INTENSIFIED COW-CALF PRODUCTION IN THE SOUTHERN GREAT PLAINS INCORPORATING NATIVE RANGELAND, WHEAT PASTURE, SEMI-CONFINEMENT AND COVER CROPS

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Abstract: Decreasing acres of grazing land along with increasing demand in red meat suggests the need for intensified beef cattle production systems. The objective of the two year trial was to decrease land area per unit of production while maintaining or improve calf performance by economically incorporating semi-confinement and cropland into a fall-calving operation. Angus and Angus x Hereford cows were allotted randomly by BW and age into two forage system treatments: extensive (EXT) or intensive (INT). Cows assigned to the EXT treatment were continuously grazed on native rangeland at a low stocking rate. Cows assigned to the INT system were fed prairie hay and mineral supplement in a dry-lot through the winter. During this time, INT cows had access to 0.3-0.4 ha of wheat pasture per cow-calf unit 6 to 12-h/wk. Calves were allowed continuous access to wheat through creep gates. Following limit grazing, cows and calves were given free-choice access to wheat pasture. At the conclusion of graze-out, INT cows were moved to native rangeland with a stocking rate of 2.6-3.3 ha/cow-calf pair. Late summer after weaning in year 1, cows and steer calves grazed sorghum-sudan, and year 2 INT weaned calves grazed crabgrass. Data were analyzed using the GLIMMIX procedure of SAS. Pen was the experimental unit and the model included treatment, gender (when appropriate) and the interaction as fixed effect. Cow age was a random effect. During the limit grazing winter period EXT system cows lost substantially more weight and body condition compared to INT system cows ($P < 0.01$). As expected, calves limit grazing wheat pasture gained better than calves grazing native range ($P = 0.02$). Although, calf weight differences were narrowed, increased winter weights were maintained through the summer. At weaning, INT system calves were heavier both years. The annual cow cost was higher for INT system cows. However, calf revenue at weaning was higher for INT calves. The INT system cows raised heavier calves on less land. High annual cow costs from year 1 prompted an increase in stocking rate and change in summer crop to decrease individual cow cost in year 2.

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CHAPTER I

INTRODUCTION

In 1999 the world human population was about 6 billion. According to the U.S. Census Bureau (2011), the population is expected to increase to 9 billion by 2044, representing a 50% increase in a 45-year period. Increased demand for red meat is driven by population growth, urbanization, and improved economies (FAO, 2009). At the same time, U.S. rangelands have decreased at an average rate of 141,700 hectares per year since 1982 (Reeves and Mitchell, 2012). This decline is primarily due to increased conversion of grazing lands to cropland, increased woody plant expansion, and urban development/residential land uses.

Reduced grazing land, increased demand for meat protein and potential increases in cattle prices may encourage more intensive beef cattle production systems. In this new paradigm, more beef production per land unit while producing a healthy, flavorful meat product to consumers. Small grain forage has been used extensively in the stocker industry in the Southern Great Plains with little use in the cow-calf segment. Stocker calves with ad libitum access to abundant wheat forage typically gain 1.05 to 1.32 kg per head per day (Horn, 2006). High quality forage, maximum forage intake and faster rate of weight gain is generally associated with greater profitability because maintenance costs are diluted over more pounds of weight gain. Alternatively, under normal circumstances, the goal for beef cow wintering programs is to maintain fall weight and body condition, supply the nutrients required for fetal development and in the case of fall calving systems, provide nutrients for milk production. However, winter small grains forage exceeds beef cows' protein and energy requirements to the extent that ad libitum access to abundant forage results in excessive weight gain and "unproductive" body fat accumulation in both pregnant and lactating beef cows.

Winter feed and supplementation account for the majority of the cost of maintaining a beef cow. A logical form of cow-calf enterprise intensification in the Southern Great Plains is expanded use of small grains forage as a supplement to lower quality forages. However, few published works are available evaluating limit-grazed small grains forage as a supplemental protein and energy source for beef cows. Phillips et al. (2010) reported increased carrying capacity of the operation as well as increased calf gain per acre of wheat pasture when stocker calves were provided limited access. The use of limit-grazed winter wheat pasture as a supplement for cows and their calves was shown to increase profitability of a cow-calf enterprise when compared to continuous grazing of native pasture and feeding an oilseed protein supplement (Apple et al., 1991; Apple et al., 1993a). Alternate day winter wheat grazing of both cows and calves resulted in an increase in calf average daily gain of 0.38 kg when compared to cows and calves wintered on native range pastures only (Apple et al., 1993a). Grazing winter wheat for 4 hours on alternate days during the graze-out period from February to April resulted in dramatically greater calf weight gain and a slight economic advantage in cow wintering costs (Apple et al., 1993b).

Furthermore, with grain prices relatively low, diversified land utilization incorporating beef production may increase operation revenues. Livestock production on cropland can be efficient in terms of beef produced per unit of area (Anderson, 1986). Other advantages with the addition of partial confinement include cattle are observed much closer, increase the ability to detect problems and quickly take action. Confinement decrease the risk of herd reduction in the event of drought with the ability to maintain cattle in the pens and provide feedstuffs. Feedstuffs will be more efficiently consumed and utilized in confinement with limited feed access. Confinement of cattle will decrease nutrient requirements because less energy is expended working to obtain feed (NRC, 1996). However, incorporation of an intensified practice will increase facility management and production costs for the cow-calf enterprise. Consumer sentiment opposing confinement of beef cattle may decrease some operations from incorporating this form of beef production.

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CHAPTER II

REVIEW OF THE LITERATURE

Cool Season, Winter Annual Pasture as a Supplement for Beef Cows

Mature cows consume large amounts of forage on a daily basis, but the need for high quality forage is minimal in comparison to young growing calves. In many situations during the winter high quality forages are not available. The goal with winter supplementation programs for cow-calf operations is to maintain cow body condition with some loss of body condition acceptable. Nutrient requirements are met through grazing of dormant forages with supplemental feed and hay. However, other alternatives may be available to meet these needs at much lower costs. Incorporating cultivated land with cool season annuals in a cow-calf system can increase profit per cow and increase beef produced per unit of land area (Bagley et al., 1987; Anderson, 1986). However, it is important to integrate optimal amounts of cultivated land into a beef production system. High percentages of forage on cultivated land, in excess of 25% total land area, will decrease calf weaning weights (Bagley et al., 1987). Conversely, when calves don't have continuous access to creep grazing areas, calf weaning weights rise with increasing levels of cropland. Cool season annuals have the greatest advantage December to April because warm-season perennial forages are at their lowest quality at this time. Cows grazing little to no cool season forages lost 22 kg more than cows supplemented with cool season pastures (Bagley et al., 1987). DeRouen et al. (1991) found that grazing cow-calf pairs on cool season annuals through the winter yielded 6 to 7% heavier calves. Cows from that system rebred earlier, thus, calving earlier. Additional calf weight gain can also mean higher input costs and lower prices unit of body weight, yet revenue from higher weights may offset the difference.

Winter wheat is a staple crop in the Southern Great Plains and has traditionally been grazed by stocker calves. Growing calves require nutrient dense feedstuffs to maximize growth potential. As crude protein content of winter wheat pasture greatly exceeds cow's daily requirement, producers can use winter wheat as a protein supplement for their cattle. Limiting access to this supplement can both increase the carrying capacity of the operation and increase the amount of calf gain per area unit (Phillips et al., 2010).

The use of limit-fed winter wheat as a protein supplement for fall calving cows and their calves has shown to increase profitability when compared to continuous wintering of cows on native pasture (Apple et al., 1991; Apple et al., 1993a). Fall calving operations have a greater advantage grazing cool season forages. Compared to a spring calving system, cow nutrient requirements are higher during winter because they are producing milk and calves are old enough to optimize forage consumption. Research suggests calves 3-4 months old will be self-sufficient to harvest cool season forage, therefore, fall born calves will be old enough to benefit from grazing cool season forages before weaning (Gunter et al., 2002; Newman et al., 2014). Alternate day winter wheat grazing of cows and continual grazing by calves November 18 to March 8, resulted in an increase calf average daily gain and total grazing gain of 0.38 kg and 54 kg, respectively, compared to calves wintering on native range pastures only (Apple et al., 1993a). Additional weight gain and decreased production costs of the alternate day wheat grazing of pairs had an advantage of $109.95 compared to pairs wintered on native pasture (Apple et al., 1993a).

Calf gains increase during wheat pasture graze-out but along with gains come increased costs. Apple et al. (1993a) discovered grazing fall calving pairs alternate days on wheat pasture through the winter was an economical use of pasture, however, full-time grazing during the spring was not a profitable utilization of the resource. Compared to pairs grazing native pasture, full-time wheat pasture grazing cattle lost $22.90 per cow (Apple et al., 1993a). Full-time graze-out was not profitable, but smaller amounts may be more economical (Apple et al., 1993b). By allowing cattle to graze wheat pasture 4 h/d, alternate days, cows had a $9.08 advantage through lower nutrition costs and calves had a significant advantage in ADG of 0.33 kg over cows and calves grazing native forage (Apple et al., 1993b). Following alternate day wheat pasture grazing, calves showed similar summer gains on native range compared to calves previous grazing native range. Apple et al. (1991; 1993a; 1993b) findings are compelling as calves nutritionally restricted after being wintered on dormant range throughout winter and early spring show no sign of compensating on native range during early summer grazing. Calves grazing wheat may have been on the optimal plane of nutrition to gain at the same rate as growth restricted counterparts instead of growth restricted calves compensating (Apple et al., 1993b).

Limit grazing strategies differ by operation and resource availability. Apple et al. (1991, 1993a, 1993b) maintained cows on dormant forage at times not grazing winter wheat. Phillips et al. (2010) maintained stocker calves in a dry-lot and limit graze wheat pasture alternate days. The growing stocker calves spent 50% of the week confined to a dry-lot and the remaining time was spent grazing wheat pasture. In the dry-lot, calves were provided with supplemental feed and ad libitum access to hay. The control group had continuous access to wheat pasture. The limit grazing period lasted 120 d, followed by a 50 d spring graze-out period. Typically, spring graze-out stocking rates are increased to twice the rate of winter stocking allowing spring graze-out stocking rates to be applied from the start of the winter grazing season because calves graze half the time throughout the winter (Phillips et al., 2010). Calves continuously grazing wheat pasture during the spring had a significantly higher ADG of 0.72 kg compared to calves receiving limited wheat pasture grazing at 0.66 kg (Phillips et al., 2010). During the 50 d graze-out period, calves from the limit grazed group compensated for the limit graze period, and after the entire grazing period, average daily gain was not different (Phillips et al., 2010). Steers consumed more hay in confinement than expected, potentially explaining the decrease in ADG. Though, the carrying capacity of the limit grazed wheat pasture treatment was increased (0.43 ha/steer vs. 0.83 ha/steer), the additional costs on hay and supplemental feeding reduced the profitability of the operation.

Limit grazing a combination of rye and wheat during winter had no effect on cow weight, throughout the year, in comparison to gestating cows on dormant Bermudagrass receiving corn gluten feed as a winter supplement (Gunter et al., 2002). In the same study, cows were limit grazed 2 d/wk or 3 d/wk with no difference in BW. This suggests 2 d/wk supplemental grazing, 7 h/d, would be sufficient for wintering cows. Body condition was only different at the conclusion of the limit grazing period, with cows receiving corn gluten feed through the winter having a higher BCS. In a similar study, Gunter et al. (2002) reported cows limit grazing winter annual pasture had a higher BCS April 23 until September 11. Cows on native pasture, supplemented with a corn gluten based supplement were able to compensate during late summer for lighter winter weights and gain more weight to make up the difference. Cows grazing bahiagrass, sod-seeded cool season annual grass produced 22 kg more than cows supplemented with hay and protein supplement (DeRouen et al., 1991). Furthermore, cows produced an additional 6 kg of calf weight per 454 kg of body weight.

Creep Feeding and Creep Grazing Calves

Creep feeding/grazing young calves nursing their dam with a concentrate diet or high quality forage increases calf BW (Apple et al., 1993a and 1993b; Bagley et al., 1987; Holloway and Totusek 1973; Martin et al., 1981; Mayo et al., 2002; Prichard et al., 1989). However, feed costs may prevent a creep feeding program from being cost effect. Fall calving programs, on winter dormant native rangeland, have the highest probability of capturing the benefits of a creep feeding system. Dormant rangeland is poor quality and low in digestibility and of little value to young calves. Prichard et al. (1989) evaluated calves fed creep starting at 56 and 146 d of age and found no advantages to feeding until 146 d of age. Calves creep fed for varying durations finished with no difference in 205 d weaning weights and feed conversion. Creep feeding grain based diets will increase calf growth by substituting poor quality forage with higher quality feedstuffs. Creep feeding is an excellent way to provide high quality feedstuffs to calves without unnecessary costs associated with additional cow feed. Feed consumed by cows above requirements does not increase calf gain and only 65% of calf weight, up to 8 months of age, is attributed to cow milk production. Therefore, additional feed provided to cows doesn't improve calf weight gain (Allen and Collins, 2003).

Creep Feeding

Creep feeding grain based feeds to calves will yield increased gains, and train calves to eat from a feed bunk, preparing them for subsequent feedlot experience. However, grain based diets have been shown to have negative effects on heifer development (Hixon et al., 1982; Holloway and Totusek, 1973; Martin et al., 1981). Cows that received grain based creep feed as calves, in comparison to cows not receiving creep as calves, had lower milk production, weaned lighter calves, weaned fewer calves and had poorer lifetime productivity (Hixon et al., 1982; Martin et al., 1981). Creep fed heifer calves were heavier at weaning but lighter at 365 d of age (Martin et al., 1981). In addition, Holloway and Totusek (1973) reported heifers exhibiting high rates of gain early in life having poorer maternal ability.

Steer calves creep fed had 57 kg higher weaning weights and continued to gain at a faster rate in the feedlot, with no ill effects to carcass quality (Scarth et al., 1967). However, Martin et al. (1981), found a decrease in calf gain post weaning, but calves in this study still had higher adjusted 365 d weights. Heavier weaning weights and faster post weaning daily gains generated heavier hot carcass weights (HCW) for creep fed steer calves (Scarth et al., 1967). Mayo et al. (2002b) reported creep fed calves had heavier HCW, lower ADG and F:G, but increased dressing percentage. Advantages have been reported in each creep feeding management system.

Data from Marsten et al. (1993) suggest that cow nutrition had an effect on calf gains. When cows received the same amount of protein with high or low levels of energy supplementation, high energy supplemented cows raised smaller calves. Mayo et al. (2002a) would propose alternative practices of economically increasing calf gain. Fall born calves from cows receiving lower levels of winter supplement which were provided access to creep feed gained 10 kg more than their counterparts nursing cows receiving a higher level of winter supplement. Creep fed calves gained less weight during early summer but were able to maintain 79% of additional creep feed gain acquired during the winter with no effect on cow performance. Additional gains were also more efficient. Creep intake was significantly higher for calves nursing cows receiving low supplementation, resulting in an increase in efficiency of gain. Feed consumed by the calves was converted to calf weight gain better than feed consumed by cows. Therefore, the most cost effective way to increase calf gain was to provide creep feed to calves and feed lower levels of winter supplement to cows because calves were more efficient converting feed to gain when consuming feed directly. Grain based creep feed may be viable management practice in a terminal breeding system when heifers are not retained as replacement females. It prepares calves for feedlot bunk style feeding and increases total gains that are typically not compensated for.

Creep Grazing

Another source of providing quality nutrition to young calves still nursing dams is providing access to high quality growing forages. Creep grazing requires more inputs but is typically more economical than creep feeding. Operations may be established to allow cows to graze low quality forage and calves to access improved pastures through the use of creep gates. Creep grazing is an efficient way to utilize small areas of high quality grasses and increase cow reproduction efficiency (Newman et al., 2014). Apple et al. (1993b) found that cows with calves creep grazing wheat pasture through graze-out had an $11.20 cow advantage and produced 11.7 kg more calf compared to cattle on dormant native forage. Moreover, calves nursing cows with alternated day wheat grazing had increased rate of gain but decreased profitability. This is further indication that calves are more efficient converting feed to gain compared to cows transferring feed to calf gain. On dormant native range, calves had similar daily gains creep grazing winter wheat compared to calves consuming commercially formulated corn based feed (Apple et al., 1991).

In a study evaluating varying amounts of cultivation, calves with the ability to creep graze warm and cool season annuals had 8% and 12% higher 205-d weaning weights; furthermore, cows lost less weight with creep grazing calves (Bagley et al., 1987). Calves creep grazing pearl millet and alfalfa had higher gains than did calves grazing Bermudagrass and tall fescue alongside their dam (Bagley et al., 1997). In addition, cows grazing Coastal and Tifton 85 Bermudagrass, in a two year trial, had increased ADG and raised heavier calves when the calves were allowed access to aeschynomene (Corriher et al., 2007). Cow-calf pairs grazing Tifton 85 experienced higher performance because of higher nutritive values. So, it was expected creep fed calves grazing Coastal Bermudagrass would obtain greater improvements to daily gains, yet no differences were observed. Milk yields show contrasting results, one year cows from the Coastal Bermudagrass, non-creep calves produced more milk, and the following year cows grazing Tifton 85 nursing calves creep grazing produced more milk. Difference in milk collection dates may explain the differing results by year. Calves may be able to compensate for decreased cow milk production because of increased dry matter intake (DMI) creep grazing high quality forage.

Rotational grazing systems allow calves to creep graze ahead of the cows providing them with the opportunity to select higher quality forages prior to cows (Drennan, 1971). Calves in this study had no advantages over non-creep grazing calves. Pastures had previously been grazed, possibly contributing to the lack of effects from forward creep grazing. If pastures have been grazed by cows earlier in the growing season, rest periods need to be long enough for regrowth to occur; otherwise, no advantages are present in forward grazing system.

