Increased Calf Production and Returns From Improved Range and Livestock Management on a Northern Utah Ranch

Michael H. Ralphs

Utah State University

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INCREASED CALF PRODUCTION AND RETURNS FROM IMPROVED
RANGE AND LIVESTOCK MANAGEMENT ON A
NORTHERN UTAH RANCH
by
Michael H. Ralphs

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Range Science

UTAH STATE UNIVERSITY
Logan, Utah
1977
ACKNOWLEDGMENTS

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Finally, thanks to my parents for their support and encouragement.

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ABSTRACT

Increased Calf Production and Returns from Improved Range and Livestock Management on a Northern Utah Ranch

by

Michael H. Ralphs, Master of Science
Utah State University, 1977

Major Professor: Dr. Frank E. Busby
Department: Range Science

The operating costs for farms and ranches in the United States have increased 81 percent between 1970 and 1976. Calf prices over this same period have fluctuated dramatically and have fallen from a high of $58/cwt in 1973 to a low of $26/cwt in 1975. Since 1973, the increasing operating costs have exceeded the returns generated by the low calf prices and have left operators in a negative financial position. This case study has shown that the operator has increased both the scale and efficiency of his operation through improved livestock husbandry and range improvements, yet has been unable to keep up with the increase in operating costs.

A rest rotation grazing system and associated range improvements were implemented in 1970 on the summer mountain range. The resultant increase in forage production allowed a 45 percent increase in the breeding herd. The meadow hayland and crested wheatgrass pastures were also improved to provide winter and spring forage for the increased number of cows. The calf crop weaned and average
weaning weights increased from 86 percent and 347 pounds in 1970 to 93 percent and 363 pounds in 1976. The total pounds of calf weaned increased 60 percent between 1970 and 1976.

The tremendous increase in beef production was offset by the rampant increase in operating costs. The net return in 1970 was $2,106 but dropped to a loss of -$3,671 in 1976. However, had the operator not increased the level of production while the operating costs increased, his net loss in 1976 would have been -$24,718.

Although the net returns are negative, the increase in returns over the base level of production is positive. The internal rate of return and net present worth of the grazing system and its associated improvements was 25 percent and $95,027 respectively.

The operator has been successful in developing his range and livestock resource and increasing calf production. It is paradoxical that the increase in returns above the base production have rendered the improvements economically profitable yet the combination of increasing operating costs and low livestock prices have produced a negative return from 1974 through 1976.
INTRODUCTION

The conditions of the livestock industry since 1973 have put the rancher in the proverbial position between a "rock and a hard spot." The "rock" has been the accelerating increase in operating costs while the "hard spot" has been the drastic fall in livestock prices caused by the excess inventory of livestock. Many ranchers have incurred net losses during the last 2 years. A survey by Hopkin (1975) of money lenders financing cow-calf and stocker operations revealed that 67 percent of the cattle producers are experiencing some degree of financial difficulty. Hopkin further stated that "if calf prices remain at the low levels of April, 1975, which projections indicate they will, 20 percent of the producers will likely go out of business."

In the past, ranchers have been able to "get by" with average productivity from their cows. But now average productivity won't pay the bills. Higher calf crops and heavier weaning weights are necessary to cover the increasing cost of maintaining the mother cow.

Another way of increasing net income is by economically expanding the operation. The profit margin in the livestock industry is typically very small. Increasing the efficiency of the operation will increase net returns per cow, but increasing the scale of operation is necessary to substantially increase net income. In a situation where the range, pasture and hay lands can be developed, the scale
of operation can be economically increased. However, the level of management must also improve, to maintain an efficient level of productivity while expansion is taking place. Adequate feed to meet the nutrient demands of the entire herd must be provided. Feed supplement programs, early spring pastures, range improvements, grazing systems, and herd health care, as well as effective management strategies must be considered and economically evaluated in selecting the combination that will produce the optimum level of beef production and thus maximize net returns.

Objectives

The general objective of this study was to document the effect of improved range and livestock management on calf production on a northern Utah ranch.

The specific objectives were:

1. Describe the grazing system, range improvements, management strategies, and animal husbandry practices that contributed to increased calf production.

2. Determine the annual productivity of the herd in terms of calf crop weaned, weaning weights, and total pounds of calf weaned.

3. Compare annual returns generated from sale of weaner calves, cull cows and bulls to the annual operating costs to determine the profitability of the operation.
4. Determine the internal rate of return and net present worth of the grazing system and associated range improvements.
Production Efficiency

The objective of any business firm is to get as much output as possible from a given level of expenditure on inputs, or to produce a given level of output for the least expenditure on inputs (Leftwich p.111, 1969). Production efficiency in a commercial cow-calf operation is to raise and sell the greatest amount of beef for a given budget, or to raise and sell a given amount of beef for the least cost of input resources--land, labor and capital. In either case the net return to the operator is maximized. It is assumed that most commercial cow-calf operators have a limited budget. Therefore their objective would be to wean the greatest number of calves (high calf crop) weighing as much as possible (heavy weaning weights) under the constraints of their limited budget.

Percent calf crop and weaning weight are the end products of the breeding herd's reproductive performance. There are many factors and practices that contribute to production efficiency. Minyard (1973) lists several factors which describe the task of the cow:

1. reach sexual maturity at an early age,
2. come into heat promptly after calving,
3. conceive early in the breeding season,
4. produce a calf every 12 months at the desired time of year, and
5. nourish the calf to a heavy weaning weight.
Neumann and Snapp (1969) also include, within the function of production efficiency:

1. the genetic capability of the cow to produce milk,
2. genetic growth ability of the calf,
3. fertility of the cow and bulls, and
4. the distribution and libido of the bulls.

In addition to the above factors that make up production efficiency, Table 1 lists several specific causes of reproductive failure and gives the percent of calf crop that may be lost to each cause.

**Timetable for reproduction**

The gestation period of a cow is 283 days. To maintain a 12-month calving cycle, the cow has 82 days to repair herself, return to estrus, and conceive (Figure 1). The average period from calving to first estrus is 60 days (Kaltenbach, 1973). This period can be reduced through good management and proper nutrition. The estrus cycle of a cow is 21 days. Assuming a cow takes 60 days to return to a regular estrus cycle, this leaves only one or at the most two heat periods in which to breed. This tight time schedule is further complicated by cows which won't conceive at first service.

With mediocre management or inadequate nutrition, many cows will fail to conceive by the beginning of the 12-month reproductive cycle. This doesn't concern some operators. They would "rather have a late calf than no calf at all." But late calves can severely cut into potential profits. For example, if a cow fails to conceive either because of nutrition or low genetic fertility, and goes 21 days
Table 1. Causes of reproductive failure.

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<th>Dunn(^b) Montana (%)</th>
<th>Temple(^c) Southeastern U.S. (%)</th>
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<tr>
<td>a. pneumonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. bloat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. accidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>22</td>
<td>29.5</td>
</tr>
</tbody>
</table>

\(^a\) Neumann and Snapp (1969), p. 129.

\(^b\) Dunn (1975).

\(^c\) Temple (1967).
Fig. 1. Reproductive cycle of a cow.
beyond 12 months before conceiving, the calf she will produce next year will weigh 36 pounds less (1.7 average daily gain x 21 days) than it would have had the cow conceived during the first or second period of estrus following calving. If the cow continues to extend her calving date one estrus cycle or 21 days each year, she will be dry every fifth year, given a 90-day breeding season. Also, her calves would be continually weighing less due to their progressively later birth dates. The lifetime loss of production at age twelve could be 1,354 pounds, or about 29 percent less pounds of beef produced had she maintained a 12-month calving cycle. Table 2 shows the potential weight loss of late calves as compared to early calves and the resultant loss in income.

Table 2. Calving periods and estimated returns.

<table>
<thead>
<tr>
<th>Calving date</th>
<th>Ave. days calving to weaning</th>
<th>Ave. weaning weight</th>
<th>Value of calf (@ $36/cwt)</th>
<th>Operating cost/cow</th>
<th>Return/cow ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-10 to 3-1</td>
<td>237</td>
<td>473</td>
<td>170</td>
<td>127</td>
<td>43</td>
</tr>
<tr>
<td>3-2 to 3-21</td>
<td>217</td>
<td>439</td>
<td>158</td>
<td>127</td>
<td>31</td>
</tr>
<tr>
<td>3-22 to 4-10</td>
<td>197</td>
<td>405</td>
<td>146</td>
<td>127</td>
<td>19</td>
</tr>
<tr>
<td>4-11 to 4-30</td>
<td>177</td>
<td>371</td>
<td>133</td>
<td>127</td>
<td>6</td>
</tr>
<tr>
<td>5-1 to 5-20</td>
<td>157</td>
<td>337</td>
<td>121</td>
<td>127</td>
<td>-6</td>
</tr>
<tr>
<td>5-21 to 6-9</td>
<td>137</td>
<td>303</td>
<td>110</td>
<td>127</td>
<td>-17</td>
</tr>
<tr>
<td>6-10 to 6-29</td>
<td>117</td>
<td>269</td>
<td>96</td>
<td>127</td>
<td>-30</td>
</tr>
</tbody>
</table>

a Wiltbank, 1974.

b Average operating costs expressed in 1976 dollars from Workman (1970), Peryam and Olsen (1975), Stevens (1975), Gray (1970), Kearl (1971), Olsen and Jackson (1975), and Doan (1976).
Critical Nutrition Periods Associated with Reproduction

Most researchers agree that the condition of the cow or her nutritional state, especially during the critical nutrition periods, is a major determinant of her reproduction success. Wiltbank et al. (1965) conducted some of the first controlled experiments to evaluate the effects of nutrition for 1) heifers not reaching puberty, 2) a majority of the 2-year-old first calf cows failing to return to estrus, and 3) a low conception rate among those cows that did cycle.

Many other researchers have since analyzed the effects that various levels of nutrition at specific times of the reproduction cycle have had on all aspects of reproduction. Church (1974) reviewed the literature on the effects of energy on reproduction and summarized his findings by stating that levels of energy less than NRC recommendation during gestation and lactation cause delayed estrus and low conception rates. Wiltbank (1967) concluded that the condition of the cow determined the subsequent calf crop and that a cow should either be in good condition or rapidly gaining weight prior to and during the breeding season.

Most of the reviews and papers cited indicated a deficiency in energy was the leading cause of failure in conceiving or bearing a healthy calf (Wiltbank, 1967; Maynard and Loosli, 1969; Kerchner and Dunn, 1971; Church, 1974; and Clanton and Zimmerman, 1970). Protein, when deficient, caused a decline in fertility, but its effects may be confounded with energy deficiency. Protein deficiency depressed
the intake thus limiting the consumption of dry matter and energy (Wiltbank, 1967; Cook and Harris, 1968; and Clanton and Zimmerman, 1970).

The critical nutritional periods in the reproductive cycle of a beef cow are the last trimester of gestation and the interval between calving and conception (Neumann and Snapp, 1969; Kerchner and Dunn, 1971; and Kalthenback, 1973). Nutrition is also critical in growing out replacement heifers to reach puberty at an early age and to calve as 2-year-olds. Survivability of the calf and its weight gain also depend on the dam's nutrition level during these critical nutrition periods. The following sections will discuss the effect that nutrition has on each of the above mentioned critical periods.

**Last trimester of gestation**

Gestation increases the nutrient requirement above the level required for basic maintenance. Ninety percent of the fetal growth occurs during the last one-third of gestation (Brody, 1945) with the greatest amount of growth occurring during the last month (Neumann and Snapp, 1969). Adequate nutrients must be available for the fetal growth during this period to insure a healthy and vigorous calf. The preparation for milk production is also taking place during this last part of the gestation period (Maynard and Loosli, 1969). These physiological functions combine to increase the nutrient requirement of the cow prior to calving. The length of this critical period extends from a minimum of the last 30 days (Dunn, 1975), to the entire third trimester of gestation (Neumann and Snapp, 1969).
Research suggests that the feed level of the cow during the last 30-90 days has the largest effect on the interval from calving to first estrus. When energy is deficient prior to calving, the cow will take longer to come into heat (Dunn, 1975; Kerchner and Dunn, 1971; and Kearl and Cordingly, 1975). Table 3 presents data from many researchers over different areas of the United States relating feeding level both before and after calving to the reproductive performance of beef cows and heifers. The column entitled "Interval calving to first estrus" reveals that cows and heifers on a restricted energy intake prior to calving took between 6 and 90 days longer to return to estrus compared to cows receiving the required energy level. There were between 18 and 35 percent fewer cows cycling at the beginning of the breeding season among those having a restricted energy intake. Between 1/5 and 1/3 more cows would have the opportunity to breed earlier in the season on an adequate diet than those on an energy deficient diet.

Two of the studies (Wiltbank et al., 1962, Dunn, 1975), continued to study the effects of post-partum nutrition on the interval to first estrus. Both noted that the post-partum energy affected length of interval but the pre-partum energy level had the greatest effect.

*Interval between calving and conception*

The interval between calving and conception is perhaps the most critical nutrition period in the reproductive cycle (Kalthenback, 1973; Wiltbank et al., 1964). During this period the cow is at her peak lactation and must replace a large part of the nutrients she
Table 3. Summary of papers reporting the effect of energy on fertility.

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Location</th>
<th>Class</th>
<th>Before calving (lb TDN)</th>
<th>After calving (lb TDN)</th>
<th>Interval calving to estrus (Days)</th>
<th>Cycling at start of breeding</th>
<th>Conceived at first service</th>
<th>Percent pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiltbank et al., 1962</td>
<td>Ft. Robinson,</td>
<td>Mature</td>
<td>9</td>
<td>16</td>
<td>48</td>
<td>Diff.</td>
<td>Diff.</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Nebraska</td>
<td></td>
<td>4.5</td>
<td>16</td>
<td>65</td>
<td>45</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>8</td>
<td>43</td>
<td>33</td>
<td>20</td>
<td>42</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>4.5</td>
<td>8</td>
<td>52</td>
<td>77</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>Clanton, 1969</td>
<td>North Platte,</td>
<td>Pasture</td>
<td>54</td>
<td>11</td>
<td>77</td>
<td>75</td>
<td>2</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Nebraska</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Diff.</td>
<td>Diff.</td>
<td>94</td>
</tr>
<tr>
<td>Bellovs and Thomas, 1976</td>
<td>Miles City,</td>
<td>Pasture</td>
<td>7.5</td>
<td>13.9</td>
<td>67</td>
<td>20</td>
<td>31</td>
<td>79</td>
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<tr>
<td></td>
<td>Montana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>47</td>
<td>31</td>
<td>60</td>
</tr>
<tr>
<td>Dunn, 1975</td>
<td>Ft. Robinson,</td>
<td>2 yr old</td>
<td>8.6</td>
<td>13.6</td>
<td>49</td>
<td>19</td>
<td>32</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Nebraska</td>
<td></td>
<td>8.6</td>
<td>24.1</td>
<td>56</td>
<td>62</td>
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<td></td>
<td>4.4</td>
<td>13.6</td>
<td>68</td>
<td>14</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.4</td>
<td>24.1</td>
<td>63</td>
<td>39</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>Corah et al., 1972</td>
<td>Laramie,</td>
<td>2 yr old</td>
<td>8.8</td>
<td>15.8</td>
<td>50</td>
<td>6</td>
<td>74</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Wyoming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Clanton and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Diff.</td>
<td>Diff.</td>
<td>40</td>
</tr>
<tr>
<td>Zimmerman, 1970</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Diff.</td>
<td>Diff.</td>
<td>40</td>
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<tr>
<td>Renburger et al., 1974</td>
<td>Oklahoma</td>
<td>2 yr old</td>
<td>High</td>
<td>High</td>
<td>11 Meals ME</td>
<td>8.5 Meals ME</td>
<td>83</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
<td>140</td>
<td>90</td>
<td>87</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td>High</td>
<td>30 days earlier</td>
<td>73</td>
<td>73</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td>Low</td>
<td>82</td>
<td>87</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Wiltbank et al., 1967</td>
<td>Lincoln,</td>
<td>Mature</td>
<td>50%</td>
<td>75% requirement</td>
<td>73</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Nebraska</td>
<td></td>
<td></td>
<td>100%</td>
<td>49</td>
<td>74</td>
<td>74</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150%</td>
<td>31</td>
<td>74</td>
<td>74</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>502, 4 wks,</td>
<td>83</td>
<td>92</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100% thereafter</td>
<td>46</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>502, 4 wks,</td>
<td>82</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150% thereafter</td>
<td>87</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Wiltbank et al., 1966</td>
<td>Maryland</td>
<td>2 yr old</td>
<td>Ad libitum</td>
<td></td>
<td>57</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65% ad libitum</td>
<td>Maintenance</td>
<td>81</td>
<td>74</td>
<td>74</td>
<td>18</td>
</tr>
</tbody>
</table>
loses in milk production. Involution of the uterus must occur and the cow must return to a regular estrus cycle. If mature size has not been attained, growth needs must also be met. Thus the energy requirements for a lactating range cow are almost double that of a dry, pregnant cow (Clanton and Zimmerman, 1970). An energy deficiency would further delay estrus and thus conception until the cow was in proper condition to carry out the above mentioned physiological functions (Wiltbank et al., 1975).

Wiltbank (1962) states that the conception rate is influenced most by the nutrition level after calving. If energy is lacking, conception is the function that will suffer first (Kercher and Dunn, 1971). Table 3 shows that both mature cows and heifers on the NRC recommended nutrition level after calving have a higher conception at first service than those on a low level. This insures a higher percent of the calves will be born earlier in the calving season. Correspondingly, there was a higher percent pregnant at the end of the breeding season among those cows on a higher plane of nutrition.

Renbarger et al. (1964) agreed that the high plane of nutrition both before and after calving produce the highest conception rates but stated that a low feeding level before calving is not made up by feeding recommended levels after calving. Wiltbank et al (1964), however, showed that the under-nourished cows could reach maximum conception levels by feeding more than the recommended amounts of energy after calving. Dunn (1975) also showed a higher conception rate in heifers on a restricted energy intake prior to calving and then increased to above recommended levels after calving.
In a range situation, the importance of proper nutrition is brought out by Carrol and Hoerlein (1966). The drought in eastern Colorado in 1964 drastically reduced the amount of available feed. The conception rate dropped from 87 percent the previous year to 41 percent during the drought and then rose to 90 percent the following year which had above average precipitation.

In summary, the pre-calving nutrition levels (especially energy) has a direct effect on the length of interval to first estrus. The energy level after calving has the greatest influence on the conception rate. The cow should, therefore, be maintained in good condition or supplemented to be gaining weight prior to and after calving. The goal of the operator should be to shorten the interval from calving to first estrus so that the cow will have started cycling before the beginning of the breeding season and to have a large percent of the cows conceive at first service. This insures a high percentage calf crop and a larger number of early calves.

Replacement heifers

A replacement heifer represents a substantial investment in a cow-calf operation. In any economic venture, it is necessary for the capital investment to produce and provide returns as soon as possible. Thus it is important to have a heifer begin producing as soon as she is physiologically capable. In most spring calving operations, the operator has the choice of breeding his replacements as yearlings to calve at age two, or breeding them at two to calve at age three. Tripplet (1967) stated that it requires superior
management to calve heifers at two. A balanced ration must be provided to obtain the size and maturity to successfully calve at two. Also, the difficult births common among 2-year-old heifers require additional manpower to render assistance at calving. With average or mediocre management, Tripplet suggested that calving at age three would be advantageous.

Disadvantages of calving 2-year-old heifers. The major problem of calving 2-year-old heifers is the difficulty they experience in bearing their first calf. Table 4 shows that a high percent of 2-year-old heifers have difficult births and lose their calves. Lack of size and condition is the major cause of calving difficulty. Proper nutrition can help alleviate this difficulty.

Table 4. Calving difficulty of heifers.

<table>
<thead>
<tr>
<th></th>
<th>2-year-old heifers</th>
<th>3-year-old heifers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difficulty (%)</td>
<td>Calf died (%)</td>
</tr>
<tr>
<td>Binks, 1973</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Pope, 1967</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Bellows, 1971</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>

Rebreeding is another problem in calving 2-year-heifers. Neumann and Snapp (1969) state that the physiological functions of lactation and growth take precedence over reproduction. The strain of calving and recuperating from a difficult birth add to the nutrient
demands mentioned. The nutrient requirement of heifers and young cows, per unit of body weight, is greater than mature cows. Thus due to their smaller body size and limited rumen capacity, young cows require a higher quality diet than mature cows. If the quantity or quality of the diet, as expressed by intake of digestible nutrients, is not sufficient to meet the nutrient demands, rebreeding is the first function to suffer. Heifers typically take longer to return to estrus than mature cows (Table 3). If nutrient intake is deficient, the 2-year-old cow will take longer to conceive and thus have a late second calf, or she may not settle during the breeding season and be dry as a 3-year-old. Keetch (1969) shows the magnitude of this problem on a desert range operation in Utah. Only 55 percent of the heifers calving at two were diagnosed as pregnant even though they received cotton seed meal supplements prior to and throughout the breeding season.

Besides these disadvantages mentioned, the calves of 2-year-old heifers are much smaller than those from 3-year-olds and mature cows. Pope (1967) reported 2-year-old cows weaned calves 50 pounds lighter than 3-year-olds and 75-80 pounds lighter than mature cows.

Advantages of calving 2-year-old heifers. The biggest advantage of calving a 2-year-old heifer is the extra calf she will produce. Pinney et al. (1972) reported that 2-year-old heifers produced 339 pounds more beef in their lifetime than heifers calving first as 3-year-olds. Pope (1967) reported that heifers calving at age two produced 0.8 calves per cow year compared to 0.71 calves per cow
year from those calving at age three. Pinney et al. (1972) and Pope (1967) further stated that the longevity of cows calving at age 2 years is not significantly different than those calving at age three.

Although the costs of calving 2-year-old heifers are somewhat greater than calving 3-year-olds, the cost per pound of calf weaned is lower. Pope (1967) reported that the net lifetime cost per hundredweight (cwt) of calf weaned was $10.33 for heifers calving at age 2 years compared to $11.33 for those calving at age three.

