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The Optimal Cow Size for Intermountain Cow-Calf Operations: The Impact of Public Grazing Fees on the Optimal Cow Size

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THE OPTIMAL COW SIZE FOR INTERMOUNTAIN COW-CALF OPERATIONS: THE IMPACT OF PUBLIC GRAZING FEES ON THE OPTIMAL COW SIZE

by

Jesse Russell

A thesis submitted in partial fulfillment

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To simplify the complexity of this problem, three different resource bases common in the Intermountain West (resource base 1, time grazing = 100%; resource base 2, time grazing = 75%; and resource base 3 time grazing = 50%) were defined, as well as three different weights of cattle (small, medium and large). Grazing plans were created for each resource base and winter rations were balanced to ensure adequate nutrition and accurate budgeting. Linear programming was used to determine an optimal cow size for each resource base when charging on a per head basis and by a true AUE.

When grazing on public land was charged on a true AUE basis, the small cows generated the highest net returns on all resources. Also, each resource base was able to maintain a larger number of the smaller cows than the medium or large cows under these conditions. When grazing on public lands was charge on a per head basis, as is typical, the large cow generated the greatest net returns on resource base 1 and 2. However, the small cow generated the greatest net return on resource base 3. These findings suggest that the current practice of charging for grazing public land on a per head basis does have an impact on cow size.

(119 Pages)

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Jesse Russell

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CHAPTER 1

INTRODUCTION

A large amount of the land in the United States is suitable for livestock production. The United States Forest Service (USFS) issues grazing permits on approximately 90 million acres (Thompson 2004). The Bureau of Land Management (BLM) manages grazing on 155 million acres (BLM 2014). Privately owned range and pasture totals about 528 million acres and is approximately 27% of the total acreage of the lower 48 states. These range lands total about 770 million acres which is about 30% of the entire land cover of the United States. (USDA NASS 2014). In Utah 8.6 million acres are considered permanent pasture and rangeland, this is 78.4% of the total 10 million acres used for agriculture (USDA Census of Agriculture 2012). Cattle and other grazing animals can convert the grasses and forbs the land provides into high quality protein, which positively impacts the national and local economy.

The beef cattle industry is an important industry in the United States. Total farm gate receipts for 2013 were $44 billion. Furthermore, 2013 national beef cow inventory was 29.3 million head. The U.S. also exported 2.5 billion pounds (lbs.) of beef in 2013 (NCBA 2014). Total value of Utah agriculture products in 2012 was $1.8 billion. The total sales of cattle and calves in Utah for 2012 was $364 million, which accounted for 20% of total agriculture products and made the Utah cattle industry the largest single portion of the agriculture industry in Utah (USDA Census of Agriculture 2012).

The national cattle inventory has been shrinking as well as the number of beef cows. In 1983 the total cattle inventory was 115 million head, and shrank 22% over 30 years to 89.3 million in 2013. The number of beef cows in 1983 was 48.9 million, and shrank about 40% to 29.3 million in 2013. However, production per cow in pounds increased 161 lbs. from 1983 to 2009 (National Cattlemen's Beef Association 2014).

Even though the national beef cow herd is shrinking the total pounds of beef produced is increasing. In 1983 the beef cattle industry produced just over 23 million pounds of beef and in 2009 the beef industry produced 25.9 million pounds of beef, an 11% increase. The use of new science and technology introduced in the last 30 years has allowed the beef cattle industry to increase the pounds of beef while the national cow herd has been shrinking. One example of this is use of Expected Progeny Differences (EPDs). Lalman et al. (2011), indicates that there has been an increased pressure to increase yearling weight through the use of EPDs. However, yearling weight is correlated with mature cow weight, therefore mature weight has also increased over 22% in the last 30 years. The cattle industry now supports an average mature cow weight of more than 1350 lbs. (McMurry 2014).

Problem

Cattle producers today face a significant problem in finding the optimum mature cow weight or cow size. While larger cows wean larger calves than smaller cows, the smaller cow weans a larger percentage of her body weight. Also, while the smaller cow has a reduced feed efficiency, the larger cow requires more nutrients for maintenance. Furthermore the smaller cows bring less $/head (hd.) on sale day than a larger cow. A larger number of smaller cows and smaller number of large cows can be maintained on a fixed set of resources. When raising replacements a similar argument could be made;

smaller heifers take fewer inputs to reach sexual maturity. However, a producer would be feeding more heifers. Labor may also play a part in this puzzle.

Is there an optimal cow size in the U.S.? The answer to this question is probably no, but is there an optimal cow size for a given set of land resources? This research attempts to answer that question. State what the following models are at this point.

Objective

The goal of this paper is to identify the optimum cow size for Utah cattle operations when three cow size choices are given: 1,000 lbs., 1,200 lbs., and 1,400 lbs. In Utah there is a great diversity in ranching operations with some being able to graze the cow herd throughout the year, while others are likely feeding harvested forages for at least six months of the year. It would be very difficult to model every ranch type in the state so this research will simulate three main types of cattle operations: the first resource base (resource base 1) is able to graze their cow herd year around with minimal supplementation; the second resource base (resource base 2) is where the operation is required to provide the cow herd with all nutritional requirements for 3 months of the year through the use of mechanically harvested forages; and the third resource base (resource base 3) requires the cow herd to be provided with all nutritional requirements for 6 months of the year through the use of mechanically harvested forages. The specific objectives of this paper are to:

1. Identify the economically optimum cow size (1,000, 1,200 or 1,400 lbs.) for each of the three basis ranch types in Utah (no winter feeding, three months feeding, and six months feeding);and

2. Determine if the practice used by the BLM, the USFS, and the Utah State Lands of charging for grazing on public range on a per head basis rather than a true AUM basis impacts the optimal cow size.

Methodology

Several steps were taken to accomplish the objectives stated. First, an inventory was assumed to establish the number of cattle of each type (cows, first-calf heifers, replacement heifers and bulls) and their replacement rates that were needed to maintain a cow herd. Second, rations were balanced for each type of cattle based on the resources available. Third, a production budget was created using the data obtained from the inventories and rations. Finally, a linear program was developed using the price data, feed requirements and production data. The linear program was then used to determine the most profitable cow size on each resource base. To illustrate the impact of the BLM, USFS, and the Utah State Lands charging on a per head basis rather than a true AUM basis, forage demand coefficients were altered in the linear program to mimic this.

Scope

The scope of this thesis is limited to the production returns of the cow herd on each resource base identified for Utah. However, the results should also be applicable for much of the Intermountain West where there is a reliance of public land grazing. Similar resource bases exist in Colorado, Idaho, Montana, Nevada, New Mexico, Oregon and Wyoming.

Thesis Outline

This discussion will begin in chapter 2 with a review of literature. Chapter 3 will discuss the methods and procedures used in obtaining the results. The results of the base model will be discussed in chapter 4 as well as the answer to the first objective. Chapter 5 will then discuss the model, results and findings relative to the second objective. Chapter 6 will summarize the findings and implications of this thesis, as well as identify the need for additional research.

CHAPTER 2

REVIEW OF LITERATURE

This literature review will focus on studies that show differences in feed, production and reproductive efficiency. Some of these studies show the importance of matching cow size to resource base. Others discuss the biological efficiencies of the cow based on mature weight. Studies have also been conducted to illustrate the economic impact of these efficiencies. This literature review will also discuss the use of linear programming in production agriculture.

The debate of the optimum cow size is partially due to the fact that over the last 30 years, cattle have been selected for feedlot performance, weaning weight and yearling weight. This selection has increased the average cow size from 1000 lbs. to 1400 lbs. Selecting cow size to be used on an operation based on the percentage of body weight the cow is able to wean, is biased towards the smaller cow. However, actual weaning weight is biased towards the larger cows, but the larger cow has an increased feed requirement, nevertheless the larger cow does have a higher savage value (Schmid 2013).

Matching Cows to their Forage Base

With the increasing cost of fossil fuels there is downward pressure on the amount of mechanically harvested forages fed on cattle operations. Forage harvested by the animal is generally the cheapest source of nutrients available to maintain a beef cow herd. Therefore, matching cows to their environment has become a goal of ranchers and academicians. A cow herd on a forage base where their nutritional need cannot be met will become thin and reproductive performance would decrease, as well as calf production performance (Lalman et al. 2013).

Lalman et al. (2013) also indicate a positive link between animal growth potential and mature weight. Continued genetic selection for growth potential may expose a cow-calf enterprise to more risk of not meeting nutritional needs if grazed forages become limiting due to larger cow size. Lalman et al. (2013) encourage moderation in growth and mature size to better fit cattle to existing forage resources.

Feed Efficiency

Due to the competitive nature of the cattle industry there is pressure to increase the biological and economic efficiency of the cow herd. Johnson et al. (2010) discuss cow size and efficiency. They define overall efficiency of a cattle production system as a combination of biological efficiency and economic efficiency. Furthermore, they point out that an efficient cow herd exhibits minimum maintenance requirements, and the ability to convert available energy into the greatest possible pounds of calf weaned. They also indicate that selecting animals for increased weaning weight leads to increased mature cow size. They show that cattle partition feed energy for maintenance first, growth second, lactation third, and reproduction fourth. This feed partitioning essentially indicates that as the forage supply becomes increasingly limited, the cow becomes less productive, and as cow size increases, so does the energy required for maintenance. On a given cow ranch, the ability of the cows to reproduce is one of the most important contributors towards efficiency and profitability, and the ability to reproduce in a given environment is related to mature cow size.

Estimating efficiency of grazed forage is of equal importance as harvested forages. Johnson et al. (2010) show the importance of calculating animal unit equivalents. Even though a 1200 lb. cow weighs 20% more than a 1000 lb. cow, the 1200 lb. cow only requires 13% more feed than the 1000 lb. cow.

Schmid (2013) attempted to sort through cow efficiency. Even though a 1,400 lb. cow weans a calf that is 40 lbs. heavier than a calf from a 1,100 lb. cow, the 1,100 lb. cow weans 10% more of her body weight than a 1,400 lb. cow. Schmid also points out that the same pasture can carry a larger number of lighter cows than heavier cows. Yet, increasing body weight by 27% increases maintenance requirements by only 20%, showing that the relationship is not linear. This shows the 1,400 lb. cow utilizing her feed 5.5% more efficiently than a 1,100 lb. cow. However, energy required for maintenance for the larger cow is still greater.

Cow feed efficiency is discussed further by Hersom (2009) where he shows that a cow herds feed requirements amount to 50% to 75% of the annual maintenance costs of the herd. He points out the importance of grazing as much as possible, and that stocking density then becomes increasingly important as well. He shows the difference in nutrient requirements consisting of a 1,000 lb. cow and a 1,200 lb. cow during early lactation (three months after calving), at weaning (seven months before calving), and late gestation (one month before calving). The difference in dry matter intake, total digestible nutrients, and crude protein required are illustrated in Table 1. The data in Table 1 show that no matter the stage of production the heavier cow always requires a larger quantity of dry matter as well as total digestible nutrients and crude protein.

Table 1. Relationship of Cow Weight to Intake During Stages of Production

Cow Wt.	Nutrient Requirement Dry Matter Intake	Nutrient Requirement Total Digestible Nutrients, lb./d	Nutrient Requirement Crude Protein, lb./d
Early Lactation			
1000	25.4	14.9	2.6
1200	28.4	16.4	2.8
% difference	11.8	10.1	7.7
After Weaning			
1000	21.1	9.5	1.3
1200	24.2	10.9	1.5
% difference	14.7	14.7	15.4
Late Gestation			
1000	21.4	11.9	1.9
1200	24.6	13.8	2.2
% difference	15	16	15.8

Hersom (2009)

Reproductive and Production Efficiency

By and large, reproductive efficiency is critical in beef production where the value of the calf crop makes up the majority of revenue. Hersom (2009) also pointed out that as mature weight increases the age at puberty increases. Similarly, as weight increases the percent of heifers cycling and conception rate decreases. Hersom also showed that as cow size increased, calving rate decreased. This difference in calving rate specifically led to a reduced ability to remain in the herd (cull rate). Large cows had a cull rate of 52% compared to a 19% cull rate for smaller cows. He also showed weaning rates for first and second parity were greater for the smaller cow sizes compared to large cows where the large cows had overall weaning rates less than 50%.

Productive efficiency is also important since smaller cows can wean a larger percentage of their body weight than larger cows. While a larger cow can produce a larger calf, they are less efficient and require more energy for maintenance. Research also shows that providing larger cows with more energy does not increase their production efficiency. Larger cattle may be more profitable in a system with unlimited feed resources. However, when feed resources are limited smaller cows are more efficient and more profitable (Mathis and Sawyer, 2000).

Dhuyvetter (2009) showed the difference in the weaning weights as a percentage of a cow's body weight. A 1000 lb. cow will wean approx. 48.5% of her body weight, a 1200lb cow weans 45.8% of her body weight and a 1400lb cow will only wean 43.6% of her body weight. Table 2 illustrates the relationship between stocking rate weaning rate and percent of body weight weaned.

Table 2. Equivalent Production and Stocking by Cow Size

Cow Wt.	Stocking Rate	Calf Weaning Wt.	% of Cow Wt. Weaned
1000	100	485	48.50%
1100	94	520	47.30%
1200	88	550	45.80%
1300	83	585	45.00%
1400	79	610	43.60%
1500	75	650	43.30%

Dhuyvetter (2009)

Economic Impact

Because of narrowing profit margins and increasing fossil fuel costs cattle producers must evaluate their management practices. Riggs (2009) noted that maintenance requirements of the cow account for about 70% of the feed consumed, leaving the remaining 30% for production. This means the 70% of feed used for maintenance provides no economic returns.

Riggs (2009) showed the difference in the amount of revenue received when different weights of calves were sold. She assumed that the ranch would have 50,000 lbs. of calf to sell; 111, 450 lb. calves at $110/cwt, and 71, 700 lb. calves at $96/cwt. Her calculation illustrated the lot of 450 lb. calves selling for $55,000 and the lot of 700 lb. calves selling for $48,000—for a difference of $7,000 in favor of the lighter weight calves. Riggs then went on to show that a ranch that can support 100 head of 1,300 lb. cows can in turn support 120 head of 1,000 lb. cows.

Riggs also indicated that calf weight sold accounted for only about 5% of profit variation between high profit and low profit operations. The most critical profit factor is feed cost which can account for 50% of the variation between low and high profit producers. Also, 50% of cows were culled due to poor reproductive performance which is influenced by mature weight.

> "Mature size of the cow is arguably the most influential factor in nutritional requirements. The larger the cow, the more feed inputs she needs to maintain body weight and produce at the same rate as a smaller cow. Controlling cow size is a tool that can be used to manage feed inputs." (Riggs, 2009)

This research seeks to build on Riggs's findings, and determine if they hold in Utah. This thesis will also address the impact the current method of charging for federal and state grazing permits has on the selection of an optimal cow size.

Linear Programming

Linear programming is a useful tool when conducting research studies in production agriculture. It allows the researcher to find optimal solutions when production, resources and prices vary. Research has been done in the past illustrating how farm plans have been optimized using linear programming.

Woodworth (1973) conducted a study in an attempt to determine the optimal range allocation of calves that would maximize profits. In the study there were two different ranges available, which were referred to as “inside range” and “outside range.” Cost of range rental and weight gain realized were the major concerns of the producers. Both ranges considered had the same carrying capacity; however, the outside range cost \$2.18/AUM but produced the best gains. The inside range cost \$1.50/AUM and produced smaller gains. The major constraint in the model was the available forage on each range.

The findings of this model indicate that there was an optimum pattern of allocation of cattle on the two ranges. The model showed the majority of steers to be placed on the outside range where the greatest weight gain could be realized. And all of the heifer calves were placed on the inside range where costs are minimized. The linear program shows a 4% increase in profits when cattle were allocated as the model indicated over random allocation.

Bartlett et al. (1974) developed a serial linear program to aid in alternative management decisions. The model accounted for the seasonal growth of vegetation, the buying and selling of livestock, and cash flow of income and costs. The intent of the model was to arrive at the best possible mix of activities based on cost and revenue for a fixed natural resource base. The resulting management approach could then be used by the manager as a guide for the development of the simple long-term management plan for his operation. The model provided a tool that enabled managers to compare alternative strategies comprehensively.

Cattle operations attempt to maximize their returns by employing different management strategies including rangeland improvement, increased hay harvest efficiency, and enhanced herd management. Workman and Evans (1996) developed a linear program to aid in determining the optimum intensity and mix of improvements to identify limiting resources, while measuring combined impacts on total ranch net returns.

Production and economic data for the typical Utah ranch were based on detailed surveys of 96 Utah cattle ranches. The objective of this particular linear program was to select the optimum mix of management strategies from 16 available while maximizing net ranch income. The optimum management option produced an annual net ranch income of $45,152, compared to $31,278 for the typical Utah cow-calf operation. The model also indicated that forage was the limiting constraint in the month of May.