Compensatory Gain

Cattle management systems can positively or negatively affect subsequent performance. At times of the year when feed costs are high, it is often desirable to take advantage of low quality feedstuffs. Cattle managed on low quality forages, reducing performance, followed by a period of improved nutrition will experience gains in excess of cattle fed on a level plane of nutrition (Choat et al., 2003; Drouillard and Kuhl, 1999; Gill et al., 1992; Hersom et al., 2004; Lewis et al., 1990; White et al., 1987). This phenomenon of accelerated, more efficient, growth after a period of restricted nutrition or environmental stress is termed compensatory growth by National Research Council (1996). Compensatory growth is derived from increased feed intake and decreased net energy requirements. Compensatory gain is used to cattle manager’s advantage when feed costs are typically high and resources are low, followed by relatively cheaper feed. Cattle can be maintained at a constant to slightly decreasing body weight or composition until feed resources are available.

Nutritional deprivation is not the only factor influencing compensatory gain. Environmental effects such as extreme temperatures, disease, plant toxins, and parasite infestation can also yield compensatory growth effects (Drouillard et al., 1999). Compensatory gain is expected in early stages of a recovery period, 60 to 90 d (White et al., 1987; NRC, 1996). Age of animal plus severity and duration of restriction must be considered when evaluating the effects of compensatory gain.

Winter Weight Change on Subsequent Calf Performance

Cheapest cattle gains take place when forages are green and growing; however, many regions require a winter feeding period (Lewis et al., 1990). Quality, harvested feedstuffs and supplements can be expensive avenues of weight gain. Dormant forages and restricted diets can reduce feed costs with advantages in calf performance in subsequent feeding periods. Furthermore, increased winter gains have an inverse relationship on subsequent pasture gains (Lewis et al., 1990; White et al., 1987). Optimal winter gains have been suggested by Baker et al. (1975) to be between .25 to .50 kg/d. Lewis et al. (1990) fed steers on mixtures of corn residue and protein supplements to gain .28, .38 and .50 kg/d to determine the effects on spring and summer pasture gain. As level of winter gain increased, summer pasture gain decreased. At the conclusion of the pasture grazing, there was no difference in weight. The optimal calf winter nutrition program would then be based on an economic decision as to which program is more profitable. Furthermore, weight gain is typically not completely compensated (White et al., 1987). White et al. (1987) reported 20-30% compensation in calves on pasture for 112 d following restriction. Lewis et al. (1990) review of the literature disagrees with White et al. (1987), finding compensation was 70-90%. Compensation of restricted cattle varies, but typically, 100% recovery is uncommon in cattle management programs because recovery would take much longer to observe or does not ultimately take place.

Beef cattle management systems are typically segmented, decreasing the ability to identify benefits from compensatory gain if retained ownership is not maintained. However, negative effects of compensatory gain in cattle can decrease profitability of subsequent segments as well. Since it is understood cattle do not grow on a constant plane throughout life, it becomes important to understand how that affects performance in the feedlot and carcass characteristics.

It is common practice in the Southern Plains to grow stocker cattle on winter wheat pasture. Hersom et al. (2004) evaluated the effects of high weight gain (HGW) and low weight gain (LGW) on wheat pasture and native rangeland (NR) through the winter. As expected, calves on wheat gained better throughout the winter so calves entered the feedlot following winter grazing at much different weights and body composition. Final weight was higher for HGW and NR compared to LGW. When DMI was evaluated as a % mean BW, NR and LGW calves consumed more feed in both years of the study. Choat et al. (2003) reported increased DMI during the first 28 d of calves which had previously grazed wheat but no difference was observed in the total trial average. Therefore, compensating calves consumed less feed for the remainder of the finishing period. Lewis et al. (1990) reported no difference in DMI, however, calves from this study grazed pasture following nutritional deprivation, allowing restricted calves to compensate on pasture. It is suggested that once cattle "catch up," they will no longer experience compensating growth effects.

Gill et al. (1992) backgrounded heifers in dry-lots at three levels of targeted gain and on native pasture during the winter before spring and summer grazing followed by a finishing period. Wintered gains increased linearly with increasing nutrition. Summer grazing was separated into two grazing treatments, intensive early stocking (IES) and season long (SLS). IES heifers had better daily gains but grazed for a shorter period, yielding lighter initial feedlot weights. During the finishing phase, there was a decrease in feed efficiency, 19.7%, for SLS heifers compared to IES. There was no difference in DMI but increased daily gains (1.72 vs. 1.54 kg). Summer grazing had a larger effect on feedlot performance than winter backgrounding. Only small differences were observed finishing the heifers from winter background because the wintering period was only 42 d long.

Increased daily gains of 0.12 and 0.13 kg during finishing have been reported from calves wintered on native range compared to wheat pasture (Hersom et al., 2004; Choat et al., 2003). Calves grazing native range had 7.4% increase in ADG (Choat et al., 2003). However, data from Hersom et al. (2004) found contrasting results between years. In year 1 there was no difference in steer performance but was in year 2. Some data would suggest a tendency to increase gain during finishing with increasing winter nutrition (Lewis et al., 1990). On the other hand, these cattle were grazed on pasture prior to feedlot entry. Calves allowed to graze-out winter wheat during the spring, following winter grazing of wheat and native range yielded higher daily gains from native grazing calves (Phillips et al., 1991). Entering the feedlot, winter wheat grazing calves were heavier but gained less weight and were 10% less efficient.

Cattle with compensating potential may exhibit an adjustment period when provided a higher energy diet (McDonalds et al., 2011). Research evaluating winter restriction, pasture performance and finishing period showed improved ADG during the initial 28 d of finishing period for calves fed to gain 1.13 kg/d, followed by no difference in total daily gain (White et al., 1987). Choat et al. (2003) witnessed similar results in the first 14 d when calves previously grazing native range had lower daily gains followed by overall better gains. This data suggests that it may take previously, native grazing, restricted calves 14-28 d before they gain at a faster rate.

No differences were observed in carcass characteristics of cattle finished previously grazing pasture following a restricted wintering period (Lewis et al., 1990; White et al., 1987). However, if calves were not allowed to compensate prior to entering the feed yard, differences were observed (Gill et al., 1993; Choat et al., 2003; Hersom et al., 2004). Hersom et al. (2004) saw a difference in HCW in one of two years but nothing else. Interestingly, calves wintered on wheat pasture at two rates of gain yielded heavier HCW for the faster gaining group with native range grazing calves intermediate. IES yielded no difference in carcass characteristics compared to SLS; however, level of winter nutrition did (Gill et al., 1993). Heifers programmed to gain 0.68 kg/d obtained the greatest advantage in performance. Advantages were reported in HCW, fat thickness and yield grade over dry grass wintered heifers. Level of winter nutrition had no effect on finishing performance following summer grazing. In contrast, summer grazing had significant effects on feedlot performance but no effect in carcass characteristics.

Feeding During Calfhood and Subsequent Performance

Reduction in energy early in a calf's life may have both positive and negative effects later. Restricting energy intake in young ruminants can reduce maintenance requirements, Ledger and Sayer, 1977, found it took 56 days of restriction to program calves to lower maintenance energy requirements. In a review of the literature, Bagley (1993) found that reducing energy intake in calves < 7 months of age will result in 14 to 18 months of additional recovery to compensate to 70 to 80% of weight gain in control groups. Further reviews showed that calves 10 to 22 months of age will take only 4 to 7 months to compensate. Therefore, energy restriction in calfhood can play a major role on subsequent performance.

Fall born calves in the Southern Great Plains are often weaned in July after grazing summer forages alongside their dams. July is the point at which summer native forages reach peak quality and begin declining for the remainder of the summer. Research suggests winter grazing programs have an effect on summer calf performance. As stated earlier, calves grazing winter rangeland throughout the winter would be expected to outperform calves wintered on wheat pasture on summer pasture. However, Apple et al. (1993a) found no significant difference in summer, May to July, daily gains between calves wintered with alternate day wheat access and native range. Speculations were made that calves grazing winter wheat were not fat enough to reduce growth rates compared to native range wintered calves. In addition, cow-calf pair alternate day grazing wheat pasture proved to be more profitable. Pairs were commingled grazing summer native pasture to prevent pasture effects on calf gain.

Hereford crossbred calves, pre-weaning, managed at different stocking rates experienced decreased weaning weights as stocking rate increased. However, no difference in performance was observed in subsequent stocker grazing on winter wheat or dormant native range (Phillips et al., 1991). Further research evaluating varying the impact of levels of nutrition on pre-weaned calves yielded no difference in subsequent feedlot performance (Stuedemann et al., 1968). Nonetheless, with a decreasing plane of nutrition, days of finishing increased, resulting in older calves. Consequently, as calves mature the probability of grading choice or better begin to decrease. Calves fed normal to low levels of nutrition utilized feed more efficiently than did calves fed high levels of winter nutrition. Contrasting evidence from Scrarth et al. (1967), showed calves receiving creep feed prior to entering the feedlot gained at a faster rate and required less feed per unit of BW than their counterparts not receiving creep feed.

Protein and Energy Utilization during Compensatory Gain

Many studies have examined the effects of energy restriction or protein restriction on compensatory gain but few evaluate the two simultaneously. Again, duration and severity of restriction plays a role in compensating effects; however, effects may more pronounced in energy restriction than protein (Drouillard et al., 1991). With both protein and energy, "long" (154 d) and "short" (77 d) duration restriction, calves experienced compensatory gains compared to controls. Furthermore, long duration protein restriction yielded no difference in finishing performance or efficiency of gain compared to short duration protein restriction. Crossbred steers restricted energy long term incurred marginal advantages in finishing gains and feed efficiency compared to short term. Severity of restriction played a larger role in compensation and happened to be more apparent in energy restriction. Severely energy restricted steer calves were 40% more efficient and gained 0.37 kg/d better. No differences in severity of protein restriction were observed. Since, calves did not experience greater gains following restriction, it may not be logical to restrict protein.

When calves are compensating from previous growth restriction, protein is deposited prior to fat followed by the inverse (Fox et al., 1972). After 154 and 190 d of maintenance calves were full fed to reach weights of 364 or 454 kg. A portion of the calves were slaughtered at 364 kg and the other half continued to 454 kg. Calves fed to 364 kg were significantly higher in protein and lower in fat compared to controls fed full feed continually but at 454 kg there was no difference in body composition. Suggesting protein deposition occurs early and fat deposition occurs later in the alimentation period. This data suggests that compensating cattle may require a higher protein to energy ratio.

Rest for Native Rangeland

It is important to monitor the health and vigor of native rangelands. If not managed well range will deteriorate and less productive for livestock production. Moderate grazing of native grasses is good for rangeland productivity by removing biomass from the area and prevent accumulation of mulch (Holechek et al., 2010). When quantity of mulch exceeds annual herbage yields, herbage production is decreased. However, it essential that enough forage remains to allow proper health and growth of climax plants to take place in years to come. Retaining biomass conserves soil moisture and stores carbohydrate reserves.

Carbohydrate (CHO) reserves are closely related to plant vigor and regrowth (Trlica and Cook, 1971). When plants are defoliated late in the growing season, near plant maturity, CHO reserves are greatly reduced. Energy reserves are depleted for regrowth and reproduction. Trlica and Cook (1971) clipped plants to mimic grazing and saw only 20% regrowth in fall clipping dates. If plants are defoliated in the early to late spring, they still have time to grow and build up reserves. Low amounts of CHO reserves at the initiation of the growing season will delay plant growth and reduce total plant production for the entire growing season. So the more regrowth allowed to occur, the greater the CHO reserve accumulation by fall (Trlica and Cook, 1971). Late clippings, compared to controls, decreased plant vigor and total production in following years (Drawe et al., 1972).

Other negative influences on plant vigor is clipping or grazing intensity. As intensity increases, herbage volume increases but plant vigor is compromised over time. IES is a management practice many stocker operators have used instead of SLS. Intensive early stocked cattle are stocked at twice the rate as season long grazing but graze half the time. Cattle are grazed until mid-July, the point most summer grasses in the Southern Plains decrease in quality. Cattle will gain better on the higher quality forages during this time. In addition, the majority of total forage production has taken place by this time. Owensby et al. (1977) evaluated the effects of intensive early stocking on CHO reserves. CHO reserves were lower during the grazing period but no different 6 week after cattle were removed and remained the same until the beginning of the next growing season. Furthermore, big bluestem increased in cover and relative abundance under intensive early season stocking compared to season long stocking that experienced no change. Lacey et al. (1994) reported improvements in ground cover from spring grazing compared to summer grazing. Increased ground cover may be attributed to increased crown diameter (Drawe et al., 1972). Other positive influences in plant community were witnessed in spring grazing. Decreaser, desirable plant species, plant frequency increased from 93 to 99, representing an upward trend in rangeland conditions. Rangelands have to be managed properly to maintain or improve plant vigor and health.

Summary

The literature shows advantages to using cool season forages as a supplement to beef cattle through calf gains and improved cow reproduction. The most profitable way to increase calf gain is through calf nutrition, instead of additional cow feed. Calves will convert feed to gain more efficiently than cows can transfer feed to calf gain. Improved winter nutrition early in a calf's life can yield advantages on subsequent performance. Compensating calves rarely catch up to non-restricted calves. In addition, proper rest is essential to native rangeland to maintain long term productivity.

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CHAPTER III

MATERIALS AND METHODS

Animals and Diet

Year 1 Cow/calf, Grazing. This report summarizes a multi-year project. Year 1 began December 9, 2013 and continued through December 4, 2014. The experiment is being conducted at the Range Cow Research Center, North Range Unit, and wheat pasture unit, just West of Stillwater, Oklahoma. Fall calving Angus and Angus x Hereford cows (n = 84; BW = 527 ± 70 kg; BCS = 5.0 ± 0.9; Cow age = 5.6 ± 3 yrs.) were allotted randomly by body weight and age into two forage system treatments: extensive (EXT) or intensive (INT). Cows were assigned to three pasture or management groups within the EXT system and three pasture or management groups within the INT system. The INT system was designed to reduce the land area required per cow-calf pair and/or increase production through increased calf weaning weight. Cattle were individually weighed and cows were BCS (1 = Emaciated and 9 = Obese) at the beginning of each grazing period.

Cows assigned to the EXT treatment were continuously grazed with year-around access to 5.4 ha of open native rangeland for each cow-calf pair. This is considered to be a low stocking rate in this region and should provide adequate forage through the winter with little supplemental hay required except in the case of severe drought. Cattle were fed prairie hay (6.7% CP, DM basis) five different occasions during year 1, only during severe inclement weather. A cottonseed meal and wheat middling-based supplement (38% CP, DM basis) was provided to the EXT cows and calves three days a week through the winter (December 1 – March 31) at a rate of 1.4 kg/pair/d and 0.9 kg/pair/d during late fall (November) and early spring (April) (Lalman, 2008). Supplement feeding rate for EXT managed cows was designed to provide adequate protein while grazing low quality dormant forage. The feeding rate was not increased to meet energy requirements because fall-calving cows typically compensate for winter weight loss during the spring and summer to the point where they can become over-conditioned.

Cows assigned to the INT system were fed prairie hay (6.7% CP, DM basis) and mineral supplement in a dry-lot through the winter period beginning December 9, 2013. Table 3.1 shows the INT grazing schedule throughout year 1. During this time, INT cows had access to 0.4 ha of wheat pasture per cow-calf unit on Monday, Wednesday and Friday each week and were allowed to graze for four hours on each of those days. Calves were allowed continuous access to wheat through creep gates. Beginning March 27, cows and calves were given free-choice access to wheat pasture because it was "getting ahead" of the cows and calves. The graze-out period continued through May 7 when most of the wheat forage had been consumed. The INT cows were moved back to native rangeland on May 7 with a stocking rate of 3.2 ha of open native rangeland per cow-calf pair. INT system cattle were expected to graze native pasture 64% of the growing season. Therefore, they were stocked 64% higher than the EXT system.

Native pastures were prescribe burned April 22. April 21, EXT cattle were removed from their respective pastures and placed in alternative pastures until May 7. Experimental pasture groups assigned to both treatments grazed their respective native rangeland pastures from May 7 through July 16 when the cattle were gathered and calves were weaned. Calves were commingled until summer grazing started, July 22.

A cover crop of brown mid rib sorghum-sudan, cowpeas and sun hemp was no-till planted in the wheat acreage on June 15. On July 22, INT cows and weaned steer calves began grazing the cover crop. The pastures were broken up into thirds. Cows limit grazed 4-h/d on 2 ha (1/3) and remained in the dry-lot with free-choice mineral and no additional feed the remaining time. Limit grazing was to reduce trampling of the crop and prevent increased BCS. Abundant sorghum prompted the decision to graze steer calves, in addition to cows, as a preconditioning period prior to entering the feedlot. Steers were given access to 2 ha (1/3) of cover crop with the remaining 2 ha (1/3) ungrazed for hay production (Early cutting). After cover crop grazing, August 22, cows returned to the native rangeland pastures until wheat pasture was established. INT and EXT native range grazing steers were transported to the feedlot for finishing. Because abundant forage was still available in the steer pastures at the conclusion of grazing, it was cut and baled for hay on August 23 (Late cutting).

Cow and calf wheat consumption was estimated during the 4-h limit grazing period on 6 different occasions: March 7, 10, 14, 17, 24, and 27. Intake data was collected twice within each pasture. Each day two different pairs from the same pasture were randomly selected. An individual weight was recorded immediately prior to turnout on wheat pasture. Cows were separated from their calves by a fence during the collection period to prevent nursing. Cows and their calves were closely monitored during the grazing period. Fecal material was immediately collected in plastic bags and later weighed on an electronic scale. After 4-h of grazing, cattle were gathered immediately and weight was recorded. Urine output was not accounted for. The following equation was used to determine wheat consumption:

Wheat DM Consumption = (Final Weight, kg – Initial Weight, kg + Wet Fecal Weight, kg) * Wheat DM, %

Year 1 Steers, Finishing. Steer calves produced during the first year of the experiment entered the feed yard following 30 days of grazing sorghum-sudan grass (INT) or native rangeland (EXT). This portion of the experiment was conducted at the Willard Sparks Beef Research Center, just west of Stillwater, Oklahoma. Fall born Angus and Angus X Hereford calves (n = 39; BW = 351 ± 36.4 kg) were penned based on their original pen assignment and fed in two pens per replicate group (12 pens total, 6 per treatment). Calves were processed upon arrival and fed a starter ration for ten days before initiation of a gradual ration concentrate step-up program. All calves were administered a Component TE-S implant on d 0 and re-implanted with Component TE-IS on d 94. Calves were finished to reach a common back fat thickness (1.3 cm) according to the feedlot manager. The INT system steers were sold on day 158 (January 27) and EXT on day 178 (February 16). Calves were slaughtered at Tyson, in Amarillo, Texas. All carcass grading measurements were VIA camera based. Carcass data from one calf in the EXT group was unable to be retrieved.