Growing out replacement heifers. In order to calve heifers as 2-year-olds, special care is necessary in feeding them so that they will reach sexual maturity at age 12-14 months. The greater nutrient demands placed on a 2-year-old first calf heifer make it desirable to have her calve earlier than the regular calving season to allow more time to repair herself and return to estrus (Kercher and Dunn, 1971; Kearl, 1971; Tripplet, 1976; Strohbehn et al., 1976).

To calve 1 month ahead of the rest of the herd, the heifer must be bred when she is 14 months old.

A ration containing adequate amounts of energy and protein are necessary to bring a heifer to puberty by age 14 months. Clanton and Zimmerman (1970) report that first estrus occurred in heifers at 384 days (12.8 months) on high energy and protein rations. Ninety-five percent of the heifers on the high energy and protein ration were cycling by 15 months. On low levels of energy or protein, first estrus was not attained by 15 months. Wiltbank (1967) reported that all heifers on moderate and high energy levels reached estrus
within 15 months, but only 44 percent of those on the low energy level came into heat during the same period. Most of these cycled one or two times then stopped.

There is a relationship between size or weight and age at first estrus. The critical weight at which a heifer has reached puberty and can be bred at 14 months ranges between 525 pounds to 700 pounds (Table 5). If a heifer is weaned on November 1 at 400 pounds, she must gain over 1 pound per day for 6 months to weigh 600 pounds when she is bred in May.

Table 5. Critical breeding weights and average daily gains of heifers to breed at 14 months.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Area</th>
<th>Critical breeding weight (lbs)</th>
<th>Daily weight gains (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiltbank</td>
<td>Nebraska</td>
<td>525</td>
<td>1.5-1.8</td>
</tr>
<tr>
<td>Keetch (1969)</td>
<td>Utah</td>
<td>600-700</td>
<td>1.0</td>
</tr>
<tr>
<td>Tripplet (1976)</td>
<td></td>
<td>575-700</td>
<td>.75-1.25</td>
</tr>
<tr>
<td>Strohbehn (1976)</td>
<td></td>
<td>650</td>
<td>1.2</td>
</tr>
<tr>
<td>Kercher (1971)</td>
<td>Wyoming</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On lower than optimum feed levels and less than 1 pound gain/day, many straight-bred heifers have difficulty reaching puberty by 14 months (Wiltbank, 1967). However, cross-bred heifers have
shown an advantage of higher rates of gain to reach sexual maturity at a younger age (Wiltbank, 1967 and Kearl, 1971).

The recommendation of most researchers is to keep the largest and best heifers to use as replacements. This means the earliest born and fastest gaining heifers. Besides the fact that earlier calves are usually heavier, Neumann and Snapp (1969) suggest that the time and regularity of calving may be heritable and recommended that late dropped heifers never be kept for replacements.

Pope (1967), Tripplet (1967), and Wiltbank (1974) present several items a manager must accomplish to obtain maximum reproductive performance from calving 2-year-old heifers:

1. Maintain 1 pound average daily gains from weaning through first gestation.

2. Feed heifers to reach puberty at 600 pounds by 14 months of age.

3. Feed heifers to weight 775 pounds by 120 days before calving.

4. Feed heifers to gain 100-120 pounds during the last 3 months of gestation to make up for the fetus growth.

5. Calve 1 month earlier than regular herd. More labor is available to render assistance, and the heifer has more time to return to estrus before the beginning of the breeding season.

6. Provide high quality feed during lactation. Limited intake will reduce conception rates.

7. Breed to small type bull.

8. Restrict breeding season to 45 days. This gives at least
37 days for heifers to return to estrus, repair themselves and conceive at first service.

9. Pregnancy test after 60 days and cull open heifers.

10. Keep more heifers than are needed. Cull open heifers as yearlings and as 2-year-olds. Also cull poorer heifers until desired number of 2-year-old replacements are obtained.

Neumann and Snapp (1969) recommend feeding high nutrient levels to heifers during gestation and lactation and then reduce to moderate nutrient levels when mature. This extends the production lifetime of the brood cow.

Effect of dam's nutrition on weight gain of calf

Weaning weight is the second component of a cow's production efficiency. When combined with percent calf crop, it determines the annual production of beef. Weaning weight is determined by the birth weight plus the daily gains of the calf. The three major components of daily gains are milk production of the dam, calf's genetic growth capability, and amount and quality of available forage.

Milk production has more influence on weaning weight than any other factor (Swanson, 1967). Gleddie and Berg (1968) reported that milk production accounted for 71 percent of the variance in calf gains. However, during the peak of lactation the nutrient requirement is so great that a cow has difficulty consuming enough nutrients to meet all her requirements. Fortunately, a cow will sacrifice her own body tissue and other physiological functions to
maintain lactation. This is apparently an evolutionary characteristic to insure the survival of the offspring (Neumann and Snapp, 1969).

Even though the cow will draw upon her body reserves to maintain lactation, the yield of milk is somewhat reduced by malnutrition. Renberger et al. (1964) and Corah et al. (1974) reported higher weight gains from calves whose dams produced higher yields of milk (Table 6). Swanson (1967) also reported increased milk production from heavy feeding just prior to calving. However, these high milk yields may not benefit the calf during the first month or two. The calf has a physical limit to the amount of milk it can consume. If the cow is producing in excess of consumption, she will decrease production to only that amount consumed by the calf (Gleddie and Berg, 1968).

It appears that overfeeding is just as detrimental to milk production as underfeeding. Bond and Wiltbank (1970) stated that both underfed and overfed heifers produce less milk than properly fed heifers. Swanson (1967) agreed and observed a 15 percent reduction in milk yield in both overfed and underfed heifers. Therefore, recommended levels of feeding should be adhered to in obtaining optimum milk yields.

In another experiment, Corah et al. (1974) found that heifers receiving 65 percent of the TDN requirement prior to birth weaned calves 29 pounds lighter than heifers on the full TDN requirement. However, there was no significant difference in milk production between the two groups (Table 6). The difference may be due to the increased vigor and aggressiveness of calves from adequately fed dams.
Table 6. Milk production and weight gains.

<table>
<thead>
<tr>
<th>Location</th>
<th>Precalving nutrition</th>
<th>Post-calving nutrition</th>
<th>Milk production (lbs)</th>
<th>Difference (lbs)</th>
<th>ADG (lbs)</th>
<th>Difference (lbs)</th>
<th>Mean wt. (lbs)</th>
<th>Difference (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renberger et al. 1964 Oklahoma Low a</td>
<td>High</td>
<td>9.4</td>
<td>1.3</td>
<td>1.47</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High b</td>
<td>High</td>
<td>10.7</td>
<td>1.0</td>
<td>1.62</td>
<td>.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High c</td>
<td>Low</td>
<td>9.7</td>
<td>1.5</td>
<td>1.54</td>
<td>.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low d</td>
<td>Low</td>
<td>8.2</td>
<td>1.5</td>
<td>1.36</td>
<td>.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corah et al. 1974 Wyoming 100% TDN e</td>
<td>65% TDN e</td>
<td>100% TDN 11.0</td>
<td>0.4</td>
<td>324</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% TDN 10.6</td>
<td>353</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last 4 months Last 30 days 50% TDN 130% TDN 100% TDN 12.1</td>
<td>3.1</td>
<td>320</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% TDN 50% TDN 100% TDN 9.0</td>
<td>294</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a: 21% loss of fall weight.
- b: 71% loss of fall weight.
- c: 10% loss of fall weight.
- d: 25% loss of fall weight.
- e: percent of NRC recommended nutrient intake.
The time of birth has a great effect on weaning weight. Calves born early are heavier at weaning than those born late in the calving season. As stated before, nutrition plays an important role in allowing a cow to conceive early in the breeding season. Beyond the additional time in which to gain weight, early calves have a higher rate of gain (Minyard, 1973). Dunn (1975) reported that 70 percent of the top one-third of a calf crop were born in the first 20 days of a 60-day calving season. The average daily gain of the calves in the top one-third of the calf crop was 1.68 pounds compared to 1.28 pounds/day of the late calves in the bottom one-third.

It is difficult to separate the effect that the calf's vigor and genetic growth capability, the dam's milking ability, and quality of forage have on weaning weight. Weaning weight is the summation of all of these factors. Table 6 shows, however, that the high or recommended nutrition level of the dam both before and after calving increase the daily gains and weaning weights of calves.

Survivability of calves

Precalving nutrition of the dam also influences the health and vigor of the calf. Maynard and Loosli (1969) and Neumann and Snapp (1969) state that the vigor of the calf is influenced by the nutrition level of the last quarter of gestation. Proper nutrition insures a good strong calf and increases its chances of survival. In first calf heifers, Corah et al. (1974) reported that the neonatal loss was 7 percent higher in heifers receiving 65 percent of recommended TDN as compared to 100 percent of the
requirement. Dunn (1975) and Dunn et al. (1969) reported 9.5 percent calf loss in energy restricted dams compared to no losses when sufficient energy was provided.

The influence of the precalving nutritional level of the dam on the vigor of the calf extends past birth. Corah et al. (1974) reported that calves from energy restricted dams were more susceptible to scours. Fifty-two percent of the calves from low nutrition dams, compared to 33 percent from high nutrition dams, developed scours. Nineteen percent of the calves from the low nutrition dams died from scours. The neonatal death loss was also 9.6 percent higher among the low nutrition dams. The total result was that the dams on the recommended nutrition level weaned 28.6 percent more calves, of the calves born, than those on a low nutrition level.

**General Livestock Management Practices**

**Supplementation of livestock diets**

Where any nutrient is inadequate in an animal's diet, whether it be deficient in the vegetation or just that the animal is not consuming enough feed to obtain the proper amount of the nutrient, supplementation of that nutrient is essential if high production is to be maintained. The highest quality supplements will naturally produce the greatest production, but a slight increase in production may not pay for the cost of expensive supplements. The test of the supplement is that it economically produce the desired results.

There are many different purposes or conditions for which an operator would want to supplement his herd. He must first define
his production objectives, determine which nutrients are deficient, and then provide the nutrients in a supplement to obtain the desired results.

It has been shown that the rapid gains during spring and summer compensate for the winter weight loss of non-supplemented cattle (Parker et al., 1974). Thus, in feeding out young animals on range and pasture to be sold in the fall, a high level of supplementation would not be necessary. However, if the animals were to be sold in the spring, the higher gains from supplementation would be warranted. Likewise, in growing out replacement heifers to be bred at 14 months and calve as 2-year-olds, a high level of winter supplementation would be desirable to insure she weighed over 600 pounds and had reached puberty.

The key to an effective supplementation program is to identify the deficient nutrient and provide it. Providing the wrong nutrient or incorrect combination of nutrients in a supplement will result in inefficient use or even decreased production. Cook and Harris (1968b) found that high energy supplements greatly reduced the digestibility of a fibrous diet. Carrol et al. (1966) found that feeding a protein supplement during a drought where energy was severely lacking caused ovarian inactivity and post-partum anestrus in young lactating cows.

Over supplementing can also be a problem. Over-fat cows have more difficulty in calving and thus lose more calves and have lower conception rates (Minyard, 1969; Maynard and Loosli, 1969; Bond and
Wiltbank, 1970). Their milk production may also be hindered, resulting in lighter weaning weights of their calves (Waldrip and Marion, 1963).

**Supplement during drought.** Wallace and Foster (1976) indicated that the reduction in beef production during drought could be minimized by supplemental feeding of nutrients lacking in the diet. Both energy (or dry matter) and protein would become limiting during the drought due to reduction in total herbage and low nutrient content of the vegetation. The two entries in Table 7 from drought conditions reveal that supplementation can greatly increase weaning weights and conception rates.

**Seasonal supplementation.** Supplements have also been effective in supplying deficient nutrients during the dry or winter season (Table 7). Since plant growth has stopped, the quantity of herbage is limited, plus its availability may be reduced by snow or other climatic factors. The nutrient quality of the forage, specifically protein, carotene and phosphorus, drops to extremely low level in grass and to a lesser degree in shrubs. These seasons, therefore, have similar effects as drought on livestock production but their occurrence is predictable and can be planned for. Supplements can be used to maintain production or increase it during these seasons.

Supplements are not a "cure-all" that will increase calf production under any situation. Where nutrients are lacking in the forage, supplying them can maintain a high level of production. However, if sufficient quantities of forage are available containing
Table 7. Summary of papers comparing calf production from supplemented and nonsupplemented cows.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Location</th>
<th>Non supplemented</th>
<th></th>
<th></th>
<th>Supplemented</th>
<th></th>
<th></th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagon et al. 1959</td>
<td>California</td>
<td>66</td>
<td>406</td>
<td>270</td>
<td>83</td>
<td>464</td>
<td>385</td>
<td>17</td>
</tr>
<tr>
<td>Knox &amp; Watkins 1958</td>
<td>New Mexico</td>
<td>76</td>
<td>380</td>
<td>289</td>
<td>85</td>
<td>393</td>
<td>334</td>
<td>11</td>
</tr>
<tr>
<td>Waldrip &amp; Marion 1963</td>
<td>Texas</td>
<td>84</td>
<td>no</td>
<td>no</td>
<td>90.5</td>
<td>no</td>
<td>no</td>
<td>6</td>
</tr>
<tr>
<td>Pinney et al. 1972</td>
<td>Oklahoma</td>
<td>88</td>
<td>slightly higher</td>
<td>81</td>
<td>91</td>
<td>slight higher</td>
<td>85</td>
<td>slight increase</td>
</tr>
<tr>
<td>Parker et al. 1974</td>
<td>New Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ray et al. 1975</td>
<td>Arizona</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Low level of supplements - 60 percent of recommended level.*
adequate amounts of nutrients, supplements then become just an added expense that won't increase production and in some cases, it will decrease production. Knox and Watkins (1958) reported that in normal years, supplement did not increase production in mature cows. However, young growing cows did benefit from supplementation. Bellows and Thomas (1976) showed that a grain supplement in a good forage year actually decreased the productivity of cows. The calf weaning weights were not affected by the supplements, but the conception rate dropped from 94 percent among cows on range forage to 61 percent among cows supplemented with grain. The range forage appeared to supply the required nutrients and the grain supplement acted as a substitute rather than a supplement for the forage and decreased intake.

Pinney et al. (1972), in a study of the lifetime productiveness of beef cow herds in Oklahoma, reported that total amount of beef produced per cow was greater in the low level of supplementation (60 percent of recommended level) than at recommended levels and greater. The low level produced 340 kg more beef than the recommended level and 478 kg more beef than the high supplement level. The calf crop of the low level was 88 percent compared to 82 percent and 81 percent or the recommended and high level, respectively.

The longevity of the cows was also greater in the low supplement level. The life span of the low level was 14.65 years. The moderate level was 13 years and the high level was 11 years. Pinney concluded that cows were more productive in Oklahoma without protein winter supplement if adequate forage is present.
Performance testing

Performance testing is a means of measuring the reproductive and economic traits of a beef herd. The productivity of individual cows within a herd can be compared by measuring the performance of their calves. Selection for the high producing cows can be made while culling the low producers. Over a period of time the performance of the entire herd can be improved by keeping replacements with high performance records which come from highly productive cows.

The economic traits for which most commercial producers select are fertility and weaning weights. Fertility, which is a major component of calf crop weaned, is the most important economic trait in beef production. However, the heritability of fertility is low—only 10 percent (Minish, 1975)—thus rate of improvement in the herd will be slow. However, replacement heifers from those cows that calve regularly and early in the calving season should still be selected. Those cows that calve beyond the 12-month calving cycle or skip a year without calving should be culled. An operator cannot afford to keep a dry cow.

Weaning weight is the next most important economic trait. It is a result primarily of the dam's mothering and milking ability. Its heritability is 25 percent (Leasay, 1972). By selecting for cows that wean heavy calves, the average weaning weight can be improved substantially. In order to compare weaning weights, they must be standardized or adjusted for age, age of dam, and sex. The Beef Improvement Federation (1972) has given standards to adjust weaning weights for comparison:
Age of calf. The age of the calf is adjusted to a standard 205-day age at weaning by the following formula:

\[ AWW = \frac{WW - BW}{A} \times 205 + BW \]

where: \( AWW \) = adjusted 205-day weaning weight, \( WW \) = actual weight of calf, \( BW \) = birth weight of calf, and \( A \) = actual age of calf in days.

Time of calving has a great impact on weaning weights. Calves born early are generally heavier than late calves and are thus more valuable. If this trait is to be interjected into the comparison, the actual weaning weight should be used rather than the 205-day adjusted weaning weight.

Age of dam. Maturity of the cow affects the size of her calf. Young cows bear smaller calves (Pope, 1967). Milk production is usually less for young and old cows, thus further reducing the weaning weights. The weaning weight is adjusted by the following ratios to compensate for this age difference:

- 2-year-olds - multiply computed 205-day weight by 1.15
- 3-year-olds - " " 1.10
- 4-year-olds - " " 1.05
- 5-10-year-olds - " " 1.00
- 11-year-olds - " " 1.05

Sex. The male hormones produce a greater growth stimulus than the female. Heifers are adjusted up and bulls adjusted down to the steer weight for comparison. Usually, calves are only compared to those of the same sex.
Heifers - multiply adjusted 205-day weight by 1.05
Bulls - multiply adjusted 205-day weight by .95

Weaning weight ratio. This ratio is a numerical ranking of the individual calf in the group in which it was weaned.

\[
\text{adjusted weaning weight} \quad \frac{\text{average adjusted weight of all calves in group}}{	ext{average adjusted weight of all calves in group}}
\]

Most probable producing ability (MPPA). MPPA is a method of ranking cows by their cumulative production. It is useful in comparing dams which do not have the same number of calf records in their averages. Those cows in the herd with the lowest MPPA should be culled and replacements kept from only those with high MPPA.

\[
\text{MPPA} = \bar{H} + \frac{NR}{1 + (N-1)R} \times (\bar{C} - \bar{H})
\]

where: \(\bar{H} = 100\), the herd average weaning weight ratio,
\(N = \text{number of calves included in cow's average}\),
\(R = 0.4\), the repeatability factor for weaning weight ratio,
\(\bar{C} = \text{average weaning weight ratio for all calves the cow has produced}\).

Records. Records are the key to performance testing. The following items must be adhered to and an up-to-date record kept.

1. Permanent identification of cow.
2. Permanent record for each cow.
   a. birth date
   b. birth date of each calf
   c. actual and adjusted weaning weight of each calf
3. Carefully relate calf's identification to the identification of its dam.

4. Birth date and birth weight of calf.

**Breeding season**

One way of insuring a high proportion of early calves is to have a short breeding season (45-60 days). The breeding season can be manipulated to concentrate the calving season and give all the cows in the herd a minimum amount of time to resume the normal estrus cycle prior to the beginning of the breeding season. A breeding season of 90 days results in the last cow calving 8 days into the breeding season. Her calf is late and she will probably continue to calve late. It is very difficult for a cow to gain time, or calve earlier in the season, due to the long gestation period and the burden of lactation.

A breeding season of 45 days gives all of the cows at least 37 days before the breeding season begins to return to estrus and start cycling. A breeding season of 60 days gives all the cows a minimum of 22 days before the breeding season. This insures that a high percent of the cows will be in heat during the first 20 days of the breeding season, and also that a high percent will conceive at first service (Kaltenback, 1973). Burns (1967) states that most of the cows that will settle will do so within the first three estrus cycles or 60 days. He maintained a 95 percent calf crop by limiting the breeding season to 60 days.
The key to a successful limited breeding season is proper nutrition. The cows must receive all the nutrients they require for lactation, growth, and reproduction in order to conceive within the limited time.

A short breeding season may be of limited use on an extensive range operation. Rounding up the bulls at the end of a short breeding season may be difficult. Also, many grazing associations require a specified bull to cow ratio on a grazing allotment for the entire summer. However, a prudent operator could get the benefits of a modified breeding season by pregnancy testing in the fall and culling the open cows and also those which will calve late. He could also move up the breeding and calving season and thus make sure most of his cows are pregnant before going onto the summer range.

Advantages of Seeded Spring Pastures in Calf Production

The previous sections have stated that improved nutrition or the recommended amounts of nutrients increase reproductive efficiency in beef cows. Most of these experiments were conducted in feed lots with the intake and amount of nutrients carefully controlled. Range and pasture experiments are more difficult to conduct because of lack of control over intake quantity and nutrient content of the diet. However, some gross comparisons between seeded pastures and native range show that good spring pastures can substantially increase beef production.
Total pounds of calf produced on seeded spring pastures

Total pounds of calf weaned per acre can be increased by grazing seeded spring pastures comprised of cool season grasses as compared to native range. Fertility of the cow, as indicated by percent calf crop, is higher on the seeded pastures. The average daily gains are slightly higher and there is a large increase in stocking rate. The summary of the four experiments in Table 8 reveals that the average daily calf gains on seeded pasture increased 30 percent, from 1.54 pounds on native range to 2 pounds on seeded pasture. The carrying capacity increased from 7.4 acre/AUM on native range to 2.4 acre/AUM on seeded pasture or 208 percent. The calf production per acre increased from 7.6 pounds/acre on native range to 25.6 pounds/acre on seeded pasture. At $36.00/cwt the 18 pounds/acre increase in beef would give an increase in gross annual return of $6.48/acre.

Improved fertility from seeded spring pastures

Table 9 reveals that calf crops can be increased on seeded spring pastures compared with native range. Generally, good condition range would not be converted to cool season pastures, but if a small area was to be placed under intensive management, the seedings could increase the calf crop 10 percent (Houston and Urick, 1972). When native foothill sagebrush grass range in poor to fair condition is seeded to cool season species, calf crop can be expected to increase 30 percent (Frischknecht, 1964).
Table 8. Summary of papers comparing total calf production from seeded spring pastures with native range.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Location</th>
<th>Native range</th>
<th>Seeded pasture</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Calf Acre/</td>
<td>Prod/acre</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>crop AUM</td>
<td>(lbs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(lbs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>81</td>
<td>4.3</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.13</td>
<td>91</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.76</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>Houston &amp; Urick</td>
<td>Montana</td>
<td>1.76</td>
<td>81</td>
<td>4.3</td>
</tr>
<tr>
<td>1967</td>
<td></td>
<td></td>
<td>9</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>Jefferies et al.</td>
<td>Wyoming</td>
<td>1.73</td>
<td>4</td>
<td>1.8</td>
</tr>
<tr>
<td>1967</td>
<td></td>
<td></td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Lloyd &amp; Cook</td>
<td>Utah</td>
<td>1.3</td>
<td>11.3</td>
<td>2.2</td>
</tr>
<tr>
<td>1960</td>
<td></td>
<td></td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Cook 1966</td>
<td>Utah</td>
<td>1.37</td>
<td>10</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>2.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.54</td>
<td>7.4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>7.6</td>
<td>2.4</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1.54</td>
<td>2.56</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.36</td>
<td>21</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.70</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.90</td>
<td>69</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.46</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.11</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.0</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.0</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.0</td>
<td>237</td>
<td></td>
</tr>
</tbody>
</table>

* Production per acre calculated by a modified formula of Lloyd and Cook (1960) where:

\[
Pounds \ of \ calf \ weaned \ per \ acre = \frac{DFG}{AC}
\]

D = days of grazing
G = average daily gains
F = percent calf crop
C = carrying capacity
T = AUM time factor
Spring pastures offer many other benefits associated with calf crops (Houston and Urick, 1972; Kearl and Cordingly, 1975):

1. Relatively confined calving pastures facilitate observation and enables the operator to render assistance in difficult births.