Rimbey et al. (2003) conducted a study to provide a long-term economic analysis of ranch level impacts of alternative public land forage allocations in the area of Owyhee County, Idaho. They defined two typical resource bases: One medium ranch (528 Animal Units, AU) and a larger ranch (735 AU). Reductions to the Bureau of Land Management (BLM) allotment were phased in over five years in equal increments.

Their linear programming model for the smaller ranch showed when BLM grazing was reduced by 25% there was an economic impact of reducing net returns by $5,563. As BLM grazing was reduced to 50% and 100%, annual net cash income decreased from $21,234/year under the 50% reduction to -$13,958/year with 100% BLM grazing reduction. The model for the larger ranch annual net cash income decreased from $67,881/year under the current situation to $3,480/year with 100% BLM grazing cut.

Doye and Lalman (2011) used linear programming to determine the optimal cow size, moderate (1,100 lb. cow) or big (1,400 lb. cow), on native and improved pasture. The pasture options were 1,000 acres of native pasture valued at $12/acre, while the improved pasture consisted of 160 acres of fescue valued at $22/acre plus 160 acres of Bermuda valued at $17/acre. They used as a base case 100 moderate cows plus 4 bulls as the number of cattle that could be stocked on 1,000 acres of native pasture. The improved pasture was also designed to meet the needs of the 100 moderate cows.

A linear program was then run to identify the combination of resources that maximizes returns. The linear program showed that moderate sized cattle on native pasture offer the greatest returns to land, management and overhead.

The data presented in the studies discussed in this literature review show the need for managers to assess their management practices. Where profit margins are narrow and could become narrower, it is increasingly important that cows are matched to their environment due the variance in their nutrient requirements based on cow size. It has also been shown that production as a percentage of body weight combined with the price difference based on calf weight can have a significant economic impact on an operation.

This literature review has shown that linear programming can be a useful decision making tool in agriculture. This thesis will use the efficiency data, as well as other economic data and linear programming, to answer the objectives stated in the previous chapter. The research here will add to the previous work done by including three different resource bases with three weights of cattle on each resource base. This paper will also include a heifer development program and revenue received from cull animals. Finally, the research will evaluate the impact of public land grazing fees on cow size as discussed in the previous chapter.

CHAPTER 3

METHODOLOGY AND PROCEDURES

Methodology

Three typical ranches are modeled in this research based on different assumed resource scenarios: the first resource base (resource base 1) is one able to graze the cow herd year around with minimal supplementation, the second resource base (resource base 2) is where the operation is required to provide the cow herd with all nutritional requirements for 3 months of the year through the use of mechanically harvested forages, and the third resource base (resource base 3) requires the cow herd to be provided with all nutritional requirements for 6 months of the year through the use of mechanically harvested forages. Cow herd inventories, feed requirements and enterprise budgets are created for each of these typical resource scenarios. However, for the purpose of brevity, most of the discussion will focus on resource base 2 but similar procedures were applied for resource base 1 and 3 as well.

A ranch inventory was created for resource base 2 to establish the retention rate of heifer calves to replace cull cows leaving the mature cow herd. The inventory also established the percentage of cattle sold from each source. The inventory was created using production benchmarks that will be discussed later. Once the inventory was completed, rations were balanced for each age group of cattle, as well as the bulls. The rations were needed to establish feed requirements of all cattle. A budget was also created for the resource base 2 using the cattle numbers from the inventory and the feed requirements found in the ration balancing process. The budget showed the interaction of cattle prices and sales. It also illustrated the interaction between the production requirements and feed and forage prices, as well as labor and other common expenses. Linear programming was then used to optimize the number and size of cattle used given a set resource base.

A budget can be defined as a summary of likely income and expenses over a period of time. A budget can be a useful decision making tool from personal finance to corporate finance.

> "A budget can help manage limited resources. Budgeting coordinates resources, production and expenditures. It helps you predict the outcomes of an adjustment before you act or change an action. The usefulness of a budget depends on accuracy of information. How you answer a question could influence the profits of the farm. Should I replace or sell a tractor? What crops will be profitable? Tear down a barn or build a new one? Buy or rent additional land? Buy equipment or hire a custom operator?" (Penn State Extension 2014)

Linear Programming (LP) is a technique where multiple decision variables are used to optimize a certain linear objective function, while simultaneously satisfying a set of linear constraints that are involved with the objective function. An LP contains several essential quantitative elements: decision variables; objective function; constraints; and right hand side (McCarl and Spreen 2005).There are seven important assumptions to a conventional linear programming problem, as defined by McCarl and Spreen (2005). They are as follows:

1. Objective Function Appropriateness
2. Decision Variable Appropriateness
3. Constraint Appropriateness
4. Proportionality
5. Additivity

6. Divisibility
7. Certainty

The general problem can be formulated and expressed in an equation format or an algebraic form as follows respectively:

Equation Format:

$$Maximize\ Z = p_1x_1 + p_2x_2 + \cdots + p_nx_n$$

$$Subject\ to: \quad a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \leq b_2$$

$$\begin{array}{cc} . & . \\ . & . \\ . & . \end{array}$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \leq b_m$$

$$x_1 \geq 0, \quad x_2 \geq 0, \ldots, \quad x_n \geq 0$$

Algebraic Format:

$$Maximize\ Z = \sum_{j=1}^{m} p_jx_j$$

$$Subject\ to: \quad \sum_{j=1}^{m} a_{ij}x_j \leq b_i$$

$$all\ x_j \geq 0$$

(i = 1,.., m)

Where:

Z is the objective to be maximized;

P_j's are the objective function coefficients and represent costs or returns associated with each unit of an activity that is included in the model;

X_j's are activities (buy feed, and sell cattle);

A_{ij}'s are the technical coefficients (feed demand per cow);

B_i's are resource constraints (AUMs available).

Now that the general problem has been discussed, further elaboration can be made concerning the setup of the problem previously discussed in this thesis. Essentially, there are 5 main parts to an LP, including X_j activities, B_i constraints, transfer rows, A_{ij} coefficients, and the P_j coefficients of the objective function. The activities can include growing and weaning calves, growing and developing replacement heifers, buying and selling inputs and outputs, and transferring products or livestock from one activity to another. This model will include all of the above activities.

Constraints can set an upper bound or a lower bound on resources such as labor, capital, or, in this case, grazing permits available. These constraints or restraints can allow a certain activity to enter a solution at a particular level. Transfer rows are straight forward in that they facilitate the transferring of inputs or products/livestock from one activity to another with in the model. This will be useful in this model to transfer weaned calves from a cow activity to the replacement heifer activity or to a selling activity. The right hand side constraints of the transfer rows are normally zero to ensure a complete transfer.

The A_{ij} coefficients indicate a requirement for a resource based on the units of activity the model uses. They also reflect supply and demand with in the transfer rows. For example, a coefficient (A_{ij}) of negative .20 in the cow activity column and heifer row with a positive one in the replacement heifer column and heifer row indicates that 20% of the possible heifer calves would be transferred to the replacement heifer activity.

The objective function coefficients (P_j) can have both a positive and a negative effect on the optimal solution with each one unit inclusion of an activity into the solution. For example, a coefficient (P_j) of 722.73 on a calf sales activity would mean that for every calf sold the objective solution would increase by $722.73. A coefficient ($P_j$) of -14.35 on a BLM grazing permit activity would decrease the objective solution by $14.35 for each AUM that is purchased. In this thesis net return is the objective to be maximized since the goal is to find the cow size that generates the greatest net returns.

Procedures

Inventory

As mentioned in the previous chapter, there are production differences, as well as nutritional requirements, when considering cow size. The first step toward answering the question of the optimal cow size was to develop an inventory. The typical ranch on resource base 2 was created in a manner that the resources would meet the needs of 500 mother cows weighing 1,200 lbs. and the replacement heifers and bulls that would be needed to maintain this cow herd. To develop an inventory that was representative of the cattle industry, production benchmarks were found. CHAPS 2000 benchmark Standardized Production Analysis (SPA) data was gathered from 2008 to 2012 from a total of 91,414 cows exposed to bulls and processed (CHAPS 2000 (2013)). CHAPS shows a pregnancy rate of 93.6%, a weaning rate of 90%, a replacement rate of 15% which also includes the cow diagnosed as open, and a death loss of 1% for mature cows. This leaves the ranch with 420 good pregnant cows and 75 to sell and 5 dead. The operation would then need to provide 80 pregnant cows or replacement heifers to replace those sold and lost.

To continue developing an inventory, pregnancy rates for replacement heifers and first-calf heifers had to be estimated. The pregnancy rate for the replacement heifers were shown at 92% in heifers bred at 65% of mature weight (Summers et al. 2013). Furthermore, heifers that calved in a body condition score of 5 to 6 bred back at 80% and 96% respectively (Spitzer et al. 1995). For this research we assumed that heifers would calve at a body condition score of 5.5 and would breed back at 88%. A death loss for the replacement heifers and first-calf heifers was also assumed at 2% and 1.5, respectively.

The base ranch would require 91 pregnant first-calf heifers. These heifers would calve and 80 would be pregnant and replace the cows that were culled or have died. This also requires the ranch to retain 100 heifer calves for replacements. This is 44.5% of the heifer calf crop of the mature cow herd, or 22% of the mature cow herd calf crop (steers and heifers), or 18.8% of the total calf crop.

In Utah most cows are bred through natural service. Thus a number of bulls are required. Holmgren (2014) shows a bull to cow ratio of 1:25. All the females on the ranch must have an opportunity to become pregnant and this requires a total of 28 bulls.

The inventory spread sheet that was developed appears in Appendix A. The inventory runs from November 1 and to October 31, at this point all cattle are transferred to their respective herd inventory categories or sold.

Rations

The next step in building an LP model that was representative of the three resource bases was to balance rations for all the animals on each ranch. This totaled 12 rations, a ration for four groups of animals on three resource bases. These groups of animals were the mature cows, first-calf heifers, replacement heifers, and bulls. The animals were divided in this manner since this is normally practiced to ensure proper nutrition as well as keeping feed costs down. These rations were needed to determine hay and supplement requirements as well as ensure cattle would gain or maintain an appropriate body condition score.

Body Condition is the manner in which nutritional status of beef cattle are judged. Rasby et al. (2007) have noted that average length of the post-partum interval (PPI, time between calving and first estrus) for cows that calve in a condition score of 3 and 4 is 80 days compared to 55 days for cow calving in a BCS of 5 and 6. Furthermore, Houghton et al. (1990) found that thin cows gaining condition increased the probability of cows becoming pregnant, and fat cows losing condition also increased the number of cows that became pregnant.

Cows

Rations were balanced for the cows using the Oklahoma State University Cowculator (OSU Cowculator 1997). This program balances a diet based on cow weight, milking ability, breed, and stage of production. The cow weights that were used were 1,000 lb., 1,200 lb., and 1,400 lb. Milking ability was assumed to be average or 17 lbs./day for all weights. The breed of cattle used was 50% Angus and 50% Hereford. Stage of production was based on the average calving date of April 1st and a weaning date of Nov 1st. The program used 4 stages or periods of production which were classified as follows:

1. Mid Gestation – dry, Nov 1 to Jan 11, 71 days
2. Late Gestation – dry, Jan 11 to April 1, 80 days
3. Early Lactation, April 1 to June 30, 90 days
4. Late Lactation, June 30 to Nov 1, 124 days.

Grazing plans were then created for each ranch. The grazing plans showed the time that the cattle would spend on each range or pasture type and the stage of production while there. These grazing plans are given in Table 3.

The next step was to determine feed values for the feed stuffs and forages. The nutritional value of forages used was taken exclusively from the NRC (1996). The hay used in the ration balancing process was determined by taking an average of several of the different grass hays available in the NRC book. The included hay types are shown in Table 4 with their %TDN and %CP values. The average of the TDN and CP feed values was used for the feed rations. The alfalfa hay and Dried Distillers Grains (DDG's) feed values were also taken from the NRC book. The forage values for the BLM range, USFS range, spring meadow and fall meadow pastures were also taken from the Beef NRC tables. The forage values used for BLM range were range winter, and range June diet for springe BLM. The forage values used for the USFS were an average of the July, August, and September range diets. It was determined that DDG cubes would be used as a protein supplement on winter BLM range since feeding hay on BLM range is not allowed and generally is not a feasible option for supplementation.

Table 3. Cow Grazing Plans for Each Resource Base

Period	Pasture/Range	Date On	to	Date Off	Days	Months
			Resource Base 1			
1	BLM	1-Nov	to	11-Jan	71	2.4
2	BLM	11-Jan	to	1-Apr	80	2.6
3	BLM	1-Apr	to	1-May	30	1
3	Spring Meadow	1-May	to	1-Jun	31	1
3	USFS	1-Jun	to	1-Jul	30	1
4	USFS	1-Jul	to	1-Oct	92	3
4	Fall Meadow	1-Oct	to	1-Nov	31	1
Total					**365**	**12**
			Resource Base 2			
1	BLM	1-Nov	to	11-Jan	71	2.5
2	Hay	11-Jan	to	1-Apr	80	2.5
3	Hay	1-Apr	to	16-Apr	15	0.5
3	Spring Meadow	16-Apr	to	1-Jun	46	1.5
3	USFS	1-Jun	to	1-Jul	30	1
4	USFS	1-Jul	to	1-Oct	92	3
4	Fall Meadow	1-Oct	to	1-Nov	31	1
Total					**365**	**12**
			Resource Base 3			
1	Hay	1-Nov	to	11-Jan	71	2
2	Hay	11-Jan	to	1-Apr	80	3
3	Hay	1-Apr	To	1-May	30	1
3	Spring Meadow	1-May	to	1-Jun	31	1
3	USFS	1-Jun	to	1-Jul	30	1
4	USFS	1-Jul	to	1-Oct	92	3
4	Fall Meadow	1-Oct	to	1-Nov	31	1
Total					**365**	**12**

Table 4. Hay Nutritional Values

Hay Type	%TDN	%CP
Brome Hay Mid bloom	56	10
Fescue Meadow Hay	56	9.1
Fescue, Alta Hay	55	10.2
Fescue K31 Full Bloom	58	12.9
Orchard grass Late bloom	54	8.4
Timothy Mid Bloom	57	9.7
Prairie Hay	48	5.3
Average	**55**	**9.37**

Once all of this information was gathered, the rations were balanced based on energy crude protein and dry matter intake requirements and limitations to maintain a minimum body condition of 5-6. The OSU cowculator also predicted the time it would take gain or lose one body condition score during the period of time for which the ration was balanced. Diets were balanced for 500 cows of each weight class on each resource base. The results from these diets can be found in Appendix B.

The diets balanced for the remainder of the cattle were done using Cowbytes (Alberta Agriculture, Food and Rural Development 1999). The diets balanced through Cowbytes used the same criteria energy, protein, dry matter intake, and average daily gain or body condition score.

First-Calf Heifers

It was assumed that the first-calf heifers would be treated the same on all three resource bases since their nutritional requirements would not allow winter grazing on BLM range. However, they were fed to meet their nutritional requirements as their body weight dictated. The first-calf heifers beginning Nov. 1 were fed hay until May 1 when they were combined with the cow herd on spring meadow pasture and remained with the cow herd. Alfalfa was used as a protein supplement where it is much cheaper than DDGs and provided more energy for continued growth. The diets balanced for the first-calf heifers can be found in Table 5.

Table 5. First-Calf Heifer and Replacement Heifer Grazing Plans for all Resource Bases

Pasture/Range	Date On	to	Date Off	Days	Months
1st Calf Heifer Grazing Plan					
Hay	1-Nov	to	1-May	181	6
Spring Meadow	1-May	to	1-Jun	31	1
USFS	1-Jun	to	1-Oct	122	4
Fall Meadow	1-Oct	to	1-Nov	31	1
Total				**365**	**12**
Replacement Heifer Grazing Plan					
Hay	1-Nov	to	1-May	181	6
Breeding Pasture	1-May	to	1-Aug	92	3
Bred Heifer Range	1-Aug	to	1-Oct	61	2
Fall Meadow	1-Oct	to	1-Nov	31	1
Total				**365**	**12**

Replacement Heifers

Patterson et al. (1992) reported acceptable reproductive performance by development programs that allowed heifers to reach about 65% of their expected mature body weight by breeding. To ensure an acceptable reproductive performance the replacement heifers were fed to reach 65% of mature weight by May 15th.

It was also assumed that the replacement heifers would be treated the same on all three resource bases. However, their genetic potential affected their acceptable breeding weight and, therefore, their nutritional requirements. For example a 1,000 lb. cow was expected to wean a 470 lb. heifer calf with an acceptable breeding weight of 650 lbs. for a needed gain from weaning to breeding of 180 lbs. A 1,200 lb. cow was expected to wean a 535 lb. heifer calf with an acceptable breeding weight of 780 lbs. for a needed gain from weaning to breeding of 245 lbs. A 1,400 lb. cow was expected to wean a 590 lb. heifer calf with an acceptable breeding weight of 910 lbs. for a needed gain from weaning to breeding of 320 lbs.