Year 2 Cow/calf, Grazing. Year 2 of the project began December 4, 2014 and continued through early December 2015. In Year 2, fall calving Angus and Angus x Herford cows (n = 93; BW = 584 ± 74 kg; BCS = 5.6 ± 0.7; Cow age = 6 ± 2.7 yrs.) were maintained in two forage system treatments: extensive (EXT) or intensive (INT).
Following year 1 all pregnant and healthy cows remained in the same respective treatment and pasture management groups. Eight cows from EXT and eight cows from INT were culled for standard management practices such as poor udder structure and failure to become pregnant. To maintain stocking rate for EXT system or increase stocking rate for INT system, pregnant cows of similar genetics and management were added to each pasture group. These replacement cows were allotted by BW and age to maintain similar age and mature BW among treatments.

Similar to year 1, cows assigned to the EXT treatment were continuously grazed on native rangeland. Only during severe inclement weather were cattle fed prairie hay (5.5% CP, DM basis). Dried distillers grain (32% CP, DM basis) was provided to the EXT cows and calves through the winter (December 1 – March 31) at a rate of 1.8 k/pair/d and 1.4 kg/pair/d during late fall (November) and early spring (April) (Lalman, 2008). The supplement feeding rate for EXT managed cows was designed to provide adequate protein while grazing low quality, dormant, forage.

Table 3.2 shows the grazing schedule of the INT system cattle throughout year 2. The INT system was managed comparable to year 1 with the following exceptions. During the winter, cow-calf pairs began limit grazing winter wheat on December 4, 2014. Winter wheat pasture was planted September 13 & 14. Seed was planted at a rate of 112 kg/ha and N fertilizer was applied at 79 kg/ha. On January 3, cow access to winter wheat was reduced from 12 to 9-h/wk on three separate d. Further reduction in grazing access took place February 24 from 9 to 6-h/wk on three separate d. Greater than expected body condition from year 1 encouraged the decision to decrease wheat access in year 2. In addition, stocking rate was increased to 0.3 ha of wheat pasture per cow-calf unit. Calves were allowed continuous access to wheat through creep gates throughout the winter and early spring. Beginning April 3, cows were given free-choice access to wheat pasture until the majority of the forage had been consumed.

Cow-calf pairs were moved to native rangeland on May 1 with an increased stocking rate of 2.6 ha of open native rangeland per cow-calf pair. Concluding year 1, excessive forage was available. Stocking rate was based on total grazing time instead of growing season alone. In year 1, credit was given to pasture rest during the dormant season. Later discussions decided that the most logical stocking rate should be based on the entire year. Cattle were expected to graze native pastures 47% of the year, creating a stocking rate 47% higher than EXT system.

All native range pastures were prescribe burned March 27. EXT cattle were placed in an alternative pasture until April 16. Experimental pasture groups assigned to both treatments grazed their respective native rangeland pastures from May 1 through June 18 when the cattle were gathered and calves were weaned. Calves were commingled until June 22 when summer grazing began.

Red River ® crabgrass seed (6.7 kg/ha) and N fertilizer (51 kg/ha actual N) were broadcast on the wheat land area on March 13. Sustained heavy rainfall through mid-June resulted in excellent crabgrass establishment and growth in approximately 65% of the area within each paddock. Crabgrass establishment and growth in the remaining area was nonexistent or delayed due to extended flooding of the lower areas within the paddocks. Calves from within the three INT replications plus additional yearling calves (ADD) were returned to the cropland to graze the cover crop from June 22 through August 11. After summer cover crop (INT) and native range grazing (EXT), steer calves were shipped to a feed yard for finishing and heifers returned to native rangeland. The summer cover crop was terminated and planted back to wheat in September to repeat the limit-grazing system for cows the following winter.

After weaning, INT cows grazed Bermudagrass to allow rest for native rangeland. On August 13 cows were removed from Bermudagrass and placed back in respected native pastures until wheat pasture was established.

During winter grazing cow and calf wheat consumption was estimated during the 3-h/3 d and 3-h/2 d limit grazing period on 4 different occasions, on 2 occasions for each limit grazing schedule: January 16, February 20, March 20, and 27. Each day, 2-4 cow-calf pairs from the same pasture were randomly selected. An individual weight was recorded immediately prior to turnout on wheat pasture. Cows were separated from their calves by a fence during the collection period to prevent nursing. Cows and calves were closely monitored during the grazing period, if defecation occurred fecal material was immediately collected in plastic bags and later weighed on an electronic scale. After planned grazing time had expired, cattle were gathered immediately and weight was recorded. While the cows and calves were grazing wheat, forage samples were collected in the grazing area to determine wheat dry matter content. Urine output was not accounted for. The following equation was used to determine wheat consumption:

$$\text{Wheat DM Consumption} = (\text{Final Weight, kg} - \text{Initial Weight, kg} + \text{Wet Fecal Weight, kg}) * \text{Wheat DM, \%}$$

Forage Sampling

Forage samples were collected once a month in all of the pastures to evaluate forage mass. Four to six sample locations per pasture were mapped by GPS coordinates to maintain location consistency. Forage was clipped at a height of approximately 2 cm. The samples were weighed and placed in a drying oven at 115ºF for 72 hours before being weighed again to determine DM content of the forage.

Economics

Enterprise costs were estimated based on current local commodity prices, calf prices (National Stockyards, Oklahoma City, OK) and cropland and pasture rental rates (Doye and Sahs). Income was based on calf weights at weaning or following summer grazing. The U.S. Number 1 classification and Large and Medium frame was used for sale price. Calf revenue is the value of the calf at weaning. Total revenue for the INT system is the calf revenue plus land rent received from stocker enterprise on the summer crop and hay production produced by the land in year 1. The early cutting of hay was rained on so the value of hay per ton was

$80. The late cutting of hay was higher quality and valued at $90 per ton. In year 2, there was no hay production so no value was given to the land. Cow-calf cost are all costs associated with the cow-calf enterprise, which are detailed in budgets in the appendices. Cow-calf net income is the profit of the cow-calf enterprise excluding cull cow income (cow death losses and culls are assumed to be independent of the treatment so are not included in this analysis). Stockers during the late summer were charge a rent value to the cow-calf enterprise for their time grazing sorghum in year 1 and crabgrass in year 2.

Statistical Analysis

Cow/calf, Grazing. Data was analyzed using GLIMMIX procedures of SAS 9.4 (SAS Inst., Inc., Cary, NC). The pasture was considered the experimental unit and the model included treatment, calf gender (when appropriate) and the interaction as fixed effects. For all analyses, when the *P*-Value for the F-Statistic was ≤ 0.05, least square means were separated using PDIFF and reported. Tendencies were reported at 0.05 < P-Value ≤ 0.10.

Steers, Finishing. Data were analyzed using GLIMMIX procedures of SAS 9.4 (SAS Inst., Inc., Cary, NC). Pen was considered experimental unit and the model included treatment as fixed effect and back fat thickness as a covariate. For all analyses, when the *P*-Value for the F-Statistic was ≤ 0.05, least square means were separated using PDIFF and reported. Tendencies were reported at 0.05 < P-Value ≤ 0.10.

Economics. Data were analyzed using GLIMMIX procedures of SAS 9.4 (SAS Inst., Inc., Cary, NC). The pasture was considered the experimental unit and treatment was a fixed effect. For all analyses, when the *P*-Value for the F-Statistic was ≤ 0.05, least square means were separated using PDIFF and reported. Tendencies were reported at 0.05 < P-Value ≤ 0.10.

Sensitivity Analysis

The year 2 budgets were used in the sensitivity analysis. The four largest input costs (hay, protein supplement, native pasture rent and wheat pasture rent) and calf prices were used to evaluate the sensitivity of net income per hectare to changes in those costs. All other values were held constant. Two values in the analysis were evaluated at a time, with other values set to a constant amount based on the original budget for year 2: hay $70/ton, protein supplement $260/ton, native pasture rent $42/ha, wheat pasture rent $95/ha and calf price $4.40/kg. Hay values in the analysis ($60, $70, $80 and $90/ton) were chosen because low quality hay prairie was used in the trial and the cost was expected to increase more than decrease from $70/ton. Supplement costs changed greatly from year 1 to year 2. The supplement values used in the analysis ($260, $300, $350 and $400/ton) ranged from the high in year 1 to the low end of year 2 to represent current high and low costs. Native rental rate was increased from the current year as land values tend to increase over time. Calf prices in the analysis are at the time of weaning and the values began at the five year average (OSU Cow-calf Enterprise Budget) and increased up towards the record high prices of 2014. It is also important to note that there is no price difference between systems even though the INT system calves were heavier at weaning.

Table 3.1 Intensive forage grazing system schedule, year 1

Item	Time	Days	Feed/forage	Hectare/Cow[6]
Winter[1]	Dec. 9 – Mar. 27	109	Dry-lot limit grazing wheat	0.4
Spring graze-out[2]	Mar. 27 – May 7	41	Ad libitum wheat	0.4
Early summer[3]	May 7 – Jul. 16	69	Native rangeland	3.4
Later summer[4]	Jul. 22 – Aug. 22	30	Sorghum-sudan, cow peas and sun hemp	0.2 – cows and 0.3 - steers
Fall[5]	Aug. 22 – Dec. 4	102	Native rangeland	3.4

[1]Winter = Prairie hay (6.7% CP) was fed in the dry-lot. Cows limit grazed 4-h/d, 3 d/wk. Calves had continuous access to wheat pasture through creep gates.
[2]Spring graze-out = Prescribed burns took place on the native rangeland pastures April 22.
[3]Early summer = Calves were weaned on July 16.
[4]Late summer = Cows limit grazed one third of the pasture 4-h/d, 7 d/wk and calves had continuous access to one third of the cover crop and the remaining one third was cut for hay. The portion of pasture that calves grazed was cut for hay after they were removed.
[5]Fall = Calving season began September 1.
[6]Hectare/cow = The total amount of land for the intensive (INT) system cow-calf enterprise is 3.8 ha/cow. Winter wheat and Spring graze-out wheat is the same land. Early summer native and Fall pasture is the same land they are expressed at separate times to show how much land is available in the grazing period.

Table 3.2. Intensive forage system grazing schedule, year 2

Item	Time	Days	Feed/forage	Hectare/cow[6]
Winter[1]	Dec. 4 – Apr. 3	120	Dry-lot and limit grazed wheat	0.3
Spring graze-out[2]	Apr. 3 – May 1	28	Ad libitum wheat	0.3
Early summer[3]	May 1 - Jun. 19	49	Native rangeland	3.2
Late summer[4]	Jun. 22 – Aug. 11	48	Bermudagrass or crabgrass	0.2 - cows and 0.2 - calves
Fall[5]	Aug. 11 – Dec. 4	96	Native rangeland	3.2

[1]Winter = Prairie hay and sorghum-sudan hay was fed in the dry-lot. Limit grazing time began at 12-h/wk (December 4 – January 3), followed by 9-h/wk (January 4 – February 23) and then 6-h/wk (February 24 – April 2). Calves had continuous access to wheat pasture through creep gates. Prescribed burns on the native rangeland pastures March 27.
[2]Early summer = Weaning took place on June 19.
[3]Late summer = Cows grazed Bermudagrass and Intensive (INT) system and additional (ADD) weaned calves grazed crabgrass.
[4]Fall = Calving season September 1 – October 31.
[5]Hectare/cow = The total amount of land for the INT system cow-calf enterprise is 3.6 ha/cow. Winter wheat and Spring graze-out wheat is the same land. Early summer native and Fall pasture is the same land they are expressed at separate times to show how much land is available in the grazing period.
[6]Hectare/cow = The total amount of land for the INT system cow-calf enterprise is 3.6 ha/cow. Winter wheat and Spring graze-out wheat is the same land. Early summer native and Fall pasture is the same land they are expressed at separate times to show how much land is available in the grazing period.

Table 3.3. Intensive forage system land preparation schedule

Event	Date
Planted Wheat and Apply Fertilizer	September, 2013
Terminate Wheat	May 15, 2014
Planted Summer Crop	June 15 & 16, 2014
Cut Summer Crop for hay (Early Cutting)	August 4, 2014
Cut Summer Crop for hay (Late Cutting)	August 21, 2014
Terminate Summer Crop (Early Cutting)	August 20, 2014
2 L/ha of 2-4-d and 4 L/ha of glyphosate	
Terminate Summer Crop (Late Cutting)	September 2, 2014
2 L/ha of 2-4-d and 4 L/ha of glyphosate	
168 kg/ha of urea (46-0-0) applied	September 4, 2014
Plant Wheat and Apply Fertilizer 57 kg/ha of 18-46-0 with seed 3.4 L/ha of glyphosate applied directly after planting.	September 10 & 11, 2014
Top Dress Fertilizer and Plant Crabgrass 136 kg/ha of Urea 8 kg/ha of red river crabgrass	March 13, 2015
Spray for Broad Leaves	June 3, 2015
Terminate Crabgrass	August 27, 2015
2 L/ha of 2-4-d and 4 L/ha of glyphosate	
168 kg/ha of urea (46-0-0) applied	September 10, 2015
Wheat planted 3.4 L/ha of glyphosate directly after planting 56 kg/ha of 18-46-0 in furrow with drill	September 15 and 16, 2015

CHAPTER IV

RESULTS AND DISCUSSION

Year 1 Cow/calf, Grazing. The winter of 2013-2014 was remarkable with long periods of extreme cold and below average rainfall (Table 4.1). The minimal precipitation provided favorable conditions for INT cow-calf pairs in the dry-lot. However, total precipitation was sufficient to produce adequate amounts of wheat forage to be used as a winter supplement and later for high quality graze-out forage during early spring. During the winter period, wheat forage mass ranged from 1,790 kg DM/ha in December to 2,381 kg DM/ha in February (Figure 4.1). Also shown in Figure 4.1, native rangeland forage mass was abundant throughout the wintering period for EXT system cows and calves. A prescribed burn was executed in April in all experimental native rangeland pastures. Consequently, forage mass was low in the early spring and gradually increased to around 2,807 kg DM/ha in July (Figure 4.2) in both treatment groups' pastures.

During the first winter of the experiment, cattle assigned to the EXT system were fed hay on five occasions during severe weather events. Cows from both treatments lost weight during the winter period although EXT system cows lost substantially more weight and body condition ($P < 0.01$; Table 4.2). As expected INT system calves gained more weight compared to EXT system calves during winter (25 kg or 0.3 kg/d). At the beginning of the limit grazing period, the INT calves did not utilize the creep gates to the wheat pasture. As the trial progressed, a limited number of the calves began to access the wheat pasture via creep gates. Additional weight was thought to come from the allotted limit grazing time and potentially higher milk production of the cows.

Wheat forage intake was measured during several 4-hr grazing bouts. Results indicated that on average the cows consumed 6.7 kg of forage DM and calves consumed 1.1 kg of forage DM during each 4-hr grazing bout (Table 4.3). Cows consumed 1.4% of their BW and calves consumed 0.7% of their BW of wheat forage. The wheat forage ranged from 35-45% DM across pastures and collection days.

Hay bales were weighed on an electronic scale before being placed in basket style ring feeders. Hay was replaced when the bale was approximately 90-95% consumed. Hay disappearance averaged 11.1 kg as-fed/cow-calf pair each day (Table 4.4). During the winter period, hay was fed every 3-6 d. After the onset of the wheat pasture graze-out phase, pairs consumed little to no hay as it never had to be replaced.

During the graze-out phase, continuous access to wheat pasture resulted in more rapid weight gain for INT system cows and calves ($P < 0.01$ and $P = 0.05$, respectively; Table 4.2) compared to their EXT counterparts. Cows assigned to the INT treatment started the spring grazing phase with a higher numerical body condition score and continued to increase this advantage during spring ($P < 0.01$; Table 4.2). During the 41 day spring graze-out stage, calves grazing wheat pasture gained 12 kg more than EXT calves grazing native range forage ($P = 0.05$; Table 4.3).

The first week of May, INT system cows were returned to native rangeland pastures with a high stocking rate of 3.2 ha/pair. During the late spring and early summer, treatment group rate of weight gain was reversed as EXT cows narrowed the gap between them and their counterparts from the INT system (Table 4.2). A similar trend was witnessed between calves as the EXT system calves gained more weight ($P = 0.05$; Table 4.2). Previous research found, calves grazing wheat pasture before native range performed better than calves wintered on native range or that there was no difference in calf gain (Apple et al., 1993a; Apple et al., 1993b). Different situations may have different effects on calf performance. Similarly, EXT system cows had greater gains in BCS (Table 4.2) during the early summer period than did INT system cows.

However, at weaning, cows from the INT system had higher BCS and raised heavier calves ($P < 0.01$ and $P = 0.06$, respectively; Table 4.2). The original weight gained by calves and maintained by cows during winter was not ever, completely, made up by the EXT system cattle. Interestingly, steer calves from the INT group were heavier than heifers ($P \leq 0.05$; Table 4.5) and there was no difference in weight between genders for EXT system calves ($P \leq 0.05$) at weaning.

During the summer crop grazing period, EXT systems cows increased their BCS more than their counterparts in the INT system as evidence by no difference between system leading into the calving season ($P = 0.12$; Table 4.2). Steers from the INT system had poorer weight gains grazing sorghum than EXT steers on native rangeland ($P = 0.05$; Table 4.2). There was little to no shade in the INT system pastures which may have decreased performance. The excess cover crop was cut as hay with average production between pastures yielding 1957 and 3419 kg/ha for the Early and Late cutting, respectively, based on bale weights (Appendix 34).