2. Seedings make good flushing pastures. The abundant, accessible, and highly nutritious grass meets all of a lactating cow's nutritional needs.

3. Relatively confined breeding pastures increase the opportunity for breeding and requires fewer bulls.

Table 9. Summary of papers comparing calf crops from native range with seeded spring pastures.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Location</th>
<th>Native range (%)</th>
<th>Seeded pasture (%)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston and</td>
<td>Northern</td>
<td>81.3</td>
<td>91</td>
<td>10</td>
</tr>
<tr>
<td>Urick, 1972</td>
<td>Great Plains</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frischknecht,</td>
<td>Utah</td>
<td>65.0</td>
<td>95</td>
<td>30</td>
</tr>
<tr>
<td>1964</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kearl, 1975</td>
<td>Wyoming</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Wiltbank,</td>
<td>Texas</td>
<td>84.0</td>
<td>93</td>
<td>9</td>
</tr>
<tr>
<td>1976</td>
<td></td>
<td>(poor pasture)</td>
<td>(good pasture)</td>
<td></td>
</tr>
</tbody>
</table>

Weight gains from seeded spring pasture

In addition to the data on increased production summarized in the preceding two sections, many other researchers have evaluated the
increased weight gains obtained from spring pastures compared to native range. Table 10 reveals that the average weaning weight increased from 392 pounds on native range to 412 pounds on seeded pasture. The average increase of 20 pounds (5 percent) was gained mainly from grazing seeded pastures in the spring. The average daily gains on seeded pastures was 1.97 pounds compared to 1.4 pounds on native range. This represents an increase of 44 percent in average daily gains during the spring grazing season.

The increase in calf production results mainly from the increase in available forage. On native range, there is usually a variety of shrubs, grasses, and forbs that vary considerably in palatability. As the condition of the range declines, the abundance of the unpalatable vegetation increases while the desirable grasses, forbs, and shrubs decrease. Thus the quantity of palatable forage declines with declining condition of native range. Those palatable grasses and forbs that do remain are often protected by the dominant shrubs and are unavailable to livestock.

In contrast to native range, almost all of the vegetation on seeded pastures is available. Prior to seeding, brush control is usually administered to remove competition for soil moisture and nutrients. Also, most seeded improved species are high in palatability.

The nutrient content of seeded grasses is not much different than native grasses. However, growth begins earlier in the spring for most seeded grass species (Cook and Harris, 1968a). This earlier growth adds high quality protein to the old growth and hastens the period of high livestock gains. Seeded grasses also retain more
Table 10. Summary of papers comparing calf gains on seeded pastures with native range.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Location</th>
<th>Native Range</th>
<th></th>
<th></th>
<th></th>
<th>Seeded Spring Pasture</th>
<th></th>
<th></th>
<th></th>
<th>Increase</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wean Wt.</td>
<td>ADG</td>
<td></td>
<td></td>
<td>Wean Wt.</td>
<td>ADG</td>
<td></td>
<td></td>
<td>Wean Wt.</td>
<td>ADG</td>
<td>%</td>
</tr>
<tr>
<td>Houston and Urick 1967</td>
<td>Montana</td>
<td>415</td>
<td>1.76</td>
<td></td>
<td></td>
<td>433</td>
<td>2.13</td>
<td></td>
<td></td>
<td>18</td>
<td>0.37</td>
<td>21</td>
</tr>
<tr>
<td>Houston and Urick 1972</td>
<td>Montana</td>
<td>433</td>
<td></td>
<td>453</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>21</td>
</tr>
<tr>
<td>Clanton 1969</td>
<td>Nebraska</td>
<td>328</td>
<td>1.16</td>
<td></td>
<td></td>
<td>339</td>
<td>1.41</td>
<td></td>
<td></td>
<td>11</td>
<td>0.25</td>
<td>21</td>
</tr>
<tr>
<td>Currie 1966</td>
<td>Colorado</td>
<td>392</td>
<td></td>
<td>424</td>
<td></td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jefferies 1967</td>
<td>Wyoming</td>
<td>1.73</td>
<td></td>
<td>1.80</td>
<td></td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Springfield &amp; Reid 1967</td>
<td>New Mexico</td>
<td>1.16</td>
<td></td>
<td>2.18</td>
<td></td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lloyd and Cook 1960</td>
<td>Utah</td>
<td>1.3</td>
<td></td>
<td>2.2</td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook 1966</td>
<td>Utah</td>
<td>1.37</td>
<td></td>
<td>1.97</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>McIlvain 1976</td>
<td>Oklahoma</td>
<td>700</td>
<td>2.25</td>
<td></td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Frischknecht and Harris 1968</td>
<td>Utah</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Kearl 1975</td>
<td>Wyoming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoliak and Slen 1974</td>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td>0.57</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>392</td>
<td>1.4</td>
<td>412</td>
<td>1.97</td>
<td>20</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
of their nutrients at maturity than native grasses (Cook and Harris, 1968a). This extends the period in which the seeded grasses can meet the nutrient demand of livestock and can sustain a high level of production.

Carrying capacity increase from seeded pastures

Much of the literature reviewed included increased carrying capacity as one of the benefits of seeded pastures. Table 11 lists several studies that compared the carrying capacity of native range to that of seeded pasture in the Intermountain and Great Plains areas. The carrying capacity of native range in the sagebrush-grass type in the Intermountain area ranged from 66 acres/AUM in poor condition to 10 acres/AUM in fair condition to about 2 acres/AUM in excellent condition. In contrast, the carrying capacity of seeded pastures ranged from 3.66 acres/AUM to .75 acre/AUM on these same sites. The average percentage increase was 348 percent.

The carrying capacity of native range on shortgrass and midgrass prairies of the Great Plains ranged between 5 and 3 acres/AUM. The carrying capacities on seeded pastures ranged between 2.5 and .83 acres/AUM. This was an average increase of 192 percent. The carrying capacity of irrigated pastures were measured in AUM/acre and ranged from 2 to 18 AUM/acre in Nebraska and Oklahoma. The average increase in carrying capacity of seeded pastures over native range was 368 percent.
Table 11. Summary of papers comparing the carrying capacity of seeded pastures with native range.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Native range</th>
<th>Seeded pasture</th>
<th>Type</th>
<th>Acre/ AUM</th>
<th>Percent Use</th>
<th>Increase (%)</th>
<th>Early turn-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERMOUNTAIN AREA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frischknecht</td>
<td>1964</td>
<td>Utah</td>
<td>Sagebrush-grass</td>
<td>12-25</td>
<td>CW</td>
<td>2.5</td>
<td>627</td>
<td>2 wks.</td>
<td></td>
</tr>
<tr>
<td>Lloyd &amp; Cook</td>
<td>1960</td>
<td>Utah</td>
<td>Sagebrush-grass</td>
<td>11.3</td>
<td>CW</td>
<td>3.8</td>
<td>199</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook</td>
<td>1966</td>
<td>Utah</td>
<td>Sagebrush-grass</td>
<td>10</td>
<td>CW</td>
<td>2.43</td>
<td>311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rumsley</td>
<td>1971</td>
<td>Idaho</td>
<td>Sagebrush-grass</td>
<td>Excellent</td>
<td>CW</td>
<td>1283 lb/ac</td>
<td>116</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Springfield</td>
<td>1963</td>
<td>New Mexico</td>
<td>Sagebrush-blue grama</td>
<td>66</td>
<td>CW</td>
<td>3.66</td>
<td>65-70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray &amp; Springfield</td>
<td>1962</td>
<td>New Mexico</td>
<td>Sagebrush-blue grama</td>
<td>114 lb/ac</td>
<td>CW</td>
<td>976 lb/ac</td>
<td>756</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GREAT PLAINS</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoliak &amp; Slen</td>
<td>1974</td>
<td>Alberta</td>
<td>Midgrass prairie</td>
<td>4.6</td>
<td>CW RW</td>
<td>2.5</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston &amp; Urick</td>
<td>1972</td>
<td>Montana</td>
<td>Mixed prairie</td>
<td>4.3</td>
<td>CW RW</td>
<td>1.5</td>
<td>196</td>
<td>10 days-5 wks</td>
<td></td>
</tr>
<tr>
<td>Kearl &amp; Cordingly</td>
<td>1975</td>
<td>Wyoming</td>
<td>Poor to fair</td>
<td>2.7-5</td>
<td>CW RW</td>
<td>1-1.5</td>
<td>393</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeffries</td>
<td>1967</td>
<td>Wyoming</td>
<td>Short &amp; midgrass prairie</td>
<td>2.7-5.9</td>
<td>CW RW</td>
<td>2</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currie</td>
<td>1966</td>
<td>Colorado</td>
<td>Ponderosa pine bunchgrass</td>
<td>4.16</td>
<td>CW RW</td>
<td>Big bluegrass</td>
<td>401</td>
<td>1 month</td>
<td></td>
</tr>
<tr>
<td>Barns &amp; Nelson</td>
<td>1950</td>
<td>Wyoming</td>
<td>Shortgrass prairie</td>
<td>200-300</td>
<td>CW RW</td>
<td>WW Alf</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lang &amp; Landers</td>
<td>1960</td>
<td>Wyoming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 11. Continued.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Native range</th>
<th>Acre/ AUM</th>
<th>Seeded pasture</th>
<th>Type</th>
<th>Acre/ AUM</th>
<th>Percent use</th>
<th>Increase (%)</th>
<th>Early turn-out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoliak</td>
<td>1968</td>
<td>Alberta</td>
<td>Midgrass prairie</td>
<td></td>
<td></td>
<td>CW</td>
<td>RW</td>
<td>200-300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nichols</td>
<td>1974</td>
<td>Nebraska</td>
<td></td>
<td></td>
<td></td>
<td>IP</td>
<td>5.4-18 AUM/ac.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McIlvain</td>
<td>1976</td>
<td>Oklahoma</td>
<td>Midgrass prairie</td>
<td>.2 AUM/ac.</td>
<td>IP</td>
<td>2 AUM/ac.</td>
<td>2 AUM/ac.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\text{CW} = \text{crested wheatgrass}\)
\(^b\text{RW} = \text{Russian wildrye}\)
\(^c\text{W} = \text{western wheatgrass}\)
\(^d\text{W} = \text{wheatgrass}\)
\(^e\text{Alf} = \text{alfalfa}\)
\(^f\text{IP} = \text{irrigated pasture}\)
Other benefits of seeded spring pastures

Seeded spring pasture offers advantages to the livestock operator other than increased fertility and calf production mentioned earlier. Spring grazing, even when properly managed at moderate intensities, is detrimental to native range. Houston and Urick (1972) observed that grazing native range during April-June, under moderate intensities (44 percent utilization), changed the condition of the range from 62 percent of climax (good) to 53 percent of climax (low good) in just 4 years. The literature reviewed indicated that seeded spring pastures were ready for grazing 2-5 weeks earlier than native range. They therefore offer a means of deferring native range during these critical spring months as well as reducing the amount of hay fed in the late spring.

If livestock are taken off the seeded pastures at the beginning of summer when there is still adequate soil moisture, or if there is substantial summer or fall precipitation, regrowth of these seeded grasses can be expected and can provide excellent forage for fall grazing (Springfield, 1963; Cook, 1966; and Frischknecht and Harris, 1968).

Calf gains usually decline toward the end of summer and fall due to maturing forage. Both nutrient content and digestibility of the forage decline. If there is regrowth of seeded grasses following spring grazing, maturity is delayed and the nutrient content of the seeded grasses meet the livestock requirements for a longer period in the fall. Therefore, gains can be maintained into the fall on seeded pastures (Currie, 1966).
Climate, though uncontrollable, has the greatest influence on forage production. In drought, seeded pastures have shown less fluctuation than native range—particularly poor condition range—and can thus add more stability to an operation. Houston and Urick (1972) reported a drought that reduced forage production from good condition native range by 45 percent while the seeded pastures remained unaffected. Cook (1966) stated that in the drought year of 1956, in which annual precipitation was only 60 percent of normal, ground cover of crested wheatgrass was reduced only 16 percent compared to an average reduction of 25 percent of other grasses.

Forage species for seeded spring pasture

Almost all of the literature reviewed reported the use of crested wheatgrass (*Agropyron cristatum, A. desertorum*) in seeding spring pastures. Russian wildrye (*Elymus juncus*) was mentioned in about half of the research. Cook (1966) stated that crested wheatgrass started growth earliest in the spring of three other wheatgrasses tested—pubescent wheatgrass (*Agropyron trichophorum*), intermediate wheatgrass (*A. intermedium*), and tall wheatgrass (*A. elongatum*)—but was one of the first to mature. He recommended that crested wheatgrass be used first in the spring and then use some of the later maturing grasses—pubescent and intermediate wheatgrass—in the late spring in order to utilize seeded grasses when they are most nutritious throughout the spring. Houston and Urick (1972) reported that Russian wildrye-alfalfa (*Medicago sativa*) pastures produced higher gains and calf crops than crested wheatgrass-
alfalfa. However, regrowth for fall grazing was greatest on the crested wheatgrass-alfalfa pastures.

When alfalfa is added to either crested wheat or Russian wildrye, the carrying capacities of pasture can be increased by one-third over the straight grass pastures (Whitman et al., 1963; Barnes and Nelson, 1950).

**Irrigated pastures**

Nichols et al. (1974) reported carrying capacities from irrigated pastures in Nebraska ranging from 5.4-18 AUMs/acre, with an average of 10-13 AUMs/acre. They concluded that herbage yields and profits from the pastures will compete with other crops. Irrigated pastures can be profitable when they can fill a forage need cheaper than other sources. Another advantage is that the high quality forage can also fill the nutrient requirements during the critical periods of the reproductive cycle.

As the intensity of management increases, so does the returns per unit. McIlvain (1976) suggests using seeded grass and annual temporary pastures to complement the mid grass native range in the Southern Great Plains. Eleven acres of native range and 1 acre of farmed forage (winter wheat and sudan grass) were used to support a cow-calf pair for 1 full year. This combination produced average daily gains of 2.25 pounds in the calves. The native range provided stability and flexibility and the farmed forage supplied quality and quantity of forage. This provided year-round green feed and allowed each forage component to be rested during its critical development, and used during its most productive period. There
are also advantages in flushing and breeding pastures, and the opportunity existed to harvest excess forage to use as supplement if necessary during the winter months. McIlvain's goal is to wean a 1,000 pound steer at 1 year of age.

**Effect of Grazing Intensity on Calf Production**

On any livestock operation, whether it be an extensive range operation or confined pasture, grazing intensity or stocking rate has a great effect on the livestock production. If the number of animals is out of balance with the feed available, overgrazing and reduced livestock performance, or under-utilization of the costly land and capital resource will occur.

Table 12 lists several experiments where livestock production from cow-calf operations were compared in three intensities of grazing: light, moderate, and heavy. Production was calculated in two categories: 1) pounds of calf produced per cow, and 2) pounds of calf produced per acre.

**Production per cow**

Table 12 shows that the light stocking rates on native range produced an average of 358 pounds of calf per cow compared to 340 pounds from moderate and 260 pounds from heavy stocking rates. Stoddart, Smith and Box (1975) indicate that at low stocking rates, the diet is not limited. Cows and calves are able to exercise grazing selectivity for the desirable forage and select the most palatable and nutritious plants and parts of plants. Thus, if disease, social behavior, and other factors influenced by management
Table 12. Summary of papers comparing calf production on light, moderate, and heavy grazing intensities.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Location</th>
<th>Light</th>
<th></th>
<th></th>
<th>Moderate</th>
<th></th>
<th></th>
<th>Heavy</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acre/</td>
<td>Mean ADG</td>
<td>% calf</td>
<td>Acre/</td>
<td>Mean ADG</td>
<td>% calf</td>
<td>Acre/</td>
<td>Mean ADG</td>
<td>% calf</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>AUM</td>
<td>wt.</td>
<td>per cow</td>
<td>AUM</td>
<td>wt.</td>
<td>per cow</td>
<td>AUM</td>
<td>wt.</td>
<td>per cow</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston and Woodward 1966</td>
<td>No. Great Plains</td>
<td>4.31</td>
<td>420</td>
<td>1.91</td>
<td>91</td>
<td>384</td>
<td>8.7*</td>
<td>3.48</td>
<td>402</td>
<td>1.83</td>
<td>84</td>
<td>333</td>
<td>9.6*</td>
</tr>
<tr>
<td>Johnson et al. 1951</td>
<td>S. Dakota</td>
<td>3.1</td>
<td>384</td>
<td>1.67</td>
<td>83</td>
<td>326</td>
<td>14</td>
<td>2.3</td>
<td>373</td>
<td>1.59</td>
<td>86</td>
<td>321</td>
<td>19</td>
</tr>
<tr>
<td>Lewis et al. 1956</td>
<td>West S. Dakota</td>
<td>3.78</td>
<td>370</td>
<td>1.3</td>
<td>83</td>
<td>307</td>
<td>8.6*</td>
<td>2.85</td>
<td>350</td>
<td>1.27</td>
<td>72</td>
<td>259</td>
<td>9.6*</td>
</tr>
<tr>
<td>Reed and Peterson 1961</td>
<td>No. Great Plains</td>
<td>3.1</td>
<td>443</td>
<td>1.9</td>
<td>87</td>
<td>385</td>
<td>16*</td>
<td>2.3</td>
<td>437</td>
<td>1.89</td>
<td>90</td>
<td>393</td>
<td>22*</td>
</tr>
<tr>
<td>Marsh et al. 1959</td>
<td>Montana</td>
<td>39ac/</td>
<td>435</td>
<td>90</td>
<td>391</td>
<td>30ac/</td>
<td>442</td>
<td>89</td>
<td>393</td>
<td>23ac/</td>
<td>372</td>
<td>70</td>
<td>260</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crested Wheatgrass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frischknecht and Harris 1958</td>
<td>Utah</td>
<td>2.24</td>
<td>1.78</td>
<td></td>
<td>23.5*</td>
<td>1.8</td>
<td>1.82</td>
<td>(37)*</td>
<td>(43)*</td>
<td>1.49</td>
<td>1.7</td>
<td>(40)*</td>
<td>1.7</td>
</tr>
<tr>
<td>Springfield 1963</td>
<td>New Mex.</td>
<td>2.34</td>
<td>19.8</td>
<td>2.13</td>
<td>27.7</td>
<td>2.13</td>
<td>33.9</td>
<td>(37)*</td>
<td>(43)*</td>
<td>1.49</td>
<td>1.7</td>
<td>(40)*</td>
<td>1.7</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Pounds of calf per acre calculated from modified formula of Lloyd and Cook, 1960.

* Total pounds of beef. Includes yearlings and cows.
are optimum, livestock can approach their genetic potential in fertility and gains. Johnstone-Wallace and Kennedy (1944) state that as dry matter per acre decreased through grazing, so did the dry matter intake of the animal. Furthermore, Leigh, Wilson, and Mulham (1968) reported that as available forage decreased through grazing, and the digestibility declined with the maturing of the forage, production as measured by wool growth on sheep dropped off. They also noted that as the available forage decreased because of grazing, the grazing time of the animals increased.

Marsh (1959) reported that the decline in animal production is a result of decreased quantity of forage only. The nutrient content of the forage in the heavily stocked pasture was similar to the light stock pastures. Cook, Kothmann, and Harris (1965) agreed that there is little difference in nutrient content and digestibility of forage on good and poor condition range as brought about by light and heavy stocking. However, on the heavily grazed poor condition range, the scarce palatable plants were readily consumed at the beginning of the grazing season. Thereafter the animals were forced to go on to the less palatable plants and their total intake declined.

Martin (1975) stated that animals on an overstocked range must use a higher percent of total intake for maintenance. On full feed, an animal uses 70 percent of the intake for maintenance and 30 percent for growth, lactation, and production. If overstocking the range reduces intake to 80 percent of the requirement, only one-third as many nutrients are available for growth, lactation, and reproduction.
Production per acre

Table 12 also indicates that pounds of calf weaned per acre increased from a low of 14.72 pounds/acre on light intensity to 18.7 pounds/acre on moderate, and 23 pounds/acre on heavy intensities. Even though the production per cow decreased, the number of cows/acre increased, therefore increasing the total production per acre. There comes a point, however, when increasing number of animals per acre depresses production per cow so that total production per acre begins to decline (Figure 2).

Grazing intensity and range condition

In most of the studies reviewed, range condition declined as grazing intensity increased (Table 13). The heavy grazed pastures decreased in condition and productivity while the moderate and lightly grazed pastures improved in condition and productivity.