A grazing plan was also created for the replacement heifers where they were fed hay from November 1st to May 1st. They then grazed what was termed the “breeding pasture” from May 1st to August 1st. The nutritional value of this pasture was assumed to be the same as the summer grass pasture taken from the National Research Council (1996). From August 1st to October 1st they grazed a second pasture called the “bred heifer range”. This pasture’s nutritional value was assumed to be equal to the USFS range. From October 1st to November 1st they grazed the fall meadow pasture. The balanced diets for the first-calf heifers can be found in Appendix C and Appendix D.

Bulls

The bulls were expected to maintain weight throughout the year. Their grazing plan would follow the females that they were placed with during the breeding season up through weaning. However, during their off season they would be treated differently based upon the resources available. It was determined that resource base 1 would not feed their bulls and did not charge them any grazing fees assuming they would graze pasture residual throughout the winter. On resource base 2 the bulls’ grazed pasture residual while the cows were on the BLM range and were fed hay the same length of time as the cow herd. On resource base 3 the bulls were fed hay the same as the cows. The diets balanced for the bulls are found in Appendix E.

Budget

Creating a production budget was the next step in the process of determining the optimal cow size. The inventory provided the production data, bull to cow ratio, death loss, and replacement rates. Once the percentages of cattle and calves to be sold were determined, prices received had to be ascertained. The rations established the amount of feeds (hays and DDGs) needed for each weight and class of animal. However, Animal Unit Equivalents (AUEs) also had to be established to accurately charge the cattle for grazing. The grazing plans and the AUE equation were used to determine the AUMs required for each weight and class of animal for each pasture or range type. Furthermore, other costs associated with production needed to be determined. These will be discussed in the following sections.

Income/Revenue

Market prices for the cattle sold were obtained from the Livestock Marketing Information Center (LMIC 2014) and Cattle Fax (Cattle Fax 2014). The values used were a five-year average of October and November prices to account for any year-to-year market fluctuations. The months of October and November were used since cattle are normally processed, weaned and culled during that time frame. The cattle prices used in all three models are presented in the following tables: calf prices in Table 6 and cull cow prices in Table 7. The price of cull first-calf heifers was based on the cull cow price plus

$20/cwt. The body weight of the first-calf heifers and the replacements heifers were projected by the ration balancing program (cowbytes) as diets were balanced.

Table 6. Calf Prices

	Calf Gender					
	Steers			**Heifers**		
Cow Weight	1000	1200	1400	1000	1200	1400
Calf Weight	500	565	630	470	535	590
$/cwt.	$ 144.55	$ 133.25	$ 127.68	$ 129.23	$ 123.01	$ 121.09
$/lb.	$ 1.45	$ 1.33	$ 1.28	$ 1.29	$ 1.23	$ 1.21
$/hd.	$ 722.73	$ 752.88	$ 804.39	$ 607.37	$ 658.12	$ 714.43

Table 7. Cull Prices

	Cull Cow Prices @ $60.56/cwt.		
Cow Wt.	**1000**	**1200**	**1400**
$/hd.	$ 605.59	$ 726.71	$ 847.83
	First-Calf Heifer Prices @ $80.56/cwt.		
Wt.	**923**	**1122**	**1263**
$/hd	$ 743.56	$ 903.88	$ 1,017.46
	Replacement Heifer Prices		
Wt.	**800**	**933**	**1072**
$/lb	$ 1.20	$ 1.15	$ 0.79
$/hd	$ 962.01	$ 1,076.71	$ 847.77

Table 8 shows the projected cattle sales of the base ranch when 1,200 lb. cows were used. This budget shows that over 80% of the income is provided by calf sales and

Table 8. Projected Revenue for the Resource Base 2 Ranch

FirstClass of Cattle	Head	Unit	Unit of Measure	Price / Unit	Total Value
Heifer Calves	166	535	Lbs.	$ 1.23	$ 109,499.52
Steer Calves	266	565	Lbs.	$ 1.33	$ 200,186.28
Cull Cows	70	1200	Lbs.	$ 0.61	$ 50,869.70
Cull 1st Calf Heifers	10	1122	Lbs.	$ 0.81	$ 8,731.48
Cull Yearling Heifers	6	933	Lbs.	$ 1.15	$ 6,460.26
Annual Sales	**518**				**$ 375,747.24**

over half of the ranch's income is from the sale of steer calves alone. The cull first-calf heifers and cull replacement heifers provided less than 5% of the income combined.

Grazing and Feedstuff Costs

The value of grazed forages were taken from the budget created by Holmgren (2014). Holmgren showed typical Utah private pasture valued at $30/AUM and both BLM and USFS permits were priced at $1.35/AUM. He also reported a non-grazing fee of $13/AUM that was associated with fence and water maintenance.

Table 9 shows the five-year average prices for the feed stuffs that have been used. These data were gathered from the LMIC. Included in the price of the DDG was a transportation cost of $50/ton.

Table 9. Feedstuff Prices

Feed	**$/Ton**
Alfalfa	$ 165.62
Utah grass Hay	$ 120.36
DDG	$ 228.95

Table 10 shows the amount of grass hay and alfalfa consumed per head per year by each animal type on the base ranch. These data were determined by dividing the total pound of feed used by the herd by the number of cows in the herd, then dividing that value by 2000 to convert it to tons. In the case of the Utah grass hay, the 1,200 lb. cow herd of 500 head on the base ranch was estimated to consume 1,267,500 lbs. This number is found in Appendix Table B5.The respective ration for each animal type and weight on the separate resource bases are found in Appendices B, C, D and E.

Table 10. Annual Hay Consumption in Tons/Animal for the Resource Base 2 Ranch

Cow Weight	1,000		1,200		1,400	
Animal Type	Utah Grass Hay	Alfalfa	Utah Grass Hay	Alfalfa	Utah Grass Hay	Alfalfa
Cows	1.11	0.00	1.27	0.00	1.42	0.00
First-Calf Heifers	1.10	0.75	1.20	1.15	1.37	1.26
Replacement Heifers	0.69	0.63	0.51	1.00	0.00	1.70
Bulls	1.72185	0.00	1.72185	0	1.72185	0.00

In order to charge the operation accurately, an AUE had to be determined for each weight of animal. The formula for determining an AUE is as follows:

$$Animal\ Unit\ Equivalent\ (AUE) = \frac{(Live\ animal\ weight)^{0.75}}{1000^{0.75}}$$

Using this formula the animal unit equivalents were found for each weight and class of animal during the grazing season. These values are found in Table 11. The weights for the first-calf heifers and the replacement heifers were found when balancing diets for these animals.

Table 11. Animal Unit Equivalents

Cow Weight	1000 lb.	1200 lb.	1300 lb.
Cow	1	1.15	1.29
1st Calf Heifer	0.9	1.02	1.13
Replacement Heifer	0.79	0.89	0.99

Table 12 shows the expected costs of the base ranch when running 1,200 lb. cows. The costs of grazing are a combination of the grazing plans, grazing cost per AUM and the respective AUE. For example, the grazing plan show the cows grazing the BLM range for 2.5 months and an AUE of 1.15 for a product of 2.875 AUMs of forage removed per animal from the BLM range annually. The non-grazing fees are the sum of the AUMs used on all public land.

Other Costs

The reproduction and health costs are charged on a per head basis and are not affected by cow size. All of the prices found in Table 13 have been taken from a recent budget created and published for Northern Utah by Holmgren (2014).

Holmgren (2014) indicates bulls can be purchased for $3,500 and culls sold for $1,176 for a difference of $2,324. This amount is depreciated over 5 years, to obtain a cost of $464.80 per bull per year.

Holmgren (2014) showes an annual cow's labor cost to be $32.75/hd. This is equivalent to $13.10/hr. for 2.5 hours per head per year. Cleere (2006) indicated that replacement heifers require five hours per head annually. Five hours per year, at $13.10/hour equals $65.50/hd. annually. First-calf heifer labor is assumed to be 3.75

hours annually at $13.10, for a total of $50/hd. annually. Table 14 depicts the budget for labor and bull depreciation costs.

Coefficient Description

As mentioned in the methodology section there are several essential parts of an LP: the decision variables or objective function coefficients (Cj's); objective function activities (Xj's); technical (supply and/or demand) coefficients (Aij's); and constraints or right hand side (Bi's). This section will discuss the origin of the Cj's, Aij's, and the Bi's, whereas the Xj's will be discussed in the results section.

The objective function coefficients are those that have a direct effect on the objective value as the activities are conducted. In this model the coefficients are, for example, costs associated with grazing and revenue associated with cattle sales based on animal size and type.

Annual Cow Costs

The annual cow cost is a cost that is accrued on a per head basis and not affected by body weight. The fixed cow cost includes the bull cost as a percentage of each cow. We have assumed that the ranch can purchase bulls for $3,500 and sell cull bulls for $1,176 for a difference of $2,324. This difference is then depreciated over five years for a $464.80 cost per year per bull. There is also a $140 bull maintenance fee for each bull each year which is associated with breeding soundness exams and other health costs. This comes to a total non-feed bull cost of $604.80. This number is then divided by the 25 cows he is able to service each year for a total $24.19/cow non-feed bull cost.

Table 12. Expected Feed and Forage Costs for Resource Base 2 Ranch

Feed or Forage Type	Head	Unit	Unit of Measure	Price / Unit	Total Value
			Cows		
Grass Hay	500	1.27	Ton	$ 120.36	$ 76,428.60
Alfalfa	500	0	Ton	$ 165.62	$ -
BLM Grazing Fees	500	2.875	AUM	$ 1.35	$ 1,940.63
USFS Grazing Fees	500	4.6	AUM	$ 1.35	$ 3,105.00
Non-Grazing Fees	500	7.475	AUM	$ 13.00	$ 48,587.50
Private Pasture	500	2.875	AUM	$ 30.00	$ 43,125.00
Protien Supplement	500	0	Ton	$ 228.95	$ -
Cows Subtotal					*$ 173,186.73*
			First-Calf Heifers		
Grass Hay	92	1.2	Ton	$ 120.36	$ 13,287.74
Alfalfa	92	1.15	Ton	$ 165.62	$ 17,522.60
USFS Grazing Fees	92	4.08	AUM	$ 1.35	$ 506.74
Non-Grazing Fees	92	4.08	AUM	$ 13.00	$ 4,879.68
Private Pasture	92	2.04	AUM	$ 30.00	$ 5,630.40
First-Calf Heifer Subtotal					*$ 41,827.16*
			Replacement Heifers		
Grass Hay	100	0.51	Ton	$ 120.36	$ 6,138.36
Alfalfa	100	1	Ton	$ 165.62	$ 16,562.00
Private Pasture	100	5.31	AUM	$ 30.00	$ 15,930.00
Yearlings Subtotal					*$ 38,630.36*
			Bulls		
Grass Hay	28	1.72	Ton	$ 120.36	$ 5,730.29
USFS Grazing Fees	24	6.4	AUM	$ 1.35	$ 204.60
Non-Grazing Fees	24	6.4	AUM	$ 13.00	$ 1,970.18
Private Pasture FM	24	1.6	AUM	$ 30.00	$ 1,136.64
Yearling Pasture	4	9.6	AUM	$ 30.00	$ 1,152.00
Bulls Sub total					*$ 10,193.70*
Salt and Mineral	720	1	Head	$ 15.00	$ 10,795.20
Grand Total Feed and Forage Costs					***$ 274,633.14***

Table 13. Expected Reproduction and Herd Health Costs

Cost Description	Head	Unit	Unit of Measure	Price / Unit	Total Value
			Cows & First-Calf Heifers		
Reproduction					
Breeding Bulls	28	1	Head	$ 140.00	$ 3,875.20
Veterinary Service	592	1	Head	$ 25.00	$ 14,800.00
Pregnancy test	592	1	Head	$ 4.00	$ 2,368.00
Animal Health					
Medicine and Supplies	592	1	Head	$ 8.00	$ 4,736.00
Cow Vaccine	592	1	Head	$ 8.50	$ 5,032.00
Calf Vaccine	592	1	Head	$ 12.00	$ 7,104.00
Cows & First-Calf Heifers Subtotal					*$ 37,915.20*
			Replacement Heifers		
Reproduction					
Pregnancy test	100	1	Head	$ 4.00	$ 400.00
Animal Health					
Medicine and Supplies	100	1	Head	$ 8.00	$ 800.00
Cow Vaccine	100	1	Head	$ 8.50	$ 850.00
Yearlings Subtotal					*$ 2,050.00*
Total Reproduction and Heard Health Costs					**$ 39,965.20**

Table 14. Expected Bull Depreciation and Labor Costs for Resource Base 2 Ranch

Cost Description	Head	Unit	Unit of Measure	Price / Unit	Total Value
			Bull Depreciation		
Bulls	28	1	Head	$ 464.80	$ 12,865.66
			Labor @ $13.10/hr.		
Cows	500	1	Head	$ 32.75	$ 16,375.00
First-Calf Heifers	92	1	Head	$ 50.00	$ 4,600.00
Yearlings	100	1	Head	$ 65.50	$ 6,550.00
Labor Total					$ 27,525.00
Total Bull Depreciation and Labor Costs					**$ 40,390.66**

The annual feed cost for the bull has also been added to the annual cow cost. CHAPS (2013) data also indicated 60% of all calves were born in the first 21 days of the calving season indicating a need for a bull turnout date roughly 20 days prior to the average breeding date. The bull turnout date for cow herd and first-calf heifers coincides with the time that these animals are turned out on USFS. Furthermore, the replacements are bred 2 to 4 weeks prior to the cows, so it is assumed that the bulls that are used to breed the replacement heifers use the same pasture as the replacements from May through November. Table 15 shows the bull feed cost on a per cow basis for the cows and calf heifers, where the bull is assumed to weigh 1,800 lbs. and has an AUE of 1.6.

Table 16 shows the bull feed costs per replacement heifer. The replacement heifer bull feed costs have been separated due to the difference in the grazing costs of the cow and calf heifer bulls. A separate calculation for bull feed cost was made for each resource base since bull feed costs differ based on resources available.

Table 15. Cow and First-Calf heifer Bulls for Resource Base 2 Ranch

Feed Cost	Unit	Unit/Cow	Cost	$/cow
Hay	1.722	0.068874	$ 120.36	$ 8.29
USFS	1.6	0.064	$ 1.35	$ 0.09
Non Grazing Fees	1.6	0.064	$ 13.00	$ 0.832
Fall Med	1.6	0.064	$ 30.00	$ 1.92
Salt/Min	1	0.04	$ 15.00	$ 0.60
Total Bull Feed Cost per Cow				**$ 11.73**

Table 16. Yearling Bulls for Resource Base 2 Ranch

Feed Cost	Unit	Unit/Cow	Cost	$/cow
Hay	1.722	0.068874	$ 120.36	$ 8.29
Y Past	1.6	0.064	$ 30.00	$ 1.92
Salt/Min	1	0.04	$ 15.00	$ 0.60
Total Bull Feed Cost per Yearling				**$ 10.81**

The calculations for the annual cow costs for cows and first-calf heifers also include the following costs:

- Salt / Min $15.00
- Vet service $25.00
- Pregnancy Test $4.00
- Med & Supp. $8.00
- Cow Vaccination $8.50
- Calf Vaccination $12.00

The annual cow costs for the replacement heifers excluded veterinary service and calf vaccines since the replacement heifers will not calve. Labor is also included in these calculations as discussed in the budget section of the procedures. Table 17 enumerates the annual cow costs for each class of cattle and represents the coefficients used in the base model. These values change in the separate models (resource base 1, resource base 3) since they include the bull feed costs.

Table 17. Annual Cow Cost Comparison of Resource Base 2 Ranch

Animal	**$/Animal**
Cow	$ 141.17
First-Calf Heifer	$ 158.42
Replacement Heifer	$ 136.00

Other Objective Function Prices and Costs

The rest of the values used in the objective function were discussed in more detail in the budget section of the procedures. The coefficients used in the model representing public grazing fees were $14.35, which is a combination of the grazing fee and non-grazing fee. The coefficients or dollar values used to represent the private grazing fees were $30.00. The coefficients in the objective function or the dollar value of the feedstuffs are presented in Table 9. The prices or coefficients used in the objective function for the calf sale activities of the various weights and genders are found in Table 6 and Table 7.

Technical Coefficients (Supply and Demand)

Grazing Demand

The grazing demand coefficients were found using the AUEs found in Table 11 in the budget section, and the months on each particular pasture or range which are in Table 3 in the ration section, and Table 5 in the ration section of the procedures. The 1,200 lb. cow forage demand for BLM forage of 2.88 per unit is an example of this. The base model value of 2.88 is found by multiplying the 2.5 months the animals will graze BLM range and the 1,200 lb. cow AUE of 1.15. The BLM grazing activity for each 1,200 lb. cow that the model selects, will negatively affect the optimal solution by, 2.88 AUMs times $14.35, or $41.33 per head.

Feed Demand

The feed demand coefficients were found by balancing the rations for the different types of cattle, then determining the tons per head per year. The values used in the base model are the values found in Table 10 in the budget section of the procedures.