Financial summaries of year 1 are shown in Table 4.6. Winter period costs were slightly greater for the INT system due to the wheat pasture establishment cost. The additional labor and purchase of hay at $70 per ton (Appendices 1-6) in the INT system was essentially offset by the additional land and protein supplement cost in the EXT system. No credit was given to the soil nutrients brought in to the INT system through the hay, although the majority was piled up in the dry-lot for future dispersion on land. As expected, late summer costs were greater for the INT treatment due to the high cost of establishing the sorghum based summer crop and increased labor required to limit-graze the cows. However, sorghum hay production was expected to decrease wintering costs per cow in year 2 because it was harvested cheaper than purchasing additional prairie hay. Individual pasture budgets are shown in Appendices 1-6.

Overall, weaned calf revenue tended to be higher per cow and was significantly higher based on pasture total and land area unit (hectare) for the INT system ($P < 0.01$; Table 4.6). After the addition of revenue associated with land rented to the stocker steers and summer crop hay production, total revenue was higher for the INT system. As expected, cow-calf costs were higher for the INT system. This is logical because more input and fixed costs were associated with the INT system (Appendices 1-6). Cow-calf net income was higher on the INT system on per pasture, and per hectare basis with the income advantage given to the EXT system on a per cow basis.

Year 1 Steers, Finishing. Entering the feedyard in August of 2014, steer calves previously managed in the INT system weighed significantly more ($P < 0.01$; Table 4.7) compared to EXT-managed steers. In an attempt to finish the treatment groups at a common biological (back fat) end point, steers from the INT system were harvested 20 days sooner than the EXT steers. However, EXT system steers still had less back fat ($P = 0.01$; Table 4.8) compared to INT steers. Consequently, back fat was used as a covariate in the performance and carcass data analyses to adjust to a common biological end point (1.27 cm back fat).

Our expectation was that steers from the EXT system would outperform INT system calves as a result of compensation from reduced weight gain during the winter. Surprisingly, steers from the INT system gained weight substantially faster with similar feed intake. This resulted in improved feed efficiency for the INT system steers ($P = 0.01$; Table 4.7).

Compensatory weight gain varies according to duration and extent of dietary restriction (White et al., 1987). According to White et al. (1987), compensatory gain should take place early during the recovery period. Indeed, some compensation may have occurred in EXT system steers during the summer grazing period prior to feed yard entry. Lewis et al (1990) reported no difference in finishing performance after winter restricted calves compensated on summer grass. However, following native range grazing, the treatment groups were grazing different forage species with different forage availability. Therefore, whether differences in late-summer grazing performance are due to compensatory growth or simply due to grazing system cannot be determined. Regardless, the dramatically improved performance of INT system steers was unexpected. Recall that these effects are not due to differences in-utero nutrition as the cows were managed similarly until after the calving season when cows were divided into their respective treatment groups. Early calfhood management may have attributed to the difference in feed yard performance.

As stated early, calves managed in the INT system were harvested with a higher degree of body condition, resulting in a higher degree of back fat. There were no differences in marbling or HCW between systems (P = 0.24 and P = 0.38, respectively; Table 4.8). However, yield grade was improved (lower), % KPH (percent kidney, pelvis and heart fat) lowered and ribeye are (REA) was increased in the INT system steers.

Year 2 Cow/calf, Grazing. Cows from the INT system entered the calving season of 2014 in excessive body condition (BCS = 7.2; Table 4.2). Excessive BCS prompted consideration of practical methods to reduce caloric availability to INT system cows to improve system efficiency and reduce annual cow costs. We chose to modify the INT system in three ways. First, throughout the course of the 2014/2015 winter period, cows' wheat pasture limit-grazing time was reduced as previously described in the materials and methods section. In turn, wheat pasture stocking density was increased from 0.4 ha/ cow-calf unit to 0.3 ha/cow-calf unit. Secondly, the stocking density on native rangeland was increased from 3.3 ha/pair to 2.6 ha/ pair. On average, wheat pasture forage mass was lower in year 2 (Figure 4.3) compared to year 1 (Figure 4.1), resulting in further restriction of cow caloric intake during winter in the INT system. Third, summer cover crop was changed from sorghum-sudan to crabgrass. Sorghum was a productive crop, but expensive and hard to manage for a grazing system. Summer crop costs in year 1 (Appendices 28-30) decreased profitability of the INT system. Droughty situations will increase the risk of nitrate toxicity in sorghum and the tall forage made it difficult to maneuver around the pastures gathering cows, checking cattle and managing portable electric fence. Hay production could have continued to be incorporated but was not desired from a soil nutrient management stand point. Excess hay was removed from the pastures and fed in the dry-lot. This removed nutrients from the field and complied them in the dry-lot which increased the need for fertilizer in year 2. Use of crabgrass was expected to decrease summer grazing costs compared to sorghum based summer crop as seed was broadcast with fertilizer in the spring. Following the initial establishment of crabgrass, subsequent year planting rates decrease as increasing regrowth is expected.

As shown in Figure 4.3 native rangeland forage mass was abundant throughout the wintering period for EXT system cows and calves. A prescribed burn was executed in late March in all experimental native rangeland pastures. In addition, precipitation was abundant beginning in April 2015 (Table 4.1) continuing through June resulting in abundant native rangeland forage mass for both treatment groups during the spring and summer grazing period.

Cows from both systems lost weight during the winter period although EXT system cows tended to lose more BCS ($P = 0.08$; Table 4.9). As expected, calves from the INT system gained at a faster rate from December to April ($P < 0.01$; Table 4.9) and were substantially heavier ($P \leq 0.05$; Table 4.9) in April, May and at weaning in June. In fact, at the end of the limit-grazing period, compared to EXT system calves, INT system calves weighed an additional 46 kg in year 2 whereas this difference was only 29 kg in year 1. Our observation was that creep grazing behavior began sooner and was more aggressive in year 2. Increased calf performance was observed in year 2 even though cows had less time grazing wheat and less forage available. EXT cattle began grazing prescribed burned native pastures two weeks before INT cattle. This is likely the reason EXT calves tended to gain at a faster rate during the graze-out period ($P = 0.08$; Table 4.9).

Wheat forage intake was measured during several 3-hr grazing bouts (Table 4.3). Results from the grazing bouts are separated into two categories: grazing 3 d/wk and 2 d/wk. During each grazing period, on average, the cows consumed 4.5 kg (0.81% BW) and 8.3 kg (1.6% BW) of forage DM, 3 d/wk and 2 d/wk, respectively. Calves consumed 0.64 kg (0.33% BW) and 1.2 kg (0.51% BW) of forage DM during the 3 d/wk and 2 d/wk grazing bouts. It appears that cows may have the ability to increase forage consumption and "fill up" to compensate for the reduction in grazing time. In addition, wheat forage DM mass increased over time through late-winter and early spring. Consequently, increased wheat forage DM intake during the 2 d/wk, 3-hr grazing bouts could be due to more aggressive grazing behavior when time on wheat was more restricted, to greater forage mass or both. On actively growing pastures, DMI is likely to be more related to green, growing forage than total DM mass (NRC, 1996). The wheat forage ranged from 27-48% DM across pastures and collection days.

A mixture of sorghum-sudan, cow peas and sun hemp were planted as a cover crop in year 1. Sun hemp and cow peas were incorporated to place nitrogen back in the soil. A portion of the cover-crop forage was grazed and excess forage was harvested for hay (Appendix 34). The excess forage produced within each paddock (replication) was fed to the same group of cows during winter in year 2. Hay bales were weighed on an electronic scale before being placed in basket-style ring feeders. Prairie hay disappearance averaged 7.0 kg as-fed/pair/d (Table 4.4) when fed simultaneously with sorghum and 10.2 kg as-fed/pair/d when fed alone. Sorghum disappearance averaged 6.6 kg as-fed/pair/d, but was preferred over the prairie hay because it was consumed completely before the prairie hay. Total hay net disappearance was higher when both hays were fed simultaneously. At the beginning of the dry-lot period cows consumed hay at a much faster rate because they had been accustomed to consuming native rangeland ad libitum and at peak lactation. As the winter progressed hay intake was restricted further. No hay was fed during the graze-out period. The total amount of hay fed in year 2 was higher than year 1 (Table 4.4) because cows were not allowed to graze wheat as many hours as year 1.

The first week of May INT system cows were returned to native rangeland pastures with a higher stocking rate than year 1 (2.6 ha/cow-calf pair vs. 3.3 ha/cow-calf pair). During the early summer, treatment group rate of weight gain was no different for cows or calves ($P = 0.17$ and $P = 0.12$, respectively; Table 4.9). Similar to the graze-out period, year 1 and 2 produced different results. The difference may be in response to the altered prescribed burn timing. In year 1, when burning took place in April, both systems were placed on regrowth at the same time. In year 2, EXT system cattle began grazing fresh native regrowth from the March prescribed burn on the 16th of April, two weeks before the INT system cattle. EXT cows and calves may have compensated during the graze-out period in year 2 instead of summer native rangeland grazing in year 1.

Weaning took place June 19, four weeks earlier than year 1. The crabgrass cover crop was tall enough to graze and would have become too mature if a later weaning date had been executed. At weaning, INT calves were 34 kg heavier than the counterpart steers from the EXT system (Table 4.5). INT steers weighed 40 kg more than their contemporary heifers, in contrast, EXT steers had a non-significant 14 kg advantage over their heifer counterparts.

After five days of fence line weaning, INT weaned calves were transported to the cropland to graze crabgrass with additional calves. INT claves gained significantly less weight throughout the summer grazing period compared to EXT calves (P =0.03, Table 4.10). However, there was no difference in daily calf gain between additional (ADD) calves grazing crabgrass and EXT calves grazing native rangeland (P = 0.44, Table 4.10). ADD calves were maintained on native range previously and had been for the duration of their lives. Further gender interactions were observed in the summer crop grazing period as heifers from the EXT system gained 0.9 kg/d which was significantly more than steers from all treatments ($P \leq 0.05$; Table 4.10) and 0.5 kg/d greater than INT system heifers.

During the late summer period, INT cows grazed Bermudagrass to allow allotted rest for native pastures. At this time EXT cows gained weight and BCS at a much faster rate ($P <$ 0.01 and P = 0.01, respectively; Table 4.9). When INT cows were moved back to their respected pastures on August 13, there was no difference in cow weight or BCS between treatment groups (P = 0.48 and P = 0.34, respectively; Table 4.9). It appears that adjustments in stocking rate, pasture management and reduced wheat grazing time effectively decreased cow body condition to equal EXT managed cows.

Annual costs for year 2 were significantly higher for INT systems per cow, hectare and pasture compared to EXT system (P < 0.01; Table 4.11). However, calf revenue was significantly higher for the INT system as was cow-calf total revenue (P < 0.01; Table 4.11). This is logical because there are more cows on less land in the INT system pastures. All in all, net income for the cow-calf enterprise was higher for the INT system per hectare and pasture but not different per cow (P < 0.01, P = 0.04 and P = 0.37, respectively; Table 4.11). Winter supplement was $140/ton less expensive in year 2 (Appendices 1-6 and 7-12) favoring the EXT system because they received 10 tons more supplement compared to the INT system. Renting the land to the weaned calves from the INT system on the summer cover crop may not have been the most economical use of the land because Bermudagrass had to be rented for the cows, further increasing costs.

Sensitivity Analysis. Input costs and calf prices will change from year to year. As costs increase or decrease, net income will vary and may favor one system over the other. Four of the major input costs associated with the two systems and calf prices were used in a sensitivity analysis to evaluate change over time. Table 4.12 and 4.13 show the net income per hectare for the INT and EXT systems, respectively. Table 4.14 shows the net income advantage for the INT system. Change in calf price have the greatest effect on both systems of any other variable in the analysis while the INT system shows a larger advantage as prices increase. Cropland rent had the smallest influence on the INT system and as not cropland is included in the EXT system, no impact on it. Higher protein supplement costs had little effect on the INT system because they are only given supplement a little over a month in the fall. Increasing native pasture rent decreases net income more than any other input costs for both systems but more so for the EXT system because it had a lower stocking rate. Hay price changes significantly impact net income for the INT system. Net income per hectare decreased $5 for each increase of $10/ton in hay cost. EXT system replicate pastures were fed hay three days or less throughout the winter in year 2 so hay expense had no effect on the system's net income.

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Table 4.1. Monthly temperature (C°) and rainfall (cm) of year 1 and 2 compared to the long term average

	Temperature (C°)			Rainfall (cm)		
Item[1]	Year 1	Year 2	Long Term Average[2]	Year 1	Year 2	Long Term Average[3]
December	0.80	5.10	3.30	1.63	1.45	5.08
January	1.90	2.90	2.30	0.23	2.57	3.58
February	1.80	1.70	4.80	1.02	1.24	4.52
March	7.60	10.8	9.70	3.07	3.43	8.31
April	15.7	16.5	14.8	2.13	9.88	9.04
May	21.4	18.9	19.9	1.65	23.4	13.5
June	25.4	26.2	24.6	16.0	8.08	13.2
July	25.4	28.0	27.5	10.1	9.73	7.82
August	27.6	26.1	27.2	5.11	8.51	8.13
September	22.8	24.4	22.3	10.6	8.99	9.93
October	18.1	16.6	15.9	5.54	9.47	9.30
November	6.90		9.40	5.31		6.30

[1]Item = Year 1 - December is 2013 and the following months are 2014. Year 2 - December is 2014 and the following months are 2015.
[2]Long term average = Average monthly temperature 1981-2010.
[3]Long term average = Average monthly rainfall (cm) 1981 – 2010.
All data were acquired from Mesonet.

Table 4.2. The effects of forage systems on cow-calf performance, year 1

	Forage system[1]			
Item	INT	EXT	SEM	*P* - value
No. of Pasture	6	6		
Cow BW, kg				
Initial	535	521	2.00	0.15
Winter	512	467	9.80	<0.01
Spring graze-out	572	508	6.40	<0.01
Early summer	654	604	10.8	<0.01
Late summer[2]	688	653	12.9	0.06
Cow BCS				
Initial	5.1	5.1	0.05	0.60
Winter	4.7	3.6	0.26	0.01
Spring graze-out	6.1	4.8	0.16	<0.01
Early summer	7.2	6.5	0.15	<0.01
Late summer	7.5	7.2	0.17	0.12
Calf Weight, kg				
Initial	130	126	4.80	0.44
Winter	201	173	8.40	0.03
Spring graze-out	262	222	9.80	0.02
Early summer	351	319	12.5	0.06
Late summer[3]	383	340	13.3	0.03
Calf ADG, kg				
Winter	1.0	0.7	0.05	<0.01
Spring graze-out	1.5	1.2	0.09	0.05
Early summer	1.1	1.3	0.04	0.05
Late summer[3]	0.5	0.8	0.10	0.05

[1]Forage System = INT - Semi-confinement with prairie hay (6.7% CP) and cows limit grazed wheat pasture for 4-h/d, 3 d/wk at a stocking rate of 0.4 ha/cow-calf pair while calves had continuous access through creep gates, native rangeland during spring and fall at high stocking rate of 3.4 ha/pair, cows limit grazed cover crops 4-h/d, 7 d/wk at a stocking rate of 0.2 ha/cow and weaned steers had continuous access during the late summer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha/pair and oilseed meal supplementation during winter.

[2]Late summer = Cow BW - An off test weight was recorded 8 d after INT system was removed because the INT system was limit fed for 30 d. Both systems grazed the native rangeland to allow common body fill.

[3]Late summer = Only weaned steer calves weight and ADG. Heifers didn’t graze the cover crop.

Table 4.3. The effects of limit grazing wheat pasture on cow and calf wheat intake

	Year 1	Year 2	
Item	4-h/d, 3 d/wk	3-h/d, 3 d/wk	3-h/d, 2 d/wk
Cow			
Wheat DM, kg	7.4 ± 1.59	4.5 ± 1.68	8.3 ± 0.87
% BW	1.4 ± 0.005	0.81 ± 0.33	1.6 ± 0.31
Calf			
Wheat DM, kg	1.2 ± 0.29	0.64 ± 0.60	1.2 ± 0.54
% BW	0.67 ± 0.002	0.33 ± 0.33	0.51 ± 0.17

Table 4.4. The effects of cow-calf pairs limit grazing wheat pasture on hay disappearance (as-fed)

	Hay Type[1]	
Item	Prairie	Sorghum
Year 1		
Total Disappearance, kg	52,765	
Daily Disappearance, pair/d	11.1	
Year 2		
Total Disappearance, kg		
Fed Simultaneously, 95 d	34,084	31,820
Fed Individually, 25 d	13,287	
Daily Disappearance, pair/d		
Fed Simultaneously, 95 d	7.0	6.6
Fed Individually, 25 d	10.2	

[1]Hay Type = Prairie – Hay was purchased for the system. Sorghum - Excess forage harvested from cropland after summer grazing in year 1. It was fed until it was gone.

Table 4.5. The effects of forage system and gender on weaning weight for year 1 and 2

	INT[1]		EXT[2]		
Item	Steers	Heifers	Steers	Heifers	*P* – value
Calf BW, kg					
Year 1	365[a]	320[b]	337[b]	318[b]	0.04
Year 2	339[a]	299[b]	295[b]	281[b]	0.08

[a,b]Means within a row with different super scripts differ ($P \leq 0.05$).

[1]INT = Year 1 - Semi-confinement with prairie hay (6.7% CP) and cows limit grazed wheat pasture for 4-h/d, 3 d/wk at a stocking rate of 0.4 ha/cow-calf pair while calves had continuous access through creep gates, native rangeland during spring and fall at high stocking rate of 3.4 ha/pair. Year 2 - Semi-confinement with prairie hay (5.5% CP) and limited grazed 0.3 ha per cow-calf pair on wheat pasture for 12-h/wk (Dec. 4 – Jan. 4), 9-h/wk (Jan. 4 – Feb. 24) and 6-h/wk (Feb. 24 – Apr. 4) during winter, native rangeland during spring and fall at a high stocking rate of 3.2 ha per cow-calf pair.