The vegetation is the crop that is being harvested and producing the animal gains. As a basic resource, it must be protected to produce maximum sustained yields in terms of quantity and quality of forage. Stoddart et al. (1975) state that livestock production is not a good indicator of range health. The range condition may begin to deteriorate long before any decreased livestock production is noticed. They further state that heavy grazing causes undesirable changes in species composition and reduces the carrying capacity of the range. Houston and Woodward (1966), Johnson et al. (1951), and Lewis et al. (1956) all reported that heavy grazing intensity reduced the condition of the range and thus reduced its capacity to produce beef.
Fig. 2. Effects of stocking rates on beef production (Houston and Woodward, 1966).
Table 13. Summary of papers relating range condition to grazing intensity.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Range type</th>
<th>Condition at start of study</th>
<th>Percent use (^a)</th>
<th>Percent use (^a)</th>
<th>Percent use (^a)</th>
<th>of study</th>
<th>Recommended grazing intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston and Woodward</td>
<td>1966</td>
<td>Mixed prairie</td>
<td>Fair</td>
<td>Good</td>
<td>High</td>
<td>Fair</td>
<td>10 yrs.</td>
<td>40-55% utilization</td>
</tr>
<tr>
<td>Johnson et al.</td>
<td>1951</td>
<td>Mixed prairie</td>
<td>Good</td>
<td>37 Exc.</td>
<td>46 Good</td>
<td>63 Fair</td>
<td>9 yrs.</td>
<td>30-45% utilization</td>
</tr>
<tr>
<td>Lewis et al.</td>
<td>1956</td>
<td>Short and mid-grass prairie</td>
<td>Good</td>
<td>28 High good</td>
<td>50 Low good</td>
<td>69 Fair</td>
<td>14 yrs.</td>
<td></td>
</tr>
<tr>
<td>Frischknecht and Harris</td>
<td>1958</td>
<td>Crested wheat</td>
<td>39 Wolf plants incr.</td>
<td>54</td>
<td>80 Shrubs</td>
<td>10 yrs. invaded</td>
<td></td>
<td>65% use with rotation grazing</td>
</tr>
<tr>
<td>Springfield</td>
<td>1963</td>
<td>Crested wheat</td>
<td>41</td>
<td>55</td>
<td>69</td>
<td></td>
<td></td>
<td>65-70% utilization</td>
</tr>
</tbody>
</table>

\(^a\) percent utilization of forage.
McAfee et al. (1975) made an excellent comparison of calf production on excellent and fair condition range in eastern Wyoming. Two pastures, 640 acres in size and each on loamy range sites were compared. The fair condition pasture carried 19 cow-calf pairs for the summer grazing season. Average daily calf gains were 1.4 pounds and 6,500 pounds of calf were produced. The excellent condition pastures carried 32 cow-calf pairs. The average daily calf gain was 2 pounds and a total of 12,800 pounds of calf were sold off that pasture. The excellent condition range produced twice as much beef as the fair condition range.

In the short run, heavy stocking will produce maximum production per acre (Martin, 1975). However, if this "mining of the land" continues indefinitely, productivity of the land and livestock will decline and so will profits. On the other hand, light stocking may not be desirable either. Stoddart (1960) questioned whether maximum production per animal, which is gained from light stocking rates, was ever an economically sound management objective. Bement (1969) suggested that vegetation, livestock and economics should be considered in the management decision of which rate to stock a range. Cost of grazing is a very important consideration in determining stocking rate for the rancher. The total cost (fixed plus variable costs) associated with grazing must be equal or less than the revenue generated (pounds of beef sold) from grazing a piece of land if the rancher is to remain in business over the long run (Whitson and Ragsdale, 1976). The objective of the rancher is to maximize returns per acre or unit of land area over the long run.
The long run time frame necessitates a sustained yield of forage which precludes excessive grazing to the point of deterioration of the forage and soil resource. Therefore, from the long run standpoint, the correct stocking rate from an economic point of view would never entail overgrazing.

In a situation where the grazier was the owner of the land, or he leased the land on a per acre basis, the land resource becomes a fixed cost. The grazier would be forced economically to stock the range at a rate which would produce near its long term maximum biological production in pounds of beef per acre (Whitson and Ragsdale, 1976). The variable costs (transportation, maintenance, supplements, veterinary, etc.) would be relatively small compared to the large fixed cost of the capital resource.

In a situation where the grazier leased grazing on a per head or AUM basis, the optimum stocking would be substantially below the maximum biological production. The lease fee would be added onto the other variable cost to produce a relatively high variable cost of grazing. The optimum stocking rate would be where the net returns are maximized. Each additional animal on a grazing unit adds an equal increment of cost. But, according to the law of diminishing returns, the output from each additional unit of input becomes smaller and smaller (Leftwich, 1969). There comes a point where the cost of a unit of input (marginal cost) just equals the value of the output which it produces (marginal returns). This produces maximum return per acre and would be the optimum rate at which to stock in the long run (Workman, 1977, personal communication).
Several early studies to determine the proper stocking rate, both economically and biologically, concluded that moderate stocking rates produced the maximum returns to the operator (Ramsbacher, 1958; Caton, 1959; Costello, 1959). All of the research reviewed in Tables 12 and 13 concludes that moderate is the best stocking rate to maintain the range condition and still get acceptable livestock production. In a summary of grazing intensities' effect on gains of steers and heifers, Stoddart et al. (1975) stated that moderate grazing intensities were most practical for the Great Plains and Western United States. Stoddart (1960) stated that the range manager's task is to detect vegetation changes and achieve a balance that maintains an acceptable level of production from both livestock and other range products.

Grazing Systems

Grazing the rangelands has been compared to farming, however, the application is backwards. A farmer spends a good deal of his time pulling, clipping, or spraying weeds so his crops will grow better. On the range, the livestock clip the good forage plants while the weeds go undisturbed (Arizona Interagency Range Committee, 1973). The forage plants are the primary producers on a range site. Therefore, their growth requirements must be met if they are to survive and produce forage for livestock and wildlife. However, repeat grazing during the growing season for several years is detrimental to plants. The damage ranges from slight during early growth and maturity to very severe during rapid growth prior to
seed set (McCarty and Price, 1935; Blaisdell and Pechanec, 1949). If the forage plants are grazed at their critical periods year after year, they soon lose their vigor, production drastically decreases and the plant eventually dies.

The Arizona Interagency Range Committee (1973) lists two approaches to minimizing grazing damages:

1. Graze light enough that the forage species won't be damaged.
2. Rest periodically to permit plants to regain vigor, produce seed, and establish new seedlings.

Light, continuous use has been tried in many areas with varying degrees of success. A majority of the papers reviewed stated that continuous grazing provided greater individual livestock gains than a grazing system, but it did not maintain the desirable forage species. Steger (1970) stated that ranchers cannot economically stock their ranges light enough to maintain the better forage grasses under continuous grazing. Ragsdale, Huss and Hoffman (no date) stated that continuous grazing keeps plants in low vigor and thus low condition even under light stocking. The Arizona Interagency Committee (1973) stated that continuous grazing at appropriate stocking levels is a good strategy and superior to many specialized systems. However, continuous grazing often creates a distribution problem.

Improper distribution, although a separate problem, is related to the harmful effects of continuous grazing and is often one of the problems a grazing system is designed to overcome. The shortcoming of season-long grazing is that the animals are free to return
to their favorite areas and graze their favorite plants year after
year. This is why easily accessible areas are usually overgrazed
and the less accessible areas are seldom used. This inequity causes
much valuable forage to be wasted each year while other forage is
killed out by overuse. Martin (1972) measured the distance that
use zones extended from water holes. The area within one-half mile
of water was used very heavily and supported mostly annual grasses.
Areas between one-half mile and 2 miles of water were used moderately
and areas 2 miles and greater from water were used very lightly.
The vegetation in the light use areas were predominantly desirable
perennial grasses in good condition.

The alternative to light continuous grazing then is to provide
periodic rest in order to maintain vigorous forage species in the
plant community. This is similar to the definition of a grazing
system given in the Society for Range Management Glossary of
Terms (1974): "A specialized manipulation of livestock grazing
with systematically recurring periods of grazing and deferment for
two or more pastures or management units."

Shiflet and Heady (1971) state some common objectives of a
grazing system:

1. Periodically relieve the grazing pressures from a unit
to enable the forage species to complete a growth cycle to replenish
the carbohydrate reserve, allow for root growth, restore vigor,
permit seed production, and to establish desirable seedlings.

2. Improve livestock distribution to obtain a uniform utilization
of forage.
3. Maintain a high sustained yield of livestock products from the range resource.

**Types of grazing systems**

Heady (1970) defined various types of grazing systems as follows:

**Continuous grazing:**

Unrestricted livestock access to any part of the range throughout the grazing season. The grazing season may be yearlong, spring, summer, fall, or winter or any combination of the seasonal periods.

**Rotation grazing:**

Animals are moved from one unit to another on a scheduled basis without regard to plant phenology or the critical periods when plants are most susceptible to grazing damage.

**Deferred grazing:**

The unit is not grazed until the seeds of the important forage species are mature. This also eliminates the damage which is most severe when plants are grazed during rapid growth. Deferment in a second year permits establishment of seedlings.

**Deferred rotation:**

Deferment is rotated among the units of a grazing complex in successive years. This enables all forage in the grazing complex to complete a full growth cycle within a grazing sequence.

**Rest rotation (Hormay, 1970):**

One unit is not grazed for an entire year. This allows plants to complete a full growth cycle in order to make and store
food, allow seed to ripen, and allow litter to accumulate and return some biomass to the soil. Scheduled periods of deferment often accompany the rest cycle to allow seedlings to become established. The rest and deferment are rotated systematically among all units of the grazing complex.

Short duration-high intensity (Powell, 1972):
Relatively large numbers of animals are concentrated on a unit for a short time and then moved to the next unit. The high intensity grazing forces uniform utilization of both palatable and unpalatable forage. The unit is then rested for a long period in order to recover from the heavy grazing. This system is applicable to humid areas or irrigated pasture where forage becomes rank and unpalatable when it matures.

Best pasture system (Stoddart et al., 1975):
Animals are placed in the pasture with the best forage condition and grazed until 50 percent of the forage is used. They are then moved to the next best pasture and allowed to graze one-half of the available forage before moving on to the next pasture, etc. Some pastures may not be grazed in a year and some grazed several times. This allows the poor condition pastures to improve while the best pastures take the majority of the grazing pressure. The condition of the better pastures may decline due to the heavy grazing pressure, but the overall condition of the range should improve. This system works best in arid areas where rainfall is sporadic and erratically distributed.
Because of the many different grazing systems and many different combinations of grazing and rest, comparison between the systems is impossible. Furthermore, the different range sites and vegetation types, the various grazing seasons, as well as the class and species of animals add uncontrollable variables that prevent comparison of grazing systems. However, most of the papers reviewed compared the particular system to continuous grazing, or made the comparison of uncontrolled grazing before to the effects of the system after it had been implemented for a period of years. A simple tabulation was made to determine the number of the studies that found the grazing system superior, inferior, or no different than continuous grazing in livestock response and vegetative condition.

Deferred rotation. Table 14 is an attempt to summarize 15 studies on deferred rotation grazing and to list the important findings of each study. The livestock and vegetation response to the grazing system, as compared to continuous grazing, is notated by a plus '+' for superior, minus '-' for inferior, and zero '0' for no difference. Eight of the 12 papers reporting livestock response indicated that livestock production was superior in deferred rotation grazing systems. However, half of the controlled studies, in which the variables of years, climate, and site were equal, reported that deferred rotation grazing was inferior in livestock production. One study on the Edwards Plateau, running mixed cattle, sheep, and goats, concluded there was no difference in livestock production between continuous and the deferred rotation grazing systems (Merrill, 1954).
Table 14. Summary of papers comparing livestock and vegetative response from deferred rotation with continuous grazing.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Range type</th>
<th>Class of livestock</th>
<th>Grazing season</th>
<th>Stocking rate</th>
<th>Continuous carrying capacity</th>
<th>Continuous change in veg. condition</th>
<th>Deferred rotation carrying capacity</th>
<th>Deferred rotation change in veg. condition</th>
<th>Response or change due to grazing system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leithead</td>
<td>1960</td>
<td>Washington</td>
<td>Palouse prairie</td>
<td>Cows &amp; calves</td>
<td>Mar-Oct</td>
<td>80</td>
<td>2.9 lb/ac</td>
<td>7.4 lb/ac</td>
<td>151</td>
<td>100% increase</td>
<td>Blue bunch wheat - 155% +</td>
</tr>
<tr>
<td>Dillon</td>
<td>1958</td>
<td>Eastern</td>
<td>Palouse prairie</td>
<td>Cow-calf</td>
<td>Ap-Nov</td>
<td>1000 AUM</td>
<td>Poor &amp; fair</td>
<td>2310 AUM</td>
<td>Poor &amp; fair</td>
<td>Heavier condition, proper util.</td>
<td>+100% +</td>
</tr>
<tr>
<td>Dillon &amp; Wallenmeyer</td>
<td>1966</td>
<td>Eastern</td>
<td>Palouse prairie</td>
<td>Cow-calf</td>
<td>Jul-Dec</td>
<td>1000 AUM</td>
<td>Poor &amp; fair</td>
<td>2310 AUM</td>
<td>Poor &amp; fair</td>
<td>Heavier condition, proper util.</td>
<td>+100% +</td>
</tr>
<tr>
<td>Hyder &amp; Sawyer</td>
<td>1951</td>
<td>Oregon</td>
<td>Palouse prairie</td>
<td>Cow-calf</td>
<td>Sp, su, fall</td>
<td>+9 lb/ mo</td>
<td>2.69 blue-bunch, 1d fence 39% U.</td>
<td>56% util.</td>
<td>-</td>
<td>-1.5%</td>
<td></td>
</tr>
<tr>
<td>Shepperd</td>
<td>1939</td>
<td>North Dakota</td>
<td>Tall grass prairie</td>
<td>2 yr old steers</td>
<td>May-Oct</td>
<td>10 AU</td>
<td>No change</td>
<td>14</td>
<td>No change</td>
<td>+40%</td>
<td></td>
</tr>
<tr>
<td>Rodgers</td>
<td>1951</td>
<td>North Dakota</td>
<td>Mixed prairie</td>
<td>Steers</td>
<td>May-Oct</td>
<td>5 ac/ hd</td>
<td>+45 lb/ hd</td>
<td>Maintained veg.</td>
<td>Maintained veg.</td>
<td>-0</td>
<td></td>
</tr>
<tr>
<td>Anderson</td>
<td>1940</td>
<td>Kansas</td>
<td>Blue stem pasture</td>
<td>Steers</td>
<td>May-Oct</td>
<td>5 ac/ hd</td>
<td>+45 lb/ hd</td>
<td>Maintained veg.</td>
<td>Maintained veg.</td>
<td>-0</td>
<td></td>
</tr>
<tr>
<td>Herbel</td>
<td>1959</td>
<td>Flint Hills</td>
<td>Tall grass prairie</td>
<td>Steers</td>
<td>May-Oct</td>
<td>42 lb/ac</td>
<td>1.1 lb ADG</td>
<td>65 lb/ac.</td>
<td>Grass maintained +55% +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McIlvain</td>
<td>1951</td>
<td>Southern Plains</td>
<td>Sand sage</td>
<td>Summer</td>
<td>+10 lb</td>
<td>No sig. diff.</td>
<td>42.5 lb/ ac</td>
<td>No change -21%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoffman &amp; Ragsdale</td>
<td>1939</td>
<td>Sonora, Texas</td>
<td>Cattle, sheep &amp; goats</td>
<td>Yearlong</td>
<td>Fair</td>
<td>+11 AU</td>
<td>Good</td>
<td>+100 lb/ hd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoffman &amp; Ragsdale</td>
<td>No date</td>
<td>Barnhart, Texas</td>
<td>Cattle, sheep &amp; goats</td>
<td>Yearlong 25 ac/AU</td>
<td>14.4 lb/ ac</td>
<td>16.2 lb/ hd</td>
<td>+12%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoffman &amp; Ragsdale</td>
<td>No date</td>
<td>Texas</td>
<td>Mid &amp; short grass prairie</td>
<td>Cow-calf</td>
<td>Yearlong 20 ac/AU</td>
<td>+30 lb</td>
<td>Calf</td>
<td>Side oats grama +</td>
<td>+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 14. Continued.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Range type</th>
<th>Class of livestock</th>
<th>Grazing season</th>
<th>Stocking rate</th>
<th>Continuous</th>
<th>Deferred rotation</th>
<th>Response or change due to grazing system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merrill b</td>
<td>1954</td>
<td>Edwards Plateau</td>
<td>Short &amp; mid grass</td>
<td>Cattle, sheep &amp; goats</td>
<td>Yearlong</td>
<td>32 AUM/ sec</td>
<td>Steer: Curley mesquite 9.8 lb, -89% (drought)</td>
<td>Steer: Curley mesquite 9.7 lb, -78% (drought)</td>
<td>0 + 11%</td>
</tr>
<tr>
<td>Poulsen &amp; Areas b</td>
<td>1962</td>
<td>Jornada</td>
<td>Desert grassland</td>
<td></td>
<td></td>
<td></td>
<td>Black grama +2%</td>
<td>Black grama +2%</td>
<td>+ 63%</td>
</tr>
<tr>
<td>Reynolds b</td>
<td>1959</td>
<td>Desert grassland</td>
<td>Desert grassland</td>
<td></td>
<td></td>
<td></td>
<td>Desirable species increased 71%</td>
<td>Desirable species increased 31%</td>
<td>- + 24%</td>
</tr>
<tr>
<td>Hickey &amp; Garcia a</td>
<td>1964</td>
<td>Desert grassland</td>
<td>Desert grassland</td>
<td></td>
<td></td>
<td></td>
<td>Blue grama - 56%</td>
<td>Blue grama + 400%</td>
<td>+ 400%</td>
</tr>
</tbody>
</table>

Positive response | 8 + | 10 + |
No difference     | 1 0 | 4 0 |
Negative response | 3 - | 1 - |
Total number of studies | 12 | 15 |

a Comparison of pasture before and after implementation of grazing system.
b Comparison of grazing system and a control on the same site with other variables held constant.
The influence of the grazing system on vegetation condition indicates that 10 out of 15 studies reported that deferred rotation was superior in maintaining or improving vegetative condition. Four studies indicated that there was no difference in the vegetative condition and one study indicated that deferred rotation was more harmful than continuous grazing.

**Rotation.** The majority of the rotation grazing papers reviewed stated that there was no difference between rotation grazing and continuous grazing in livestock and vegetation response (Table 15). Four of the eight papers reporting livestock response indicated there was no difference between the rotation and continuous grazing. Three stated that rotation grazing was inferior in producing livestock gains and only one stated that it was superior. The vegetation response to the grazing systems revealed that four out of nine studies found no difference in vegetative condition between the two systems. Three studies reported that rotation grazing was superior in maintaining or improving the vegetation condition and two studies stated that continuous grazing was superior.

**Rest rotation.** Rest rotation is perhaps the most radical grazing system discussed. It requires that a significant part of the grazing area be left ungrazed for an entire year. This loss of forage often requires the operator to reduce the number of animals when going into this type of a grazing system. Hopefully, the grazing system will improve the range condition sufficiently to increase the stocking rate and restore the numbers that were cut.
Table 15. Summary of papers comparing livestock and vegetative response from rotation grazing with continuous grazing.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Range Type</th>
<th>Class of Livestock</th>
<th>Grazing Season</th>
<th>Stocking Rate</th>
<th>Continuous Gains</th>
<th>Change in veg. condition</th>
<th>Rotation Gains</th>
<th>Change in veg. condition</th>
<th>Livestock response</th>
<th>Vegetation response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laycock</td>
<td>1962</td>
<td>Idaho</td>
<td>Sagebrush-Grass</td>
<td>Sheep</td>
<td>Spring-fall</td>
<td>20 SD/acre</td>
<td>No diff.</td>
<td>Maintained under mod, declined under heavy stocking rates</td>
<td>No diff.</td>
<td>Maintained under mod and heavy stocking rates</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fissar et al.</td>
<td>1962</td>
<td>Wyoming</td>
<td>Subalpine</td>
<td>Steer</td>
<td>Summer</td>
<td>3.5 ac/steer/season</td>
<td>50 lb/ac 1.88 lb ADG</td>
<td>51% U. on Id. fescue</td>
<td>51 lb/ac 2.12 lb ADG fescue</td>
<td>51 lb/ac</td>
<td>2.12 lb ADG fescue</td>
<td>0</td>
</tr>
<tr>
<td>Smith et al.</td>
<td>1967</td>
<td>Wyoming</td>
<td>Subalpine</td>
<td>Steers</td>
<td>Summer</td>
<td>2.2 lb ADG</td>
<td>Id. fescue maintained beet</td>
<td>2.1 lb ADG</td>
<td>2.1 lb ADG</td>
<td>2.1 lb ADG</td>
<td>2.1 lb ADG</td>
<td>2.1 lb ADG</td>
</tr>
<tr>
<td>Johnson</td>
<td>1965</td>
<td>Wyoming</td>
<td>Mountain</td>
<td>Cattle</td>
<td>Summer</td>
<td></td>
<td>Cover increased 5%</td>
<td>Cover increased 10% U. reduced from 61 to 161%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Black and Clark</td>
<td>1942</td>
<td>South Dakota</td>
<td>Mixed grass prairie</td>
<td>Yearling steers</td>
<td>Year long</td>
<td></td>
<td>No diff.</td>
<td>+0.1 lb</td>
<td>No diff.</td>
<td>+0.1 lb</td>
<td>No diff.</td>
<td>+</td>
</tr>
<tr>
<td>Biswell</td>
<td>1951</td>
<td>North Carolina</td>
<td>Switchgrass</td>
<td>Steers</td>
<td></td>
<td></td>
<td>No diff.</td>
<td>No diff.</td>
<td>No diff.</td>
<td>No diff.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dickson et al.</td>
<td>1948</td>
<td>Texas</td>
<td>Mid &amp; short grass prairie</td>
<td>Steers</td>
<td>Summer</td>
<td>26 lb/ac .91 lb ADG</td>
<td>53% U.</td>
<td>24 lb/ac .87 lb ADG</td>
<td>53% U.</td>
<td>.87 lb ADG</td>
<td>+2.7%</td>
<td>+2.7%</td>
</tr>
<tr>
<td>Fisher &amp; Morton</td>
<td>1951</td>
<td>Texas</td>
<td>Short grass prairie</td>
<td></td>
<td></td>
<td>.9 lb ADG 23.8 lb/ac</td>
<td>+6.5%</td>
<td>.87 lb ADG 21.8 lb/ac</td>
<td>+8%</td>
<td>+8%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Frisch- knecht &amp; Harris</td>
<td>1968</td>
<td>Utah</td>
<td>Created wheat Mixed cattle</td>
<td>Spring</td>
<td>1.6 ac/ADM</td>
<td>1lb ADG 1.73 lb ADG 1.73</td>
<td>No sig diff.</td>
<td>No sig diff.</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Positive response 1 + 3 +
No difference 4 0 5 0
Negative responses 4 - 2 -
Total number of studies 9 10
The two papers reporting a vegetation response indicated that the rest rotation grazing system increased the vegetative cover 12-15 percent (Johnson, 1965) and 12-36 percent (Ratlift et al., 1972) over levels prior to the grazing system (Table 16). Two papers reported an increase in carrying capacity due to the grazing system. Bay (1964) reported that individual yearling steer gains increased 15-20 pounds. Woolfolk (1960) reported that the rest rotation grazing system of Harvey Valley increased calf gains by 5 to 8 pounds compared to neighboring continuous grazing during the 1959 drought. However, Ratlift et al. (1972) stated that there were no differences in longterm gains of livestock on the grazing system at Harvey Valley as compared to continuous grazing.