Weaning Rate or Calf Supply

A weaning percentage of 90% discussed in the inventory section and also shown by Holmgren (2014) will be used in this model. I also assume that 50% of the calves produced are bull calves and will be castrated and sold as steer calves. Consequently the coefficient for the supply of steer in the model is -0.45, indicating a transfer to a sale activity according to calf weight, which is dictated by the size of cow selected. All of the steer calves produced by both the cows and first-calf heifers will be sold. The heifers produced by the cows are slightly different in that the ranch will hold back 20% of their heifers from the cow herd for replacements. A coefficient of -0.20 indicates a transfer of heifer calves to the replacement heifers of the appropriate size. This also means that the model will only transfer the remaining 25% (a coefficient of -0.25) of the heifers produced by the cow herd and all of the heifers produced by the first-calf heifers (a coefficient of -0.45) into a sale activity of the appropriate calf size.

Replacement Rate and Pregnancy/Cull Rate or Cull Animal Supply

The annual cull rate of the cow herd is 15%. Where a death loss of 1% is also included in the cull rate of 15% the model transfers or supplies 14% (a coefficient of -0.14) of the cows selected by the model to the cull cow selling activity of the appropriate weight. The first-calf heifers supply 12% of their numbers to the cull first-calf heifer sale activity of the appropriate weight minus 1.5% death loss for a total of 10.5% (a coefficient of -0.105). The number of replacement heifers sent to the cull market is 8% of their numbers minus a 2% death loss for a total of 6% (a coefficient of -0.06). All of the production coefficients will be constant across all three resource bases.

Base Model Constraints or Right Hand Side

The major constraints in the LP model are the AUM's available to the cow herd from public (USFS and BLM) and private grazing (spring meadow and fall meadow). This number on the right hand side of the equation is calculated by multiplying the AUE of the 1,200 lb. cow and the respective 1st calf heifer AUE by the number of months that the animals will graze the pasture and then multiplied by the number of animals that will graze the pasture. For example on the BLM the Cow AUE of 1.15 is multiplied by the 500 cows' times 2.5 months for a total of 1,438 AUMs available. This calculation is then repeated for the spring meadow, USFS range and fall meadow. Since the first-calf heifers also graze the USFS and fall meadow together, their requirements (1.02 AUE times 4 months = 4.08AUM's per head) must be added to the cow requirements (1.15 AUE times 4 months = 4.6 AUM's per head). The AUMs available on these four resources are; 1,438 AUMs on BLM land, 956 AUMs on spring meadow pasture, 2,675 AUMs on USFS land, and 669 AUMs on fall meadow pasture. These values will be used as right hand side values in the base model.

All other constraints on the right hand side were zero indicating transfers. All constraints were less than or equal to except the constraints that forced heifer calves to be transferred to replacements and replacements forced to be transferred to first-calf heifers. These had to be equal since all animals had to be transferred.

The base model was given the opportunity to choose any one of the three weights of cattle or any mix of the three. The model was designed so that the animals that were selected would only produce a certain weight of calf and will only be transferred into the group that correlates with their mature weight potential. For example a 1,200 lb. cow can only produce steer calves at 565 lbs. and heifer calves at 535 lbs. Furthermore heifer calves from a 1,400 lb. cow can only be transferred to the large group of replacement heifers and then to large first-calf heifers. This is a result of their growth potential and nutritional requirements when compared with the other cattle in the model. The base model is found in Appendix F.

CHAPTER 4

BASE MODEL RESULTS

The first objective of this thesis was to identify the economically optimum cow size for each of the three base ranch types in Utah. This chapter will discuss the results for each resource base as well as a comparison of the different cow sizes on each resource base. The method of charging for grazing fees in these models is on an AUE basis.

The initial solution from the base linear programming model selected only the lightweight cattle (1,000 lb. cows), indicating the 1,000 lb. cows were the most profitable. Furthermore, the model indicates that resource base 2 was able to carry 74 more 1,000 lb. cows than the 500 head of 1,200 lb. cows which the model was designed for. The results also show 115 heifer calves being retained for replacements and 106 first-calf heifers so the ranch could maintain a herd size of 574 mother cows. The number of cattle sold was 306 steers weighing 500 lbs., each, 191 heifers weighing 470 lbs. each, 6 open replacement heifers weighing 800 lbs. each, 11 open first-calf heifers weighing 923 lbs. each, and 80 (1,000 lbs.) cull cows.

In the base model the AUMs available on the USFS land was the binding constraint limiting cow numbers. While the BLM constraint of 1,435 AUMs is not technically binding since there are 3AUMs remaining, that is only enough forage to feed one additional 1,000 lb. cow for the 3 months. Therefore, in practical terms both the USFS and the BLM grazing allotments are binding and closely balanced on this model ranch which may likely be the case for many ranches dependent on public land grazing.

The cattle in the base model require 6,275 AUMs annually. The amount of forage required from each pasture or range type is broken down as follows:

- BLM, 1,435 AUMs
- Spring Meadow, 956 AUMs
- USFS, 2,675 AUMS
- Fall Meadow, 669 AUMs
- Breeding Pasture, 255 AUMs
- Bred Heifer Range, 286 AUMs

The cattle also require 984 tons of mechanically harvested forages (alfalfa and Utah grass hay) to maintain body condition or gain to reach an acceptable breeding weight. The feedstuffs are broken down this way; 0 tons of dried distillers grain (DDG, cake), 159 tons of alfalfa and 843 tons of grass hay. This ranch does not need to feed cake since the grass hay and alfalfa meet the requirements in a cheaper fashion.

The optimal solution for the model generated a net return of $34,885. The objective function was broken down into a total cost of $365,025, and a total revenue of $399,911. Total costs can then be broken down into fixed cow costs of $113,339, grazing costs of $123,930, and feed costs of $127,755. Total revenue can also be broken down into sales revenue from calves of $336,946, and sales revenue from cull animals of $62,965.

Forced Base Model Results

To demonstrate the different effects of running each weight class of animal or mature cow size, the model was forced to select the optimum number of animals for each different cow size. All constraints were held at the same level. A comparison of the number of cattle the ranch was able to carry is shown in Table 18. Where the 1,200 lb. cow served as the base animal, this table illustrates the ranch could carry 74 more 1,000 lb. cows than 1,200 lb. cows. It also shows that resource base 2 is able to support 54 fewer 1,400 lb. cows than 1,200 lb. cows, and 128 fewer 1,400 lb. cows than the 1,000 lb. cows.

Table 18. Base Model Carrying Capacity Comparison

Cow Wt.	Cows	1st Calf Heifers	Replacement Heifers
1000 lb.	574	106	115
1200 lb.	500	92	100
1400 lb.	446	82	89

The reduction in net returns as cow weight increases is due to a decrease in revenue as cow weight increases. This combined with the increased carrying capacity as cow weight decreases causes net returns to increase as cow weight decreases. Table 19 shows the number of calves and cull cows sold under each scenario and the respective revenue. The data show, when compared to the 1,200 lb. cow herd, that the ranch could increase revenue from calves sold $26,868 using 1,000 lb. cows. Conversely the ranch would reduce revenue from calves sold $13,065 using 1,400 lb. cows. However, revenue from cull animals decreased by $2,558 when 1,000 lb. cows are chosen, and revenue form cull animals increased $302 when 1,400 lb. cows are chosen. Essentially, total revenue increased by $24,310 if 1,000 lb. cows are used in place of 1,200 lb. cows, and total revenue decreased $12,762 if 1,400 lb. cows are used in place of 1,200 lb. cows.

Table 19. Base Model Cattle Sold and Revenue Comparison

Cow Weight	1000 lb.	1200 lb.	1400 lb.	Difference from 1,200 lb. Cow Herd 1000-1200	Difference from 1,200 lb. Cow Herd 1400-1200
Number of Calves Sold					
Steers	306	266	237	40	(29)
Heifers	191	166	148	25	(18)
Total Calves Sold	497	432	385	65	(47)
Calf Revenue					
Steer Revenue	$220,959.66	$200,567.23	$191,033.27	$ 20,392.43	$ (9,533.96)
Heifer Revenue	$115,987.01	$109,511.17	$105,979.32	$ 6,475.84	$ (3,531.85)
Total Calf Revenue	$336,946.67	$310,078.40	$297,012.59	$ 26,868.27	$(13,065.81)
Number of Cull Animals Sold					
Cows	80	70	62	10	(8)
Replacement Heifers	6	6	5	0	(1)
First-Calf Heifers	11	10	9	1	(1)
Total Cull Animals	97	86	76	11	(10)
Cull Revenue					
Cows	$ 48,649.62	$ 50,869.70	$ 52,907.22	$ (2,220.08)	$ 2,037.52
Replacement Heifers	$ 6,072.18	$ 5,921.91	$ 4,156.70	$ 150.28	$ (1,765.20)
First-Calf Heifers	$ 8,243.20	$ 8,731.48	$ 8,761.99	$ (488.28)	$ 30.51
Cull Revenue	$ 62,965.00	$ 65,523.09	$ 65,825.91	$ (2,558.08)	$ 302.82
Total Revenue	***$399,911.68***	***$375,601.49***	***$362,838.50***	***$ 24,310.19***	***$(12,762.98)***

Table 20 shows a feed consumption and cost comparison. As expected, annual cow costs increased as the number of cattle increased since the annual cow cost was not dependent upon weight. However, feed costs increased significantly for the larger cows. The model indicates feed mechanically harvested and fed to a 1,000 lb. cow herd is $4,645 cheaper compared to a 1,200 lb. cow herd, and $6,644 cheaper when compared to

Table 20. Base Model Feed and Forage Consumption and Cost Comparisons

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	794	692	617	102	(75)
Total Fixed Cow Cost	$113,339.74	$ 98,759.64	$ 88,041.54	$14,580.10	$(10,718.10)
Feedstuff/Tons					
Alfalfa	159	206	255	(47)	49
Grass Hay	843	796	745	47	(51)
Total Tons	*1002*	*1002*	*1000*	*0*	*(2)*
Feedstuff Costs					
Alfalfa Cost	$ 26,313.41	$ 34,051.95	$ 42,159.89	$ (7,738.54)	$ 8,107.94
Grass Hay Cost	$101,441.94	$ 95,828.34	$ 89,719.25	$ 5,613.60	$ (6,109.09)
Total Feedstuff Costs	*$127,755.35*	*$129,880.28*	*$131,879.14*	*$ (2,124.94)*	*$ 1,998.85*
Grazed Forage/AUMs					
BLM	1435	1438	1438	(3)	0
Spring Meadow	956	956	955	(1)	(1)
USFS	2675	2675	2671	0	(5)
Fall Meadow	669	669	668	0	(1)
Breeding Pasture	255	252	251	3	(1)
BH Range	286	279	278	7	(1)
Total AUMs	*6275*	*6269*	*6261*	*6*	*(8)*
Grazed Forage Costs					
BLM Cost	$ 20,585.65	$ 20,628.13	$ 20,628.13	$ (42.47)	$ -
Spring Meadow Cost	$ 28,672.44	$ 28,690.20	$ 28,655.33	$ (17.76)	$ (34.87)
USFS Cost	$ 38,391.42	$ 38,391.42	$ 38,324.69	$ -	$ (66.73)
Fall Meadow Cost	$ 20,065.20	$ 20,065.20	$ 20,030.33	$ -	$ (34.87)
Breeding Past. Cost	$ 7,643.23	$ 7,560.00	$ 7,541.86	$ 83.23	$ (18.14)
Bred Heifer Past. Cost	$ 8,572.81	$ 8,370.00	$ 8,344.19	$ 202.81	$ (25.81)
Total Grazed Forage Cost	*$123,930.75*	*$123,704.94*	*$123,524.51*	*$ 225.81*	*$ (180.43)*
Total Feed Costs	$251,686.10	$253,585.23	$255,403.65	$ (1,899.13)	$ 1,818.42
Total Costs	***$365,025.83***	***$352,344.87***	***$343,445.19***	***$ 12,680.96***	***$ (8,899.68)***

a 1,400 lb. cow herd. This is primarily due to the fact that larger animals require more energy for maintenance, and for the animal to get the nutrients that it requires, a feed having more energy and protein costs more to meet those demands.

It cost $225 more to graze 574 -- 1,000 lb. cows, and $180 less to graze 446 -- 1,400 lb. cows than 500 -- 1,200 lb. cows. There is little difference in the cost or amount of the AUMs used. This is due to the fact that BLM, spring meadow, USFS and fall meadow are the major constraints in the model, and the model is trying to maximize the use of these federal ranges. Total costs increase by $10,160 when 1,000 lb. cows are run in place of 1,200 lb. cows. The opposite is true when 1,400 lb. cows are run in place if 1,200 lb. cows where total costs decrease $8,899.

Table 21 compares net returns from the three different cow weight scenarios. The data show, when compared to a 1,200 lb. cow herd, that net returns decreased by $3,863 when using a 1,400 lb. cow herd, and increased by $14,149 when a 1,000 lb. cow herd was used. The data show the net returns per reproducing cow (cows and first-calf heifers) decreased as mature weight increased. The data indicate there to be a $15.72/hd. increase in net returns with the 1,000 lb. cow and a $2.56/hd. decrease in net return with the 1,400 lb. cow herd. Essentially, there was a reduced cost of $28.30 for every 1,200 lb. cow used and $40.27 for every 1,400 lb. cow used. The reduction in net returns as cow weight increases is due to a decrease in revenue as cow weight increases. This combined with the increased carrying capacity as cow weight decreases causes net returns to increase as cow weight decreases.

Table 21. Base Model Net Return Comparison

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
Total Revenue	$399,911.68	$375,601.49	$362,838.50	$ 24,310.19	$(12,762.98)
Total Costs	$365,025.83	$352,344.87	$343,445.19	$ 12,680.96	$ (8,899.68)
Net Return	*$ 34,885.84*	*$ 23,256.62*	*$ 19,393.31*	*$ 11,629.22*	*$ (3,863.31)*
Number of Reproducing Cows					
Reproducing Cows	680	592	528	88	(64)
Profit Per Reproducing Animal					
Revenue Per cow	$ 588.11	$ 634.46	$ 687.19	$ (46.36)	$ 52.73
Costs Per Cow	$ 536.80	$ 595.18	$ 650.46	$ (58.37)	$ 55.29
Net Return Per Cow	**$ 51.30**	**$ 39.28**	**$ 36.73**	**$ 12.02**	**$ (2.56)**

Objective One Results

Since there is more than one type of resource base in Utah, I have included two other examples of typical resource bases found in Utah. These two other typical resource bases include operations where the mature cow herd grazes BLM range the entire winter and receive minimal supplementation and no hay (resource base 1) and where mature cows are not able to graze through the winter and require hay 6 months of the year to remain productive (resource base 3).

Resource Base 1

New Coefficient Description

To represent an operation that is able to forego feeding their mature cows hay through the winter some changes were made to the model. The only coefficients that were changed in the model were the feed and grazing demand coefficients and the right hand constraints. The BLM AUM's available increased from 1438 to 3450. The grazing demand coefficients changed as dictated by the grazing plans. The new feed and grazing demand coefficients were obtained from the rations that were balanced and a combination of the AUE's and grazing plans. The method used has been discussed more fully in the procedures.

Results

This model selected the 1,000 lb. cows, the same as the base model. Once again indicating the 1,000 lb. cows generated the greatest net return. The way the models have been constructed causes the number of animals used of each type will be the same as the base model. This attribute also means that the revenue generated from this model will be the same as the base model.

In the base model the AUMs available on the USFS land, spring meadow and fall meadow were the binding constraints that limit cow numbers. While the BLM constraint of 3,450 AUMs was not binding since there were 7 AUMs remaining, which would only be enough forage to feed one additional 1,000 lb. cow for the 7 months. This was enough feed to run one more 1,000 lb. cow on the BLM allotment. However, in practical terms grazing allotments were balanced reasonably well.

The cattle in this model required 7,996 AUMs annually which was a 1,721 AUM increase over the base model. This is due to the increased grazing time on the BLM and the decrease in the amount of mechanically harvested feeds fed. The cattle required 390 tons of mechanically harvested forages (alfalfa and Utah grass hay) to maintain body condition or to gain enough weight to reach an acceptable breeding weight. This was a total decrease in the mechanically harvested feeds fed of 594 tons annually. The feedstuffs are broken down this way: 25 tons of cake, 159 tons of alfalfa and 206 tons of grass hay.

The optimal solution for this model was $92,137 which was a $57,252 increase in net returns over the base model. The increase in the objective function value was completely due to decreased costs where revenue remained constant. Total costs calculated for this model are $307,773. Total costs could be broken down into annual cow costs of $106,756 (a $6,583 decrease from the base model), grazing costs of $144,143 (a $20,212.67 increase from the base model), and feed costs of $56,874.26 (a $70,881.09 decrease from the base model).

Resource Base 1 Forced Results

For comparison purposes the model developed for resource base 1 where the cow herd did not receive harvested forages as part of their annual diet was forced to choose all cow weight options. Table 22 compares the feed consumption and feed cost which were very similar to the forced results of the base model. However, there was a narrower spread in the costs between the different cow weight classes in this model when compared with the base model. The reduction in the cost spread was primarily due to the reduction of the fixed cow cost in the resource base 1 model which, in turn, was the elimination of the bulls winter feed costs. The annual cow cost accounted for 63% of the cost change and total feed costs accounted for the remaining 37% of the change. Ninety-five percent of the change in the total feed cost was the reduction in the amount of mechanically harvested forages, where grazing cost accounted for only 5%.