[2]EXT = Year 1 - Graze native rangeland continuously with a low stocking rate of 5.4 ha/pair and oilseed meal supplementation during fall and winter. Year 2 - Graze native rangeland continuously with a low stocking rate of 5.4 ha per cow-calf pair and Dried Distillers Grains supplementation during late fall and winter.

Table 4.6. Financial evaluation of forage systems, Year 1

Item	Forage System[1] INT	EXT	SEM	*P* - value
Calf Revenue[2]				
Per Cow	$1,561.00	$1,465.00	38.8	0.07
Per Hectare	$415.00	$269.00	10.8	<0.01
Per Pasture[3]	$21,849.00	$19,531.00	222	<0.01
Cow-calf Total Revenue[4]				
Per Cow	$1,593.00	$1,465.00	39.6	0.03
Per Hectare	$424.00	$269.00	7.31	<0.01
Per Pasture	$22,309.00	$19,531.00	246	<0.01
Cow-calf Cost[5]				
Per Cow	$792.00	$607.00	14.0	<0.01
Per Hectare	$214.00	$111.00	4.19	<0.01
Per Pasture	$11,244.00	$8,083.00	98.9	<0.01
Cow-calf Net Income[6]				
Per Cow	$801.00	$858.00	26.3	0.1
Per Hectare	$210.00	$158.00	4.03	<0.01
Per Pasture	$11,065.00	$11,448.00	180	0.1

[1]Forage System = INT - Semi-confinement with prairie hay (6.7% CP) and cows limit grazed wheat pasture for 4-h/d, 3 d/wk at a stocking rate of 0.4 ha/cow-calf pair while calves had continuous access through creep gates, native rangeland during spring and fall at high stocking rate of 3.4 ha/pair, cows limit grazed cover crops 4-h/d, 7 d/wk at a stocking rate of 0.2 ha/cow and weaned steers had continuous access during the late summer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha/pair and oilseed meal supplementation during winter.
[2]Calf Revenue = Calf value at weaning.
[3]Pasture = Each replicate pasture (three replicate pastures per treatment).
[4]Cow-calf Total Revenue = INT - Calf revenue, (cull cow income is presumed to be equal across treatments and is excluded). EXT – Value is equal to Calf Revenue. No other revenue was generated through the system.
[5]Cow-calf Cost = All cost associated with the cow-calf grazing systems.
[6]Cow-calf Net Income = Cow-calf Total Revenue minus Cow-calf Cost.

Table 4.7. The effects of previous forage system on steer feedlot performance, year 1

	Forage System[1]			
Item	INT	EXT	SEM	*P* - value
No. Pens	6	6		
Initial Weight, kg	371	334	10.9	<0.01
Final Weight, kg	668	635	34.3	0.06
ADG, kg/d	1.9	1.7	0.15	<0.01
DMI, kg/d	11.1	11.0	1.10	0.88
F:G	5.8	6.7	0.56	0.13
Days on Feed[2]	158	178		

[1]Forage System = INT - Semi-confinement with prairie hay (6.7% CP) and access to wheat pasture through creep gates at a stocking rate of 0.4 ha/cow-calf pair, native rangeland during spring and fall at high stocking rate of 3.4 ha/pair, grazed cover crops during summer at a stocking rate of 0.3 ha/steer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha/pair and oilseed meal supplementation during winter.

[2]Days on Feed = Each treatment was fed to approximately the same biological end point (1.27 cm). Heavier initial weight and faster daily gain for INT steers reduced days on feed.

Table 4.8. The effects of previous forage system on carcass characteristics, year 1

	Forage System[1]			
Item	INT	EXT	SEM	*P* – value
No. Pens	6	6		
Hot carcass weight, kg	417	404	13.7	0.38
Marbling score[2]	448	490	3.30	0.24
Fat thickness, cm	1.56	1.31	0.08	0.01
Ribeye are, cm^2	36.5	32.3	1.40	0.02
KPH, %	1.7	1.8	0.04	.01
Yield grade	3.1	3.6	0.13	<0.01

[1]Forage System = INT - Semi-confinement with prairie hay (6.7% CP) and access to wheat pasture through creep gates at a stocking rate of 0.4 ha/cow-calf pair, native rangeland during spring and fall at high stocking rate of 3.4 ha/pair, grazed cover crops during summer at a stocking rate of 0.3 ha/steer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha/pair and oilseed meal supplementation during winter.
[2]Marbling score = 400 – Small^{00}, 500 – Modest^{00}.

Table 4.9. The effects of forage systems on cow and calf performance, year 2

	Forage System[1]			
Item	INT	EXT	SEM	*P* - value
No. of Pasture				
Cow BW, kg				
Initial	601	565	10.8	0.03
Winter	526	497	12.6	0.08
Spring graze-out	585	556	22.0	0.22
Early summer	620	595	15.1	0.17
Late summer	665	678	17.1	0.48
Cow BCS				
Initial	5.7	5.5	0.29	0.65
Winter	4.9	3.7	0.30	0.02
Spring graze-out	5.6	5.2	0.14	0.06
Early summer	6.6	6.2	0.29	0.27
Late summer	6.7	6.9	0.20	0.49
Calf Weight, kg				
Initial	117	112	4.5	0.28
Winter	227	180	9.0	<0.01
Spring graze-out	264	227	7.3	<0.01
Early summer	319	289	11.5	0.05
Calf ADG, kg				
Winter	0.91	0.55	0.05	<0.01
Spring graze-out	1.50	1.73	0.11	0.08
Early summer	1.09	1.23	0.12	0.33

[1]Forage System = INT - Semi-confinement with prairie hay (5.5% CP) and limited grazed 0.3 ha per cow-calf pair on wheat pasture for 12-h/wk (Dec. 4 – Jan. 4), 9-h/wk (Jan. 4 – Feb. 24) and 6-h/wk (Feb. 24 – Apr. 4) during winter, native rangeland during spring and fall at high stocking rate of 3.2 ha per cow-calf pair and cows grazed Bermudagrass during summer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha per cow-calf pair and Dried Distillers Grains supplementation during late fall and winter.

Table 4.10. The effects of forage system on stocker calf performance, year 2

	Forage Sytem[1]			*P* - value		
Items	INT	EXT	ADD	INT X EXT	INT X ADD	EXT X ADD
Calf BW, kg						
Initial	320	294	264	0.04	<0.01	0.02
Steers	344	304	267	0.01	<0.01	0.02
Heifers	297	285	260	0.27	0.02	0.10
Final	346	330	290	0.16	<0.01	<0.01
Steers	371	331	294	<0.01	<0.01	0.03
Heifers	321	328	285	0.61	0.03	0.01
ADG, kg	0.50	0.73	0.55	0.03	0.44	0.09
Steers	0.55	0.59	0.59	0.82	0.86	0.95
Heifers	0.41	0.91	0.55	<0.01	<0.01	0.03

[1]Forage system = INT – Previous management - Semi-confinement with prairie hay (5.5% CP) and limited grazed 0.3 ha per cow-calf pair on wheat pasture for 12-h/wk (Dec. 4 – Jan. 4), 9-h/wk (Jan. 4 – Feb. 24) and 6-h/wk (Feb. 24 – Apr. 4) during winter, native rangeland during spring and fall at high stocking rate of 3.2 ha per cow-calf pair and cows grazed Bermudagrass during summer. Current management; Graze crabgrass summer crop. EXT – Previous management - Graze native rangeland continuously with a low stocking rate of 5.4 ha per cow-calf pair and Dried Distillers Grains supplementation during late fall and winter. Current management - Graze native rangeland. ADD – Previous management - Graze native rangeland continuously and Dried Distillers Grains supplementation during late fall and winter. Current management - Graze crabgrass summer crop with INT system. ADD cattle were used to increase stocking rate in INT crabgrass pastures.

Table 4.11. Financial evaluation of forage systems, year 2

	Forage system[1]			
Item	INT	EXT	SEM	*P* - value
Calf Revenue[2]				
Per Cow	$1,557.00	$1,444.00	31.1	0.02
Per Hectare	$492.00	$265.00	18.4	<0.01
Per Pasture[3]	$27,554.00	$19,271.00	1121	<0.01
Cow-calf Total Revenue[4]				
Per Cow	$1,575.00	$1,445.00	30.9	0.01
Per Hectare	$498.00	$265.00	18.4	<0.01
Per Pasture	$27,869.00	$19,271.00	1121	<0.01
Cow-calf Cost[5]				
Per Cow	$726.00	$554.00	10.8	<0.01
Per Hectare	$229.00	$101.00	20.5	<0.01
Per Pasture	$12,839.00	$7,346.00	151	<0.01
Cow-Calf Net Income[6]				
Per Cow	$849.00	$890.00	40.4	0.37
Per Hectare	$116.00	$67.00	8.02	<0.01
Per Pasture	$15,033.00	$11,925.00	1043	0.04

[1]Forage System = INT - Semi-confinement with prairie hay (5.5% CP) and limited grazed 0.3 ha per cow-calf pair on wheat pasture for 12-h/wk (Dec. 4 – Jan. 4), 9-h/wk (Jan. 4 – Feb. 24) and 6-h/wk (Feb. 24 – Apr. 4) during winter, native rangeland during spring and fall at high stocking rate of 3.2 ha per cow-calf pair and cows grazed Bermudagrass during summer; EXT - Graze native rangeland continuously with a low stocking rate of 5.4 ha per cow-calf pair and Dried Distillers Grains supplementation during late fall and winter.
[2]Calf Revenue = Calf value at weaning.
[3]Pasture = Each replicate pasture (three replicate pastures per treatment).
[4]Cow-calf Total Revenue = INT - Calf revenue and land charge to stockers grazing the crabgrass summer crop. EXT – Value is equal to Calf Revenue. No other revenue was generated through the system.
[5]Cow-calf Cost = All cost associated with the cow-calf grazing systems.
[6]Cow-calf Net Income = Cow-calf Total Revenue minus Cow-calf Cost.

Table 4.12. Intensive net income per hectare sensitivity analysis

		Hay ($/ton)				Supplement ($/ton)				Native rental ($/ha)				Wheat rental ($/ha)				Calf Prices ($/kg)			
		$60.00	$70.00	$80.00	$90.00	$260.00	$300.00	$350.00	$400.00	$37.00	$42.00	$49.00	$62.00	$62.00	$74.00	$95.00	$111.00	$3.30	$3.85	$4.40	$4.95
Hay ($/ton)	$60.00					$240	$237	$235	$235	$242	$240	$232	$220	$242	$242	$240	$237	$121	$180	$240	$296
	$70.00					$235	$232	$232	$230	$237	$235	$227	$217	$237	$237	$235	$232	$116	$175	$235	$294
	$80.00					$230	$227	$227	$225	$232	$230	$222	$212	$232	$232	$230	$227	$111	$170	$230	$289
	$90.00					$225	$222	$222	$220	$230	$225	$217	$207	$227	$227	$225	$222	$106	$165	$225	$284
Supplement ($/ton)	$260.00	$240	$235	$230	$225					$237	$235	$227	$217	$237	$237	$235	$232	$116	$175	$235	$294
	$300.00	$237	$232	$227	$222					$237	$232	$225	$215	$237	$235	$232	$230	$114	$173	$232	$291
	$350.00	$235	$232	$227	$222					$235	$232	$225	$212	$235	$235	$232	$230	$114	$173	$232	$289
	$400.00	$235	$230	$225	$220					$235	$230	$222	$212	$235	$232	$230	$227	$111	$170	$230	$289
Native rental ($/ha)	$37.00	$242	$237	$232	$230	$237	$237	$235	$235					$242	$240	$237	$237	$121	$178	$237	$296
	$42.00	$240	$235	$230	$225	$235	$232	$232	$230					$237	$237	$237	$232	$116	$175	$235	$294
	$49.00	$232	$227	$222	$217	$227	$225	$225	$222					$230	$230	$227	$225	$109	$168	$227	$287
	$62.00	$220	$217	$212	$207	$217	$215	$212	$212					$220	$217	$217	$215	$99	$158	$217	$274
Wheat rental ($/ha)	$62.00	$242	$237	$232	$227	$237	$237	$235	$235	$242	$237	$230	$220					$119	$178	$237	$296
	$74.00	$242	$237	$232	$227	$237	$235	$235	$232	$240	$237	$230	$217					$119	$178	$237	$294
	$95.00	$240	$235	$230	$225	$235	$232	$232	$230	$237	$237	$227	$217					$116	$175	$235	$291
	$111.00	$237	$232	$227	$222	$232	$230	$230	$227	$237	$232	$225	$215					$114	$173	$232	$291
Calf Prices ($/kg)	$3.30	$121	$116	$111	$106	$116	$114	$114	$111	$121	$116	$109	$99	$119	$119	$116	$114				
	$3.85	$180	$175	$170	$165	$175	$173	$173	$170	$178	$175	$168	$158	$178	$178	$175	$173				
	$4.40	$240	$235	$230	$225	$235	$232	$232	$230	$237	$235	$227	$217	$237	$237	$235	$232				
	$4.95	$296	$294	$289	$284	$294	$291	$289	$289	$296	$294	$287	$274	$296	$294	$291	$291				

Grey highlighted values are values used in the year 2 budget. All other costs remained constant during the analysis. The Intensive system was only fed protein supplement November 1 – December 3. Therefore, change in protein cost had little effect on net income.

Table 4.13. Extensive net income per hectare sensitivity analysis

		Hay ($/ton)				Supplement ($/ton)				Native rental ($/ha)				Cropland rental ($/ha)				Calf Prices ($/kg)			
		$60.00	$70.00	$80.00	$90.00	$260.00	$300.00	$350.00	$400.00	$37.00	$42.00	$49.00	$62.00	$62.00	$74.00	$95.00	$111.00	$3.30	$3.85	$4.40	$4.95
Hay ($/ton)	$60.00					$131	$128	$126	$121	$136	$131	$124	$111	-	-	-	-	$72	$101	$131	$161
	$70.00					$131	$128	$124	$121	$136	$131	$124	$111	-	-	-	-	$72	$101	$131	$161
	$80.00					$131	$128	$124	$121	$136	$131	$124	$111	-	-	-	-	$72	$101	$131	$158
	$90.00					$131	$128	$124	$121	$136	$131	$124	$111	-	-	-	-	$72	$101	$131	$158
Supplement ($/ton)	$260.00	$131	$131	$131	$131					$136	$131	$124	$111	-	-	-	-	$72	$101	$131	$161
	$300.00	$128	$128	$128	$128					$128	$128	$121	$109	-	-	-	-	$69	$99	$128	$158
	$350.00	$126	$124	$124	$124					$128	$124	$116	$104	-	-	-	-	$67	$96	$124	$153
	$400.00	$121	$121	$121	$121					$126	$121	$114	$101	-	-	-	-	$64	$91	$121	$151
Native rental ($/ha)	$37.00	$136	$136	$136	$136	$136	$128	$128	$126					-	-	-	-	$77	$106	$136	$165
	$42.00	$131	$131	$131	$131	$131	$128	$124	$121					-	-	-	-	$72	$101	$131	$161
	$49.00	$124	$124	$124	$124	$124	$121	$116	$114					-	-	-	-	$64	$94	$124	$153
	$62.00	$111	$111	$111	$111	$111	$109	$104	$101					-	-	-	-	$52	$82	$111	$141
Wheat rental ($/ha)	$62.00	$131	$131	$131	$131	$131	$128	$124	$121	$136	$131	$124	$111					$72	$101	$131	$161
	$74.00	$131	$131	$131	$131	$131	$128	$124	$121	$136	$131	$124	$111					$72	$101	$131	$161
	$95.00	$131	$131	$131	$131	$131	$128	$124	$121	$136	$131	$124	$111					$72	$101	$131	$161
	$111.00	$131	$131	$131	$131	$131	$128	$124	$121	$136	$131	$124	$111					$72	$101	$131	$161
Calf Prices ($/kg)	$3.30	$72	$72	$72	$72	$72	$69	$67	$64	$77	$72	$64	$52	-	-	-	-				
	$3.85	$101	$101	$101	$101	$101	$99	$96	$91	$106	$101	$94	$82	-	-	-	-				
	$4.40	$131	$131	$131	$131	$131	$128	$124	$121	$136	$131	$124	$111	-	-	-	-				
	$4.95	$161	$161	$158	$158	$161	$158	$153	$151	$165	$161	$153	$141	-	-	-	-				

Grey highlighted values are values used in the year 2 budget. All other costs remained constant during the analysis. Cropland was not incorporated in the Extensive system so there are no net income values in that column.