Short duration-high intensity. The theory of short duration-high intensity grazing is to concentrate a large number of animals on a small area for a short time. This promotes uniform use and allows the more palatable forage species to compete effectively. Because of the heavy use from concentrated grazing, long recuperation periods are necessary and available soil moisture is essential to provide for regrowth. For these reasons, a large number of pastures is required, and a humid climate or dependable soil moisture is necessary.

Benefits (Powell, 1972; Turner, 1973):

1. Uniform distribution of livestock.
2. Even utilization of all forage species.
3. Palatable forage species can compete effectively and increase in density.
<table>
<thead>
<tr>
<th>Researcher</th>
<th>Year</th>
<th>Location</th>
<th>Range Type</th>
<th>Class of Livestock</th>
<th>Grazing Season</th>
<th>Forage Response</th>
<th>Livestock Response</th>
<th>Carrying Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson</td>
<td>1965</td>
<td>Wyo.</td>
<td>Mountain</td>
<td>Cattle</td>
<td>Summer</td>
<td>Cover + 12-15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bay</td>
<td>1964</td>
<td>Mountain</td>
<td>Mountain</td>
<td>Cow-calf yearling</td>
<td>Summer</td>
<td>Yearling gains + 15-20 lb.</td>
<td>+ 10%</td>
<td></td>
</tr>
<tr>
<td>Ratliff et al.</td>
<td>1972</td>
<td>Calif.</td>
<td>Mountain</td>
<td>Cow-calf yearling</td>
<td>Summer</td>
<td>+ 12-36%</td>
<td>No diff.</td>
<td>+ 15%</td>
</tr>
<tr>
<td>Woolfolk</td>
<td>1960</td>
<td>Calif.</td>
<td>Mountain</td>
<td>Cow-calf yearling</td>
<td>Summer</td>
<td>Calf gain + 5-8 lb.</td>
<td>Maintained</td>
<td>no. in drought</td>
</tr>
</tbody>
</table>
4. Range condition improves.
5. Less vegetation is trampled and wasted.
6. Small pastures allow for individual treatment for different range sites or vegetation types.
7. Long rest allows for cultural treatments within the growing cycle.
8. Concentrated livestock allows for easier observation and better bull coverage.
9. Improved range condition increases carrying capacity and livestock production per acre.

The major disadvantage is the lowered individual livestock performance. The reduced selectivity and forced consumption of less palatable species reduces the dry matter intake and the disturbance and adjustment from frequent moving further reduces individual gains. If carrying capacity does increase, livestock production per acre will offset the reduced gains per animal. A study of a five-pasture short duration-high intensity grazing system at the Virginia Forage Research Station showed the system increased forage production by 72 percent and gave 41 percent more live weight gains per acre as compared to continuous grazing. The gains per animal, however, were 10 percent less (Anonymous, 1973). Turner (1973) was able to increase the carrying capacity 25 percent while running sheep and cattle in common in Texas.

Seasonal suitability. Seasonal suitability consists of grazing the various range, vegetation types, sub-types, and condition class areas comprising a ranch when grazing is most advantageous to both
vegetation and livestock (Vallentine, 1967). Rotation grazing requires similar topography and vegetation that can be used at all times of the season. This system excels where there is a great diversity of vegetation types and condition classes. It is especially applicable in the Southwest.

Advantages:

1. Improvement of poor condition range by using lightly at least harmful time of the year.
2. Concentrate grazing on least palatable species when they are most vulnerable.
3. Use good condition range during rapid growth to get maximum livestock production.
4. Fully utilize the spring flush of annual forbs and grasses throughout the ranch.

Rotating access to water. Martin and Ward (1969) reported a system of rotating access to water to shift the grazing pressure around a large grazing unit. Martin (1972) reported that intensity of use decreases with distance from water. In large pastures with limited water, the grazing pressure could be rotated, thereby deferring use on traditionally overused areas. This would allow overgrazed areas to recoupereate without the high cost of fencing.

Complementary grazing system. The rationale of any of the specialized grazing systems is to provide a periodic rest at the period when a grass is most damaged by grazing. This is usually in the spring or summer when grasses are growing most rapidly. Hubbard (1951) and Rogler (1951) both stated that the real value of rotation
grazing is the spring deferment it offers. Anderson (1940) recommended continuous spring deferment and planting cool season grasses for spring grazing. Lodge (1970) proposed that seeded spring pastures are complementary to a grazing system. He stated that the improved cool season grasses start growth earlier in the spring, yield large quantities of palatable forage, and are fairly resistant to grazing. Table 10 indicated that carrying capacity of seeded pastures were 2–3 times greater than native range. A large number of livestock could be concentrated on a relatively small area for the spring while the native vegetation was deferred until seed set. Rogler (1962) and Lodge (1963) reported gains per acre were double on the complementary spring pasture-summer native range system compared to season-long grazing on native range. Gains per steer were also higher. This type of a complementary system extends the grazing season by turning out earlier in the spring. It also reduces the amount of hay fed in the spring. If livestock are taken off while there is still adequate soil moisture, substantial regrowth can be expected and the grazing season can be extended longer into the fall.

Response of livestock and vegetation to grazing systems

Table 17 is a tabulation of the number of grazing systems that were superior, inferior, or no different than continuous grazing. Thirty-four papers were reviewed on various types of grazing systems. Livestock response. Continuous grazing generally benefited livestock gains. Fifteen of 27 studies indicated that continuous was
just as good or better than the grazing system in producing acceptable gains. Shiflet and Heady (1971) state that those systems that minimized livestock movement showed the best livestock response. When animals are moved to a new pasture, they spend a considerable amount of time walking the fences and getting accustomed to the area, thus much grazing time is lost (McIlvain and Savage, 1951).

Table 17. Summary of livestock and vegetation response to grazing systems.

<table>
<thead>
<tr>
<th></th>
<th>Superior</th>
<th>No different</th>
<th>Inferior</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Livestock response</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deferred rotation</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Rotation</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Rest rotation</td>
<td>2</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td><strong>Vegetation response</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deferred rotation</td>
<td>12</td>
<td>4</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Rotation</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Rest rotation</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td>8</td>
<td>3</td>
<td>29</td>
</tr>
</tbody>
</table>

Another reason for reduced livestock performance is the elimination of selectivity (choosing plants and parts of plants that are most palatable and oftentimes most nutritious). One of the objectives of a grazing system is to concentrate the livestock to get an even utilization of all the forage, thus reducing selectivity. Heady (1961) states there is a positive correlation between selectivity and quantity and quality of intake. Once the palatable plants and parts
of plants are gone, the animals are forced to consume the less palatable forage species which decreases dry matter intake. Johnstone-Wallace and Kennedy (1944) have also shown a positive correlation between the amount and quality of available forage and animal performance. They state that there exists a critical level of forage in any pasture. Above this critical level, livestock performance is not limited. However, when grazing removes forage to below this level, livestock gains decline. The concentration of animals in a grazing system usually results in heavy utilization of a unit. Thus available forage is reduced below the critical level and becomes a limiting factor in producing animal gains.

Where the grazing system is able to improve the vegetation condition and species composition, the amount of available forage increases as does the more palatable species. Thus individual animal gains will increase as the range condition increases. Furthermore, the carrying capacity increases and the increased number of animals allows for an increased livestock production per acre.

Vegetation response. Of the 29 studies reporting vegetative response to the grazing system, 18 indicated that the grazing system maintained or improved the vegetation condition better than continuous grazing. Eleven studies indicated that the grazing system offered no advantage or was inferior. Those studies indicating that the system was inferior stated that the system concentrated the animals on a fraction of the area and the damage incurred was not repaired sufficiently during the rest periods (Hyder and Sawyer, 1951;
Smith et al., 1967; Fisher and Marion, 1951; McIlwain and Savage, 1951). This problem could be alleviated by reducing the stocking rate to the number of animals that the unit could carry without damage to the vegetation. A larger percentage of the deferred rotation and rest rotation systems reported superior vegetation response than the rotation systems. This may be due to the benefits of the planned deferment. Hubbard (1951) and Rogler (1951) both stated that the real value of a grazing system was the deferment during the growth period. The rotation system did not always provide this.

The initial condition of the range determines the magnitude of improvement that is possible. The studies that reported the greatest increase in vegetative condition were on ranges in relatively poor condition (Hickey and Garcia, 1964; Poulsen and Ares, 1962; Leithead, 1960; Dillon, 1958; Dillon and Wallermeyer, 1966). Several authors agreed that the beneficial effects of a deferred or rotation grazing appear to be most evident in restoring over-grazed range rather than maintaining range in good condition (Sampson, 1951; Hubbard, 1951; Rogler, 1951).

Magnitude of response. It is interesting that the "evaluation reports" comparing the livestock production and vegetative condition before to the results after the grazing system was implemented showed tremendous increases (100-400 percent) from both livestock and vegetation (Leithead, 1960; Dillon, 1958; Dillon and Wallenmeyer, 1966; Hickey and Garcia, 1964). On the other hand, those "direct comparison" studies that listed magnitude showed only moderate
increases (11-63 percent) (Merrill, 1964; Craddock and Forsling, 1938; Poulsen and Ares, 1962; Reynolds, 1959; Hyder and Sawyer, 1951). The evaluation studies are mostly ranges in poor condition to begin with and had a great potential for improvement. The range sites in the comparison studies were generally in good condition and little change was evident.

Other range improvements associated with grazing systems

When a grazing system is implemented, many other improvements may be required to make it work (i.e., reduction in stocking rate, fencing, water developments, trails, and improved salting practices). Furthermore, the rest and deferment periods are conducive to brush control and seeding within the grazing cycle. A number of the papers reviewed reported extensive developments associated with the grazing system (Turner, 1973; Powell, 1972; Ratliff et al., 1972; Bay, 1964; Merrill, 1954; Leithead, 1960; Dillon, 1958; Dillon and Wallenmeyer, 1966). Many authors, especially those of reviews, questioned attributing the improvement in range condition and livestock production to a grazing system alone when other improvements were included (Heady, 1961; Sampgon, 1951; Herbel, 1971; McIlvain and Savage, 1951; Shiflet and Heady, 1971; Hubbard, 1951; Biswell, 1951). The improved management, which is responsible for the grazing system as well as the other improvements, may be the source of the improvement in range and livestock production rather than the grazing system by itself.
Economics of grazing systems

Sampson (1951) stated that the benefits of any grazing system should be justified against the cost of implementing the system. Most of the reports say nothing about the costs. They may not have been considered in the study or were not reported because the grazing system was not economical. Hubbard (1951) concluded that it is unlikely that the benefits on vegetation would be sufficient to offset the increased costs of extra fencing and water developments in the short grass prairie of western Canada. Biswell (1951) stated that if rotation grazing necessitates extra labor, fencing, or water developments, continuous grazing is more practical on swithcane pastures of the southeastern United States. Turner (1973) was not sure that the returns from a short duration grazing system were going to pay for its costs. Ratliff et al. (1972) mentioned other economic considerations in considering a rest rotation grazing system at Harvey Valley:

1. It is not necessary to cut numbers when implementing cultural treatments within the rest cycle.
2. There was an increase in permitted numbers.
3. There was emergency feed available in rested pastures that could be used in drought years.

Three papers did quantify the returns received from the grazing system. Leithead (1960) reported that net returns increased from $.04/acre prior to implementation of a deferred rotation system to $.83/acre after 7 years on the system. Ragsdale et al. (no date) reported a 33 percent increase in net income from a Merrill four-pasture deferred rotation system. This was an increase of $11.75/acre.
A South African two-pasture switchback system also increased net income by 33 percent. Nazir (1972) completed a comprehensive survey of 24 BLM allotments in Utah, Idaho, and Nevada which had a grazing system. The grazing systems increased rancher profits by an average of 11.4 percent. The internal rate of return varied from -1 percent to 18 percent with an average of 2.37 percent. This average is extremely low, indicating that most of the grazing systems are not economical when justified only on monetary returns from increased AUMs leased. However, such unquantifiable social benefits as improved watershed, wildlife habitat, aesthetic and recreation values may be able to justify the grazing system.

Conclusions from other reviews

Hickey (1966), in a review of 101 papers on grazing studies and systems from 1891-1966, concluded that the two-pasture rotation offers no benefits from livestock gains or range improvement. Other rotation systems offered some advantage to increased vegetative condition but decreased livestock yields. Deferred rotation benefited livestock gains, pasture improvement in both vegetation and soils, and increased net returns. Rest rotation appeared to give the greatest increase in vegetative condition and livestock production in the long run. However, he stated that no grazing management system is entirely satisfactory on over-grazed range. The stocking rate must first be adjusted and management applied for range rest.
Lodge (1970) concluded that deferred rotation grazing systems had little or no advantage on vegetation and continuous grazing gave maximum livestock gains on good condition range in the northern Great Plains.

Shiflet and Heady (1971) found results from grazing systems ranging from highly unfavorable to highly successful. They concluded that the successful systems must allow little damage when plants are susceptible to grazing and foster as much improvement as possible in ungrazed pastures. Flexibility and simplicity are the keys to any grazing system.

Herbel (1971) stated that grazing schemes had only limited success in yielding greater livestock and forage production than continuous grazing on seasonal ranges. He listed several reasons why the grazing systems were less successful.

1. The advantage of spring deferment is seldom balanced against the detrimental effects of concentrating livestock on one unit during the critical period of plant growth.

2. In areas with a short growing season, a relatively small number of desirable plants are actually grazed during rapid growth under continuous grazing at moderate intensities and when livestock are well dispersed.

3. Most systems have a fixed stocking rate. The forage crop fluctuates thus causing over- and under-utilization.

Deferment of bunchgrass range every 3 years is highly beneficial to the vegetation. On mountain lands with short growing seasons,
rotation grazing is essential and on sodgrass range, moderate season long grazing gives better livestock performance without apparent injury to the vegetation (Sampson, 1951).

Heady (1961) concluded that grazing systems have no advantage over continuous grazing on good condition range with comparable stocking rates, and similar levels of management.

Overriding considerations

A grazing system is not a panacea that will solve all the problems that exist on the range. It is only one of several tools available to the range manager. If used properly, it can create the conditions that allow for improvement of the vegetation. Herbel (1971) stated that weather conditions influence range condition more than the grazing treatment applied to the range. Grazing can either aggravate or enhance these natural fluctuations. Heavy grazing at the critical periods in a drought will hasten the natural mortality of vegetation. Proper grazing treatments can reduce the severity of a drought and allow for rapid recovery following. In wet years, conditions will naturally improve with reasonable grazing management.

Blaisdell and Pechanec (1949) stated that grazing injury may be as much due to lack of soil moisture and opportunities for regrowth as to physiological factors. This is evident in irrigated pasture grasses and legumes. Regrowth will occur following several clippings or grazing treatments within a season and the plants remain in a healthy and vigorous condition. The key to seasonal grazing on
rangeland would be to get off a unit while there was still sufficient soil moisture for regrowth.

When a grazing system is implemented, it is usually to correct a problem. The manager or operator realizes the need to improve the condition of the range. The level of management usually rises and other developments and range improvements accompany the grazing system. Therefore, the improvement in range condition and livestock management is just as much the result of a higher level of management and the other improvements as it is the grazing system (Heady, 1961). For this reason, many grazing systems that are imposed on an allotment by an administering agency fail to achieve the desired results. The rancher using the allotment may not understand or appreciate the objectives of the system and as a result, the level of management does not change.

**Developing a grazing system**

The major items to be considered in developing a grazing system are:

1. A basic understanding of the forage resource is essential. The key species must be identified and their critical growth and reproductive periods determined (Anderson, 1967a).

2. The grazing, deferment, and rest periods must be tied to the phenology of the key species to give maximum benefit to the desirable plants (Steger, 1970).

3. Grazing units should be fenced along the different vegetation and soil types. Management should be based on the plant-soil requirements of each pasture.
4. Grazing units of similar carrying capacity should be created (New Mexico Interagency Range Committee, 1970). Additional forage can be created to balance the carrying capacity through brush control and reseeding (Anderson, 1967b).

5. Proper use on those units grazed is essential. Shiflet and Heady (1971) stated that rest doesn't compensate for over-use or heavy use during the critical periods. Ragsdale et al. (no date) recommended 50 percent utilization as a maximum.

6. In order to maintain proper use, the base herd size should be smaller than the average estimated carrying capacity of the range. There are usually more years of below average precipitation than above average years (Ragsdale et al., no date).

7. FLEXIBILITY is the key to any grazing system (Herbel, 1971; Steger, 1970; Ragsdale et al., no date). Since the forage crop is variable and dependent on the amount and time of precipitation, all aspects of the grazing system must be flexible.

   a. Livestock numbers must be reduced in a drought, and can be expanded or the time extended in above normal years of precipitation.

   b. The deferment periods must be adjustable, since the growth stages of the vegetation vary with the weather.

   c. Moving times must be flexible to accommodate proper use and growth stages of vegetation.

   d. The system itself must be changed when problems are observed.
8. Gates should be strategically located to enable livestock to drift into new units. The stress of moving will be reduced and the adjustment period shortened (Anderson, 1967b).

9. Proper distribution is a very important component in making a grazing system work. Skolvin (1965) lists several items to improve distribution.

   a. Strategically located fences and use of natural barriers separates vegetation types and facilitates movement and handling.
   b. Develop water on ungrazed and lightly grazed areas to equalize grazing pressure.
   c. Salt in lightly grazed areas or locations that will encourage greater use.
   d. Ride and move cattle from heavily grazed areas to light or ungrazed areas.

10. Develop the entire range. Implement brush and weed control and reseed to desirable grasses on responsive sites when these treatments are economically justifiable.

11. It is important that the grazing system be simple and blend into the ranch operation (Steger, 1970; Herbel, 1971).

Grazing systems do have their place in range management and can be powerful tools in improving the range condition when they are flexible and geared to the phenology of the key forage species. Little improvement can be gained from a grazing system on good condition range. However, a grazing system may be necessary to maintain a desired species composition. Individual livestock gains
are usually less under a grazing system compared to continuous grazing. If improvement is sufficient, the carrying capacity of the range will increase and livestock production per acre will compensate for loss of individual gains.

**Brush Control**

Control of undesirable shrubs is perhaps the most common method of increasing forage production. Big sagebrush and pinyon-juniper occupy much of the foothill rangeland upon which most ranchers depend for spring-fall and, to a limited extent, summer grazing. The foothill vegetation zone offers the greatest potential for forage production. The growing season is fairly long, the temperatures are not extreme, and there is usually adequate precipitation.

Overgrazing and fire suppression within these two shrub types have reduced the competition from perennial grasses and forbs and allowed the shrubs to increase in density and extent until they now totally dominate much of the foothill zone (Pechanec et al., 1954; Aro, 1970; Johnson, 1962). Because of the shrub domination, forage production is greatly below its potential and can be increased many times by control of these shrubs. Where desirable understory grasses and forbs are inadequate, reseeding to desirable cool season grasses and legumes may be necessary to insure a rapid recovery of the site.
Sagebrush control

Nielsen and Hinckley (1975) reviewed a great deal of literature on control of sagebrush. Table 18 is a summary of forage production before and after different methods of control.

Table 18. Forage production and returns following big sagebrush control (Nielsen and Hinckley, 1975).

<table>
<thead>
<tr>
<th>Method</th>
<th>Forage production</th>
<th>Internal rate of return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before (lbs)</td>
<td>After (lbs)</td>
</tr>
<tr>
<td>Controlled burning</td>
<td>391</td>
<td>669</td>
</tr>
<tr>
<td>Spray with herbicide</td>
<td>190</td>
<td>1148</td>
</tr>
<tr>
<td>Chaining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plow and seeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roto beating</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pinyon-juniper control

Dwyer (1975) in a state-of-the-art paper on pinyon-juniper control, reviewed several papers and concluded that forage production could be increased from 100-350 percent by manipulating the pigmy woodland. Aro (1971) presented several methods that have been effective in controlling pinyon-juniper. Most treatments require seeding to obtain an increase in forage.

1. Burning - most effective and least expensive.
2. Dozing into windrows and seeding cleared areas.
3. Chaining - most widely used method.
   a. single chaining gave 30 percent kill.
   b. double chaining gave 60 percent kill.
METHODS OF PROCEDURE

Description of Ranch and Operation

Overview

A ranch in Rich County, northern Utah, was used as a case study to evaluate the increased beef production attained from improved range and livestock management. The ranch is a family-sized commercial Hereford operation. But unlike many ranches in Utah, the ranching operation was the only source of income. In 1970, when accurate records started being kept, the ranch maintained 336 mother cows. In 1976 483 mother cows were on the ranch. The homestead consists of 1,600 acres of meadow hay and seeded pastures. One crop of native and improved varieties of grass hay is harvested in the summer and fed during the 4 months of late winter and early spring. The breeding herd is grazed on crested wheatgrass pastures where breeding begins about the 15th of May. The cows and calves are trailed 20 miles to the summer mountain range on June 1. The summer range consists of 7,120 acres of mountain loam and high mountain loam (aspen) range sites. Elevation on summer range varies from 6,000 feet to 9,120 feet and precipitation is from 16 to 40 inches (see Range Site Information, Appendix A). Although most of the mountain range is deeded land, it is similar to much of the public as well as private mountain grazing land through the Intermountain area.
The cattle are taken off the summer range around October 15 and are trailed back to the home ranch and grazed on semi-wet meadows and meadow hay aftermath until mid-December. The calves are weaned in late October. Depending on the market, the steers and part of the heifers are then sold or fed until early spring. Replacement heifers and some of the replacement bulls are kept from the top performance tested dams. The operator of this ranch is very progressive and had maintained a relatively efficient operation before the grazing system was implemented in 1970. The 1970 calf crop was 86 percent and the average weaning weight was 351 pounds. Pregnancy testing was a regular practice. All of the yearling heifers and cows were tested and those found open were culled. Calving barns and facilities were available to give special treatment to first calf heifers and older cows requiring assistance at calving. The barns also provide shelter from the early spring storms and were responsible for saving many calves. A regular health program was maintained. All calves were vaccinated for blackleg and malignant edema at branding time and replacement heifers were vaccinated for brucellosis in the fall. All females were vaccinated for leptospirosis and vibriosis annually.