Table 22. Resource Base 1 Feed and Forage Consumption and Cost Comparisons

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	795	692	617	103	(75)
Total Fixed Cow Cost	*$ 106,756.14*	*$ 93,022.96*	*$ 82,927.44*	*$ 13,733.18*	*$ (10,095.52)*
			Feedstuff/Tons		
Cake	25	23	27	2	4
Alfalfa	159	206	255	(47)	49
Grass Hay	206	161	112	45	(49)
Total Tons	*390*	*390*	*394*	*0*	*4*
			Feedstuff/Costs		
Cake Cost	$ 5,780.51	$ 5,228.65	$ 6,123.08	$ 551.86	$ 894.44
Alfalfa Cost	$ 26,313.41	$ 34,051.95	$ 42,159.89	$ (7,738.54)	$ 8,107.94
Grass Hay Cost	$ 24,780.34	$ 19,399.74	$ 13,537.90	$ 5,380.60	$ (5,861.84)
Total Feedstuff Cost	*$ 56,874.26*	*$ 58,680.33*	*$ 61,820.87*	*$ (1,806.07)*	*$ 3,140.54*
			Grazed Forage		
BLM	3443	3450	3450	(7)	0
Spring Meadow	669	669	668	0	(1)
USFS	2675	2675	2671	0	(5)
Fall Meadow	669	669	668	0	(1)
Breeding Pasture	255	252	251	3	(1)
BH Range	286	279	278	7	(1)
Total AUMs	*7996*	*7994*	*7986*	*2*	*(8)*
			Grazed Forage Costs		
BLM Cost	$ 49,405.56	$ 49,507.50	$ 49,507.50	$ (101.94)	$ -
Spring Meadow Cost	$ 20,065.20	$ 20,065.20	$ 20,030.33	$ -	$ (34.87)
USFS Cost	$ 38,391.42	$ 38,391.42	$ 38,324.69	$ -	$ (66.73)
Fall Meadow Cost	$ 20,065.20	$ 20,065.20	$ 20,030.33	$ -	$ (34.87)
Breeding Past. Cost	$ 7,643.23	$ 7,560.00	$ 7,541.86	$ 83.23	$ (18.14)
Bred Heifer Past. Cost	$ 8,572.81	$ 8,370.00	$ 8,344.19	$ 202.81	$ (25.81)
Total Grazed Forage Cost	*$ 144,143.42*	*$ 143,959.32*	*$ 143,778.89*	*$ 184.10*	*$ (180.43)*
Total Feed Costs	$ 201,017.68	$ 202,639.65	$ 205,599.76	$ (1,621.97)	$ 2,960.11
Total Costs	***$ 307,773.81***	***$ 295,662.61***	***$ 288,527.20***	***$ 12,111.21***	***$ (7,135.40)***

Where the number of cattle and the revenue was identical to the base model, there was little to discuss concerning ranch revenue. The reduction in net returns as cow weight increases is due to a decrease in revenue as cow weight increases. This combined with the increased carrying capacity as cow weight decreases causes net returns to increase as cow weight decreases. Table 19 has illustrated these differences. Table 23 illustrates the differences in revenue and cost on a per head basis for the reproducing animal (cows and first-calf heifers). In this comparison, the 1,400 lb. cow has a $5.25 per head greater net return than the 1,000 lb. cow on a per head basis. However this comparison also shows the net return for the 1,000 lb. cow herd was $17,826.56, generating a greater net return than the 1,400 lb. cow herd. This twist is primarily due to the ability to spread the costs over 152 more animals and there are 133 more animals to sell from the lighter weight cow herd.

Table 23. Resource Base 1 Net Return Comparison

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
Total Revenue	$ 399,911.68	$ 375,601.49	$ 362,838.50	$ 24,310.19	$ (12,762.98)
Total Costs	$ 307,773.81	$ 295,662.61	$ 288,527.20	$ 12,111.21	$ (7,135.40)
Net Return	*$ 92,137.86*	*$ 79,938.88*	*$ 74,311.30*	*$ 12,198.98*	*$ (5,627.58)*
	Number of Reproducing Animals				
	680	592	528	88	(64)
	Profit Per Reproducing Animal				
Revenue Per cow	$ 588.11	$ 634.46	$ 687.19	$ (46.36)	$ 52.73
Costs Per Cow	$ 452.61	$ 499.43	$ 546.45	$ (46.82)	$ 47.02
Net Return Per Cow	**$ 135.50**	**$ 135.03**	**$ 140.74**	**$ 0.46**	**$ 5.71**

Resource Base 3

New Coefficient Description

Once again changes to the model were necessary to represent operations where the mature cow herd requires 6 months of full feed. The same coefficients that were changed to develop the ranch 1 model were again altered to simulate the demands of a 6 month feeding period for the mature cow herd. These included the feed and graze demand coefficients and the right hand restraints. The new feed and grazed demand coefficients were obtained from the rations that were balanced and a combination of the AUE's and grazing plans. The method used has been discussed more fully in the procedures.

Results

This model did not make a selection since net return was negative. However, when forced the model shows that the 1,000 lb. cow generates the greatest net return.

Resource Base 3 Forced Results

Many ranch operations have other sources of income such as hay sales, wildlife harvesting sales and other natural resources which will help them turn a profit. In plain terms, other sources of revenue can make this scenario a feasible one. The model was forced in order to make a comparison. As mentioned earlier the revenue of the different scenarios will not change and does not merit further discussion.

The feed and forage consumption and cost comparison shown in Table 24 are very similar to the comparisons of the two previous resource bases. Once again we see the spread between the light and heavy cows widen based on the amount of mechanically-harvested feed used. The amount of feed fed to the bulls also played a significant part in the widening of the cost spread. It is also interesting to note in all scenarios even though the 1,000 lb. cow herd had the lowest total feed cost it also had the highest total cost. The reason the 1,000 lb. cows have the greatest total cost is due to the increase in cow numbers.

The profit or loss comparison in Table 25 shows a loss for each cow weight scenario. However, it is obvious that the 1,000 lb. cow herd generates a $10,522 greater net return when compared to the 1,200 lb. cow herd, and a $13,611 greater net return when compared to the 1,400 lb. cow herd. Even on a per head basis, the light cattle had a $20.30 per head greater return than the medium size cattle.

These results are based on the assumption that the BLM and USFS charge on a true AUM basis for grazing permits. However, these federal agencies charge on a per head basis. For example a 1,000 lb. cow and a 1,400 lb. cow both with calf at side would be charged a set rate. The influence this policy has on cow size will be discussed in chapter 5.

Table 24. Resource Base 3 Feed and Forage Consumption and Cost Comparisons

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	795	692	617	103	(75)
Total Fixed Cow Cost	*$ 119,295.95*	*$ 103,949.64*	*$ 92,829.63*	*$ 15,346.31*	*$ (11,120.01)*
			Feedstuff/Tons		
Cake	0	0	0	0	0
Alfalfa	159	206	255	(47)	49
Grass Hay	1422	1373	1322	49	(51)
Total Tons	*1580*	*1578*	*1577*	*2*	*(1)*
			Feedstuff/Costs		
Cake Cost	$ -	$ -	$ -	$ -	$ -
Alfalfa Cost	$ 26,313.41	$ 34,051.95	$ 42,233.29	$ (7,738.54)	$ 8,181.35
Grass Hay Cost	$ 171,100.39	$ 165,206.85	$ 159,119.65	$ 5,893.54	$ (6,087.20)
Total Feedstuff Cost	*$ 197,413.80*	*$ 199,258.80*	*$ 201,352.94*	*$ (1,845.00)*	*$ 2,094.15*
			Grazed Forage		
BLM	0	0	0	0	0
Spring Meadow	669	669	669	0	0
USFS	2675	2675	2675	0	0
Fall Meadow	669	669	669	0	0
Breeding Pasture	255	252	252	3	0
BH Range	286	279	279	7	0
Total AUMs	*4554*	*4544*	*4543*	*10*	*(1)*
			Grazed Forage Costs		
BLM Cost	$ -	$ -	$ -	$ -	$ -
Spring Meadow Cost	$ 20,065.20	$ 20,065.20	$ 20,065.20	$ -	$ -
USFS Cost	$ 38,391.42	$ 38,391.42	$ 38,391.42	$ -	$ -
Fall Meadow Cost	$ 20,065.20	$ 20,065.20	$ 20,065.20	$ -	$ -
Breeding Past. Cost	$ 7,643.23	$ 7,560.00	$ 7,554.99	$ 83.23	$ (5.01)
Bred Heifer Past. Cost	$,572.81	$ 8,370.00	$ 8,358.71	$ 202.81	$ (11.29)
Total Grazed Forage Cost	*$ 94,737.86*	*$ 94,451.82*	*$ 94,435.52*	*$ 286.04*	*$ (16.29)*
Total Feed Costs	$ 292,151.66	$ 293,710.61	$ 295,788.47	$ (1,558.95)	$ 2,077.85
Total Costs	***$ 411,447.60***	***$ 397,660.25***	***$ 388,618.09***	***$ 13,787.35***	***$ (9,042.16)***

Table 25. Resource Base 3 Net Return Comparison

Cow Weight	1000 lb.	1200 lb.	1400 lb.	Difference from 1,200 lb. Cow Herd 1000-1200	1400-1200
Total Revenue	$ 399,911.68	$ 375,601.49	$ 363,470.23	$ 24,310.19	$(12,131.25)
Total Costs	$ 411,447.60	$ 397,660.25	$ 388,618.09	$ 13,787.35	$ (9,042.16)
Net Return	$ (11,535.93)	$ (22,058.77)	$ (25,147.86)	$ 10,522.84	$ (3,089.09)
	Number of Reproducing Animals				
	680	592	528	88	(64)
	Profit Per Reproducing Animal				
Revenue Per cow	$ 588.11	$ 634.46	$ 688.39	$ (46.36)	$ 53.93
Costs Per Cow	$ 605.07	$ 671.72	$ 736.02	$ (66.65)	$ 64.30
Net Return Per Cow	**$ (16.96)**	**$ (37.26)**	**$ (47.63)**	**$ 20.30**	**$ (10.37)**

CHAPTER 5

OBJECTIVE TWO RESULTS

The second objective of this thesis is to determine the impact of charging on a per cow or cow-calf pair on BLM, USFS and Utah State lands on optimal mature cow weight. This chapter will discuss the results for each resource base as well as a comparison of the method of charging for grazing fees, on a per cow/cow-calf pair or on an AU basis.

Federal Model Coefficient Change

In these models the grazing demanded from the USFS and BLM land were relaxed so that a cow or cow-calf pair will be charged the same amount regardless of weight. For example the a 1,400 lb. cow grazing BLM land for 3 months will be charged for 3 AUMs the same as the 1,000 lb. cow and the 1,200 lb. cow. This will be done to each of the following models (resource base 1, 2, and 3). However the constraints were different based on resource availabilities.

The right-hand side coefficients for spring and fall meadow were relaxed giving the models the opportunity to rent more private pasture so the public grazing permits could be fully utilized. Similar to the previous models, these next models used the USFS and BLM constraints using the 1,200 lb. animal as the base animal. For example in the resource base 1 model 3000 BLM AUMs were assumed available and, in the resource base 3 model, there were zero BLM AUMs assumed available.

Resource Base 1 Public Land Grazing Policy Results

The optimum cow size for this model was the 1,400 lb. sized cow herd. Under the current public grazing permit charges, resource base 1 could run 500 head of 1,400 lb. cows and will require 92 first-calf heifers and 100 replacement heifers to maintain the herd. The net return under this scenario is $104,851, where total costs were $302,158 and total revenue was $407,010.

Total costs were broken down into fixed cow cost, feedstuff costs and grazing costs. Annual cow cost was $93,022 (31% of total cost), feedstuff costs were $69,346.89 (23% of total cost), and grazing costs were $139,788.40 (46% of total cost).

The revenue was acquired from the sale of 266 steer calves and 166 heifer calves for a calf revenue of $333,170.65, accounting for 82% of the income. The cull sales were as follows: 70 cows, 6 replacement heifers, 10 first-calf heifers. Total cull sales were $73,839.50, accounting for 18% of the income.

Forced Results

The model was forced to select the other two cow sizes so that the difference between the cow sizes could be shown. Table 26 compares the number of cattle sold and the revenue from these sales. Since the only two constraints in the model were the amount of BLM and USFS AUMs available, the number of cattle was the same across the three weight classes. Similar to the previous models, the number of cows will be constant across all three resource bases as well. This in turn means that the revenue comparison will be the same for all three resource bases similar to the previous models. From a

Table 26. Cattle Sold and Revenue Comparison at Federal Rates

Cow Weight	1000 lb.	1200 lb.	1400 lb.	Difference from 1,200 lb. Cow Herd 1000-1200	Difference from 1,200 lb. Cow Herd 1400-1200
Calves					
Steers	266	266	266	0	0
Heifers	166	166	166	0	0
Total Calves Sold	*433*	*433*	*433*	*0*	*0*
Calf Revenue					
Steer Revenue	$192,535.27	$ 200,567.23	$ 214,289.50	$ (8,031.96)	$ 13,722.26
Heifer Revenue	$101,066.37	$ 109,511.17	$ 118,881.15	$ (8,444.80)	$ 9,369.98
Total Calf Revenue	*$293,601.64*	*$ 310,078.40*	*$ 333,170.65*	*$ (16,476.76)*	*$ 23,092.25*
Culls					
Cows	70	70	70	0	0
Replacement Heifers	6	6	6	0	0
First-Calf Heifers	10	10	10	0	0
Total Cull Animals	*86*	*85*	*85*	*0*	*0*
Cull Revenue					
Cow Revenue	$ 42,391.30	$ 50,869.70	$ 59,348.10	$ (8,478.40)	$ 8,478.40
Replacement Heifer Revenue	$ 5,291.05	$ 5,921.91	$ 4,662.74	$ (630.85)	$ (1,259.17)
First-Calf Heifer Revenue	$ 7,182.79	$ 8,731.48	$ 9,828.66	$ (1,548.69)	$ 1,097.18
Total Cull Revenue	*$ 54,865.14*	*$ 65,523.09*	*$ 73,839.50*	*$ (10,657.94)*	*$ 8,316.41*
Total Revenue	**$348,466.78**	**$ 375,601.49**	**$ 407,010.15**	**$ (27,134.70)**	**$ 31,408.66**

revenue perspective the 1,400 lb. cow herd generates $31,408 more than a 1,200 lb. cow herd and $58,543 more than the 1,000 lb. cow herd.

Table 27 compares the cost of each weight class on resource base 1 under the current public grazing policy. The data show that there are no differences in the annual cow cost since the number of cattle run is not effected by size. On the same note, public grazing cost will not differ between cow weights. However, feedstuff consumption will be very similar to the results shown in the previous chapter, where the larger cow requires more and therefore costs more. For example the 1,400 lb. cow herd requires 52 more tons of feedstuffs than a 1,200 lb. cow herd which costs $10,666 more. This is also true when considering private grazing fees. For example it requires 86 fewer AUMs of spring meadow when running a 1,000 lb. cow herd when compared to a 1,200 lb. cow herd, and costs $2,581 less. This model shows the smaller cow accruing $33,448 less costs. Table 28 displays the total net returns comparison as well as a per head comparison. This comparison shows the 1,400 lb. cow herd to have the highest cost, highest revenue and highest net returns over all, as well as on a per head basis. This table shows a total net return spread of $25,094 and a per head net return spread of $42

<u>Resource Base 1 Net Return Swing</u>

Table 29 shows the net return swing under the current method of charging for public grazing permits on a per head basis compared to the scenario where grazing permits were charged on an AUE basis. This data shows that under the current public land grazing policy that the 1,400 lb. cow herd is $12,714 more profitable than the 1,000 lb. cow herd when compared to running the 1,000 lb. when grazing fees are charged in a true AUM basis. We can then deduce that the current policy has an influence on the size of cattle a producer chooses to run on this type of resource base.