Table 4.14 Intensive net income per hectare advantage, sensitivity analysis

		Hay ($/ton)				Supplement ($/ton)				Native rental ($/ha)				Cropland rental ($/ha)				Calf Prices ($/kg)			
		$60.00	$70.00	$80.00	$90.00	$260.00	$300.00	$350.00	$400.00	$37.00	$42.00	$49.00	$62.00	$62.00	$74.00	$95.00	$111.00	$3.30	$3.85	$4.40	$4.95
Hay ($/ton)	$60.00					$109	$109	$109	$114	$106	$109	$109	$109	-	-	-	-	$49	$79	$109	$136
	$70.00					$104	$104	$109	$109	$101	$104	$104	$106	-	-	-	-	$44	$74	$104	$133
	$80.00					$99	$99	$104	$104	$96	$99	$99	$101	-	-	-	-	$40	$69	$99	$131
	$90.00					$94	$94	$99	$99	$94	$94	$94	$96	-	-	-	-	$35	$64	$94	$126
Supplement ($/ton)	$260.00	$109	$104	$99	$94					$101	$104	$104	$106	-	-	-	-	$44	$74	$104	$133
	$300.00	$109	$104	$99	$94					$109	$104	$104	$106	-	-	-	-	$44	$74	$104	$133
	$350.00	$109	$109	$104	$99					$106	$109	$109	$109	-	-	-	-	$47	$77	$109	$136
	$400.00	$114	$109	$104	$99					$109	$109	$109	$111	-	-	-	-	$47	$79	$109	$138
Native rental ($/ha)	$37.00	$106	$101	$96	$94	$101	$109	$106	$109					-	-	-	-	$44	$72	$101	$131
	$42.00	$109	$104	$99	$94	$104	$104	$109	$109					-	-	-	-	$44	$74	$104	$133
	$49.00	$109	$104	$99	$94	$104	$104	$109	$109					-	-	-	-	$44	$74	$104	$133
	$62.00	$109	$106	$101	$96	$106	$106	$109	$111					-	-	-	-	$47	$77	$106	$133
Wheat rental ($/ha)	$62.00	$111	$106	$101	$96	$106	$109	$111	$114	$106	$106	$106	$109					$47	$77	$106	$136
	$74.00	$111	$106	$101	$96	$106	$106	$111	$111	$104	$106	$106	$106					$47	$77	$106	$133
	$95.00	$109	$104	$99	$94	$104	$104	$109	$109	$101	$106	$104	$106					$44	$74	$104	$131
	$111.00	$106	$101	$96	$91	$101	$101	$106	$106	$101	$101	$101	$104					$42	$72	$101	$131
Calf Prices ($/kg)	$3.30	$49	$44	$40	$35	$44	$44	$47	$47	$44	$44	$44	$47	-	-	-	-				
	$3.85	$79	$74	$69	$64	$74	$74	$77	$79	$72	$74	$74	$77	-	-	-	-				
	$4.40	$109	$104	$99	$94	$104	$104	$109	$109	$101	$104	$104	$106	-	-	-	-				
	$4.95	$136	$133	$131	$126	$133	$133	$136	$138	$131	$133	$133	$133	-	-	-	-				

Grey highlighted values are values used in the year 2 budget. All other costs remained constant during the analysis. Cropland was not incorporated in the Extensive system so the advantage was not reported in this analysis.

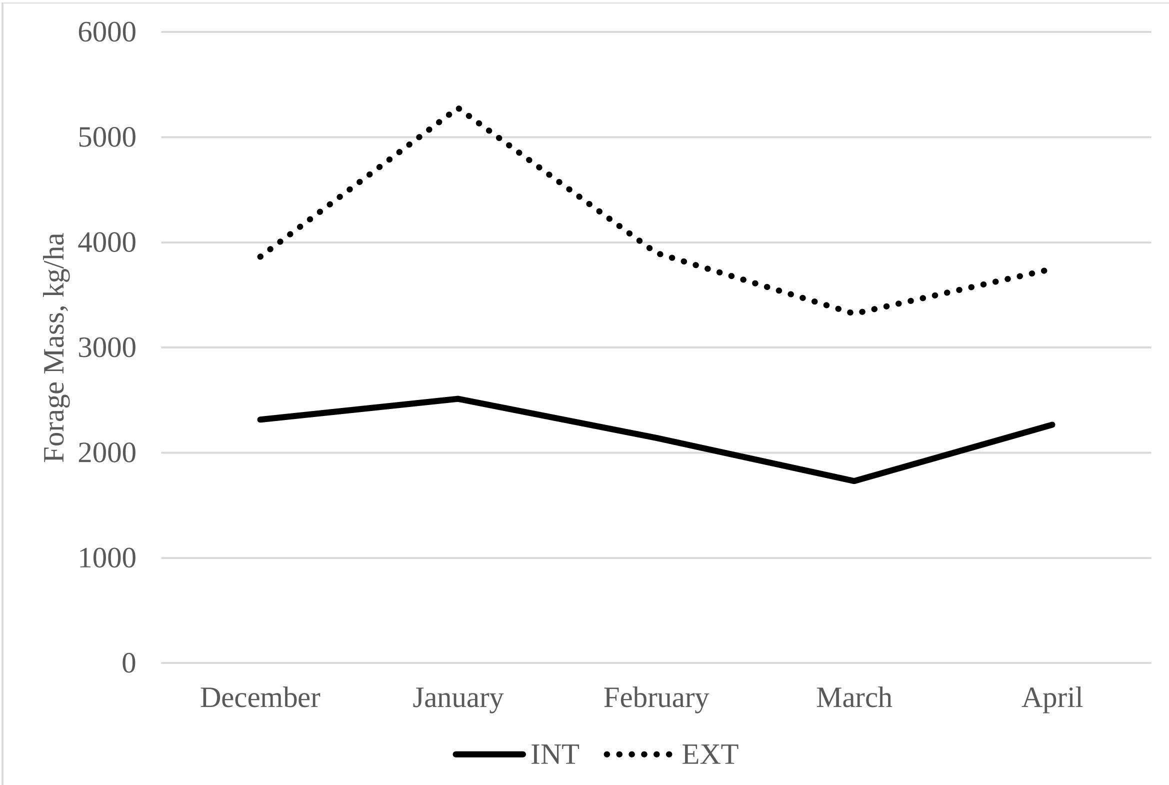

Figure 4.1. Winter and early spring forage mass for wheat pasture (INT) and native rangeland (EXT), year 1.

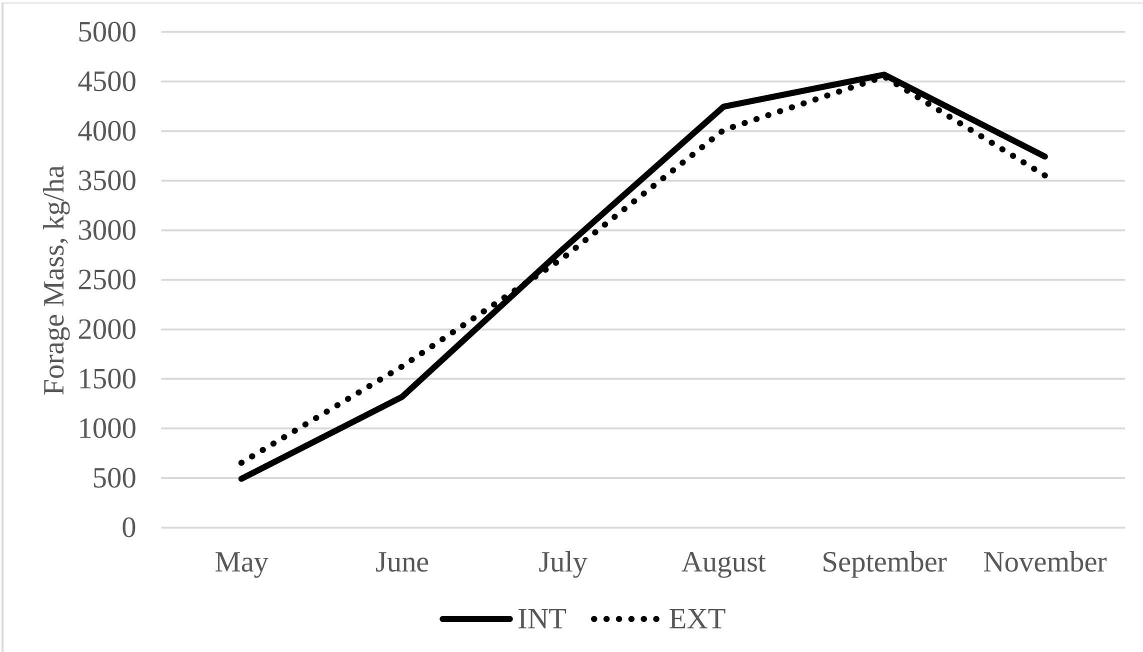

Figure 4.2. Early spring and summer forage mass for native rangeland, year 1.

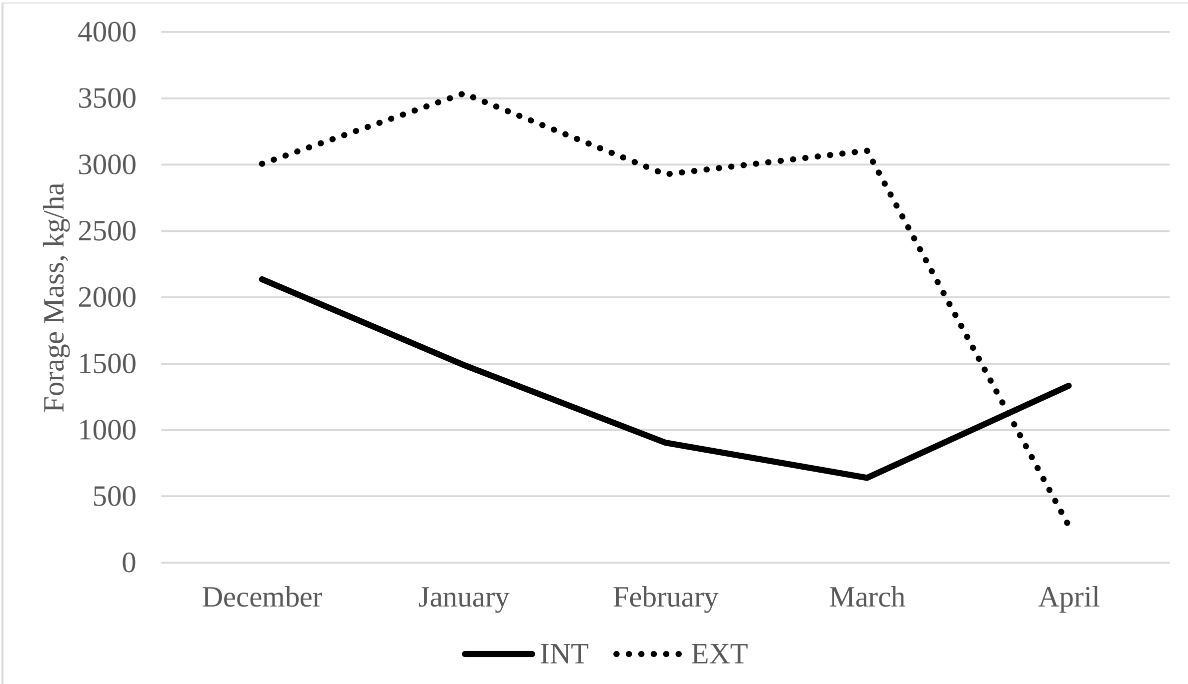

Figure 4.3. Winter and early spring forage mass for wheat pasture (INT) and native rangeland (EXT), year 2.

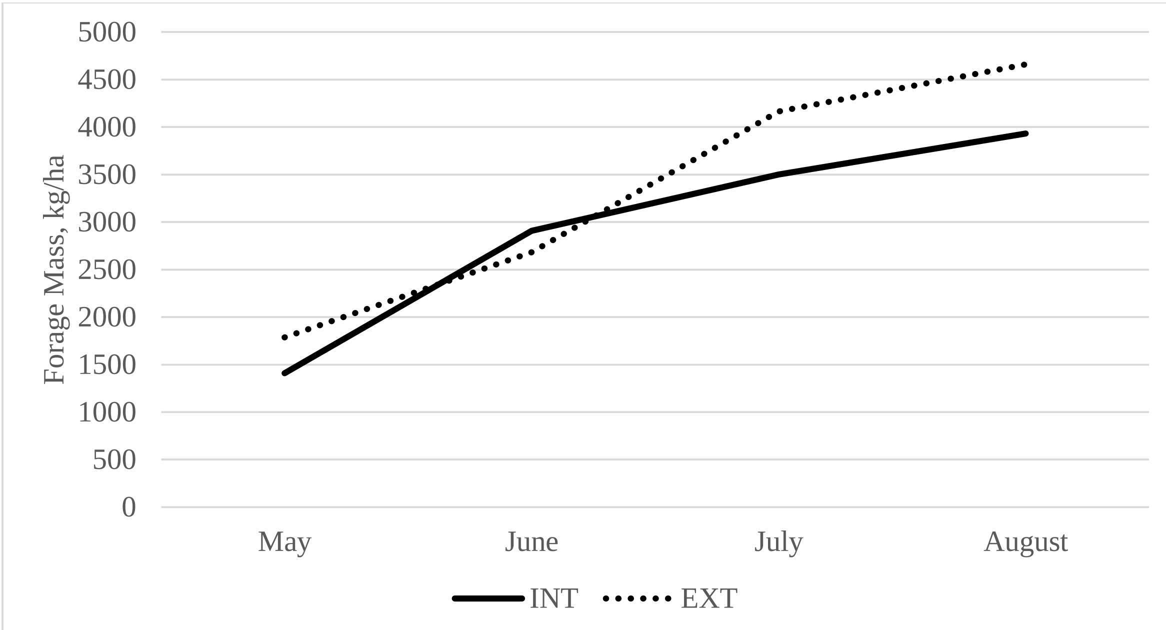

Figure 4.4. Early spring and summer forage mass for native rangeland, year 2.

CHAPTER V

CONCLUSION

Year to year changes were made to improve the profitability and efficiency of the INT system. This is a representation of real world operations. Changes have to be made from year to year based on market prices of cattle and commodities. Late spring and summer rains were abundant in the two years of this trial. Therefore, large amounts of forage on the native range were available. It would be interesting to measure the outcome of cattle production for these two systems in below average years for forage production. Low prices for protein supplement for winter feeding may favor the EXT system because cow wintering costs are decreased; on the other hand, low hay prices help reduce costs associated with the INT system. Cow wintering costs make up the largest percentage of the cost associated with maintaining a cow. In this scenario, winter wheat as a supplement for cows is not as economical as purchasing hay and supplement. However, having wheat pasture available is a great way to increase calf gains. Based on observations, as calf creep grazing increases so does calf weight.

After one year of data, increased calf nutrition through the winter increased calf feed yard performance. EXT calves may have been slightly “stunted” or not properly programmed in calfhood to perform at the level of INT system calves.

Crabgrass as a summer cover crop proved to be cheaper than the sorghum-sudan mixture with similar results in calf daily gain. In future years, cows will graze the summer crop instead of calves. Calves were retained in year 2 and grazed on crabgrass increasing land required to maintain cows. This is counterproductive to one of the major goals of this study which is reduce land area per cow-calf pair.

Costs per cow were much higher for the INT system because of the increased inputs for production. A better way to evaluate the two system's profit is as a pasture unit or on a per hectare basis. If you can efficiently raise more beef on the same amount of land, individual cow returns are less important than the returns to the land base.

Semi-confined cattle are observed more often and are easier to treat when found sick because they are already in a small area near working facilities. The cattle become docile and easy to handle. However, increased labor plus more intensive management requirements may prevent operations from incorporating semi-confinement or intensive management systems. In conclusion, this trial proved that the INT system was able to economically produce more units of beef (calf weight) on less land, incorporating cropland and semi-confinement.

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APPENDICES

Appendix 1. Intensive system east pasture cow-calf enterprise budget, year 1

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					14	54	
Weaning							
Heifers	327	kg	$4.38	7	$1,433	$186	$10,030
Steers	355	kg	$4.62	7	$1,642	$213	$11,495
Calf Revenue					$1,538	$399	$21,525
Land Rent - Stockers		ha	$52.00	2	$8	$2	$105
Hay Production					$76	$20	$1,065
Total Revenue					$1,621	$420	$22,695
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	18.24	$91	$24	$1,276
Protein Supplement		Ton	$400	1.32	$38	$10	$526
Mineral		Sacks	$11	12.26	$10	$3	$137
Labor		Hours	$12	62.67	$54	$14	$752
Vet Medicine					$34	$9	$470
Vet Supply					$3	$1	$45
Transportation					$14	$3	$168
Native Pasture		ha	$42	48	$143	$37	$2,006
Crop Land		ha	$95	6	$41	$11	$578
Wheat					$146	$38	$2,038
Sorghum					$79	$20	$1,103
Manure Removal					$15	$4	$204
Total Inputs					$666	$172	$9,303
Fixed Costs							
Tractor					$33	$11	$600
Truck					$85	$22	$1,204
ATV					$8	$3	$150
Equipment					$3	$1	$63
Total Fixed Costs					$130	$37	$2,016
Total Costs					$796	$210	$11,319
Net income to Cow-calf Operation					$825	$211	$11,376

Appendix 2. Intensive system center pasture enterprise budget, year 1

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					14	53	
Weaning							
Heifers	338	kg	$4.33	7	$1,466	$194	$10,260
Steers	375	kg	$4.51	7	$1,691	$223	$11,839
Calf Revenue					$1,578	$417	$22,099
Land Rent - Stockers		ha	$52	2	$8	$2	$105
Hay Production					$75	$20	$1,046
Total Revenue					$1,586	$419	$22,204
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	19.30	$97	$25	$1,351
Protein Supplement		Ton	$400	1.32	$38	$10	$526
Mineral		Sacks	$11	12.26	$10	$3	$137
Labor		Hours	$12	62.67	$54	$14	$752
Vet Medicine					$34	$9	$470
Vet Supply					$3	$1	$45
Transportation					$2	$0	$9
Native Pasture		ha	$42	47	$140	$37	$1,955
Crop Land		ha	$95	6	$41	$11	$578
Wheat					$146	$38	$2,038
Sorghum					$79	$21	$1,103
Manure Removal					$15	$4	$204
Total Inputs					$656	$173	$9,168
Fixed Costs							
Tractor					$35	$11	$600
Truck					$85	$23	$1,204
ATV					$9	$3	$150
Equipment					$4	$1	$63
Total Fixed Costs					$133	$38	$2,016
Total Costs					$789	$211	$11,184
Net income to Cow-calf Operation					$797	$208	$11,019