Problems

Summer range was the bottleneck of the operation. For many years, the condition of the range had been declining. The Soil Conservation Service conducted a range survey in 1970 and found the Mountain Loam range site in poor condition. However, the High Mountain Loam (Aspen) site was in high good condition
The cattle had concentrated in the bottom land areas around the streams and springs and on the benches and heavily overgrazed these areas. In 1962 the broad canyon bottoms were aerial sprayed to kill thick concentrations of sagebrush. A majority of the big sagebrush overstory was killed, thus permitting the desirable grasses and forbs to increase. However, there was no control of grazing following treatment. The heavy grazing on the grasses gave the sagebrush seedlings that survived a competitive advantage and they rapidly regained dominance of the site. The hillsides received very little use and thus remained in good condition. The problem was improper distribution. The steep and broken terrain inhibited uniform distribution and concentrated the majority of the herd on a relatively small part of the range. This condition prohibited the expansion of the operation and kept the weaning weights relatively low even though the fertility was high.

**Improvements on summer range (Appendix A)**

**Grazing system.** A four-pasture rest rotation grazing system was implemented in 1970. Two miles of cross fences were constructed and existing fences and natural barriers used to divide the 7,120 acres into four units. To facilitate movement of cattle from one unit to another, and improve the size ratio of the pastures, the system was modified to a three-pasture rest rotation grazing system in 1974. One pasture was used first until seed set. Then the gates were opened and cattle drifted into the second pasture after seed set. The third pasture was completely rested. Since all three pastures joined, movement of cattle was held to a minimum.
Stock trails. The major problem on this grazing allotment was improper grazing distribution. Thirty miles of stock trails were constructed or improved since 1970 to provide access to all parts of the allotment. Trails leading to ridge tops and traversing even the steep slopes have allowed the cows to use all of the summer range.

Water developments. Water developments have also helped improve the distribution by providing dependable water in all areas of the units. Fifteen springs have been developed and 23 troughs have been installed. Twenty earthen ponds have been constructed to collect runoff and three pipelines totaling 3.5 miles were laid to provide water in previously dry areas. Half of the troughs and ponds have been put in and one of the pipelines (1 mile) installed since 1970 when the grazing system was implemented.

Brush control. Many of the productive areas in the canyon bottoms and around water had dense concentrations of sagebrush that restricted forage production. Nine hundred acres of big sagebrush were sprayed with 2,4-D (butyl ester) to kill the sagebrush in 1974 and 1975. Another 200 acres are planned for spraying within the rest cycle of the grazing system. The herbicide treatment effectively killed a large part of the big sagebrush in the valley bottoms. The released soil moisture and nutrients, proper grazing management and a complete rest every third year has enabled the
native grasses to fill in and regain dominance in the productive bottoms. In 1968, 50 acres of the best bottomland were plowed and seeded to crested wheatgrass.

**Improved management practices**

**Maintaining crested wheatgrass pastures.** The 726 acres of crested wheatgrass is fenced into four pastures and two are rested each year. This allows the plants to replenish their carbohydrate reserves and increase in vigor. The breeding herd grazes one pasture for 2 weeks prior to going on the summer range. Another pasture is used as a breeding pasture for the yearling replacement heifers for 2.5 months in the late spring and early summer. Additional river bottom pasture was leased to provide flexibility in the late spring and early summer.

**Increased production from meadow hay.** Native meadow hay land will produce about 1 ton of hay per acre. Hay yields were increased to 1.5 tons per acre by interseeding improved varieties of grass or planting alfalfa-grass mixtures. Alfalfa will not survive more than a few years because of the cold dry winters. Nitrogen fertilizer (300 lbs. ammonia nitrate per acre) further increased yields of improved grasses and alfalfa mixtures to 2 tons per acre (Table 19).

All hay is irrigated and then harvested prior to seed set in order to preserve the high nutrient content. Protein content ranges from 6.2-8 percent. The meadows are irrigated after harvest to stimulate regrowth which provides aftermath grazing for fall.
Table 19. Hayland production.

<table>
<thead>
<tr>
<th></th>
<th>Native meadow</th>
<th>Improved grasses</th>
<th>Alfalfa grass</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres</td>
<td>205</td>
<td>515\textsuperscript{a}</td>
<td>26\textsuperscript{a}</td>
<td>746</td>
</tr>
<tr>
<td>Yield</td>
<td>1 ton</td>
<td>2 tons</td>
<td>2</td>
<td>1,287 tons</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Fertilized acres.

Replacement heifer development. Replacement heifers weigh around 400 pounds when weaned in October. They are fed 2 pounds of barley, 0.06 pound urea, mineral supplement and 10-12 pounds of good quality hay daily throughout the winter and spring. This maintains a gain of over 1 pound per day and allows them to weight 600 pounds going into the breeding season.

Winter supplementation of young cows. Two and 3-year-old cows, and also old cows, need a higher quality diet than mature cows in order to maintain a high level of production. Young cows that have nursed a calf all summer probably need to improve their condition and put on some growth before calving in the spring. Also old cows with poor teeth have a hard time consuming a high roughage diet. These two groups of cows, which make up about 30 percent of the herd, are separated from the herd and fed a supplement of 2 pounds of barley, 0.1 pound of urea and a mineral supplement every other day. Plus they are fed grass hay \textit{ad libitum}. This feeding begins about December 1 and continues until they are
put out on pasture in the spring (about May 15). The regular herd is fed good quality grass hay ad libitum until they calve.

Supplementation of all cows after calving. Lactation substantially increases the nutrient requirement of a cow. TDN requirement increases 19 percent and protein increases 79 percent (NRC, 1976). All cows, after they calve, are fed a supplement of 2 pounds barley, 0.1 pound urea every other day. They still are fed all the meadow hay they can eat and a phosphorus and mineral supplement each day.

Early calving. Table 2 pointed out the advantages of early calves. Calves weighing between 170 and 200 pounds when they go onto the crested wheatgrass pastures on May 15 are large enough to take advantage of the full milk producing capacity of the cow. The crested wheatgrass stimulates milk production and the calf can utilize all that the cow will produce. The calf is also mature enough that it can use a significant amount of the lush and palatable new grass and increase its gains further. In 1975, the breeding season was moved up to May 10 from June 1 in order to begin calving in February of 1976. Bulls remain with the cows until the roundup in October.

**Evaluation of Increased Livestock Production**

**Records**

Complete records are essential in evaluating the productivity of any operation. Relatively complete records dating back to
1970 were available for this ranch. Records had been kept prior to this time but only those beginning in 1970 contained enough similar information for comparison between years. Each cow was individually identified by a metal hot iron brand and a plastic ear tag noting her number and the year born. A permanent record was kept on each cow in order to evaluate her lifetime performance. This record included each calf that she bore, its sex, birth date, and weaning weight.

Detailed calving records were kept each year. As each calf was born, it received an ear tag and number corresponding to its mother's number. The date of birth was recorded as well as its sex. A standard birth weight of 70 pounds was assumed for each calf. The calving records also contained comments such as calving difficulty, assistance required, abnormal presentation, calf died as result of difficult birth, weak calf, or calf died shortly thereafter. This identifies cows that are persistently difficult calvers and also provides a good record of neonatal losses.

The calving records were not complete. Many of the late calves born after May 15 when the cows were turned out on pasture were not marked or identified. However, an effort was made to indicate on the calving record if a cow did calve, thus making the number of cows calving as complete as possible.

Weaning usually occurred during the last week in October. The weaning date of November 1 was used for all years in computing average daily gains. At this time most of the calves were weaned, individually weighed, and the weights recorded.
Number of livestock

The number of cows in the breeding herd each year was taken from the calving record. This included all cows coming 2 years old and older on January 1. The number of replacement heifers kept in 1974-76 was taken from the operator's records and the number kept from 1969-73 was the operator's estimate. The replacement rate was calculated by dividing the number of heifers kept by the number of cows in the breeding herd that year.

The operator has kept the bull to cow ratio near 1/20. The number of bulls was estimated each year by taking 5 percent of the total number of cows and replacement heifers.

Calving percent

The number of cows calving each year was taken from the calving record. This number was divided by the total number of cows in the breeding herd on January 1 to reach the percent of cows calving. Those cows found open in the fall were removed from the breeding herd, fattened and then sold. The conception rate could not be determined because the number of open cows were never recorded and the total number of cows culled included old cows with bad teeth and cancer eyes.

Calf crop

The calf crop is the number of calves weaned expressed as a percent of cows in the breeding herd on January 1, which were given the opportunity to breed. There did not exist in the records
of the operator a total number of calves weaned except for 1970 and 1973. Therefore the calf crop for the remainder of the years was calculated with information from a variety of sources. The total number of cows that calved each year was a fairly accurate record. So was the number of calves that died before going on to the summer range. The number of calves that died between entry onto the summer range and weaning time was not known. However, the operator estimated this loss to be about 2 percent. The calf crop was calculated by subtracting the death loss prior to turnout and the estimated death loss on the range from the number of cows calving. The neonatal deaths in Table 22 were used as the number of calves lost prior to turnout and the estimated postnatal deaths as the number lost on summer range. It is realized that this is not a good estimate of calf crop but it is the best estimate available from the existing data.

Weaning weights

Weaning weights were not available for all of the calves each year. Some of the small late calves were not weaned until winter and were never weighed. Seldom were more than 10 percent of the calves in this category. The average weaning weights therefore, do not include those late calves. The comparison of weaning weights between the years is made in spite of this discrepancy.

Calving periods

A record of the birth dates of calves born before May 15, for 1973-1976, enabled a determination of the number and percent
of cows calving within specific periods of the calving season. This also enabled the comparison of weaning weights and average daily gains of calves born within each period. The 20-day calving periods were: (1) February 22-March 14, (2) March 15-April 4, (3) April 5-April 25, (4) April 26-May 14, (5) after May 15. The number of calves born in each period was determined for each year and the percentage calculated. The weaning weight of all the calves in the period were summed and divided by the number of calves in the period to determine the average weaning weight for that period each year. A trend of weaning weights as the calving season progressed was determined by a weighted average weight for each period. This calculation can be explained algebraically by the following formula:

\[
W_{AWW} = \frac{\sum_{i=1}^{y} (\bar{W}_i \times N_i)}{TN}
\]

where: \(W_{AWW}\) = weighted average weaning weight,

\(\bar{W}\) = average weaning weight for the period each year,

\(N\) = number of calves born in the period each year,

\(TN\) = total number of calves born in the period for 4 years, and

\(y = 4\) years included in the average.

The average daily gain for each period was derived from the weaning weight and number of days to weaning:
\[
\text{ADG}_p = \frac{\bar{W} - 70}{D}
\]

where: \( \text{ADG}_p \) = average daily gain of the period,
\( \bar{W} \) = average weaning weight of the period,
70 = standard birth weight, and
\( D \) = number of days from the middle day of the period until weaning on November 1.

The average daily gains for the entire group of calves each year was calculated by the following formula:

\[
\text{ADG} = \frac{\sum_{i=1}^{y} \text{ADG}_i \times C_i}{y}
\]

where: \( \text{ADG} \) = average daily gain for the year,
\( \text{ADG}_p \) = average daily gain for the period,
\( C \) = percent of calves born in the period, and
\( y \) = 5 periods.

**Approximate average age at weaning**

The average age at weaning along with the percent of calves born in each period can be useful to determine if the operator has been successful in increasing the number of cows calving in the early calving periods. The average age at weaning was calculated as follows:
Age = \sum_{i=1}^{y} C_i \times D_i

where: Age = average age at weaning,

C = percent calves born in each period,

D = number of days from the middle day of period to weaning on November 1, and

y = 5 periods.

Since there was no middle day in period 5, a standard figure of 10 days from the end of period 4 was used as middle day for period 5. This over-estimates the average age of calves born after May 15 but because of the small percent of late calves for which records are available, the error is small.

Total pounds of calf weaned

The total pounds of calf weaned each year was calculated as if all calves were weaned on November 1. Since not all of the calves were weighed each year, an estimation of the weight of the late calves was made. The average weaning weight of period 5 was used as the weaning weight of all the calves not weighed. This estimate was added to the actual weaning weights to derive the total pounds of calf weaned for 1974-1976. For years 1970-1973, only the average weaning weight was available and was used to calculate the total pounds of calf weaned.
Economic analysis

The operating costs for 1970 through 1976 were obtained and compared to the gross returns from cattle sales. The gross returns were calculated by assuming all calves, except replacement heifers, were sold at weaning for the statewide average October prices (Utah Ag. Statistics, 1976). The cull cows and bulls sold for the average yearly price at 1,000 pounds and 1,500 pounds respectively. The operating costs plus depreciation were subtracted from the gross returns to obtain net returns to land, labor, and management. Cost per pound of calf sold, and cost per cow were calculated by dividing the operating costs by the number of calves sold and the number of brood cows in the herd.

Since the grazing system and improvements on the summer range enabled the expansion of the operation, the cost of implementing the grazing system and the associated improvements were compared to the increase in net returns. The net present value and internal rate of return were calculated to determine the profitability of the grazing system.
RESULTS AND DISCUSSION

Increased Livestock Production

Total cattle numbers

Total cattle numbers on the ranch increased 43 percent between 1970 and 1976 (Table 20). Cow numbers increased from 336 in 1970 to 483 in 1976. The bull to cow ratio remained constant at 1:20, as did the percent of replacement heifers--19 percent of the cow herd.

Reasons for increase. The bottleneck of the operation prior to 1970 was the limited carrying capacity of the summer range which was caused by poor distribution. In 1970 a four pasture rest rotation grazing system was implemented to improve the condition of the summer range and improve the cattle distribution. The concentration of all the livestock in the grazed units forced the animals out of the canyon bottoms and onto the ridges and hillsides in order to find forage. The trails provided access to all areas of the units while the additional water developments and good salting practices kept the cattle scattered. The improved distribution made available a considerable amount of forage that had gone unused in prior years. In 1974 the grazing system was modified to a three pasture rest rotation grazing system to facilitate handling and moving cattle.
Table 20. Cattle numbers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td>336</td>
<td>371</td>
<td>384</td>
<td>396</td>
<td>420</td>
<td>490</td>
<td>483</td>
<td></td>
</tr>
<tr>
<td>Replacement heifers</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>90</td>
<td>85</td>
<td>77</td>
</tr>
<tr>
<td>Bulls</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>29</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>421</td>
<td>458</td>
<td>471</td>
<td>484</td>
<td>509</td>
<td>609</td>
<td>600</td>
<td></td>
</tr>
</tbody>
</table>
Since 1974, 900 acres of big sagebrush in the canyon bottoms have been sprayed. By 1975 there had been sufficient improvement in forage production that the numbers of cattle were increased 100 head to the high point of 609. There have been two complete rest and deferment cycles of the grazing system. As a result, the range condition has improved and together with the improved distribution has allowed the 45 percent increase in cattle numbers. The stocking rate on the summer range increased from 4.7 acres/AUM in 1970 to 2 acres/AUM on the grazed units in 1976.

Calving percent

While the total numbers have increased, fertility of the breeding herd has remained high. In fact, the regression line in Figure 3 indicates that the calving percentage has been increasing. A statistical analysis of the slope of the regression line by a t-test revealed that there is a significant increase in calving percent at the 10 percent level. The calving percent was 93 percent in 1970 and rose to 98 percent in 1976. There was considerable fluctuation during the years ranging from 89 percent to 99 percent, but the mean was 95 percent.

Accurate pregnancy evaluation was responsible for detecting most of the open cows in the fall. The open cows as well as the old cows with bad teeth and feet, the cancer eye cows, and the unhealthy cows were removed from the breeding herd, fattened up, and then sold.
Fig. 3. Percent of cows that calved, and percent of calves weaned.
Reason for high fertility. The literature review on reproduction efficiency reported that the critical nutrition periods of a breeding beef cow were the last trimester of gestation and the period between calving and breeding. It also pointed out that young cows should be given special consideration to insure that all of their nutrient demands are met.

The ration fed on alternate days to this group consisted of 2 pounds of barley, 0.1 pound urea, and a phosphorus and trace mineral supplement. They were fed each day all of the meadow hay they would eat. Throughout the winter, all cows have access to the hay fields and river bottoms which provide additional dry forage.

The mature cows do not receive the precalving supplement but are given all of the meadow hay they will eat each day plus free access to a phosphorus and salt supplement. They also have access to the standing mature forage in the fields and river bottoms. The protein content of the hay is 8 percent which is adequate to supply their needs (Figure 13, Appendix B).

The nutrient demand between calving and breeding is the greatest of the reproductive cycle (Table 33). Therefore, after calving, all of the cows are placed on a ration similar to the young cows before calving: 2 pounds of barley, 0.1 pound of urea, phosphorus and trace mineral supplement every other day plus all of the meadow hay they will eat daily. The cows are fed in the hay field until they are moved onto crested wheatgrass pasture on
May 15. The meadow grasses start greening up during the first part of May which gives the cows some green grass in addition to the ration supplement. The crested wheatgrass pastures are grazed alternately every other year. When the breeding herd goes onto the pastures, the previous year's growth as well as the new green growth is available.

Breeding begins on the crested wheat pastures. The pastures are relatively small and confined and thus give good bull coverage. Most of the cows that are cycling have the opportunity to breed during the 15 days on crested wheatgrass. Since the diet has been adequate, a large number of the cows should conceive at first service. This insures a high proportion of calves at the beginning of the next calving season.

Calf crop

The number of calves weaned has steadily increased over the 7-year study period (Table 21 and Figure 4). Most of this increase has been due to the increased number of cows. However, the percent of cows weaning calves has also increased. The slope of the regression line in Figure 3 was statistically analyzed by a t-test and found significant at the 10 percent level. This increase in calf crop has been mainly due to the increased percent of cows calving. Adequate nutrition, accurate pregnancy evaluations, good herd health and reproductive disease prevention programs have all contributed to the high calving percentage and subsequent high calf crop.
Table 21. Number of cows, calves born, calves weaned, calving percent, and calf crop weaned by years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cows</th>
<th>Number calves born</th>
<th>Calving percent</th>
<th>Number of calves weaned</th>
<th>Percent calf crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>336</td>
<td>312</td>
<td>93</td>
<td>288</td>
<td>86</td>
</tr>
<tr>
<td>1971</td>
<td>371</td>
<td>353</td>
<td>95</td>
<td>331</td>
<td>89</td>
</tr>
<tr>
<td>1972</td>
<td>384</td>
<td>340</td>
<td>89</td>
<td>319</td>
<td>84</td>
</tr>
<tr>
<td>1973</td>
<td>396</td>
<td>395</td>
<td>99</td>
<td>374</td>
<td>94</td>
</tr>
<tr>
<td>1974</td>
<td>420</td>
<td>397</td>
<td>95</td>
<td>376</td>
<td>90</td>
</tr>
<tr>
<td>1975</td>
<td>490</td>
<td>478</td>
<td>98</td>
<td>442</td>
<td>90</td>
</tr>
<tr>
<td>1976</td>
<td>483</td>
<td>476</td>
<td>98</td>
<td>449</td>
<td>93</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>95</td>
<td></td>
<td>89</td>
</tr>
</tbody>
</table>
Fig. 4. Number of cows, calves born, and calves weaned.
Calf losses. A number of calves will die before weaning from a variety of causes. Neonatal death accounts for the largest loss of calves. Losses range between 4 and 6 percent and average 5 percent over the 7 years observed (Table 22). This is similar to the neonatal losses expressed in Table 1. Dunn (1975) reported 6.4 percent loss and Temple (1967) reported 6.9 percent loss. Careful observation and assistance during calving as well as access to a calving barn account for a low neonatal loss. Number of losses have increased due to the increased number of cattle. However, the increase as shown in the regression line in Figure 5 is not statistically significant at the 10 percent level. The percent loss has actually decreased over the years as shown in the regression line in Figure 6, but the decline is not significant. This indicates that the level of management has increased in order to maintain low losses while increasing cow numbers.

Once the calf has survived birth and the associated diseases and exposures, the chances of death are slight. However, there are occasions when calves are lost. Pneumonia, accidents, poisoning, predators, or strayed calves further reduce the number of calves weaned. It is difficult to account for the number of causes of postnatal deaths on a range. Therefore, the operator's estimate of 2 percent is used to account for this loss. This is similar to postnatal deaths reported in Table 1.

Total number of calves lost is tallied in column 9 of Table 22. The average loss is 25 calves or 6.4 percent. Over the 7 years,
Table 22. Number and percent of neonatal, postnatal and total calf losses.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cows numbers</th>
<th>Number of cows calves</th>
<th>Percent of cows calved</th>
<th>Deaths from difficult births</th>
<th>Neonatal death</th>
<th>Neonatal deaths (%)</th>
<th>Estimated postnatal deaths (2%)</th>
<th>Total deaths</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>336</td>
<td>312</td>
<td>93</td>
<td>6</td>
<td>19</td>
<td>6</td>
<td>5</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>1971</td>
<td>371</td>
<td>353</td>
<td>95</td>
<td>1</td>
<td>15</td>
<td>4</td>
<td>7</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>1972</td>
<td>384</td>
<td>340</td>
<td>89</td>
<td>2</td>
<td>13</td>
<td>4</td>
<td>a</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>1973</td>
<td>396</td>
<td>395</td>
<td>99</td>
<td>7</td>
<td>18</td>
<td>5</td>
<td>a</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>1974</td>
<td>420</td>
<td>397</td>
<td>95</td>
<td>1</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>1975</td>
<td>490</td>
<td>478</td>
<td>98</td>
<td>11</td>
<td>27</td>
<td>6</td>
<td>9</td>
<td>36</td>
<td>8</td>
</tr>
<tr>
<td>1976</td>
<td>483</td>
<td>476</td>
<td>98</td>
<td>2</td>
<td>18</td>
<td>4</td>
<td>9</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>95</td>
<td>4.3</td>
<td>5</td>
<td>2</td>
<td>25</td>
<td>25</td>
<td>6.4</td>
</tr>
</tbody>
</table>

a actual.
Fig. 5. Total calf loss.