Table 27. Resource 1 Feed and Forage Consumption and Cost Comparisons at Federal Rates

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	692	692	692	0	0
Total Fixed Cow Cost	*$ 93,022.96*	*$ 93,022.96*	*$ 93,022.96*	*$ -*	*$ -*
			Feedstuff/Tons		
Cake	22.00	22.84	30.00	(0.84)	7.16
Alfalfa	138.44	205.60	285.55	(67.16)	79.94
Grass Hay	179.40	161.18	126.17	18.22	(35.01)
Total Tons	*339.84*	*389.62*	*441.72*	*(49.78)*	*52.10*
			Feedstuff/Costs		
Cake Cost	$ 5,036.90	$ 5,228.65	$ 6,868.50	$ (191.75)	$ 1,639.85
Alfalfa Cost	$ 22,928.43	$ 34,051.95	$ 47,292.40	$ (11,123.51)	$ 13,240.45
Grass Hay Cost	$ 21,592.58	$ 19,399.74	$ 15,185.99	$ 2,192.84	$ (4,213.75)
Total Feedstuff Cost	*$ 49,557.92*	*$ 58,680.33*	*$ 69,346.89*	*$ (9,122.41)*	*$ 10,666.56*
			Grazed Forage		
BLM	3000	3000	3000	0	0
Spring Meadow	583	669	749	(86)	80
USFS	2368	2368	2368	0	0
Fall Meadow	583	669	749	(86)	80
Breeding Pasture	222	252	282	(30)	30
BH Range	249	279	312	(30)	33
Total AUMs	*7005*	*7237*	*7460*	*(232)*	*223*
			Grazed Forage Costs		
BLM Cost	$ 43,050.00	$ 43,050.00	$ 43,050.00	$ -	$ -
Spring Meadow Cost	$ 17,484.00	$ 20,065.20	$ 22,468.80	$ (2,581.20)	$ 2,403.60
USFS Cost	$ 33,980.80	$ 33,980.80	$ 33,980.80	$ -	$ -
Fall Meadow Cost	$ 17,484.00	$ 20,065.20	$ 22,468.80	$ (2,581.20)	$ 2,403.60
Breeding Past. Cost	$ 6,660.00	$ 7,560.00	$ 8,460.00	$ (900.00)	$ 900.00
Bred Heifer Past. Cost	$ 7,470.00	$ 8,370.00	$ 9,360.00	$ (900.00)	$ 990.00
Total Grazed Forage Cost	*$ 126,128.80*	*$ 133,091.20*	*$ 139,788.40*	*$ (6,962.40)*	*$ 6,697.20*
Total Feed Costs	$ 175,686.72	$ 191,771.53	$ 209,135.29	$ (16,084.81)	$ 17,363.76
Total Costs	**$268,709.68**	**$284,794.49**	**$302,158.25**	**$ (16,084.81)**	**$ 17,363.76**

Table 28. Resource 1 Net Return Comparison at Federal Rates

				Difference from 1,200 lb. Cow Herd	
	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
Total Revenue	$ 348,466.78	$ 375,601.49	$ 407,010.15	$ (27,134.70)	$ 31,408.66
Total Costs	$ 268,709.68	$ 284,794.49	$ 302,158.25	$ (16,084.81)	$ 17,363.76
Net Return	*$ 79,757.11*	*$ 90,807.00*	*$ 104,851.90*	*$ (11,049.89)*	*$ 14,044.90*
Number of Reproducing Animals					
	592	592	592	0	0
Profit Per Reproducing Animal					
Revenue Per cow	$ 588.63	$ 634.46	$ 687.52	$ (45.84)	$ 53.06
Costs Per Cow	$ 453.90	$ 481.07	$ 510.40	$ (27.17)	$ 29.33
Net Return Per Cow	**$ 134.72**	**$ 153.39**	**$ 177.11**	**$ (18.67)**	**$ 23.72**

Resource Base 2 Public Land Grazing Policy Results

The optimum cow size in this model was also the 1,400 lb. cow with a net return of $65,965. Total revenue generated was $407,010 and total cost of $371,044. The number of cattle marketed and the revenue generated was the same as the previous model, which can be found in Table 26. The costs accrued were also similar to the previous model, though there was an increased consumption of feedstuffs and private pasture associated with the reduction in the available public grazing. The cost of feeding mechanically harvested forages in this model was $147,933, total annual cow costs were $98,759, and total grazing costs were $124,350, these costs were 27%, 40%, and 34% of total costs, respectively.

Table 29. Resource Base 1 Net Return Swing with Federal Policy Change

	Public Grazing Policy		
	$/AUE	$/Cow or Cow-Calf Pair	*Difference With Policy Change*
	1000 lb. Cows		
Total Revenue	$ 399,911.68	$ 348,466.78	*$ 51,444.89*
Total Costs	$ 307,773.81	$ 268,709.68	*$ 39,064.14*
Total Net Return	*$ 92,137.86*	*$ 79,757.11*	*$ 12,380.75*
	Number of Reproducing Animals		
	680	592	*88*
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 588.11	$ 588.63	*$ (0.52)*
Costs Per Cow	$ 452.61	$ 453.90	*$ (1.29)*
Net Return Per Cow	**$ 135.50**	**$ 134.72**	***$ 0.77***
	1200 lb. Cows		
Total Revenue	$ 375,601.49	$ 375,601.49	*$ -*
Total Costs	$ 295,662.61	$ 284,794.49	*$ 10,868.12*
Total Net Return	*$ 79,938.88*	*$ 90,807.00*	*$ (10,868.12)*
	Number of Reproducing Animals		
	592	592	*0*
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 634.46	$ 634.46	*$ -*
Costs Per Cow	$ 499.43	$ 481.07	*$ 18.36*
Net Return Per Cow	**$ 135.03**	**$ 153.39**	***$ (18.36)***
	1400 lb. Cows		
Total Revenue	$ 362,838.50	$ 407,010.15	*$ (44,171.64)*
Total Costs	$ 288,527.20	$ 302,158.25	*$ (13,631.05)*
Total Net Return	*$ 74,311.30*	*$ 104,851.90*	*$ (30,540.60)*
	Number of Reproducing Animals		
	528	592	*(64)*
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 687.19	$ 687.52	*$ (0.32)*
Costs Per Cow	$ 546.45	$ 510.40	*$ 36.05*
Net Return Per Cow	**$ 140.74**	**$ 177.11**	***$ (36.37)***

Forced Results

For comparative purposes the model was forced to select each weight class of cattle to demonstrate the differences associated with mature weight. As mentioned revenue and cattle marketed was the same as the previous. However, even though the feed and forage consumption and costs were very similar to those in the previous model there is a greater spread between weight classes. For example the spread between the 1,000 lb. cow herd and the 1,400 lb. cow herd was $33,448 in the resource base 1 model under federal grazing policy, and in this model the spread was $52,447 an $18,999 increase in the spread. The feedstuff and forage consumption and cost comparisons are shown in Table 30. Where revenue stayed the same as the previous model and costs rose, then net return spread narrowed on both a total and a per head basis. Table 31 shows the narrowing of net returns between weight classes. The large increase in the spread in the costs of this models forced results caused the net return spread to narrow considerably. For example, total net return spread in the previous model was $25,094 and this model's total net return spread narrowed to $6,095, a reduction of $18,999. Net return per head also narrowed from $42.39 in the previous model to $10.29, a reduction in the net return per head of $32.10.

<u>Resource Base 2 Net Return Swing</u>

The net return swing from the resource base 2 model under the current public land grazing policy and the base model are shown in Table 32. Here it can be seen the 1,400 lb. cow herd generates the greatest net returns under the current policy. If public grazing permit fees were charged in an AUE basis, the 1,000 lb. cow herd generates the greatest net returns. These results also show that the current public land grazing policy has an influence on the size of cow that a producer chooses to run on this type of resource base.

Resource Base 3 Public Land Grazing Policy Results

Under the conditions of resource base 3 the model chose to run zero cows. Under these circumstances, the costs of feeding cattle for 6 months outweighed the revenue for any of the three cow sizes. Where the operation cannot generate any net revenue running cattle, the operation would then lease the pasture and sell the hay it produced.

Forced Results

In order to compare the losses incurred by each weight of cattle, this model was also forced to select each weight class. As mention earlier revenue was the same as the previous two models as shown in Table 26. Similar to the earlier models, as the public land available for grazing decreases the feedstuff and private grazing costs increase, thus broadening the cost spread between the small cattle and large cattle when compared to the two previous models. Table 33 shows this increased cost spread and the increased consumption of feedstuffs and private pasture. It is interesting to note that even though there is an equal difference in mature weight from the 1,200 lb. cow to the 1,000 lb. cow and the 1,400 lb. cow, consumption and costs are not equal. On this resource base the total cost difference between the 1,000 and 1,200 lb. cows is greater than between the 1,400 and 1,200 lb. cows.

Table 30. Resource 2 Feed and Forage Consumption and Cost Comparisons at Federal Rates

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	692.00	692.00	692.00	0.00	0.00
Total Fixed Cow Cost	*$ 98,759.64*	*$ 98,759.64*	*$ 98,759.64*	*$ -*	*$ -*
			Feedstuff/Tons		
Cake	0.00	0.00	0.00	0.00	0.00
Alfalfa	138.44	205.60	285.55	(67.16)	79.94
Grass Hay	734.40	796.18	836.17	(61.78)	39.99
Total Tons	*872.84*	*1001.78*	*1121.72*	*(128.94)*	*119.94*
			Feedstuff/Costs		
Cake Cost	$ -	$ -	$ -	$ -	$ -
Alfalfa Cost	$ 22,928.43	$ 34,051.95	$ 47,292.40	$ (11,123.51)	$ 13,240.45
Grass Hay Cost	$ 88,392.38	$ 95,828.34	$ 100,641.59	$ (7,435.96)	$ 4,813.25
Total Feedstuff Cost	*$ 111,320.82*	*$ 129,880.28*	*$ 147,933.99*	*$ (18,559.47)*	*$ 18,053.71*
			Grazed Forage		
BLM	1250	1250	1250	0	0
Spring Meadow	833	956	1071	(124)	115
USFS	2368	2368	2368	0	0
Fall Meadow	583	669	749	(86)	80
Breeding Pasture	222	252	282	(30)	30
BH Range	249	279	312	(30)	33
Total AUMs	*5505*	*5774*	*6032*	*(270)*	*258*
			Grazed Forage Costs		
BLM Cost	$ 17,937.50	$ 17,937.50	$ 17,937.50	$ -	$ -
Spring Meadow Cost	$ 24,984.00	$ 28,690.20	$ 32,143.80	$ (3,706.20)	$ 3,453.60
USFS Cost	$ 33,980.80	$ 33,980.80	$ 33,980.80	$ -	$ -
Fall Meadow Cost	$ 17,484.00	$ 20,065.20	$ 22,468.80	$ (2,581.20)	$ 2,403.60
Breeding Past. Cost	$ 6,660.00	$ 7,560.00	$ 8,460.00	$ (900.00)	$ 900.00
Bred Heifer Past. Cost	$ 7,470.00	$ 8,370.00	$ 9,360.00	$ (900.00)	$ 990.00
Total Grazed Forage Cost	*$ 108,516.30*	*$ 116,603.70*	*$ 124,350.90*	*$ (8,087.40)*	*$ 7,747.20*
Total Feed Costs	$ 219,837.12	$ 246,483.98	$ 272,284.89	$ (26,646.87)	$ 25,800.91
Total Costs	**$318,596.76**	**$345,243.62**	**$371,044.53**	**$ (26,646.87)**	**$ 25,800.91**

Table 31. Resource 2 Net Return Comparison at Federal Rates

Cow Weight	1000 lb.	1200 lb.	1400 lb.	Difference from 1,200 lb. Cow Herd 1000-1200	1400-1200
Total Revenue	$ 348,466.78	$ 375,601.49	$ 407,010.15	$ (27,134.70)	$ 31,408.66
Total Costs	$ 318,596.76	$ 345,243.62	$ 371,044.53	$ (26,646.87)	$ 25,800.91
Net Return	*$ 29,870.03*	*$ 30,357.86*	*$ 35,965.62*	*$ (487.83)*	*$ 5,607.76*
Number of Reproducing Animals					
	592	592	592	0	0
Profit Per Reproducing Animal					
Revenue Per cow	$ 588.63	$ 634.46	$ 687.52	$ (45.84)	$ 53.06
Costs Per Cow	$ 538.17	$ 583.18	$ 626.76	$ (45.01)	$ 43.58
Net Return Per Cow	**$ 50.46**	**$ 51.28**	**$ 60.75**	**$ (0.82)**	**$ 9.47**

The condition of resource base 3 has caused cost to increase to the point where the 1,400 lb. cow under current public land grazing policy is no longer the optimal cow. Table 34 shows the profit/loss for each weight class of cattle. On resource base 3 the 1,000 lb. has the lowest cost and the smallest loss. Total losses are reduced $8,507 by running a 1,000 lb. cow, versus a 1,400 lb. cow, or $14.48 per head.

Resource Base 3 Net Return/Loss Swing

The Net Return/loss swing in this model is very different from the other resource bases. Table 35 shows the swing of $955 between the 1,000 lb. cow herds under the two different policies. This difference is due to the change in cattle numbers from 680 head when charged on an AUE basis to 592 head under the current policy. This data indicates that the current public land grazing policy has little or no effect on the size of cattle a producer chooses to run on this resource base.

Table 32. Resource Base 2 Net Return Swing with Federal Policy Change

	Public Grazing Policy		
	$/AUE	$/Cow or Cow-Calf Pair	*Difference With Policy Change*
	1000 lb. Cows		
Total Revenue	$ 399,911.68	$ 348,466.78	$ 51,444.89
Total Costs	$ 365,025.83	$ 318,596.76	$ 46,429.07
Total net Return	*$ 34,885.84*	*$ 29,870.03*	*$ 5,015.82*
	Number of Reproducing Animals		
	680	592	88
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 588.11	$ 588.63	$ (0.52)
Costs Per Cow	$ 536.80	$ 538.17	$ (1.37)
Net Return Per Cow	**$ 51.30**	**$ 50.46**	**$ 0.85**
	1200 lb. Cows		
Total Revenue	$ 375,601.49	$ 375,601.49	$ -
Total Costs	$ 352,344.87	$ 345,243.62	$ 7,101.24
Total Net Return	*$ 23,256.62*	*$ 30,357.86*	*$ (7,101.24)*
	Number of Reproducing Animals		
	592	592	0
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 634.46	$ 634.46	$ -
Costs Per Cow	$ 595.18	$ 583.18	$ 12.00
Net Return Per Cow	**$ 39.28**	**$ 51.28**	**$ (12.00)**
	1400 lb. Cows		
Total Revenue	$ 362,838.50	$ 407,010.15	$ (44,171.64)
Total Costs	$ 343,445.19	$ 371,044.53	$ (27,599.34)
Total Net Return	*$ 19,393.31*	*$ 35,965.62*	*$ (16,572.30)*
	Number of Reproducing Animals		
	528	592	-64
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 687.19	$ 687.52	$ (0.32)
Costs Per Cow	$ 650.46	$ 626.76	$ 23.70
Net Return Per Cow	**$ 36.73**	**$ 60.75**	**$ (24.02)**

Table 33. Resource 3 Feed and Forage Consumption and Cost Comparisons at Federal Rates

				Difference from 1,200 lb. Cow Herd	
Cow Weight	1000 lb.	1200 lb.	1400 lb.	1000-1200	1400-1200
All Animals	692.00	692.00	692.00	0.00	0.00
Total Fixed Cow Cost	*$ 103,949.64*	*$ 103,949.64*	*$ 103,949.64*	*$ -*	*$ -*
			Feedstuff/Tons		
Cake	0.00	0.00	0.00	0.00	0.00
Alfalfa	138.44	205.60	285.55	(67.16)	79.94
Grass Hay	1238.70	1372.61	1480.40	(133.91)	107.79
Total Tons	*1377.14*	*1578.21*	*1765.94*	*(201.07)*	*187.74*
			Feedstuff/Costs		
Cake Cost	$ -	$ -	$ -	$ -	$ -
Alfalfa Cost	$ 22,928.43	$ 34,051.95	$ 47,292.40	$ (11,123.51)	$ 13,240.45
Grass Hay Cost	$ 149,089.93	$ 165,206.85	$ 178,180.51	$ (16,116.92)	$ 12,973.66
Total Feedstuff Cost	*$ 172,018.36*	*$ 199,258.80*	*$ 225,472.91*	*$ (27,240.43)*	*$ 26,214.11*
			Grazed Forage		
BLM	0	0	0	0	0
Spring Meadow	583	669	749	(86)	80
USFS	2368	2368	2368	0	0
Fall Meadow	583	669	749	(86)	80
Breeding Pasture	222	252	282	(30)	30
BH Range	249	279	312	(30)	33
Total AUMs	*4005*	*4237*	*4460*	*(232)*	*223*
			Grazed Forage Costs		
BLM Cost	$ -	$ -	$ -	$ -	$ -
Spring Meadow Cost	$ 17,484.00	$ 20,065.20	$ 22,468.80	$ (2,581.20)	$ 2,403.60
USFS Cost	$ 33,980.80	$ 33,980.80	$ 33,980.80	$ -	$ -
Fall Meadow Cost	$ 17,484.00	$ 20,065.20	$ 22,468.80	$ (2,581.20)	$ 2,403.60
Breeding Past. Cost	$ 6,660.00	$ 7,560.00	$ 8,460.00	$ (900.00)	$ 900.00
Bred Heifer Past. Cost	$ 7,470.00	$ 8,370.00	$ 9,360.00	$ (900.00)	$ 990.00
Total Grazed Forage Cost	*$ 83,078.80*	*$ 90,041.20*	*$ 96,738.40*	*$ (6,962.40)*	*$ 6,697.20*
Total Feed Costs	$ 255,097.16	$ 289,300.00	$ 322,211.31	$ (34,202.83)	$ 32,911.31
Total Costs	**$ 359,046.80**	**$ 393,249.64**	**$ 426,160.95**	**$ (34,202.83)**	**$ 32,911.31**

