the best available information and resources to producers. Experts benefit from working with producers to identify research needs, which, in turn, benefits the producers. Though computer technology will not replace common sense and experience, computers provide producers with utilities to help them manage their farm.

This computer program is a prototype mixed integer programming (MIP) model containing a forage database of forage dry matter (DM), total digestible nutrient (TDN), and crude protein (CP). For each month, the model balances the availability of forage DM, TDN, and CP with estimates of cow-calf and stocker nutrient requirements measured in DM, TDN, and CP. It also allows the user to estimate changes in quantity and quality of stockpiled forage over time. This program provides producers with a tool for analyzing their production potential along with the associated financial inflows and outflows. It also provides researchers a tool for analyzing various factors that influence farm-level behavior.

Recommendations for Future Research

The development of this program has revealed several needs for future research. Some of the forage data did not contain measurements of TDN. Percent TDN for bermuda was derived from acid detergent fiber (ADF) using a generally accepted equation (equation 1), but ADF is not characteristic of true digestibility (Lalman 1999). Percent TDN for wheat is assumed to be equal to In Vivo DOM (organic matter disappearance/digestibility as a percent of total DM as tested from the animal). Percent TDN for old world bluestem and tall grass prairie is assumed to be equal to IVDOM (In Vitro dry matter disappearance/digestibility as a percent of total DM consumed as tested in the lab). The need for a consistent and accurate measurement of energy content of forages exists.

Accurate measurements of monthly DM, TDN, and CP actual production, degradation, and carryover without gaps is needed to make this model most effective. Also, measurements or equations to simulate DM, TDN, and CP as affected by nitrogen (N) applications and environmental factors would be beneficial in making this model as accurate as possible. Enough data was compiled for five forages to be used in this model. Data is needed for a more broad spectrum of Oklahoma forages. For example, tall grass prairie was the only "native" grass with sufficient data. However, tall grass prairie is only representative of north eastern Oklahoma.

Currently, the model is not region specific. To enable the model to represent for the various regions of Oklahoma, it needs data as described earlier for each region or some adjustment coefficients to correct the data. Also, simulation of hay quality as affected by time and storing practice would be of great benefit.

This model currently is not sensitive to grazing intensity. Research of the impact of management (continuous, rotational, and strip grazing) on forage production (quantity and quality) would be useful. If research could reveal an adjustment coefficient for grazing practice, the forage data could be adjusted to compensate. Also, an important component of grazing intensity studies is some data to suggest how efficiently animals harvest various forages depending on grazing intensity.

Differences in styles of studying forages exists between agronomists and animal scientists. A cooperative effort among agronomists and animal scientists in future research could result in more consistent and widely usable data.

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APPENDIX

Appendix 1. Wheat Quality – means across variety, month of measurement, and stocking rate for 1993-1997

	CP %	In Vitro OMD %	In Vivo OMD %	(TDN) In Vivo DOM %
Oct	27.67	90.20	82.12	73.32
Nov	29.64	91.51	82.22	73.56
Dec	25.05	88.61	81.80	73.69
Jan	22.44	85.22	81.17	71.31
Feb	18.24	86.49	79.93	70.59
Mar	28.89	88.37	80.43	71.23

Sources: Horn, Gerald. Dept. of Animal Science, Oklahoma State University. Personal Contact, 1998.

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In Vitro (IV) = in the lab
In Vivo = in the animal
OMD = Organic Matter Disappearance/Digestibility as a % of total Organic Matter
DOM = Organic Matter Disappearance/Digestibility as a % of total Dry Matter
In Vivo DOM : TDN = 1:1

Appendix 2. Wheat DM

	Dual-Purpose 1-Sep DM lb/ac	Dual-Purpose 15-Sep DM lb/ac	Forage* DM lb/ac
Nov	325.91	177.21	177.21
Dec	505.16	274.68	274.68
Jan	505.16	274.68	274.68
Feb	456.27	248.10	248.10
Mar			496.19
Apr			992.39
May			992.39

Source: Krenzer, Gene. "Planting Date Effect on Wheat Forage and Grain." Oklahoma State University Department of Plant and Soil Sciences Production Technology Report PT95-22, 1995.

*Wheat for forage only data were fabricated: The values for November-February are taken from the Dual-Purpose wheat planted September 15, and the value for March is twice the February value, and April and May are each quadruple the February value.