Appendix 3. Intensive system west pasture cow-calf enterprise budget, year 1

Production	Wt.	Unit	Price	Quantity	$/Head	$/ha	Pasture
Number of Cows, Hectares					14	51	
Weaning							
Heifers	346	kg	$4.27	7	$1,478	$203	$10,348
Steers	361	kg	$4.58	7	$1,654	$227	$11,575
Calf Revenue					$1,566	$430	$21,923
Land Rent - Stockers		ha	$52	2	$8	$2	$105
Hay Production					$71	$19	$992
Total Revenue					$1,573	$432	$22,028
Operating Inputs		Unit	Price	Quantity	$/Head	$/ha	Pasture
Prairie Hay		Ton	$70	18.62	$93	$26	$1,303
Protein Supplement		Ton	$400	1.32	$38	$10	$526
Mineral		Sacks	$11	12.26	$10	$3	$137
Labor		Hours	$12	62.67	$54	$15	$752
Vet Medicine					$34	$9	$470
Vet Supply					$3	$1	$45
Transportation					$16	$3	$170
Native Pasture		ha	$42	45	$135	$37	$1,887
Crop Land		ha	$95	6	$41	$11	$578
Wheat					$146	$40	$2,038
Sorghum					$79	$22	$1,103
Manure Removal					$15	$4	$204
Total Inputs					$662	$181	$9,213
Fixed Costs							
Tractor					$33	$12	$600
Truck					$85	$24	$1,204
ATV					$8	$3	$150
Equipment					$3	$1	$63
Total Fixed Costs					$130	$40	$2,016
Total Costs					$791	$220	$11,230
Net income to Cow-calf Operation					$782	$212	$10,799

Appendix 4. Extensive system east 2 pasture cow-calf enterprise budget, year 1

Production		Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares						13	77	
Weaning								
	Heifers	345	kg	$4.29	7	$1,480	$135	$10,360
	Steers	327	kg	$4.80	6	$1,567	$122	$9,405
Weaning Revenue						$1,524	$257	$19,765
Operating Inputs			Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay			Ton	$70	3.75	$20	$3	$263
Protein Supplement			Ton	$400	4.72	$145	$25	$1,888
Mineral			Sacks	$11	11.39	$10	$2	$128
Labor			Hours	$12	50.50	$47	$8	$606
Vet Medicine						$41	$7	$530
Vet Supplies						$5	$1	$67
Native Pasture			ha	$42	77	$247	$42	$3,213
Total Inputs						$515	$87	$6,694
Fixed Costs								
Truck						$115	$19	$1,499
Total Fixed Costs						$115	$19	$1,499
Total Cost						$630	$106	$8,193
Net Income to Cow-Calf Operation						$894	$150	$11,572

Appendix 5. Extensive system 2mile cow-calf enterprise budget, year 1

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					13	70	
Weaning							
Heifers	312	kg	$4.40	6	$1,372	$118	$8,232
Steers	332	kg	$4.75	7	$1,577	$158	$11,038
Weaning Revenue					$1,474	$275	$19,270
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	3.75	$20	$4	$263
Protein Supplement		Ton	$400	4.72	$145	$27	$1,888
Mineral		Sacks	$11	11.39	$10	$2	$128
Labor		Hours	$12	50.50	$47	$9	$606
Vet Medicine					$41	$8	$530
Vet Supplies					$5	$1	$66
Native Pasture		ha	$42	70	$225	$42	$2,924
Total Inputs					$493	$91	$6,404
Fixed Costs							
Truck					$115	$21	$1,499
Total Fixed Costs					$115	$21	$1,499
Total Cost					$608	$113	$7,903
Net Income to Cow-Calf Operation					$866	$162	$11,366

Appendix 6. Extensive system stackeast pasture cow-calf enterprise budget, year 1

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					14	71	
Weaning							
Heifers	294	kg	$4.47	7	$1,311	$129	$9,180
Steers	300	kg	$4.95	7	$1,483	$146	$10,379
Weaning Revenue					$1,397	$275	$19,559
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	3.75	$19	$4	$262
Protein Supplement		Ton	$400	5.08	$145	$29	$2,033
Mineral		Sack	$11	12.26	$10	$2	$137
Labor		Hours	$12	50.50	$43	$9	$606
Vet Medicine					$41	$8	$571
Vet Supplies					$5	$1	$69
Native Pasture		ha	$42	71	$213	$42	$2,975
Total Inputs					$475	$94	$6,653
Fixed Costs							
Truck					$107	$21	$1,499
Total Fixed Costs					$107	$21	$1,499
Total Cost					$582	$115	$8,152
Net Income to Cow-Calf Operation					$815	$161	$11,406

Appendix 7. Intensive system east pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					18	57	
Weaning							
Heifers	297	kg	$4.84	9	$1,439	$227	$12,949
Steers	332	kg	$4.97	9	$1,650	$260	$14,848
Calf Revenue					$1,544	$488	$27,797
Land Rent - Stockers					$18	$6	$315
Total Revenue					$1,562	$493	$28,112
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	24.46	$95	$30	$1,712
Sorghum Hay		Ton		17.53	$25	$8	$456
Protein Supplement		Ton	$260	1.51	$22	$7	$393
Mineral		Sacks	$11	15.77	$10	$3	$177
Labor		Hours	$12	67.00	$45	$14	$804
Vet Medicine					$34	$11	$605
Vet Supply					$2	$1	$42
Transportation					$8	$3	$167
Native Pasture		ha	$42	48	$111	$35	$2,006
Bermuda		ha	$52	3.7	$11	$3	$193
Fertilizer					$34	$10	$559
Crop Land		ha	$95	6	$32	$10	$578
Wheat					$115	$36	$2,076
Crabgrass					$52	$16	$930
Waste Removal					$11	$4	$204
Total Inputs					$607	$191	$10,902
Fixed Costs							
Tractor					$33	$11	$600
Truck					$72	$23	$1,289
ATV					$8	$3	$150
Equipment					$3	$1	$63
Total Fixed Costs					$117	$37	$2,101
Total Costs					$724	$228	$13,003
Net income to Cow-calf Operation					$838	$114	$15,109

Appendix 8. Intensive system center pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows,							
Hectares					17	56	
Weaning							
Heifers	290	kg	$4.88	8	$1,419	$203	$11,349
Steers	325	kg	$4.99	9	$1,621	$260	$14,587
Calf Revenue					$1,520	$463	$25,936
Land Rent -							
Stockers					$19	$6	$315
Total Revenue					$1,538	$469	$26,251
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	25.30	$104	$32	$1,771
Sorghum Hay		Ton		16.45	$28	$8	$474
Protein Supplement		Ton	$260	1.43	$22	$7	$371
Mineral		Sacks	$11	14.89	$10	$3	$167
Labor		Hours	$12	67.00	$47	$14	$804
Vet Medicine					$34	$10	$571
Vet Supply					$2	$1	$42
Transportation					$8	$3	$161
Native Pasture		ha	$42	47	$115	$35	$1,955
Bermuda		ha	$52	3.5	$11	$3	$182
Fertilizer					$34	$10	$570
Crop Land		ha	$95	6	$34	$10	$578
Wheat					$122	$37	$2,076
Crabgrass					$55	$17	$930
Waste Removal							
Total Inputs					$625	$190	$10,652
Fixed Costs							
Tractor					$35	$11	$600
Truck					$72	$23	$1,289
ATV					$9	$3	$150
Equipment					$4	$1	$63
Total Fixed Costs					$120	$38	$2,101
Total Costs					$745	$228	$12,753
Net income to Cow-calf Operation					$793	$104	$13,498

Appendix 9. Intensive system west pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					18	55	
Weaning							
Heifers	314	kg	$4.84	9	$1,518	$248	$13,662
Steers	350	kg	$4.84	9	$1,696	$278	$15,266
Calf Revenue					$1,607	$526	$28,928
Land Rent - Stockers					$18	$6	$315
Total Revenue					$1,625	$532	$29,243
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	25.13	$98	$32	$1,759
Sorghum Hay		Ton		15.56	$24	$8	$439
Protein Supplement		Ton	$260	1.51	$22	$7	$393
Mineral		Sacks	$11	15.77	$10	$3	$177
Labor		Hours	$12	66.67	$44	$15	$800
Vet Medicine					$34	$11	$605
Vet Supply					$2	$1	$42
Transportation					$9	$3	$169
Native Pasture		ha	$42	45	$105	$34	$1,887
Bermuda		ha	$52	3.7	$11	$4	$193
Fertilizer					$34	$11	$604
Crop Land		ha	$95	6	$32	$11	$578
Wheat					$115	$38	$2,076
Crabgrass					$52	$17	$930
Waste Removal							
Total Inputs					$591	$194	$10,651
Fixed Costs							
Tractor					$33	$11	$600
Truck					$72	$23	$1,289
ATV					$8	$3	$150
Equipment					$3	$1	$63
Total Fixed Costs					$117	$38	$2,101
Total Costs					$708	$232	$12,752
Net income to Cow-calf Operation					$917	$131	$16,491

Appendix 10. Extensive system east2 pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					14	77	
Weaning							
Heifers	294	kg	$4.18	7	$1,352	$123	$9,466
Steers	321	kg	$4.53	7	$1,596	$145	$11,169
Weaning Revenue					$1,474	$268	$20,635
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	2.09	$10	$2	$146
Protein Supplement		Ton	$260	5.08	$94	$17	$1,321
Mineral		Sacks	$11	12.26	$10	$2	$137
Labor		Hours	$12	52.00	$45	$8	$624
Vet Medicine					$34	$6	$470
Vet Supplies					$3	$1	$44
Native Pasture		ha	$42	77	$230	$42	$3,213
Total Inputs					$425	$77	$5,956
Fixed Costs							
Truck					$126	$21	$1,642
Total Fixed Costs					$126	$21	$1,642
Total Cost					$552	$99	$7,598
Net Income to Cow-Calf Operation					$922	$69	$13,037

Appendix 11. Extensive system 2mile pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					13	70	
Weaning							
Heifers	282	kg	$4.64	7	$1,308	$131	$9,157
Steers	272	kg	$5.56	6	$1,521	$130	$9,129
Weaning Revenue					$1,415	$261	$18,286
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	2.79	$15	$3	$195
Protein Supplement		Ton	$260	4.72	$94	$18	$1,227
Mineral		Sacks	$11	11.39	$10	$2	$128
Labor		Hours	$12	52.00	$48	$9	$624
Vet Medicine					$34	$6	$437
Vet Supplies					$3	$1	$43
Native Pasture		ha	$42	70	$225	$42	$2,924
Total Inputs					$429	$80	$5,578
Fixed Costs							
Truck					$126	$23	$1,642
Total Fixed Costs					$126	$23	$1,642
Total Cost					$555	$103	$7,220
Net Income to Cow-Calf Operation					$859	$64	$11,067

Appendix 12. Extensive system stackeast pasture cow-calf enterprise budget, year 2

Production	Wt.	Unit	Price	Quantity	$/Cow	$/ha	Pasture
Number of Cows, Hectares					13	71	
Weaning							
Heifers	267	kg	$5.02	6	$1,341	$113	$8,044
Steers	280	kg	$5.54	7	$1,550	$153	$10,849
Weaning Revenue					$1,445	$266	$18,892
Operating Inputs		Unit	Price	Quantity	$/Cow	$/ha	Pasture
Prairie Hay		Ton	$70	2.09	$11	$2	$146
Protein Supplement		Ton	$260	4.72	$94	$17	$1,227
Mineral		Sack	$11	11.39	$10	$2	$128
Labor		Hours	$12	52.00	$48	$9	$624
Vet Medicine					$34	$6	$437
Vet Supplies					$3	$1	$43
Native Pasture		ha	$42	71	$229	$42	$2,975
Total Inputs					$429	$79	$5,580
Fixed Costs							
Truck					$126	$23	$1,642
Total Fixed Costs					$126	$23	$1,642
Total Cost					$556	$102	$7,222
Net Income to Cow-Calf Operation					$890	$67	$11,671

Appendix 13. Intensive labor hours by grazing period, year 1

Items	Hours per Week	Number of Weeks	Period Total
Limit Grazing			
East	1.7	15.4	25.7
Center	1.7	15.4	25.7
West	1.7	15.4	25.7
Graze-out			
East	1.3	5.7	7.6
Center	1.3	5.7	7.6
West	1.3	5.7	7.6
Spring Native			
East	1.0	10.0	10.0
Center	1.0	10.0	10.0
West	1.0	10.0	10.0
Summer Crop			
East	1.0	4.4	4.4
Center	1.0	4.4	4.4
West	1.0	4.4	4.4
Fall			
East	1.0	15.0	15.0
Center	1.0	15.0	15.0
West	1.0	15.0	15.0

Appendix 14. Extensive labor hours by grazing period, year 1

Items	Hours per Week	Number of Weeks	Period Total
Limit Grazing			
East 2	1.0	15.4	15.4
2Mile	1.0	15.4	15.4
Stackeast	1.0	15.4	15.4
Graze-out			
East 2	1.0	5.7	5.7
2Mile	1.0	5.7	5.7
Stackeast	1.0	5.7	5.7
Spring Native			
East 2	1.0	10.0	10.0
2Mile	1.0	10.0	10.0
Stackeast	1.0	10.0	10.0
Summer Crop			
East 2	1.0	4.4	4.4
2Mile	1.0	4.4	4.4
Stackeast	1.0	4.4	4.4
Fall			
East 2	1.0	15.0	15.0
2Mile	1.0	15.0	15.0
Stackeast	1.0	15.0	15.0

Appendix 15. Intensive labor hours by grazing period, year 2

Items	Hours per Week	Number of Weeks	Period Total
Limit Grazing			
East	1.7	19.0	31.7
Center	1.7	19.0	31.7
West	1.7	19.0	31.7
Graze-out			
East	1.3	4.0	5.3
Center	1.3	4.0	5.3
West	1.3	3.0	4.0
Spring Native			
East	1.0	7.0	7.0
Center	1.0	7.0	7.0
West	1.0	8.0	8.0
Summer Crop			
East	1.0	8.0	8.0
Center	1.0	8.0	8.0
West	1.0	8.0	8.0
Fall			
East	1.0	15.0	15.0
Center	1.0	15.0	15.0
West	1.0	15.0	15.0

Appendix 16. Extensive labor hours by grazing period, year 2

Items	Hours per Week	Number of Weeks	Period Total
Limit Grazing			
East 2	1.0	19.0	19.0
2Mile	1.0	19.0	19.0
Stackeast	1.0	19.0	19.0
Graze-out			
East 2	1.0	3.0	3.0
2Mile	1.0	3.0	3.0
Stackeast	1.0	3.0	3.0
Spring Native			
East 2	1.0	7.0	7.0
2Mile	1.0	7.0	7.0
Stackeast	1.0	7.0	7.0
Summer Crop			
East 2	1.0	8.0	8.0
2Mile	1.0	8.0	8.0
Stackeast	1.0	8.0	8.0
Fall			
East 2	1.0	15.0	15.0
2Mile	1.0	15.0	15.0
Stackeast	1.0	15.0	15.0

Appendix 17. Intensive vet medicine costs for the east pasture, year 1

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	14	$0.34	$4.75
Lutalyse	11	$55.49	Cows	14	$2.77	$38.84
Factrel	11	$25.19	Cows	14	$2.52	$35.27
Factrel	11	$25.19	Cows	14	$2.52	$35.27
CIDR	11	$114.79	Cows	14	$11.48	$160.71
Safeguard	10	$425.58	Cows	14	$3.37	$47.22
Safeguard	4	$425.58	Cows	14	$3.37	$47.22
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Bovashield Gold	12	$16.95	Calves	14	$0.34	$4.75
Bovashield Gold	6	$16.95	Calves	14	$0.34	$4.75
Presponse	12	$128.69	Calves	14	$2.57	$36.03
Presponse	6	$128.69	Calves	14	$2.57	$36.03
Vision 7	12	$47.82	Calves	14	$0.96	$13.39
Vision 7	6	$47.82	Calves	14	$0.96	$13.39
Fly tags (XP820)	5	$43.29	Calves	14	$3.61	$50.51
Safeguard	5	$425.58	Calves	14	$1.29	$18.10

Appendix 18. Intensive system vet medicine for the center pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	14	$0.34	$4.75
Lutalyse	11	$55.49	Cows	14	$2.77	$38.84
Factrel	11	$25.19	Cows	14	$2.52	$35.27
Factrel	11	$25.19	Cows	14	$2.52	$35.27
CIDR	11	$114.79	Cows	14	$11.48	$160.71
Safeguard	10	$425.58	Cows	14	$3.37	$47.22
Safeguard	4	$425.58	Cows	14	$3.37	$47.22
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Bovashield Gold	12	$16.95	Calves	14	$0.34	$4.75
Bovashield Gold	6	$16.95	Calves	14	$0.34	$4.75
Presponse	12	$128.69	Calves	14	$2.57	$36.03
Presponse	6	$128.69	Calves	14	$2.57	$36.03
Vision 7	12	$47.82	Calves	14	$0.96	$13.39
Vision 7	6	$47.82	Calves	14	$0.96	$13.39
Fly tags (XP820)	5	$43.29	Calves	14	$3.61	$50.51
Safeguard	5	$425.58	Calves	14	$1.29	$18.10

Appendix 19. Intensive system vet medicine for the west pasture, year 1

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	14	$0.34	$4.75
Lutalyse	11	$55.49	Cows	14	$2.77	$38.84
Factrel	11	$25.19	Cows	14	$2.52	$35.27
Factrel	11	$25.19	Cows	14	$2.52	$35.27
CIDR	11	$114.79	Cows	14	$11.48	$160.71
Safeguard	10	$425.58	Cows	14	$3.37	$47.22
Safeguard	4	$425.58	Cows	14	$3.37	$47.22
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Bovashield Gold	12	$16.95	Calves	14	$0.34	$4.75
Bovashield Gold	6	$16.95	Calves	14	$0.34	$4.75
Presponse	12	$128.69	Calves	14	$2.57	$36.03
Presponse	6	$128.69	Calves	14	$2.57	$36.03
Vision 7	12	$47.82	Calves	14	$0.96	$13.39
Vision 7	6	$47.82	Calves	14	$0.96	$13.39
Fly tags (XP820)	5	$43.29	Calves	14	$3.61	$50.51
Safeguard	5	$425.58	Calves	14	$1.29	$18.10