Table 34. Resource 3 Net Return Comparison at Federal Rates

Cow Weight	1000 lb.	1200 lb.	1400 lb.	Difference from 1,200 lb. Cow Herd: 1000-1200	Difference from 1,200 lb. Cow Herd: 1400-1200
Total Revenue	$ 348,466.78	$ 375,601.49	$ 407,010.15	$ (27,134.70)	$ 31,408.66
Total Costs	$ 359,046.80	$ 393,249.64	$ 426,160.95	$ (34,202.83)	$ 32,911.31
Net Return	*$ (10,580.02)*	*$ (17,648.15)*	*$ (19,150.80)*	*$ 7,068.13*	*$ (1,502.65)*
Number of Reproducing Animals					
	592	592	592	0	0
Profit Per Reproducing Animal					
Revenue Per Cow	$ 588.63	$ 634.46	$ 687.52	$ (45.84)	$ 53.06
Costs Per Cow	$ 606.50	$ 664.27	$ 719.87	$ (57.78)	$ 55.59
Net Return Per Cow	**$ (17.87)**	**$ (29.81)**	**$ (32.35)**	**$ 11.94**	**$ (2.54)**

Table 35. Resource Base 3 Net Return Swing with Federal Policy Change

	Public Grazing Policy		
	$/AUE	$/Cow or Cow-Calf Pair	*Difference With Policy Change*
	1000 lb. Cows		
Total Revenue	$ 399,911.68	$ 348,466.78	$ 51,444.89
Total Costs	$ 411,447.60	$ 359,046.80	$ 52,400.80
Total Net Return	*$ (11,535.93)*	*$ (10,580.02)*	*$ (955.91)*
	Number of Reproducing Animals		
	680	592	88
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 588.11	$ 588.63	$ (0.52)
Costs Per Cow	$ 605.07	$ 606.50	$ (1.43)
Net Return Per Cow	**$ (16.96)**	**$ (17.87)**	**$ 0.91**
	1200 lb. Cows		
Total Revenue	$ 375,601.49	$ 375,601.49	$ -
Total Costs	$ 397,660.25	$ 393,249.64	$ 4,410.62
Total Net Return	*$ (22,058.77)*	*$ (17,648.15)*	*$ (4,410.62)*
	Number of Reproducing Animals		
	592	592	0
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 634.46	$ 634.46	$ -
Costs Per Cow	$ 671.72	$ 664.27	$ 7.45
Net Return Per Cow	**$ (37.26)**	**$ (29.81)**	**$ (7.45)**
	1400 lb. Cows		
Total Revenue	$ 363,470.23	$ 407,010.15	$ (43,539.91)
Total Costs	$ 388,618.09	$ 426,160.95	$ (37,542.86)
Total Net Return	*$ (25,147.86)*	*$ (19,150.80)*	*$ (5,997.05)*
	Number of Reproducing Animals		
	528	592	-64
	Profit Per Reproducing Animal		
Revenue Per Cow	$ 688.39	$ 687.52	$ 0.87
Costs Per Cow	$ 736.02	$ 719.87	$ 16.15
Net Return Per Cow	**$ (47.63)**	**$ (32.35)**	**$ (15.28)**

CHAPTER 6

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Since there is freedom of entry and exit in the cow calf industry, cow-calf producers are price takers, each producer is a relatively small portion of the market, and every producer in the industry is producing the same product “CALF,” competition in the cow-calf industry is near perfect. Since the beef industry is such a competitive industry there is a constant need for efficiency improvements. One such opportunity is for producers to select the most efficient cow size for their operation.

Where the majority of expenses for an operation are in the cows’ feed costs, matching the cow to the environment is increasingly critical to ensure optimal feed efficiency. Furthermore, reproductive efficiency is also important since the producer’s livelihood depends on pounds of calf sold and each live calf weaned increases revenue for the operation. It is also important to realize the difference in the price received for different weights of calves especially when considering the number of cows an operation can sustain based on her mature body weight.

There are many variables in determining the optimal cow size. Some of the unanswered questions are: Does one cow size fit all situations? Does each resource base or type have a unique optimal cow size? Do public grazing fees have an impact on cow size selected?

There is diversity in the resources available in the Intermountain West. Some operations are able to graze their mature cows the entire calendar year. Other operations are not as fortunate and either grazing is not available because of snow cover or the lack of pasture or public permits. Some of these operations may have to feed cattle up to six months of the year. There is also diversity in the range of cow sizes since each producer has different opinions and goals. It would be nearly impossible to model each combination of resources and cow sizes. So, three typical resource bases were modeled.

The three resource base types modeled were based on the forage available for grazing and were as follows: resource base 1) areas where the mature cow herd is fed little or no hay; resource base 2) areas where the mature cow herd is fed hay roughly 3 months; and, resource base 3) areas where the mature cow herd is fed hay roughly 6 months. Also, three specific mature cow sizes were chosen. The optimal cow size on any specific ranch may not be one of these weights, but these weights were used to give a general comparison of large, medium, and small-framed cattle. The three cow sizes used were 1,000 lbs. (small frame), 1,200 lbs. (medium frame) and 1,400 lbs. (large frame).

The objective of this thesis was to determine the optimal cow size on three different resource bases available and to determine if the current method of charging for grazing on public land has an effect on cow size. The specific objectives were:

1. Identify the economically optimum cow size (1,000, 1,200 or 1,400 lbs.) for each of the three basis ranch types in Utah (no winter feeding, three months feeding, and six months feeding) and

3. Determine if the practice used by the BLM, the USFS, and the Utah State Lands of charging for grazing on public range on a per head basis rather than a true AUM basis impacts the optimal cow size.

Rations were balanced for each cow size on each resource base to ensure adequate nutrition throughout the year. Next careful budgeting was undertaken to reflect different nutritional requirements for different cow size and to account for resources available in different resource scenarios. Cow nutritional needs were calculated on a true AUE for grazing and alternatively on a per head basis which is typical under current federal and state grazing leases. Linear programming was then used to solve for optimal cow size on each resource base.

A basic LP model was developed using industry cattle production benchmarks, rations that were balanced for each weight and type of cattle on each resource base, and five-year average prices for feedstuffs and cattle sales. After the initial LP solution was obtained, several other LP models were run to illustrate the difference when resource bases change and test if the current policy had an influence in cow size selected by producers.

Results of the Linear Programming Models

When all grazing fees are charged on a true AUE basis, the smaller cows generate the greatest net returns on each of the three resource bases. All three resource bases were able to carry 74 more small cows than medium cows and 128 more small cows than large cows. Even though revenue per cow was lower for the smaller cow, costs were also lower per head on each of the resource bases. Being able to run more, smaller cows, combined with their reduced costs per head, more than offset the lower revenue per head from selling lighter weight calves.

The lower per head cost of the smaller cow indicates that they more efficiently used the feed they consume than the larger framed cattle. This research also shows, even though larger cows wean larger calves and generate more revenue per head, an operation cannot sustain a large enough quantity of these cattle to offset the per head costs to surpass or equal the net returns of the smaller cattle.

When grazing fees for public grazing permits are charged on a per head basis similar to the federal and state grazing leases, the large cows generated the greatest net returns on resource base 1 and resource base 2. However, the smaller cow generates the greatest net returns on resource base 3. The resource bases when public grazing fees are charged on a per head basis will sustain an equal number of cattle of any size. When public grazing fees are charged in this manner the increase in revenue from selling heavier calves from large cows is greater than the increase in the feed cost.

The smaller cow should still be used on resource base 3. The increased feed costs of the large cows due to the lack of graze are too great to be offset by the increased revenue from the sale of larger calves.

This research indicates that the current method of charging for federal and state grazing permits does, in fact, have an impact on the cow size selected by producers on certain resource bases. The exact point where increased revenue from the larger calves no longer offsets the increased cost of running large cows is not defined here. It is also indicated that even though public grazing is cheaper for the larger cow when charged on a per head basis, that the smaller cow still has a lower total per head cost.

Implications

The results of this thesis strongly suggests that if producers are charged for grazing public lands on an AUE basis that a 1,000 lb. cow would generate the greatest return on all three resource bases. However, in reality producers are charged on a per head basis for grazing their cattle on public lands. This current policy from the perspective of strictly profit generation that the 1,400 lb. cow would be best option for resource bases 1 and 2. This suggests that the current policy does play a part in the cow size that is selected by producers on these two resource bases. However, on resource base 3, 1,000 lb. cow loses the least amount of money. The results also suggest the current policy has little or no effect on cow size selected by producers on resource base 3.

In this and other research, it has been shown that body weight effects dry matter consumption and indicates that charging for grazing fees on a per head basis is not an accurate method of charging for the amount of forage removed and could have a negative effect on range condition. When considering charging for the actual amount of forage that is removed from the range charging on an AUE basis is a better representation of charging for the amount of forager moved and could possibly have a positive effect on range condition if implemented correctly since it would be a more accurate method of managing forage removal.

Additional Research

This thesis did not consider the option of holding all or part of the calf crop over the winter and partially through the summer as stocker cattle. This option would increase the desire for a high yearling weight which is correlated with mature weight. This option on some operations may be a method to add value to the calf crop while increasing profits.

This research could be taken further when considering the option to retain ownership of cattle in the feedlot. These options could have a large impact on the optimal cow size. Further research could also be done to determine if there is a resource base between resource base 2 and 3 where a moderate size cow would be optimal. Further modeling could be done to determine the effects on the optimal cow size when the cow's nutritional requirements are not met.

Additional research could be done modeling risk on a cow calf operation. Specifically, drought risk or other natural reductions in the amount of forage available such as fire and grasshopper infestations.

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APPEDCIES

APPENDIX A

BASE RANCH MONTHLY RUNNING INVENTORY

Table A 1. INVENETORY

Month	Calves	Replacement Heifers	1st Calf Heifers	Mature Cows	Bulls
Nov		100	91	500	22
Dec		100	91	500	22
Jan		100	91	499	22
Feb		100	91	499	22
Mar		100	91	498	22
Apr		100	91	498	22
May	550	100	91	498	28
Jun	546	99	91	497	28
Jul	543	99	91	497	28
Aug	540	99	90	496	22
Sep	537	99	90	496	22
Oct	533	99	90	495	22
Transfers					
Open Females		8	11	32	
Pregnant Females		91	79	464	
Replacement Females Needed				79	
Weaned Calves	533		82	451	
Culled Pregnant Females				43	
Females Retained				421	
Death Loss	16	1	1	5	

APPENDIX B

COW DIETS BALANCED USING THE OSU COWCULATOR

Table B 1. 1,000 lb. Cow Resource Base 1

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	316500							316500	21.1
31	Dec	327050							327050	21.1
31	Jan	317600	11550						329150	21.2
28	Feb	282800	15400						298200	21.3
31	Mar	313100	17050						330150	21.3
30	Apr			643500					643500	42.9
31	May					899000			899000	58.0
30	Jun						637500		637500	42.5
31	Jul						641700		641700	41.4
31	Aug						641700		641700	41.4
30	Sep						621000		621000	41.4
31	Oct							759500	759500	49.0
365	**Total**	1557050	44000	643500	0	899000	2541900	759500	6444950	
Average Daily Intake Annually										35

Table B 2. 1,200 lb. Cow Resource Base 1

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	366000							366000	24.4
31	Dec	378200							378200	24.4
31	Jan	364550	15225						379775	24.5
28	Feb	323400	15225						338625	24.2
31	Mar	358050	15225						373275	24.1
30	Apr			727500					727500	48.5
31	May					1015250			1015250	65.5
30	Jun						720000		720000	48.0
31	Jul						725400		725400	46.8
31	Aug						725400		725400	46.8
30	Sep						702000		702000	46.8
31	Oct							860250	860250	55.5
365	**Total**	1790200	45675	727500	0	1015250	2872800	860250	7311675	
Average Daily Intake Annually										40

Table B 3. 1,400 lb. Cow Resource Base 1

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	408000							408000	27.2
31	Dec	421600							421600	27.2
31	Jan	409000	15750						424750	27.4
28	Feb	364000	21000						385000	27.5
31	Mar	403000	23250						426250	27.5
30	Apr			807000					807000	53.8
31	May					1128400			1128400	72.8
30	Jun						801000		801000	53.4
31	Jul						812200		812200	52.4
31	Aug						812200		812200	52.4
30	Sep						786000		786000	52.4
31	Oct							961000	961000	62.0
365	**Total**	2005600	60000	807000	0	1128400	3211400	961000	8173400	
Average Daily Intake Annually										45

Table B 4. 1,000 lb. Cow Resource Base 2

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	316500							316500	21.1
31	Dec	327050							327050	21.1
31	Jan	105500			239925				345425	22.3
28	Feb				319900				319900	22.9
31	Mar				354175				354175	22.9
30	Apr				196875	431250			628125	41.9
31	May					891250			891250	57.5
30	Jun						622500		622500	41.5
31	Jul						613800		613800	39.6
31	Aug						613800		613800	39.6
30	Sep						594000		594000	39.6
31	Oct							719200	719200	46.4
365	**Total**	749050	0	0	1110875	1322500	2444100	719200	6345725	
Average Daily Intake Annually										35

Table B 5. 1,200 lb. Cow Resource Base 2

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	366000							366000	24.4
31	Dec	378200							378200	24.4
31	Jan	122000			275625				397625	25.7
28	Feb				367500				367500	26.3
31	Mar				406875				406875	26.3
30	Apr				217500	487500			705000	47.0
31	May					1007500			1007500	65.0
30	Jun						705000		705000	47.0
31	Jul						697500		697500	45.0
31	Aug						697500		697500	45.0
30	Sep						675000		675000	45.0
31	Oct							818400	818400	52.8
365	Total	866200	0	0	1267500	1495000	2775000	818400	7222100	
Average Daily Intake Annually										40

Table B 6. 1,400 lb. Cow Resource Base 2

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov	408000							408000	27.2
31	Dec	421600							421600	27.2
31	Jan	136000			308700				444700	28.7
28	Feb				411600				411600	29.4
31	Mar				455700				455700	29.4
30	Apr				241875	542250			784125	52.3
31	May					1120650			1120650	72.3
30	Jun						780000		780000	52.0
31	Jul						778100		778100	50.2
31	Aug						778100		778100	50.2
30	Sep						753000		753000	50.2
31	Oct							911400	911400	58.8
365	**Total**	965600	0	0	1417875	1662900	3089200	911400	8046975	
Average Daily Intake Annually										44

Table B 7. 1,000 lb. Cow Resource Base 3

Head	500				Pounds of Feed/Forage					
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov				348000				348000	23.2
31	Dec				359600				359600	23.2
31	Jan				354350				354350	22.9
28	Feb				317800				317800	22.7
31	Mar				351850				351850	22.7
30	Apr				387000				387000	25.8
31	May					880400			880400	56.8
30	Jun						615000		615000	41.0
31	Jul						607600		607600	39.2
31	Aug						607600		607600	39.2
30	Sep						588000		588000	39.2
31	Oct							713000	713000	46.0
365	**Total**	0	0	0	2118600	880400	2418200	713000	6130200	
Average Daily Intake Annually										34

Table B 8. 1,200 lb. Cow Resource Base 3

Head	500	Pound of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov				400500				400500	26.7
31	Dec				413850				413850	26.7
31	Jan				406500				406500	26.2
28	Feb				364000				364000	26.0
31	Mar				403000				403000	26.0
30	Apr				435000				435000	29.0
31	May					1007500			1007500	65.0
30	Jun						696000		696000	46.4
31	Jul						689750		689750	44.5
31	Aug						689750		689750	44.5
30	Sep						667500		667500	44.5
31	Oct							806000	806000	52.0
365	Total	0	0	0	2422850	1007500	2743000	806000	6979350	
Average Daily Intake Annually										38

Table B 9. 1,400 lb. Cow Resource Base 3

Head	500	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov				448500				448500	29.9
31	Dec				463450				463450	29.9
31	Jan				455050				455050	29.4
28	Feb				407400				407400	29.1
31	Mar				451050				451050	29.1
30	Apr				483000				483000	32.2
31	May					1108250			1108250	71.5
30	Jun						772500		772500	51.5
31	Jul						767250		767250	49.5
31	Aug						767250		767250	49.5
30	Sep						742500		742500	49.5
31	Oct							899000	899000	58.0
365	**Total**	0	0	0	2708450	1108250	3049500	899000	7765200	
Average Daily Intake Annually										43