Fig. 6. Percent calf loss.
losses have fluctuated between 5 and 8 percent but do not appear to be increasing due to the increased number of cows.

**Weaning weight**

Weaning weight is the second component that determines productivity. Calf crop is the first and most important factor of production but once the calf is alive and on the ground, the more pounds the rancher can put on the calf, the more returns it will bring. There was a considerable fluctuation in weights over the years (Table 23), but the regression line in Figure 7 does have an upward trend although it is not statistically significant.

**Total pounds of calf weaned**

The total pounds of calf weaned is a function of both the number of calves weaned and their weaning weights. This is the measure of the productivity of the operation and produces most of the returns to the operator. Figure 8 shows that the total pounds of calf weaned steadily increased except for a slight decrease in 1974 and 1976. The decrease in 1974 was due to low weaning weights. The number of calves was similar to that of 1973 but the average weaning weight was 13 pounds lighter.

**Calving Periods**

Table 24 lists the number of calves born within each period, their average weaning weight, and the average daily gain for each of the 4 years for which this data was available.
Table 23. Number of calves weaned, weaning weights, and total pounds of calf weaned.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cow number</th>
<th>Calves weaned</th>
<th>Calf crop percent</th>
<th>Calves weighed</th>
<th>Weaning weight</th>
<th>Calves not weighed</th>
<th>Assumed weaning weight</th>
<th>Total pounds weaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>336</td>
<td>288</td>
<td>86</td>
<td>169</td>
<td>59%</td>
<td>347 lbs</td>
<td>119</td>
<td>347 lbs</td>
</tr>
<tr>
<td>1971</td>
<td>371</td>
<td>331</td>
<td>89</td>
<td>315</td>
<td>95</td>
<td>348 lbs</td>
<td>16</td>
<td>348 lbs</td>
</tr>
<tr>
<td>1972</td>
<td>384</td>
<td>319</td>
<td>84</td>
<td>319</td>
<td>99%</td>
<td>366 lbs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1973</td>
<td>396</td>
<td>374</td>
<td>94</td>
<td>330</td>
<td>88%</td>
<td>358 lbs</td>
<td>44</td>
<td>290 lbs</td>
</tr>
<tr>
<td>1974</td>
<td>420</td>
<td>376</td>
<td>90</td>
<td>308</td>
<td>82%</td>
<td>345 lbs</td>
<td>68</td>
<td>238 lbs</td>
</tr>
<tr>
<td>1975</td>
<td>490</td>
<td>442</td>
<td>90</td>
<td>398</td>
<td>90%</td>
<td>380 lbs</td>
<td>44</td>
<td>275 lbs</td>
</tr>
<tr>
<td>1976</td>
<td>483</td>
<td>449</td>
<td>93</td>
<td>408</td>
<td>91%</td>
<td>363 lbs</td>
<td>41</td>
<td>302 lbs</td>
</tr>
</tbody>
</table>
Fig. 7. Weaning weights by years.
Fig. 8. Total pounds of calf weaned.
Table 24. Number and percent of calves born, weaning weight, and average daily gain by calving periods.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Before</td>
<td>Mar 15-Apr 4</td>
<td>Apr 5-Apr 25</td>
<td>Apr 26-May 15</td>
</tr>
<tr>
<td>Numbers</td>
<td></td>
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<tr>
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<td>330</td>
<td>2</td>
<td>101</td>
<td>151</td>
<td>66</td>
</tr>
<tr>
<td>1974</td>
<td>308</td>
<td>2</td>
<td>99</td>
<td>148</td>
<td>54</td>
</tr>
<tr>
<td>1975</td>
<td>398</td>
<td>16</td>
<td>188</td>
<td>144</td>
<td>49</td>
</tr>
<tr>
<td>1976</td>
<td>408</td>
<td>87</td>
<td>192</td>
<td>71</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>1444</td>
<td>107</td>
<td>580</td>
<td>514</td>
<td>211</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973</td>
<td>-</td>
<td>31%</td>
<td>46%</td>
<td>20%</td>
<td>33%</td>
</tr>
<tr>
<td>1974</td>
<td>-</td>
<td>32</td>
<td>48</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>1975</td>
<td>4</td>
<td>47</td>
<td>36</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>1976</td>
<td>21</td>
<td>47</td>
<td>17</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Weaning weight (lb)</td>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973</td>
<td>358</td>
<td>360</td>
<td>374</td>
<td>367</td>
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<td>1974</td>
<td>345</td>
<td>287</td>
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<td>304</td>
</tr>
<tr>
<td>1975</td>
<td>380</td>
<td>411</td>
<td>366</td>
<td>351</td>
<td>304</td>
</tr>
<tr>
<td>1976</td>
<td>363</td>
<td>382</td>
<td>378</td>
<td>346</td>
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</tr>
<tr>
<td>Average</td>
<td>360</td>
<td>365</td>
<td>351</td>
<td>309</td>
<td>260</td>
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<tr>
<td>Weighted average</td>
<td>384</td>
<td>380</td>
<td>362</td>
<td>318</td>
<td>287</td>
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<tr>
<td>Returns $36/cwt</td>
<td>$138</td>
<td>$137</td>
<td>$130</td>
<td>$114</td>
<td>$103</td>
</tr>
<tr>
<td>ADG</td>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973</td>
<td>1.43</td>
<td>1.2</td>
<td>1.37</td>
<td>1.48</td>
<td>1.42</td>
</tr>
<tr>
<td>1974</td>
<td>1.35</td>
<td>.89</td>
<td>1.34</td>
<td>1.40</td>
<td>1.30</td>
</tr>
<tr>
<td>1975</td>
<td>1.47</td>
<td>1.40</td>
<td>1.47</td>
<td>1.54</td>
<td>1.40</td>
</tr>
<tr>
<td>1976</td>
<td>1.37</td>
<td>1.30</td>
<td>1.39</td>
<td>1.38</td>
<td>1.37</td>
</tr>
<tr>
<td>Average</td>
<td>1.30</td>
<td>1.40</td>
<td>1.46</td>
<td>1.38</td>
<td>1.35</td>
</tr>
</tbody>
</table>
Percent of cows calving in each period

Figure 9 shows the percent of cows calving within each period. Prior to 1975, the calving season began on March 15. In 1975 the calving season started on March 10, and in 1976 it was moved up to begin on February 22. The earlier breeding seasons in 1974 and 1975 along with good nutrition that enables earlier conception, account for the increasing percent of cows calving in period 1 and 2 for 1975 and 1976. Four percent of the calves were born in the first period in 1975 and 21 percent in 1976. Besides the increasing percent of calves in period 1, 1975 and 1976 show the highest percent of calves being born in period 2 (47 percent compared to 31 and 32 percent for 1973 and 1974). In contrast, 1973 and 1974 have the highest percent of calves born in period 3 (46 and 48 percent compared to 36 and 17 percent in 1975 and 1976). There is a decreasing percentage of calves born in period 4 for the 4 years and the percent of late calves in period 5 fluctuates between 0 and 4 percent. It is interesting to note that 68 percent of the calves in 1976 are on the ground before April 5 compared to only 31 percent in 1973. This indicates that a large portion of the cows are calving earlier in the calving season. The increasing number of earlier calves is reflected in the average age of calves at weaning indicated in the following tabulation:

<table>
<thead>
<tr>
<th>Year</th>
<th>Ave. age at weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>201 days</td>
</tr>
<tr>
<td>1974</td>
<td>202 days</td>
</tr>
<tr>
<td>1975</td>
<td>207 days</td>
</tr>
<tr>
<td>1976</td>
<td>213 days</td>
</tr>
</tbody>
</table>

The calves in 1976 are on the average 12 days older than those in 1973.
Difference in percent of cows calving within periods statistically significant ($p \leq .01$).

Fig. 9. Percent of cows calving within calving period.
In order to shorten their calving cycle and calve earlier in the
season, these cows have returned to estrus well before the average
of 60 days expressed in Figure 1, and there is probably a high
conception rate at first service. A balanced ration is essential
in improving performance such as this.

A chi-square statistical test of independence was run to deter­
mine if the differences in percent of cows calving within the periods
was statistically significant over the 4 years. The results indicate
that there is a highly significant difference in the percent of
cows calving within the periods at 1 percent level. The increased
percent of cows calving in period 1 and 2 in 1975 and 1976 is probably
due to the earlier breeding season coupled with the improved
nutrition that enables them to conceive earlier.

Weaning weights by calving periods

It is logical that earlier calves should be heavier at weaning.
Figure 10 shows that this is the case for this ranch with a couple
of exceptions. Unfavorable weather in the early calving periods
accompanied by disease may result in some of the earlier born
calves weighing less. A statistical analysis was not attempted
due to the disproportionately small number of calves born in period 1.
Only 1976 has a substantial number of calves born in this period.
Data from 1977 will need to be collected before an unbiased analysis
can be made of the weaning weights of each period. Therefore, the
conclusions and recommendations that follow are made without the
support of a statistical test.
Fig. 10. Weaning weights by calving period.
A weighted average weaning weight for each period was calculated for the 4 year period to obtain a trend in weaning weights as the calving season progressed (Figure 11). It is recognized that there is a substantial difference between calves born in period 1 and period 5. Given a price of $.36/pound, the early calf is worth $35 more than the late calf at weaning. Since there is a relatively small number of calves in those extreme calving periods, a comparison between periods 2 and 4 is more realistic. The calves born in period 2 weighed 62 pounds more and are worth $23 more than those calves born 40 days later. This is very similar to the increased value of early calves in Table 2.

Average daily gains by calving period

The average daily gains (ADG) for the calves born in each period are contained in Table 24. The ADG for each year fluctuated between 1.35 pounds and 1.46 pounds. Figure 12 shows the trend over the calving periods for each year. The weighted average ADG for each period over the 4 years is summarized in column five of Figure 12. The trend rises from 1.3 pounds in period 1 to a maximum of 1.46 pounds in period 3 and declines to 1.35 pounds in period 5. This disagrees with data reported by Minyard (1973) in South Dakota. He reported average daily gains were greatest in early spring and then declined throughout the spring (Feb. 2.07 lb., Mar 2.0, April 1.91, May 1.86, June 1.77).

There is not a lot of difference in the average daily gains between the periods, thus the differences in weaning weights are
Fig. 11. Weighted average weaning weight by calving periods.
Fig. 12. Average daily gains by calving periods.
primarily due to the number of days the calves are gaining weight. The one exception to this would be the calves born in period 1. The weighted average weaning weights in period 1 are only 4 pounds greater than those of period 2 (Table 24). With the extra time to put on weight, the daily gains were substantially less. The adverse climate in late winter may be the primary cause of the low average daily gains. The late winter storms, cold temperatures, and constant wind are very hard on little calves. A large part of their energy intake is used to keep warm rather than to gain weight. Therefore, as the weather improves with the advent of spring, the average daily gains improve. There comes a point though when the forage matures and gains begin to drop off. Those calves born in the fourth and fifth periods were not old enough to take advantage of the good forage conditions and this is reflected in their declining average daily gains.

**Economic evaluation of early calving**

The additional weight gained by calves born in the early periods must be compared to the extra feed costs incurred, to determine if early calving is economically justifiable. A 1,000 pound cow with average to superior milking ability, requires an increase of 7 pounds in daily dry matter intake after she calves. If this increase is made up in a ration consisting of 6 pounds meadow hay, 1 pound barley and .05 pound urea daily, the increased cost of feeding the cow this ration for 20 extra days is $5.14
6 lb. meadow hay for 20 days = 120 lb. @ $.026/lb. = $4.00
1 lb. barley for 20 days = 20 lb. @ $.05/lb. = 1.00
.05 lb. urea for 20 days = 1 lb. @ $.14/lb = .14

The average increase in weaning weight of calves born in period 1 compared to period 2 is 4 pounds. At $.36/lb. the additional gross return gives a net loss of $3.70 for a calf born in period 1 compared to period 2 ($1.44 - $5.15 = -$3.70).

Comparing the additional returns of calves born in period 2 with period 3 reveals that the net increase per calf is $1.34 (18 lb. @ $.36/lb. = $6.48 - $5.14 = $1.34). A break-even analysis reveals that the earlier calving periods must produce calves with weaning weights 11.5 pounds greater in order to pay the cost of feeding the cow for the additional 20 days. This does not include the cost of vet supplies and labor required for calving earlier in harsh weather conditions. These costs could not be extracted from the total operating costs.

From the limited data available, it appears that the additional costs of calving in period 1 outweighs the additional returns. However, only 1 year's data is available for calves born in period 1, therefore a recommendation to move the start of calving back to the first part of March will not be made. Data from period 1 for 1 or 2 more years should be carefully evaluated to determine the most profitable calving season.
Economic Evaluation

Cost and returns from increased production

The operating costs of 1970 and 1976 are contained in Table 25. The total operating cost (cash cost plus depreciation) for 1970 was $35,954, and increased to $70,367 in 1976. The total cost per brood cow was $107 for 1970 and $147 for 1976. The cost per pound of calf weaned in 1970 was $.36/pound and $.44/pound for 1976.

The gross returns were calculated as if all the calves, except for the replacement heifers, were sold at weaning. The pounds of calf sold was determined by subtracting the number of replacement heifers from the total number of calves weaned and multiplying the remainder by the average weaning weight. The cull cows and bulls were also included in the gross returns. The number of cull cows sold was derived by subtracting the percent death loss (4 percent) from the replacement rate (19 percent) which resulted in 15 percent of the cows being marketed each year. The bulls are used for 4 years so that 25 percent of them would be culled each year. The total gross return for 1970 was $38,060 and $66,696 for 1976. The net returns for 1970 was $2,106 and -$3,671 for 1976.

It seemed ironic that the tremendous increase in livestock production from 1970 to 1976 yields a negative net return. The production costs have increased in greater magnitude than the efficiency of the operation. However, if the operator had maintained
<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>1976</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash Cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing fee</td>
<td>$26.40</td>
<td>$1,892.11</td>
</tr>
<tr>
<td>Feed purchased</td>
<td>220.41</td>
<td>2,157.96</td>
</tr>
<tr>
<td>Vet</td>
<td>523.56</td>
<td>2,500.85</td>
</tr>
<tr>
<td>Labor</td>
<td>5,351.08</td>
<td>7,792.55</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>29.50</td>
<td>1,759.84</td>
</tr>
<tr>
<td><strong>Crop expenses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td></td>
<td>701.35</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>1,709.92</td>
<td>7,252.00</td>
</tr>
<tr>
<td>Machine hire</td>
<td>239.00</td>
<td>700.00</td>
</tr>
<tr>
<td>Lease</td>
<td>10,400.00</td>
<td>12,620.00</td>
</tr>
<tr>
<td>Gas and oil</td>
<td>2,130.18</td>
<td>6,835.29</td>
</tr>
<tr>
<td>Insurance</td>
<td>510.00</td>
<td>844.60</td>
</tr>
<tr>
<td>Utilities</td>
<td>449.52</td>
<td>1,101.82</td>
</tr>
<tr>
<td>Taxes</td>
<td>2,212.10</td>
<td>2,486.19</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5,372.40</td>
<td>6,106.66</td>
</tr>
<tr>
<td>Interest</td>
<td>5,302.00</td>
<td>8,193.91</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$34,476.47</td>
<td>$62,943.62</td>
</tr>
<tr>
<td><strong>Non Cash Cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>1,478.00</td>
<td>7,423.00</td>
</tr>
<tr>
<td><strong>TOTAL OPERATING COSTS</strong></td>
<td>$35,954.47</td>
<td>$70,367.00</td>
</tr>
<tr>
<td>Cost per cow</td>
<td>107.00</td>
<td>146.00</td>
</tr>
<tr>
<td>Cost/lb calf weaned</td>
<td>.36</td>
<td>.44</td>
</tr>
<tr>
<td>Cost/lb calf sold</td>
<td>.46</td>
<td>.52</td>
</tr>
</tbody>
</table>
the same production level as in 1970 and the associated production costs reflected the inflationary increase in operating costs, the net return would have been \(-24,718\) \((40,358 - 65,077 = -24,718)\). Therefore, the operator has been very successful in minimizing his losses in this time of high inflation and rampant operating costs.

Cost and returns from grazing system

The grazing system and associated improvements on the summer range removed the bottleneck of the operation and allowed for the expansion of the herd. It is realized that the level of management and the improved animal husbandry and feeding practices were responsible for increasing the level of fertility while the expansion was taking place. However, it is impossible to estimate the proportion of the production for which each individual management item was responsible. Therefore, for purposes of economic evaluation, the costs from a higher level of management are included in the operating costs and the increase in net returns are compared to the investment of the grazing system and associated range improvements. This is not entirely accurate because the grazing system was not responsible for all of the increase in production. However, the increase in net return is the only figure available to make an economical analysis of the grazing system. The cost

\(^1\) The cost of production increased 81 percent between 1971 and 1976 (Crop Reporting Board, SRS, USDA, 1976). The 1970 costs were multiplied by an index of 1.81 to bring them up to the level of 1976.
Table 26. Costs and returns.

<table>
<thead>
<tr>
<th>Year</th>
<th>Calf No.</th>
<th>Replacements</th>
<th>Number sold</th>
<th>Weight (lbs)</th>
<th>Calf prices(^{a}) ($)</th>
<th>Cows 1000/lb</th>
<th>Cull cow prices(^{b}) ($)</th>
<th>Bulls 1500/lb</th>
<th>Cull bull prices(^{c}) ($)</th>
<th>Total return ($)</th>
<th>Costs ($)</th>
<th>Net ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>288</td>
<td>65</td>
<td>223</td>
<td>347</td>
<td>33</td>
<td>50</td>
<td>21</td>
<td>5</td>
<td>27</td>
<td>38,060</td>
<td>35,954</td>
<td>2,106</td>
</tr>
<tr>
<td>1971</td>
<td>331</td>
<td>65</td>
<td>266</td>
<td>348</td>
<td>36</td>
<td>56</td>
<td>21</td>
<td>6</td>
<td>28</td>
<td>47,604</td>
<td>41,929</td>
<td>5,675</td>
</tr>
<tr>
<td>1972</td>
<td>319</td>
<td>65</td>
<td>254</td>
<td>366</td>
<td>48</td>
<td>58</td>
<td>26</td>
<td>6</td>
<td>34</td>
<td>62,763</td>
<td>45,663</td>
<td>17,100</td>
</tr>
<tr>
<td>1973</td>
<td>374</td>
<td>65</td>
<td>309</td>
<td>358</td>
<td>58</td>
<td>59</td>
<td>31</td>
<td>6</td>
<td>38</td>
<td>85,871</td>
<td>54,985</td>
<td>30,886</td>
</tr>
<tr>
<td>1974</td>
<td>376</td>
<td>90</td>
<td>286</td>
<td>345</td>
<td>28</td>
<td>63</td>
<td>24</td>
<td>6</td>
<td>32</td>
<td>45,628</td>
<td>57,661</td>
<td>-12,033</td>
</tr>
<tr>
<td>1975</td>
<td>442</td>
<td>85</td>
<td>357</td>
<td>380</td>
<td>26</td>
<td>73</td>
<td>20</td>
<td>8</td>
<td>35</td>
<td>54,072</td>
<td>68,209</td>
<td>-14,137</td>
</tr>
<tr>
<td>1976</td>
<td>449</td>
<td>78</td>
<td>371</td>
<td>363</td>
<td>35</td>
<td>72</td>
<td>21</td>
<td>8</td>
<td>37</td>
<td>66,696</td>
<td>70,367</td>
<td>-3,671</td>
</tr>
</tbody>
</table>

\(^{a}\) October prices, Utah Ag. Statistics, 1976.
\(^{b}\) Average prices, Utah Ag. Statistics, 1976.
Table 27. Increase in net annual returns.

<table>
<thead>
<tr>
<th>Year</th>
<th>Returns ($)</th>
<th>Operating cost ($)</th>
<th>Net ($)</th>
<th>Returns&lt;sup&gt;a&lt;/sup&gt; ($)</th>
<th>% increase in costs (%)</th>
<th>Cost ($)</th>
<th>Net ($)</th>
<th>Net increase ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>38,060</td>
<td>39,954</td>
<td>2,106</td>
<td>38,060</td>
<td>1.00</td>
<td>35,954</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td>47,604</td>
<td>41,929</td>
<td>5,675</td>
<td>40,457</td>
<td>1.06</td>
<td>38,111</td>
<td>2,346</td>
<td>3,329</td>
</tr>
<tr>
<td>1972</td>
<td>62,763</td>
<td>45,663</td>
<td>17,100</td>
<td>52,693</td>
<td>1.12</td>
<td>40,268</td>
<td>12,425</td>
<td>4,675</td>
</tr>
<tr>
<td>1973</td>
<td>85,871</td>
<td>54,985</td>
<td>30,886</td>
<td>63,321</td>
<td>1.31</td>
<td>47,099</td>
<td>16,132</td>
<td>14,754</td>
</tr>
<tr>
<td>1974</td>
<td>45,628</td>
<td>57,661</td>
<td>-12,033</td>
<td>36,067</td>
<td>1.55</td>
<td>55,728</td>
<td>-19,661</td>
<td>7,628</td>
</tr>
<tr>
<td>1975</td>
<td>54,072</td>
<td>68,209</td>
<td>-14,137</td>
<td>32,744</td>
<td>1.70</td>
<td>61,122</td>
<td>-28,378</td>
<td>14,241</td>
</tr>
<tr>
<td>1976</td>
<td>66,696</td>
<td>70,367</td>
<td>-3,671</td>
<td>40,358</td>
<td>1.81</td>
<td>65,076</td>
<td>-24,718</td>
<td>21,047</td>
</tr>
</tbody>
</table>

<sup>a</sup> Returns calculated using the average yearly prices for calves, cows, and bulls in table 26.
of implementing the grazing system and its associated improvements are contained in Table 30. The current value of all the improvements on the summer range is $122,900. The original construction costs of the improvements were not available, therefore, the investment in improvements is expressed in 1976 dollars and was determined by the cost of replacing each improvement had they all been implemented in 1976. Many of these improvements were constructed prior to 1970 (boundary fences, some water developments, and trails). Therefore, only those improvements that have been implemented since 1970 and have been associated with improving the efficiency of the grazing system are considered in the economic evaluation of the grazing system. These costs total $47,226. The estimated lifetime of the structural improvements associated with the grazing system is 20 years.