Appendix 20. Extensive system vet medicine for the east 2 pasture, year 1

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	13	$0.34	$4.41
Lutalyse	11	$55.49	Cows	13	$2.77	$36.07
Factrel	11	$25.19	Cows	13	$2.52	$32.75
Factrel	11	$25.19	Cows	13	$2.52	$32.75
CIDR	11	$114.79	Cows	13	$11.48	$149.23
Safeguard	10	$425.58	Cows	13	$3.37	$43.85
Safeguard	4	$425.58	Cows	13	$3.37	$43.85
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Bovashield Gold	12	$16.95	Calves	13	$0.34	$4.41
Bovashield Gold	6	$16.95	Calves	13	$0.34	$4.41
Presponse	12	$128.69	Calves	13	$2.57	$33.46
Presponse	6	$128.69	Calves	13	$2.57	$33.46
Vision 7	12	$47.82	Calves	13	$0.96	$12.43
Vision 7	6	$47.82	Calves	13	$0.96	$12.43
Fly tags (XP820)	5	$43.29	Calves	13	$3.61	$46.90
Safeguard	5	$425.58	Calves	13	$1.29	$16.81

Appendix 20. Extensive system vet medicine for the east 2 pasture, year 1

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	13	$0.34	$4.41
Lutalyse	11	$55.49	Cows	13	$2.77	$36.07
Factrel	11	$25.19	Cows	13	$2.52	$32.75
Factrel	11	$25.19	Cows	13	$2.52	$32.75
CIDR	11	$114.79	Cows	13	$11.48	$149.23
Safeguard	10	$425.58	Cows	13	$3.37	$43.85
Safeguard	4	$425.58	Cows	13	$3.37	$43.85
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Bovashield Gold	12	$16.95	Calves	13	$0.34	$4.41
Bovashield Gold	6	$16.95	Calves	13	$0.34	$4.41
Presponse	12	$128.69	Calves	13	$2.57	$33.46
Presponse	6	$128.69	Calves	13	$2.57	$33.46
Vision 7	12	$47.82	Calves	13	$0.96	$12.43
Vision 7	6	$47.82	Calves	13	$0.96	$12.43
Fly tags (XP820)	5	$43.29	Calves	13	$3.61	$46.90
Safeguard	5	$425.58	Calves	13	$1.29	$16.81

Appendix 21. Extensive system vet medicine for the stackeast pasture, year 1

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	14	$0.34	$4.75
Lutalyse	11	$55.49	Cows	14	$2.77	$38.84
Factrel	11	$25.19	Cows	14	$2.52	$35.27
Factrel	11	$25.19	Cows	14	$2.52	$35.27
CIDR	11	$114.79	Cows	14	$11.48	$160.71
Safeguard	10	$425.58	Cows	14	$3.37	$47.22
Safeguard	4	$425.58	Cows	14	$3.37	$47.22
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Bovashield Gold	12	$16.95	Calves	14	$0.34	$4.75
Bovashield Gold	6	$16.95	Calves	14	$0.34	$4.75
Presponse	12	$128.69	Calves	14	$2.57	$36.03
Presponse	6	$128.69	Calves	14	$2.57	$36.03
Vision 7	12	$47.82	Calves	14	$0.96	$13.39
Vision 7	6	$47.82	Calves	14	$0.96	$13.39
Fly tags (XP820)	5	$43.29	Calves	14	$3.61	$50.51
Safeguard	5	$425.58	Calves	14	$1.29	$18.10

Appendix 22. Intensive system vet medicine for the east pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	18	$0.34	$6.10
Lutalyse	11	$55.49	Cows	18	$2.77	$49.94
Factrel	11	$25.19	Cows	18	$2.52	$45.34
Factrel	11	$25.19	Cows	18	$2.52	$45.34
CIDR	11	$114.79	Cows	18	$11.48	$206.62
Safeguard	10	$425.58	Cows	18	$3.37	$60.72
Safeguard	4	$425.58	Cows	18	$3.37	$60.72
Fly tags (XP820)	7	$43.29	Cows	18	$7.22	$129.87
Bovashield Gold	12	$16.95	Calves	18	$0.34	$6.10
Bovashield Gold	6	$16.95	Calves	18	$0.34	$6.10
Bovashield Gold	6	$16.95	Weaned	7	$0.34	$2.37
Presponse	12	$128.69	Calves	18	$2.57	$46.33
Presponse	6	$128.69	Calves	18	$2.57	$46.33
Presponse	6	$128.69	Weaned	7	$2.57	$18.02
Vision 7	12	$47.82	Calves	18	$0.96	$17.22
Vision 7	6	$47.82	Calves	18	$0.96	$17.22
Vision 7	6	$47.82	Weaned	7	$0.96	$6.69
Implants (Ralgro)	3	$32.05	Steers	9	$1.34	$12.02
Fly tags (XP820)	5	$43.29	Calves	18	$3.61	$64.94
Safeguard	5	$425.58	Calves	18	$1.29	$23.27

Appendix 23. Intensive system vet medicine for the center pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	17	$0.34	$5.76
Lutalyse	11	$55.49	Cows	17	$2.77	$47.17
Factrel	11	$25.19	Cows	17	$2.52	$42.82
Factrel	11	$25.19	Cows	17	$2.52	$42.82
CIDR	11	$114.79	Cows	17	$11.48	$195.14
Safeguard	10	$425.58	Cows	17	$3.37	$57.34
Safeguard	4	$425.58	Cows	17	$3.37	$57.34
Fly tags (XP820)	7	$43.29	Cows	17	$7.22	$122.66
Bovashield Gold	12	$16.95	Calves	17	$0.34	$5.76
Bovashield Gold	6	$16.95	Calves	17	$0.34	$5.76
Bovashield Gold	6	$16.95	Weaned	8	$0.34	$2.71
Presponse	12	$128.69	Calves	17	$2.57	$43.75
Presponse	6	$128.69	Calves	17	$2.57	$43.75
Presponse	6	$128.69	Weaned	8	$2.57	$20.59
Vision 7	12	$47.82	Calves	17	$0.96	$16.26
Vision 7	6	$47.82	Calves	17	$0.96	$16.26
Vision 7	6	$47.82	Weaned	8	$0.96	$7.65
Implants (Ralgro)	3	$32.05	Steers	9	$1.34	$12.02
Fly tags (XP820)	5	$43.29	Calves	17	$3.61	$61.33
Safeguard	5	$425.58	Calves	17	$1.29	$21.98

Appendix 24. Intensive system vet medicine for the west pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	18	$0.34	$6.10
Lutalyse	11	$55.49	Cows	18	$2.77	$49.94
Factrel	11	$25.19	Cows	18	$2.52	$45.34
Factrel	11	$25.19	Cows	18	$2.52	$45.34
CIDR	11	$114.79	Cows	18	$11.48	$206.62
Safeguard	10	$425.58	Cows	18	$3.37	$60.72
Safeguard	4	$425.58	Cows	18	$3.37	$60.72
Fly tags (XP820)	7	$43.29	Cows	18	$7.22	$129.87
Bovashield Gold	12	$16.95	Calves	18	$0.34	$6.10
Bovashield Gold	6	$16.95	Calves	18	$0.34	$6.10
Bovashield Gold	6	$16.95	Weaned	7	$0.34	$2.37
Presponse	12	$128.69	Calves	18	$2.57	$46.33
Presponse	6	$128.69	Calves	18	$2.57	$46.33
Presponse	6	$128.69	Weaned	7	$2.57	$18.02
Vision 7	12	$47.82	Calves	18	$0.96	$17.22
Vision 7	6	$47.82	Calves	18	$0.96	$17.22
Vision 7	6	$47.82	Weaned	7	$0.96	$6.69
Implants (Ralgro)	3	$32.05	Steers	9	$1.34	$12.02
Fly tags (XP820)	5	$43.29	Calves	18	$3.61	$64.94
Safeguard	5	$425.58	Calves	18	$1.29	$23.27

Appendix 25. Extensive system vet medicine for the east 2 pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	14	$0.34	$4.75
Lutalyse	11	$55.49	Cows	14	$2.77	$38.84
Factrel	11	$25.19	Cows	14	$2.52	$35.27
Factrel	11	$25.19	Cows	14	$2.52	$35.27
CIDR	11	$114.79	Cows	14	$11.48	$160.71
Safeguard	10	$425.58	Cows	14	$3.37	$47.22
Safeguard	4	$425.58	Cows	14	$3.37	$47.22
Fly tags (XP820)	7	$43.29	Cows	14	$7.22	$101.01
Bovashield Gold	12	$16.95	Calves	14	$0.34	$4.75
Bovashield Gold	6	$16.95	Calves	14	$0.34	$4.75
Presponse	12	$128.69	Calves	14	$2.57	$36.03
Presponse	6	$128.69	Calves	14	$2.57	$36.03
Vision 7	12	$47.82	Calves	14	$0.96	$13.39
Vision 7	6	$47.82	Calves	14	$0.96	$13.39
Implants (Ralgro)	3	$32.05	Steers	14	$1.34	$18.70
Fly tags (XP820)	5	$43.29	Calves	7	$3.61	$25.25
Safeguard	5	$425.58	Calves	14	$1.29	$18.10

Appendix 26. Extensive system vet medicine for the 2mile pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	13	$0.34	$4.41
Lutalyse	11	$55.49	Cows	13	$2.77	$36.07
Factrel	11	$25.19	Cows	13	$2.52	$32.75
Factrel	11	$25.19	Cows	13	$2.52	$32.75
CIDR	11	$114.79	Cows	13	$11.48	$149.23
Safeguard	10	$425.58	Cows	13	$3.37	$43.85
Safeguard	4	$425.58	Cows	13	$3.37	$43.85
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Bovashield Gold	12	$16.95	Calves	13	$0.34	$4.41
Bovashield Gold	6	$16.95	Calves	13	$0.34	$4.41
Presponse	12	$128.69	Calves	13	$2.57	$33.46
Presponse	6	$128.69	Calves	13	$2.57	$33.46
Vision 7	12	$47.82	Calves	13	$0.96	$12.43
Vision 7	6	$47.82	Calves	13	$0.96	$12.43
Implants (Ralgro)	3	$32.05	Steers	13	$1.34	$17.36
Fly tags (XP820)	5	$43.29	Calves	7	$3.61	$25.25
Safeguard	5	$425.58	Calves	13	$1.29	$16.81

Appendix 27. Extensive system vet medicine for the stackeast pasture, year 2

Operation	Month to Apply	Cost per Bottle	Cattle Type	Number of Head	Cost Per Head	Total Cost Per Item
Bovashield Gold	12	$16.95	Cows	13	$0.34	$4.41
Lutalyse	11	$55.49	Cows	13	$2.77	$36.07
Factrel	11	$25.19	Cows	13	$2.52	$32.75
Factrel	11	$25.19	Cows	13	$2.52	$32.75
CIDR	11	$114.79	Cows	13	$11.48	$149.23
Safeguard	10	$425.58	Cows	13	$3.37	$43.85
Safeguard	4	$425.58	Cows	13	$3.37	$43.85
Fly tags (XP820)	7	$43.29	Cows	13	$7.22	$93.80
Bovashield Gold	12	$16.95	Calves	13	$0.34	$4.41
Bovashield Gold	6	$16.95	Calves	13	$0.34	$4.41
Presponse	12	$128.69	Calves	13	$2.57	$33.46
Presponse	6	$128.69	Calves	13	$2.57	$33.46
Vision 7	12	$47.82	Calves	13	$0.96	$12.43
Vision 7	6	$47.82	Calves	13	$0.96	$12.43
Implants (Ralgro)	3	$32.05	Steers	13	$1.34	$17.36
Fly tags (XP820)	5	$43.29	Calves	6	$3.61	$21.65
Safeguard	5	$425.58	Calves	13	$1.29	$16.81

Appendix 28. Intensive system cropland budget calculations for the east pasture, year 1

Item	Units	Cost	Quantity	Hectare	Number of Cows	Pasture Cost	$/Cow
Wheat							
Chisel plowing	ha	$32	2	6	14	$380	$27
Field cultivating	ha	$27	1	6	14	$160	$11
Planting	ha	$31	1	6	14	$186	$13
Seed	kg	$0.37	115	6	14	$255	$18
Fertilizer	kg	$0.36	313	6	14	$676	$48
Fertilizer Application	ha	$12	1	6	14	$72	$5
Terminating Spray	ha	$49	1	6	14	$296	$21
Total						$2,026	$145
Summer Crop							
Planting	ha	$36	1	6	14	$215	$15
Seed	ha	$72	1	6	14	$430	$31
Spraying	ha	$37	2	6	14	$445	$32
Total						$1,089	$78

Appendix 29. Intensive system cropland budget calculations for the center pasture, year 1

Item	Units	Cost	Quantity	Hectare	Number of Cows	Pasture Cost	$/Cow
Wheat							
Chisel plowing	ha	$32	2	6	14	$380	$27
Field cultivating	ha	$27	1	6	14	$160	$11
Planting	ha	$31	1	6	14	$186	$13
Seed	kg	$0.37	115	6	14	$255	$18
Fertilizer	kg	$0.36	313	6	14	$676	$48
Fertilizer Application	ha	$12	1	6	14	$72	$5
Terminating Spray	ha	$49	1	6	14	$296	$21
Total						$2,026	$145
Summer Crop							
Planting	ha	$36	1	6	14	$215	$15
Seed	ha	$72	1	6	14	$430	$31
Spraying	ha	$37	2	6	14	$445	$32
Total						$1,089	$78

Appendix 30. Intensive system cropland budget calculations for the west pasture, year 1

Item	Units	Cost	Quantity	Hectare	Number of Cows	Pasture Cost	$/Cow
Wheat							
Chisel plowing	ha	$32	2	6	14	$380	$27
Field cultivating	ha	$27	1	6	14	$160	$11
Planting	ha	$31	1	6	14	$186	$13
Seed	kg	$0.37	115	6	14	$255	$18
Fertilizer	kg	$0.36	313	6	14	$676	$48
Fertilizer Application	ha	$12	1	6	14	$72	$5
Terminating Spray	ha	$49	1	6	14	$296	$21
Total						$2,026	$145
Sorghum							
Planting	ha	$36	1	6	14	$215	$15
Seed	ha	$72	1	6	14	$430	$31
Spraying	ha	$37	2	6	14	$445	$32
Total						$1,089	$78

Appendix 31. Intensive system cropland budget calculations for the east pasture, year 2

Item	Units	Cost	Quantity	Hectares	Number of Cows	Pasture Cost	$/Cow
Wheat							
Planting	ha	$36	1	6	18	$215	$12
Seed	kg	$0.37	115	6	18	$255	$14
Fertilizer	kg	$0.36	313	6	18	$676	$38
Fertilizer Application	ha	$12	1	6	18	$72	$4
Urea	kg	$0.37	218	6	18	$484	$27
Fertilizer/Seed Application	ha	$12	1	6	18	$72	$4
Terminating Spray	kg	$49	1	6	18	$296	$16
Total						$2,070	$115
Crabgrass							
Planting	ha	$0	1	6	18	$0	$0
Seed	kg	$11	15	6	18	$1,011	$21
Grazon	L	$9	2	7.3	18	$134	$8
Grazon Application	ha	$15	1	7.3	18	$110	$6
Total						$1,255	$35
Bermuda							
Fertilizer (Urea)	ha	$0.69	219	3.7	18	$559	$31
Fertilizer Application	ha	$12	1	3.7	18	$44	$2
Total						$603	$34

Appendix 32. Intensive system cropland budget calculations for the center pasture, year 2

Item	Units	Cost	Quantity	Hectares	Number of Cows	Pasture Cost	$/Cow
Wheat							
Planting	ha	$36	1	6	17	$215	$13
Seed	kg	$0.37	115	6	17	$255	$15
Fertilizer	kg	$0.36	313	6	17	$676	$40
Fertilizer Application	ha	$12	1	6	17	$72	$4
Urea	kg	$0.37	218	6	17	$484	$28
Fertilizer/Seed Application	ha	$12	1	6	17	$72	$4
Terminating Spray	kg	$49	1	6	17	$296	$17
Total						$2,070	$122
Crabgrass							
Planting	ha	$0	1	6	17	$0	$0
Seed	kg	$11	15	6	17	$1,011	$59
Grazon	L	$9	2	7.3	17	$134	$8
Grazon Application	ha	$15	1	7.3	17	$110	$6
Total						$1,255	$74
Bermuda							
Fertilizer (Urea)	ha	$0.69	219	3.7	17	$559	$33
Fertilizer Application	ha	$12	1	3.7	17	$44	$3
Total						$603	$35

Appendix 33. Intensive system cropland budget calculations for the west pasture, year 2

Item	Units	Cost	Quantity	Hectares	Number of Cows	Pasture Cost	$/Cow
Wheat							
Planting	ha	$36	1	6	18	$215	$12
Seed	kg	$0.37	115	6	18	$255	$14
Fertilizer	kg	$0.36	313	6	18	$676	$38
Fertilizer Application	ha	$12	1	6	18	$72	$4
Urea	kg	$0.37	218	6	18	$484	$27
Fertilizer/Seed Application	ha	$12	1	6	18	$72	$4
Terminating Spray	kg	$49	1	6	18	$296	$16
Total						$2,070	$115
Crabgrass							
Planting	ha	$0	1	6	18	$0	$0
Seed	kg	$11	15	6	18	$1,011	$56
Grazon	L	$9	2	7.3	18	$134	$7
Grazon Application	ha	$15	1	7.3	18	$110	$6
Total						$1,255	$70
Bermuda							
Fertilizer (Urea)	ha	$0.69	219	3.7	18	$559	$31
Fertilizer Application	ha	$12	1	3.7	18	$44	$2
Total						$603	$34

Appendix 34. The effects of grazing sorghum-sudan grass as a summer cover crop on hay production, kg/ha

Items	Cutting[1]	
	Early	Late
East	3521	2015
Center	3663	1750
West	3074	2107
Average	3419	1957

[1]Cutting = Early- 2 hectares were set aside for hay production, it was cut on August 4. Late - 2 hectares that were grazed by weaned steer calves for 30 d then cut.

VITA

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Master of Science

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