APPENDIX C

FIRST-CALF HEIFER DIETS USING COWBYTES

Table C 1. First-Calf Heifer with 1,000 lb. Mature Wt. Potential

Head	92			Pounds of Feed/Forage					
Days	Month	Alfalfa	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov		60895				60895	0.7	22.1
31	Dec	5170	54762				59931	0.5	21.0
31	Jan	19451	42495				61947	0.5	21.7
28	Feb	24095	32857				56952	0.4	22.1
31	Mar	52133	12530				64663	0.3	22.7
30	Apr	50381	17611				67992	0.1	24.6
31	May			145010			145010	0.4	50.8
30	Jun				101200		101200	0	36.7
31	Jul				106457.143		106457	0.2	37.3
31	Aug				105142.857		105143	0.3	36.9
30	Sep				100323.81		100324	0.4	36.3
31	Oct					122228.5714	122229	0.2	42.9
365	**Total**	151230	221150	145010	413124	122229	***1052743***		
Average Daily Intake Annually									**31**

Table C 2. First-Calf Heifer with 1,200 lb. Mature Wt. Potential

Head	92			Pounds of Feed/Forage					
Days	Month	Alfalfa	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov		68343				68343	0.7	24.8
31	Dec	8105	64400				72505	0.7	25.4
31	Jan	12968	60895				73863	0.7	25.9
28	Feb	38114	26724				64838	0.5	25.2
31	Mar	73162					73162	0.5	25.7
30	Apr	78857					78857	0.6	28.6
31	May			166038			166038	0.5	58.2
30	Jun				116095		116095	0	42.1
31	Jul				122229		122229	0.3	42.9
31	Aug				120914		120914	0.4	42.4
30	Sep				116095		116095	0.5	42.1
31	Oct					141067	141067	0.3	49.5
365	**Total**	211206	220362	166038	475333	141067	***1214006***		
Average Daily Intake Annually									**36**

Table C 3. First-Calf Heifer with 1,400 lb. Mature Wt. Potential

Head	92			Pounds of Feed/Forage					
Days	Month	Alfalfa	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov		75790				75790	0.8	27.5
31	Dec	6484	73600				80084	0.8	28.1
31	Jan	17830	64400				82230	0.8	28.8
28	Feb	38114	38552				76667	0.8	29.8
31	Mar	81486					81486	0.5	28.6
30	Apr	87181					87181	0.6	31.6
31	May			180495			180495	0.6	63.3
30	Jun				126610		126610	0	45.9
31	Jul				133619		133619	0.3	46.9
31	Aug				131867		131867	0.4	46.2
30	Sep				126610		126610	0.5	45.9
31	Oct					154210	154210	0.3	54.1
365	**Total**	231095	252343	180495	518705	154210	***1336848***		
Average Daily Intake Annually									**40**

APPENDIX D

REPLACEMENT HEIFER DIETS USING COWBYTES

Table D 1. Replacement Heifer with 1,000 lb. Mature Wt. Potential

head	100	Pounds of Feed/Forage							
Days	Month	Alfalfa	Grass Hay	Breeding Pasture	Bred Heifer Pasture	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov	20471	19796				40267	0.8	27.4
31	Dec	21866	21224				43091	0.8	28.4
31	Jan	20471	24082				44553	0.8	29.3
28	Feb	19122	22449				41571	0.8	30.3
31	Mar	21866	25714				47581	0.8	31.3
30	Apr	22181	24898				47079	0.8	32.0
31	May			91020			91020	1.6	59.9
30	Jun			93061			93061	1.5	63.3
31	Jul			100816			100816	1.5	66.4
31	Aug				66531		66531	0.6	43.8
30	Sep				65714		65714	0.6	44.7
31	Oct					125306	125306	0.3	82.5
365	**Total**	125978	138163	284898	132245	125306	***806591***		
Average Daily Intake Annually									**22**

Table D 2. Replacement Heifer with 1,200 lb. Mature Wt. Potential

Head	100			Pounds of Feed/Forage					
Days	Month	Alfalfa	Grass Hay	Breeding Pasture	Bred Heifer Pasture	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov	30000	15000				45000	0.8	32.6
31	Dec	31739	15000				46739	0.8	32.8
31	Jan	33913	18565				52478	0.8	36.8
28	Feb	31304	16261				47565	0.8	36.9
31	Mar	36522	18043				54565	0.8	38.3
30	Apr	36522	18130				54652	0.8	39.6
31	May			102609			102609	1.6	72.0
30	Jun			105217			105217	1.5	76.2
31	Jul			113478			113478	1.5	79.6
31	Aug				74783		74783	0.6	52.4
30	Sep				73913		73913	0.6	53.6
31	Oct					140000	140000	0.3	98.2
365	**Total**	200000	101000	321304	148696	140000	***911000***		
Average Daily Intake Annually									**25**

Table D 3. Replacement Heifer with 1,400 lb. Mature Wt. Potential

Head	100			Pound of Feed/Forage					
Days	Month	Alfalfa	Grass Hay	Breeding Pasture	Bred Heifer Pasture	Fall Meadow	Total	ADG	As Fed Daily Intake
30	Nov	51304					51304	0.8	37.2
31	Dec	52609					52609	0.8	36.9
31	Jan	56957					56957	0.8	39.9
28	Feb	53913					53913	0.8	41.9
31	Mar	62609					62609	0.8	43.9
30	Apr	62609					62609	0.8	45.4
31	May			116957			116957	1.6	82.0
30	Jun			117826			117826	1.5	85.4
31	Jul			127826			127826	1.5	89.6
31	Aug				83913		83913	0.6	58.8
30	Sep				82609		82609	0.6	59.9
31	Oct					156087	156087	0.3	109.5
365	**Total**	340000	0	362609	166522	156087	***1025217***		
Average Daily Intake Annually									**28**

APPENDIX E

BULL DIETS USNIG COWBYTES

Table E 1. Resource Base 1 Bull Diet

Head	28	Pounds of Feed/Forage								
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov								0	0.0
31	Dec								0	0.0
31	Jan								0	0.0
28	Feb								0	0.0
31	Mar								0	0.0
30	Apr								0	0.0
31	May								0	0.0
30	Jun						48160		48160	80.3
31	Jul						49840		49840	80.4
31	Aug						49840		49840	80.4
30	Sep						48160		48160	80.3
31	Oct							58800	58800	94.8
365	Total	0	0	0	0	0	196000	58800	254800	
Average Daily Intake Annually										25

Table E 2. Resource Base 2 Bull Diet

Head	28				Pounds of Feed/Forage					
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov								0	0.0
31	Dec								0	0.0
31	Jan				21243.6				21243.6	34.3
28	Feb				28560				28560	51.0
31	Mar				31360				31360	50.6
30	Apr				15260				15260	25.4
31	May								0	0.0
30	Jun						48160		48160	80.3
31	Jul						49840		49840	80.4
31	Aug						49840		49840	80.4
30	Sep						48160		48160	80.3
31	Oct							58800	58800	94.8
365	Total	0	0	0	96423.6	0	196000	58800	351223.6	
Average Daily Intake Annually										34

Table E 3. Resource Base 3 Bull Diet

Head	28				Pounds of Feed/Forage					
Days	Month	Winter BLM	30% Cake	Spring BLM	Grass Hay	Spring Meadow	USFS	Fall Meadow	Total	As Fed Daily Intake
30	Nov				30520				30520	50.9
31	Dec				31360				31360	50.6
31	Jan				31360				31360	50.6
28	Feb				28560				28560	51.0
31	Mar				31360				31360	50.6
30	Apr				30520				30520	50.9
31	May								0	0.0
30	Jun						48160		48160	80.3
31	Jul						49840		49840	80.4
31	Aug						49840		49840	80.4
30	Sep						48160		48160	80.3
31	Oct							58800	58800	94.8
365	Total	0	0	0	183680	0	196000	58800	438480	
Average Daily Intake Annually										43

APPENDIX F

BASE MODEL

FCH = First-Calf Heifers

Rep Hef = Replacement Heifers

BLM = BLM Range

SM = Spring Meadow

USFS = USFS Range

FM = Fall Meadow

BP = Breeding Pasture

BHR = Bred Heifer Range

DDG = Dried Distillers Grain

ALF = Alfalfa

GH = Grass Hay

SS = Small Steers born to 1,000 lb. Cows

MS = Medium Steers born to 1,200 lb. Cows

LS = Large Steers born to 1,400 lb. Cows

SH = Small Heifers born to 1,000 lb. Cows

MH = Medium Heifers born to 1,200 lb. Cows

LH = Large Heifers born to 1,400 lb. Cows

SCC = 1,000 lb. Cull Cow

MCC = 1,200 lb. Cull Cow

LCC = 1,400 lb. Cull Cow

SCH = Small Cull First-Calf Heifers

MCH = Medium Cull First-Calf Heifers

LCH = Large Cull First-Calf Heifers

SCR = Small Cull Replacement Heifers

MCR = Medium Cull Replacement Heifers

LCR = Large Cull Replacement Heifers

BLM1 = AUM’s available on BLM range

SM1 = AUM’s available on spring meadow

USFS1 = AUM’s available on USFS range

FM1 = AUM’s available on fall meadow

BP1 = AUM’s available on the breeding pasture

BHR1 = AUM’s available on the bred heifer range

DDG1 = Available DDG

ALF1 = Available Alfalfa

GH1 = Grass hay available

BLM2 = BLM AUM’s required per head

SM2 = Spring meadow AUM’s required per head

USFS2 = USFS AUM’s required per head

FM2 = Fall meadow AUM’s required per head

BP2 = Breeding pasture AUM’s required per head

BHR2 = Bred heifer range AUM’s required per head

DDG2 = Tons of DDG’s (Dried Distillers Grains) required per head

Alf2 = Tons of alfalfa required per head

GH2 = Tons of grass hay required per head

SS1 = Small steers weaned and sold

MS1 = Medium steers weaned and sold

LS1 = Large steers weaned and sold

SH1 = Small heifers weaned and sold

MH1 = Medium heifers weaned and sold

LH1 = Large heifers weaned and sold

SCC = Small cull cows

MCC = Medium cull cows

LCC = Large cull cows

SCH = Small cull first-calf heifers

MCH = Medium cull first-calf heifers

LCH = Large cull first-calf heifers

SCR = Small cull replacement heifers

MCR = Medium cull replacement heifers

LCR = Large cull replacement heifers

TSH = Transfer of small weaned heifers to the small replacement heifer herd

TMH = Transfer of medium weaned heifers to the medium replacement heifer herd

TLH = Transfer of large weaned heifers to the large replacement heifer herd

TSR = Transfer of small replacement heifers to small first-calf heifer herd

TMR = Transfer of medium replacement heifers to medium first-calf heifer herd

TLR = Transfer of large replacement heifers to large first-calf heifer herd

RHS = Right hand side

Base Model	1000lb	1200lb	1400lb	1000lb	1200lb	1400lb
Resource Base 2	Cows	Cows	Cows	FCH	FCH	FCH
Use of	574	0	0	106	0	0
Cost/Revenue	$ (141.17)	$ (141.17)	$ (141.17)	$ (158.42)	$ (158.42)	$ (158.42)
BLM1	2.500	2.875	3.225			
SM1	1.500	1.725	1.935	0.900	1.020	1.130
USFS1	4.000	4.600	5.160	3.600	4.080	4.520
FM1	1.000	1.150	1.290	0.900	1.020	1.130
BP1						
BHR1						
DDG1						
ALF1				0.820	1.148	1.256
GH1	1.110	1.270	1.420	1.200	1.198	1.371
BLM2	2.500	2.875	3.225			
SM2	1.500	1.725	1.935	0.900	1.020	1.130
USFS2	4.000	4.600	5.160	3.600	4.080	4.520
FM2	1.000	1.150	1.290	0.900	1.020	1.130
BP2						
BHR2						
DDG2						
ALF2				0.820	1.148	1.256
GH2	1.110	1.270	1.420	1.200	1.198	1.371
SS1	-0.450			-0.450		
MS1		-0.450			-0.450	
LS1			-0.450			-0.450
SH1	-0.250			-0.450		
MH1		-0.250			-0.450	
LH1			-0.250			-0.450
SCC	-0.140					
MCC		-0.140				
LCC			-0.140			
SCH				-0.105		
MCH					-0.105	
LCH						-0.105
SCR						
MCR						
LCR						
TSH	-0.200					
TMH		-0.200				
TLH			-0.200			
TSR				1.000		
TMR					1.000	
TLR						1.000

Base Model	1000lb	1200lb	1400lb	Range/Pasture		
Continued	Rep Hef	Rep Hef	Rep Hef	BLM	SM	USFS
Use of	115	0	0	1434.54	955.75	2675.36
Cost/Revenue	$ (136.00)	$ (136.00)	$ (136.00)	$ (14.35)	$ (30.00)	$ (14.35)
BLM1						
SM1						
USFS1						
FM1						
BP1	2.220	2.520	2.820			
BHR1	2.490	2.790	3.120			
DDG1						
ALF1	0.630	1.000	1.700			
GH1	0.690	0.510				
BLM2				-1		
SM2					-1	
USFS2						-1
FM2						
BP2	2.220	2.520	2.820			
BHR2	2.490	2.790	3.120			
DDG2						
ALF2	0.630	1.000	1.700			
GH2	0.690	0.510				
SS1						
MS1						
LS1						
SH1						
MH1						
LH1						
SCC						
MCC						
LCC						
SCH						
MCH						
LCH						
SCR	-0.055					
MCR		-0.055				
LCR			-0.055			
TSH	1.000					
TMH		1.000				
TLH			1.000			
TSR	-0.920					
TMR		-0.920				
TLR			-0.920			

Base Model	Range/Pasture			Feedstuff		
Continued	FM	BP	BHR	DDG	Alf	GH
Use of	668.84	254.77	285.76	0.00	158.88	842.82
Cost/Revenue	$ (30.00)	$ (30.00)	$ (30.00)	$ (228.95)	$ (165.62)	$ (120.36)
BLM1						
SM1						
USFS1						
FM1						
BP1						
BHR1						
DDG1						
ALF1						
GH1						
BLM2						
SM2						
USFS2						
FM2	-1					
BP2		-1				
BHR2			-1			
DDG2				-1		
ALF2					-1	
GH2						-1
SS1						
MS1						
LS1						
SH1						
MH1						
LH1						
SCC						
MCC						
LCC						
SCH						
MCH						
LCH						
SCR						
MCR						
LCR						
TSH						
TMH						
TLH						
TSR						
TMR						
TLR						

Base Model	Steers			Heifers		
Continued	SS	MS	LS	SH	MH	LH
Use of	306	0	0	191	0	0
Cost/Revenue	$ 722.73	$ 752.88	$ 804.39	$ 607.37	$ 658.12	$ 714.43
BLM1						
SM1						
USFS1						
FM1						
BP1						
BHR1						
DDG1						
ALF1						
GH1						
BLM2						
SM2						
USFS2						
FM2						
BP2						
BHR2						
DDG2						
ALF2						
GH2						
SS1	1					
MS1		1				
LS1			1			
SH1				1		
MH1					1	
LH1						1
SCC						
MCC						
LCC						
SCH						
MCH						
LCH						
SCR						
MCR						
LCR						
TSH						
TMH						
TLH						
TSR						
TMR						
TLR						

Base Model	Cows			First-Calf Heifers		
Continued	SCC	MCC	LCC	SCH	MCH	LCH
Use of	80	0	0	11	0	0
Cost/Revenue	$ 605.59	$ 726.71	$ 847.83	$ 743.56	$ 903.88	$ 1,017.46
BLM1						
SM1						
USFS1						
FM1						
BP1						
BHR1						
DDG1						
ALF1						
GH1						
BLM2						
SM2						
USFS2						
FM2						
BP2						
BHR2						
DDG2						
ALF2						
GH2						
SS1						
MS1						
LS1						
SH1						
MH1						
LH1						
SCC	1					
MCC		1				
LCC			1			
SCH				1		
MCH					1	
LCH						1
SCR						
MCR						
LCR						
TSH						
TMH						
TLH						
TSR						
TMR						
TLR						

Base Model	Replacement Heifers			**Max**		
Continued	SCR	MCR	LCR	**Net Return**		
Use of	6	0	0	**$ 34,885.84**		
Cost/Revenue	$ 962.01	$ 1,076.71	$ 847.77			RHS
BLM1				1435	≤	1438
SM1				956	≥	0
USFS1				2675	≤	2675
FM1				669	≥	0
BP1				255	≥	0
BHR1				286	≥	0
DDG1				0	≥	0
ALF1				159	≥	0
GH1				843	≥	0
BLM2				0	≤	0
SM2				0	≤	0
USFS2				0	≤	0
FM2				0	≤	0
BP2				0	≤	0
BHR2				0	≤	0
DDG2				0	≤	0
ALF2				0	≤	0
GH2				0	≤	0
SS1				0	≤	0
MS1				0	≤	0
LS1				0	≤	0
SH1				0	≤	0
MH1				0	≤	0
LH1				0	≤	0
SCC				0	≤	0
MCC				0	≤	0
LCC				0	≤	0
SCH				0	≤	0
MCH				0	≤	0
LCH				0	≤	0
SCR	1			0	≤	0
MCR		1		0	≤	0
LCR			1	0	≤	0
TSH				0	=	0
TMH				0	=	0
TLH				0	=	0
TSR				0	=	0
TMR				0	=	0
TLR				0	=	0