Appendix 3. Bermuda*--means across variety, cutting month, location, and year

1992-94	DM lb/ac	CP %	NDF %	ADF %	TDN (from ADF) %	IVDMD %
May	3907.78	14.13	69.52	36.91	60.15	57.58
Jun	5081.94	12.49	71.39	37.82	59.46	63.91
Jul	5780.28	12.63	69.14	37.26	59.87	63.62
Aug	4402.22	13.27	70.25	36.00	60.60	62.92
Sep	3721.94	12.56	72.15	37.55	59.59	61.89
Oct	1438.52	11.49	71.75	38.67	69.25	57.10
Nov	1346.67	10.09	63.54	36.14	60.75	61.01

*N applied unknown

Sources: Taliaferro, C. M., Tesfaye Liranso, F. T. McCollum, D.R. Gill, and Lea L. Ebro. "Evaluation of 'World Feeder' And 'Gordons Gift' Bermudagrasses." Final Report. Oklahoma Agricultural Experiment Station, Stillwater, OK. 1992-1994.

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NDF = Neutral Detergent Fiber
ADF = Acid Detergent Fiber
IVDMD = In Vitro Dry Matter Disappearance/Digestibility as a % of total Dry Matter consumed

Appendix 4. Estimates of monthly percentages of annual DM production for various forages

	NRCS Est. Bluestem	NRCS Est. Native	NRCS Est. Bermuda	NRCS Est. Tall Fescue
Jan	0%	0%	0%	2%
Feb	0%	0%	0%	5%
Mar	0%	0%	0%	15%
Apr	5%	14%	8%	22%
May	20%	35%	20%	19%
Jun	30%	27%	30%	8%
Jul	20%	10%	20%	0%
Aug	15%	4%	10%	0%
Sep	10%	8%	10%	8%
Oct	0%	2%	2%	10%
Nov	0%	0%	0%	8%
Dec	0%	0%	0%	3%

Source: Moseley, Mark. Natural Resource Conservation Service. Personal Contact, 1999.

Appendix 5. Expert opinion of expected annual yield of various forages

	Annual DM lb/ac
Bermuda	7720
Tall Fescue	6690
OWB	6440
TGP	4970

Source: Epplin, Francis, Charles Taliaferro, Ray Huhnke. 1998. Unpublished Survey. Oklahoma State University.

Appendix 6. Bermuda as affected by Nitrogen (N) rates -- means across variety and year

	1992-93	DM lb/ac	CP %	NDF %	ADF %	TDN (from ADF) %	IVDMD %
40 lb. N	Jun	3478.33	11.68	71.65	37.28	59.86	66.36
	Jul	2478.33	10.36	72.61	36.57	60.42	66.35
	Aug	3221.67	11.20	69.94	36.81	60.23	62.65
	Sep	1813.33	9.40	73.75	38.58	58.85	60.11
	Oct	1633.33	10.40	71.10	38.96	58.53	58.21
80 lb. N	Jun	3498.33	11.32	72.15	37.38	59.78	66.56
	Jul	2625.00	9.96	72.98	36.72	60.30	66.11
	Aug	3636.67	11.13	69.36	36.55	60.40	62.56
	Sep	2418.33	9.21	74.02	38.39	58.99	60.57
	Oct	1776.67	10.33	71.09	39.02	58.46	57.95
160 lb. N	Jun	4131.67	11.63	71.64	37.15	59.96	66.77
	Jul	3033.33	10.51	72.80	36.57	60.41	65.89
	Aug	4475.00	13.35	68.68	36.11	60.77	63.28
	Sep	3233.33	11.09	72.72	37.24	59.89	61.54
	Oct	2000.00	11.16	69.67	37.97	59.26	58.92
320 lb. N	Jun	4655.00	12.96	71.11	37.36	59.80	66.71
	Jul	3218.33	11.70	71.91	36.19	60.71	66.34
	Aug	4920.00	15.02	67.45	35.83	60.84	64.37
	Sep	4138.33	12.78	71.92	37.24	59.89	61.62
	Oct	2450.00	13.15	67.75	36.09	60.77	60.76

Source: Taliaferro, C. M., Tesfaye Liranso, F. T. McCollum, D.R. Gill, and Lea L. Ebro. "Evaluation of 'World Feeder' And 'Gordons Gift' Bermudagrasses." Final Report. Oklahoma Agricultural Experiment Station, Stillwater, OK. 1992-1994.