The annual gross returns from calf, cull cow and bull sales are contained in Table 26. The net increase in returns for 1971-1976 above the base year 1970, are contained in Table 27. The net increase in annual returns was calculated by subtracting from the net return of a given year, the returns from the base year production level using the same average yearly prices as in Table 26 and raising the costs by an index (Crop Reporting Board, 1976) to reflect the average increase in operating costs. The net increase in returns for years 1-6 was calculated in this manner. Even though the actual returns and the projected returns from the base production were negative for 1974-1976, the actual loss was substantially less than
the projected loss. The difference between the actual loss and the projected loss is a positive net increase in returns that resulted from the improved range and livestock management practices. For years 7-20, the net increase in returns was assumed to remain at the 1976 level due to the hazards of predicting costs and prices in the future. The expected annual production into the future is assumed to be the same as in 1976. The range has improved in condition and the stocking rate is up to the carrying capacity of the range. If fertility and weaning weights remain fairly constant, the annual beef production should remain close to the 1976 level.

The internal rate of return and the net present worth were used to evaluate the economic efficiency of the grazing system. The internal rate of return is the discount rate which makes the discounted returns equal to the investment (Nielsen, 1967). The standard discounting formula \( I = R \left[ \frac{1-(1+i)^{-n}}{i} \right] \) requires an equal annual return to calculate the internal rate of return. Since the returns for 1971-1976 are not equal, the modified discounting technique described by Hinkley (1974) was used. The annual returns were discounted separately and then summed to arrive at the current value of the income stream. The discount rate \( i \) was estimated by trial and error until the discounted returns come close to the investment cost. The actual rate of return was then extrapolated from between the two nearest discount rates (Table 28). Because of the difficulties in discounting returns from past years, 1976 was used as the base year and the returns of 1971 were assumed
Table 28. Internal rate of return.

<table>
<thead>
<tr>
<th>Year</th>
<th>Net increase in returns</th>
<th>Discounting factors $i=25%$</th>
<th>Discounting factors $i=26%$</th>
<th>Discounted net returns $i=25%$</th>
<th>Discounted net returns $i=26%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$3,329</td>
<td>.8000</td>
<td>.7936</td>
<td>$2,663</td>
<td>$2,642</td>
</tr>
<tr>
<td>2</td>
<td>$4,675</td>
<td>.6400</td>
<td>.6299</td>
<td>$2,992</td>
<td>$2,945</td>
</tr>
<tr>
<td>3</td>
<td>$14,754</td>
<td>.5120</td>
<td>.4999</td>
<td>$7,554</td>
<td>$7,375</td>
</tr>
<tr>
<td>4</td>
<td>$7,628</td>
<td>.4096</td>
<td>.3967</td>
<td>$3,124</td>
<td>$3,026</td>
</tr>
<tr>
<td>5</td>
<td>$14,241</td>
<td>.3277</td>
<td>.3149</td>
<td>$4,667</td>
<td>$4,484</td>
</tr>
<tr>
<td>6</td>
<td>$21,047</td>
<td>.2621</td>
<td>.2499</td>
<td>$5,516</td>
<td>$5,259</td>
</tr>
<tr>
<td>7</td>
<td>$21,047</td>
<td>.2097</td>
<td>.1983</td>
<td>$4,413</td>
<td>$4,174</td>
</tr>
<tr>
<td>8</td>
<td>$21,047</td>
<td>.1678</td>
<td>.1574</td>
<td>$3,532</td>
<td>$3,313</td>
</tr>
<tr>
<td>9</td>
<td>$21,047</td>
<td>.1342</td>
<td>.1249</td>
<td>$2,824</td>
<td>$2,629</td>
</tr>
<tr>
<td>10</td>
<td>$21,047</td>
<td>.1074</td>
<td>.0991</td>
<td>$2,260</td>
<td>$2,086</td>
</tr>
<tr>
<td>11</td>
<td>$21,047</td>
<td>.0859</td>
<td>.0787</td>
<td>$1,808</td>
<td>$1,656</td>
</tr>
<tr>
<td>12</td>
<td>$21,047</td>
<td>.0687</td>
<td>.0624</td>
<td>$1,446</td>
<td>$1,313</td>
</tr>
<tr>
<td>13</td>
<td>$21,047</td>
<td>.0549</td>
<td>.0496</td>
<td>$1,155</td>
<td>$1,049</td>
</tr>
<tr>
<td>14</td>
<td>$21,047</td>
<td>.0440</td>
<td>.0393</td>
<td>$926</td>
<td>$827</td>
</tr>
<tr>
<td>15</td>
<td>$21,047</td>
<td>.0352</td>
<td>.0312</td>
<td>$741</td>
<td>$656</td>
</tr>
<tr>
<td>16</td>
<td>$21,047</td>
<td>.0281</td>
<td>.0248</td>
<td>$591</td>
<td>$521</td>
</tr>
<tr>
<td>17</td>
<td>$21,047</td>
<td>.0225</td>
<td>.0196</td>
<td>$473</td>
<td>$412</td>
</tr>
<tr>
<td>18</td>
<td>$21,047</td>
<td>.0180</td>
<td>.0156</td>
<td>$379</td>
<td>$328</td>
</tr>
<tr>
<td>19</td>
<td>$21,047</td>
<td>.0144</td>
<td>.0124</td>
<td>$303</td>
<td>$206</td>
</tr>
<tr>
<td>20</td>
<td>$21,047</td>
<td>.0115</td>
<td>.0098</td>
<td>$242</td>
<td>$206</td>
</tr>
</tbody>
</table>

Total $47,609 $45,156

IRR = 25.16\%
to start in 1977. The income stream to 1997 was discounted back to 1976 dollars. The investment cost was also expressed in 1976 dollars. The internal rate of return for the grazing system was 25.16 percent.

The net present worth of an investment is calculated by discounting the net annual returns by a discount rate equal to the current market rate of interest and subtracting the cost of the investment (Hopkin, Barry, Baker, 1973). The current marked rate of interest is 9 percent (Clement, 1977).

\[
NPW = \sum_{n=1}^{N} \frac{R_n}{(1+i)^n} - I
\]

where:
- \( NPW \) = net present worth
- \( R \) = increase in net annual returns
- \( i \) = discount rate
- \( I \) = investment

Table 29 shows that the net present worth of the grazing system is $96,027. In other words, the grazing system is expected to increase the returns of the rancher by this amount in present dollars over its 20 year lifetime.
Table 29. Net present worth.

<table>
<thead>
<tr>
<th>Year</th>
<th>Net increase in returns ($)</th>
<th>Discount factor $i=9%$</th>
<th>Discounted net returns ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (1977)</td>
<td>3,329</td>
<td>.9174</td>
<td>3,054</td>
</tr>
<tr>
<td>2</td>
<td>4,675</td>
<td>.8416</td>
<td>3,934</td>
</tr>
<tr>
<td>3</td>
<td>14,754</td>
<td>.7722</td>
<td>11,393</td>
</tr>
<tr>
<td>4</td>
<td>7,628</td>
<td>.7084</td>
<td>5,404</td>
</tr>
<tr>
<td>5</td>
<td>14,241</td>
<td>.6499</td>
<td>9,255</td>
</tr>
<tr>
<td>6</td>
<td>21,047</td>
<td>.5963</td>
<td>12,550</td>
</tr>
<tr>
<td>7</td>
<td>21,047</td>
<td>.5470</td>
<td>11,513</td>
</tr>
<tr>
<td>8</td>
<td>21,047</td>
<td>.5018</td>
<td>10,561</td>
</tr>
<tr>
<td>9</td>
<td>21,047</td>
<td>.4604</td>
<td>9,690</td>
</tr>
<tr>
<td>10</td>
<td>21,047</td>
<td>.4224</td>
<td>8,890</td>
</tr>
<tr>
<td>11</td>
<td>21,047</td>
<td>.3875</td>
<td>8,156</td>
</tr>
<tr>
<td>12</td>
<td>21,047</td>
<td>.3555</td>
<td>7,482</td>
</tr>
<tr>
<td>13</td>
<td>21,047</td>
<td>.3262</td>
<td>6,865</td>
</tr>
<tr>
<td>14</td>
<td>21,047</td>
<td>.2992</td>
<td>6,297</td>
</tr>
<tr>
<td>15</td>
<td>21,047</td>
<td>.2745</td>
<td>5,777</td>
</tr>
<tr>
<td>16</td>
<td>21,047</td>
<td>.2518</td>
<td>5,299</td>
</tr>
<tr>
<td>17</td>
<td>21,047</td>
<td>.2311</td>
<td>4,864</td>
</tr>
<tr>
<td>18</td>
<td>21,047</td>
<td>.2100</td>
<td>4,420</td>
</tr>
<tr>
<td>19</td>
<td>21,047</td>
<td>.1945</td>
<td>4,094</td>
</tr>
</tbody>
</table>

\[
NPW = \sum_{n=1}^{N} \frac{R_n}{(1+i)^n} - I
\]

\[
= $143,253 - $217,266
\]

\[
= $96,027
\]
SUMMARY AND CONCLUSIONS

The operating costs for farms and ranches in the United States have increased 81 percent between 1970 and 1976 (Crop Reporting Board, 1976). Calf prices over this same period have fluctuated dramatically and have fallen from a high of $58/cwt in 1973 to a low of $26/cwt in 1975 (Utah Ag. Statistics, 1976). Since 1973, the increasing operating costs have exceeded the returns generated by the low calf prices and have left operators in a negative financial position. This case study has shown that the operator has increased both the efficiency and scale of his operation through improved livestock husbandry and range improvements, yet has been unable to keep up with the increase in operating costs.

The number of brood cows on the ranch have increased 45 percent since 1970. The increased carrying capacity of the summer range, brought about by a rest rotation grazing system and the associated range improvements, have allowed for this increase. The hayland has also been developed by planting improved grass varieties and through proper irrigation and fertilization in order to provide the necessary winter feed and fall grazing for the increased numbers of cattle.

The efficiency of the operation has also increased while the cattle numbers have expanded. The calf crop increased from 86 percent in 1970 to 93 percent in 1976. Accurate pregnancy evaluations and stringent culling practices, as well as proper
nutrition, have been responsible for maintaining high fertility in the herd. A feed supplement program was conducted during the late winter and early spring critical nutrition periods. Yearling replacement heifers and young cows were separated from the mature breeding herd and fed a precalving supplement. After calving, all cows in the herd were supplemented to insure that their nutrient demands were met. The entire herd was flushed on crested wheatgrass pastures at the beginning of the breeding season. This good nutrition was responsible for the high conception rate.

The increase in weaning weights over the study period was not significant. Calf gains depend on the environmental conditions as well as the genetic capability of the cow and calf. Climatic conditions, which determine the amount and nutrient content of the forage, vary from year to year. However, the improved range condition will provide a more stable forage yield and the flexibility of the grazing system and management strategy will allow the operator to use the pastures most efficiently. Once the nutrient requirements are satisfied, the cow and calf can then express their genetic capabilities and produce up to their potential in pounds of calf weaned per cow. There exists a large potential for genetic improvement in this herd.

An economic evaluation of the improved livestock husbandry and range improvement practices revealed that the operator has been very successful in minimizing losses. It must be realized that statewide average cattle prices were used for comparison and thus
the analysis does not reflect the true profit or loss of the operation. The total pounds of calf weaned increased 60 percent over the study period. However, this tremendous increase in beef production was offset by the rampant increase in operating costs. The net loss in 1976 was $3,671 compared to a net return of $2,106 in 1970. However, had the operator not increased the level of production while the operation costs increased, his net loss in 1976 would have been $24,718.

All aspects of the operator's management contributed to the increase in beef production. It is difficult to determine how much improvement came from a specific item. The operator did state though that the increased carrying capacity of the summer range allowed for the expansion in numbers. If all of the increased management costs associated with the expansion are included in the operating costs, the increase in net returns can be compared to the investment cost of the grazing system and improvements on the summer range to derive its economic productivity. The internal rate of return of the grazing system and improvements was 25.16 percent. The net present worth of the improvements was $96,027, given a 20 year lifetime.

It can be concluded that where the potential exists for development of the range, hayland, and pasture resources, livestock production can be increased as well as returns to the operator.
LITERATURE CITED


Hopkin, J. A. 1975. An assessment of the economic and financing situation for the beef industry. Report to the Executive Committee of ANCA by the Council of Economic Advisors to ANCA.


Hyder, D. N., and A. W. Sawyer. 1951. Rotation-deferred grazing as compared to season long grazing on sagebrush bunch grass ranges in Oregon. J. Range Manage. 4:30-34.


Appendix A
HIGH MOUNTAIN LOAM (ASPEN) RANGE SITE

This range site occurs on gently sloping to very steep mountain slopes. It is found on all exposures at higher elevations, but is primarily on the north and east facing slopes at the lower elevations. It is often adjacent to mountain sites. On this unit it is intermingled with the mountain loam site and is mapped as an association or complex. Elevation ranges from 7,000 to 9,120 feet. The average annual precipitation on this site varies from 22 to 40 inches.

The soils on this site are deep, medium textured and well drained, with less than 50 percent coarse fragments.

Potential forage production is very high, with an aspen overstory and an understory of about equal amounts of grasses and forbs and a small amount of shrubs and aspen reproduction. Important forage plants on this site include: Mt. brome, Blue wildrye, Bearded wheatgrass, Slender wheatgrass, Nodding brome, Dryland sedge, Sweet anise, Elderberry, Snowberry and Aspen. (Mt. brome will be used as the key management plant.)

MOUNTAIN LOAM RANGE SITE

This range site is found on gentle to steep mountain slopes, benches and on the wide canyon bottoms. It occurs on all exposures, but is mostly on south and west facing slopes in association with the high mountain loam (aspen) site which occupies the north and east exposures. Elevation ranges from 6,000 to 9,000 feet. This site receives from 16 to 22 inches of average annual precipitation.

The soils are deep, well drained loams with less than 50 percent coarse fragments. Sagebrush dominates the productive bottoms and falts. Bitter-brush, Snowberry and Wild rose increase in the shrub association on the steeper slopes. Forage potential for this site is high. Important forage plants include: Bluebunch wheatgrass, Tall native bluegrass, Onion grass, Slender wheatgrass, and Bitterbrush. (Bluebunch wheatgrass will be used as the key management plant.)
ROTATION-DEFERRED GRAZING SYSTEM PLAN

Hopkin-Heiner Range Unit
Woodruff, Utah

TREATMENTS:

- **A**: Maximum use--Graze early with all livestock. Enter after desired grasses have set seed.
- **B**: Complete rest.
- **C**: Enter after desired grasses have flowered.

This grazing system was designed to allow sufficient rest following grazing treatment A for (1) seed production, (2) reproduction (seedling establishment), (3) maintenance and improvement of plant vigor, and (4) accumulation of litter.

GRAZING SCHEDULE:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pastures</th>
<th>Sequence of Pasture Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1  #2   #3  #4</td>
<td>1st 2nd 3rd Rest</td>
</tr>
<tr>
<td>1</td>
<td>D A B C</td>
<td>2 1 3 4</td>
</tr>
<tr>
<td>2</td>
<td>A B C D</td>
<td>1 4 2 3</td>
</tr>
<tr>
<td>3</td>
<td>B C D A</td>
<td>4 3 1 2</td>
</tr>
<tr>
<td>4</td>
<td>C D A B</td>
<td>3 2 4 1</td>
</tr>
</tbody>
</table>

Schedule will be repeated every four years.
Table 30. Improvements on summer range.

<table>
<thead>
<tr>
<th>Improvements</th>
<th>Amount</th>
<th>Cost/unit</th>
<th>Value of new construction</th>
<th>Amount since 1970</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray sage</td>
<td>900 ac.</td>
<td>$8.50</td>
<td>$7,650</td>
<td>all</td>
<td>$7,650</td>
</tr>
<tr>
<td>Plow &amp; seed (1968)</td>
<td>50 ac.</td>
<td>$20/ac.</td>
<td>$1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>15</td>
<td>$500 ac.</td>
<td>$7,500</td>
<td>8</td>
<td>$4,000</td>
</tr>
<tr>
<td>Trough</td>
<td>23</td>
<td>$50</td>
<td>$1,150</td>
<td>12</td>
<td>$600</td>
</tr>
<tr>
<td>Ponds</td>
<td>20</td>
<td>$1000</td>
<td>$20,000</td>
<td>10</td>
<td>$10,000</td>
</tr>
<tr>
<td>Pipeline (3)</td>
<td>3.5 mi.</td>
<td>$2000/mi.</td>
<td>$7,000</td>
<td>(1)/mi.</td>
<td>$2,000</td>
</tr>
<tr>
<td>Stock trails</td>
<td>30/mi.</td>
<td>$600/mi.</td>
<td>$18,000</td>
<td>all</td>
<td>$18,000</td>
</tr>
<tr>
<td>Fences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary</td>
<td>21.25/mi.</td>
<td>$2400/mi.</td>
<td>$51,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit</td>
<td>4/mi.</td>
<td>$2400/mi.</td>
<td>$9,600</td>
<td>2/mi.</td>
<td>$4,976</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$122,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$47,226</td>
</tr>
</tbody>
</table>

Annual maintenance (fence, water developments, and trails)

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
<th>Cost/unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man days</td>
<td>25 hrs.</td>
<td>$4/hr.</td>
<td>$1,000</td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td>$150</td>
</tr>
<tr>
<td>Travel and fuel</td>
<td></td>
<td></td>
<td>$200</td>
</tr>
<tr>
<td>Cat</td>
<td>50 hrs.</td>
<td>$24/hr.</td>
<td>$1,250</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>$3,600</td>
</tr>
</tbody>
</table>
Appendix B
Fig. 13. Nutrient requirement* and nutrient content of ration.
Table 31. Nutrient content of ration.

<table>
<thead>
<tr>
<th></th>
<th>Wet weight (lb)</th>
<th>Percent D.M.</th>
<th>Crude protein (%)</th>
<th>Dig protein (%)</th>
<th>ME Mcal (Mcal/lb)</th>
<th>TDN (%)</th>
<th>C (%)</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>1.00</td>
<td>89</td>
<td>13</td>
<td>9.8</td>
<td>1.36</td>
<td>83</td>
<td>.09</td>
<td>.47</td>
</tr>
<tr>
<td>Meadow hay</td>
<td>20.00</td>
<td>90</td>
<td>8</td>
<td>2.9</td>
<td>.83</td>
<td>51</td>
<td>.57</td>
<td>.17</td>
</tr>
<tr>
<td>Urea</td>
<td>.05</td>
<td>45%N</td>
<td>.14 lb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crested wheat</td>
<td>32.00</td>
<td>30.8</td>
<td>23</td>
<td>18.0</td>
<td>1.09</td>
<td>67</td>
<td>.46</td>
<td>.35</td>
</tr>
<tr>
<td>early veg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old growth</td>
<td>12.5</td>
<td>80.00</td>
<td>3.1</td>
<td>.05</td>
<td>.80</td>
<td>49</td>
<td>.27</td>
<td>.07</td>
</tr>
</tbody>
</table>
Table 32. Nutrient content of diet.

<table>
<thead>
<tr>
<th></th>
<th>Weight (lbs)</th>
<th>Intake (lbs)</th>
<th>Minimum dry matter intake (lbs)</th>
<th>Crude protein (lbs)</th>
<th>Dib protein (lbs)</th>
<th>ME (Mcal)</th>
<th>TDN (lbs)</th>
<th>C (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young cow (pregnant)</td>
<td>900</td>
<td>17</td>
<td>15.39</td>
<td>1.42</td>
<td></td>
<td>13.20</td>
<td>8.13</td>
<td>37.86</td>
<td>13.1</td>
</tr>
<tr>
<td>Mature cow (pregnant)</td>
<td>1,100</td>
<td>20</td>
<td>17.87</td>
<td>1.62</td>
<td></td>
<td>15.31</td>
<td>9.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young cow lactating</td>
<td>800</td>
<td>20</td>
<td>18.09</td>
<td>1.63</td>
<td></td>
<td>15.47</td>
<td>9.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mature cow lactating</td>
<td>1,000</td>
<td>23</td>
<td>20.68</td>
<td>1.84</td>
<td></td>
<td>17.60</td>
<td>10.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crested wheat</td>
<td>44.5</td>
<td>20</td>
<td>2.61</td>
<td>1.85</td>
<td></td>
<td>18.90</td>
<td>11.60</td>
<td>33.00</td>
<td>19.1</td>
</tr>
</tbody>
</table>
Table 33. Nutrient requirement of breeding cattle.

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>Minimum dry matter intake (lbs)</th>
<th>Crude protein (lbs)</th>
<th>Dig protein (lbs)</th>
<th>ME (Mcal)</th>
<th>TDM (lbs)</th>
<th>C (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young cow (pregnant)</td>
<td>900</td>
<td>15.4</td>
<td>.97</td>
<td>5.9</td>
<td>.46</td>
<td>2.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Mature cow (pregnant)</td>
<td>1,100</td>
<td>17.9</td>
<td>1.12</td>
<td>5.9</td>
<td>.53</td>
<td>2.8</td>
<td>16.4</td>
</tr>
<tr>
<td>Young cow lactating</td>
<td>800</td>
<td>18.1</td>
<td>1.65</td>
<td>9.2</td>
<td>.97</td>
<td>5.4</td>
<td>15.9</td>
</tr>
<tr>
<td>Mature cow lactating</td>
<td>1,000</td>
<td>20.5</td>
<td>1.89</td>
<td>9.2</td>
<td>1.10</td>
<td>5.4</td>
<td>18.1</td>
</tr>
</tbody>
</table>
VITA

Michael H. Ralphs

Candidate for the Degree of

Master of Science

Thesis: Increased Calf Production and Returns from Improved Range and Livestock Management on a Northern Utah Ranch.

Major Field: Range Economics

Biographical Information:


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