NDF = Neutral Detergent Fiber
ADF = Acid Detergent Fiber
IVDMD = In Vitro Dry Matter Disappearance/Digestibility as a % of total Dry Matter consumed

Appendix 7. Tall Fescue

	1995-96	Mean DM lb	Mean CP %	Mean NDF %	Mean ADF %	Mean TDN %
Control	Jan	1589.41	9.95	57.91	64.19	62.27
	Feb	1421.33	12.10	56.12	32.95	63.23
	Mar	1157.20	12.75	59.02	35.05	61.60
	Apr	1124.15	14.24	55.83	33.92	62.49
	May	1369.81	13.55	63.25	36.26	60.66
	Jun	2424.56	9.54	66.26	39.64	58.03
	Jul	1755.70	10.85	67.23	38.74	58.72
	Aug					
	Sep					
	Oct	2460.33	13.05	63.54	36.38	60.56
	Nov	1852.38	12.01	65.31	38.38	59.01
	Dec	1559.91	10.89	61.48	37.10	60.00
60 lb. N – late Summer	Jan	1372.23	13.02	54.26	34.32	62.16
Grazed – early fall	Feb	1165.49	13.69	53.98	32.95	63.23
	Mar	984.27	16.08	53.38	31.14	64.64
	Apr	835.92	19.20	50.71	29.00	66.31
	May	1601.67	16.12	62.63	35.83	60.98
	Jun	3175.71	12.59	63.26	37.05	60.05
	Jul	2348.75	11.86	65.93	38.72	58.74
	Aug					
	Sep					
	Oct	2111.57	16.00	63.69	34.83	61.77
	Nov	2148.75	15.02	62.11	36.36	60.58
	Dec	1610.48	13.69	58.80	34.76	61.82
60 lb. N – late Summer	Jan	2476.67	11.02	55.26	33.54	62.78
Stockpiled	Feb	1975.65	11.73	56.73	34.13	62.31
Grazed – late Fall	Mar	1527.43	13.62	55.45	35.45	61.29
	Apr	1645.64	17.47	52.39	31.70	64.22
	May	2217.28	14.21	63.31	36.71	60.31
	Jun	5026.95	10.33	69.54	40.41	57.43
	Jul	3790.96	10.78	68.18	40.09	57.66
	Aug					
	Sep					
	Oct	3648.09	15.38	60.40	34.36	62.13
	Nov	3307.80	14.98	60.81	35.15	61.91
	Dec	2652.21	12.51	59.01	33.59	62.73

Source: Woods, R. L., L. A. Redmon, and C. L. Goad. "Production and Nutritive Value Profiles for Tall Fescue in Northeast Oklahoma." National Association of County Agriculture Agents Annual meeting, Nashville, TN, 1-5 Sept., 1996.

Appendix 8. Old World Bluestem

	DM lb/ac	CP %	TDN IVDMD%
Jan		5.00	55.67
Feb		5.25	50.00
Mar		6.65	60.00
Apr	408.00	13.50	63.50
May	2040.00	16.17	67.50
Jun	3060.00	13.50	68.50
Jul	2040.00	11.50	70.43
Aug	1530.00	9.88	67.33
Sep	1020.00	9.50	61.00
Oct		8.00	55.00
Nov		7.00	53.50
Dec		5.10	50.00

DM sources: Hodges, Mark, and T. G. Bidwell. "Production and Management of Old World Bluestem." OSU Extension Facts No. 3020. Oklahoma Cooperative Extension Service, Feb. 1993.

Moseley, Mark. Natural Resource Conservation Service. Personal Contact, 1999.

Quality source: Purvis, Hebbie. Lab tests of Native grass from OSU plots. Animal Science, Oklahoma State University. Personal Contact, 1998.

IVDMD = In Vitro Dry Matter Disappearance/Digestability as a % of total Dry Matter consumed

Appendix 9. Tall Grass Prairie

	DM lb/ac	CP %	TDN IVDMD%
Jan		4.60	51.67
Feb		5.20	49.00
Mar		7.00	57.00
Apr	890.40	13.83	63.50
May	2226.00	14.57	70.00
Jun	1717.20	11.50	67.50
Jul	636.00	10.52	66.50
Aug	254.40	9.67	61.50
Sep	508.80	8.98	58.50
Oct	127.20	8.20	59.50
Nov		5.25	55.50
Dec		5.15	52.00

DM source: Moseley, Mark. Natural Resource Conservation Service. Personal Contact, 1999.

Quality source: Purvis, Hebbie. Lab tests of Native grass from OSU plots. Animal Science, Oklahoma State University. Personal Contact, 1998.

IVDMD = In Vitro Dry Matter Disappearance/Digestibility as a % of total Dry Matter consumed

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