# An economic analysis of the value of grazing winter cover crops

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**ABSTRACT**

Cover crops can be used as forage for cattle and other grazing animals. This research investigated the net returns of using cover crops for forage or grazing under four scenarios. These scenarios were: 1) a mixed crop and livestock producer who owns a herd of cattle and has both dry or pregnant cows and weaned calves available to graze corn stover and cover crops; 2) a crop farmer who purchases stocker cattle for the purpose of grazing the cover crop and corn stover; 3) a crop farmer who leases out a corn stover and cover crop field to a livestock producer (and who provides value-added services to the livestock producer for a fee); and 4) an integrated operation with crops and cattle where cover crops are not grown and hay is fed to cattle during the winter months. Each of these scenarios had different budgets, risks, and profit potentials. The research aimed to address the risks and profit potentials for each scenario. The stocking density was initially set at three cows and 31 steers for a period of 90 days, and alternatively, three cows and 25 steers for a period of 120 days. Two sets of cattle pricing data were used: the average historical prices from 1992 to 2011 and reported prices from a regional stockyard for the period of November 2016 to March 2017.

The results showed that the initial stocking densities used for scenarios one and two were too low to provide profitable net returns regardless of pricing data used. Net returns for scenario three were also not profitable based on the services rendered and the management fee charged. Scenario four was profitable on one occasion. November steers with a 500 lb. average starting weight fed hay and concentrate for 120 days resulted in a positive net return of $375. A second analysis was done using stocking rates of 50, 75, or

100 steers to determine if increasing stocking density would result in a positive net return using only the 2016/2017 pricing data and only evaluating net returns on 2.0 and 2.5 lbs. of average daily gain. Positive net returns were achieved at various start weights and average daily gain rates at stocking rates of 75 and 100 animals. No positive net returns were realized at the stocking rate of 50 animals/100 acre field. The management fee charged for providing management services under scenario three was adjusted based on stocking densities to determine if a positive net return could be achieved at the set fee rate of $0.875/head/day. At that rate, no stocking rate resulted in a positive net return. Using the cost data, less the $900 field lease income, a breakeven pricing point for the management fee was determined for each stocking density and grazing duration within the scenario. Management of cost factors to achieve greater chances of profitability and additional research needs are discussed.

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# CHAPTER I: INTRODUCTION

Cover crops were used in years past to protect the soil between the harvest of one year's cash crop and the pre-planting activities for the next year's cash crop and as a green manure. They fell out of practice in many conventional cropping systems in the Midwest with agricultural intensification towards a system that was based on corn and soybean production. Auclair (1976:431) noted that "… there was an increase in crop specialization." during this period of agricultural intensification towards the corn and soybean cropping systems that are so prevalent today. He went on to state that during the period of 1950-1965 there was a decline in crop diversity of 35%. Cover crops have had something of a resurgence in the past couple of decades as growing concerns over water quality have driven producers to cultural methods and technologies that reduce off-site movement of agricultural fertilizers and pesticides, and the soil to which some of these chemicals are adsorbed.

Soil is the basis for all terrestrial life on Earth. Protecting our agricultural soils from degradation resulting from wind or water erosion has been a topic at farmer meetings since the 1930's. As we've learned more about soils we have come to understand that simply protecting the physical soil is inadequate. We must also protect and support the organisms dwelling in the soil. Soil health is a term in vogue in today's soil management lexicon. Soil health encompasses the protection of the soil surface and the nutrition and husbandry of soil organisms (Magdoff and Van Es, 2009).

Cover crops are usually defined as plant species grown between main crops that are not sown to produce a harvestable crop. They are not planted for the purpose of harvesting grain, hay, forage (green chop for silage), or for grazing. Grain crops are typically grown for five to six months annually; once the main crop is harvested, the soil surface remains exposed and at risk of erosion for six to seven months. The real intent of the cover crop is to protect the soil and feed soil organisms by extending the presence of living vegetative cover to 10 or more months a year. Grazing or green chopping cover crops can add value to an operation while still achieving the intent of the cover crop. Forage value may convince more producers to adopt cover cropping as an integral component of their yearly cropping plan.

Many producers who operate mixed livestock-grain farms and integrate cover crops into their cropping operation make use of cover crops for grazing. Grazing the cover crop and crop residue can provide a balanced ration for cattle and can aid in crop residue management. Cattle are often grazed on corn stover. Often these are cows in their first and second trimester of pregnancy, with or without calves by their sides. Steers and growing heifers can be backgrounded on corn stover, but the quality of the feed may not meet their nutritional needs for optimal economic performance. Adding cover crops to harvested corn fields increases the quality of the forage and better supports the nutritional requirements of growing steers and heifers. The ability of producers to make use of corn stover with or without a cover crop can reduce or possibly eliminate the requirement for hay to be fed to livestock. Reducing the hay required to sustain an animal through winter also reduces the labor and machinery costs associated with producing hay and moving the hay to the pasture for feeding (Edwards, 2014a).

By grazing crop fields in which cover crops have been sown, the livestock producer takes grazing pressure off of permanent cool season pastures. Resting permanent cool season grass pastures for several months may allow for pasture recovery. In grazing systems where animals are allowed to continuously graze a paddock or a few paddocks, the pasture plant species are expending much of their energy regrowing leaf components that were removed by the animals' grazing. Removing the animals for an extended period of time during the late fall, winter, and early spring to graze on crop residue and cover crop forage allows the cool season pasture species to put some of its energy into root development. Enhanced root development may enable the pasture species to better tolerate climatic stresses the following year. Removing the animals also allows producers to renovate pastures with legumes through direct seeding in the fall or frost seeding in late winter. Having cover crops to graze may also permit producers to spray toxic endophyte infected tall fescue pastures in anticipation of performing spring tillage and spring cover crop planting as part of a spray – smother – spray - smother approach to thoroughly killing the stubbornly persistent grass. Once killed, non-toxic cool-season grasses can then be established. Having the cover crop and corn stover to graze may prevent the need to reduce herd size or rent other pasture during the pasture renovation process.

### 1.1 Considerations When Determining the Economics of Cover Crop Grazing

Cover crops used for grazing have value, but how much value? Determining the amount of hay saved by grazing cover crops and the value of the hay saved is a straightforward determination. Determining the value of animal performance depends on the status of the animals being grazed on the cover crop (dry cows, growing steers and feeder heifers, or cows and calves). Since the performance objectives for each of these animal groups vary, the value will also vary. Determining the value of rested pasture is not as straightforward; in fact, most of the value in resting pastures might be intrinsic. Benefits to rested pasture might not be seen until the following summer or may take several years to manifest, depending on soil fertility and climatic conditions.

Lastly, different cover crop species have different forage value depending on what forage source they are replacing and when they are replacing the forage source (Anil et al., 1998). For example, adding a legume like crimson clover to the cover crop mix may increase the protein content of the forage. Crimson clover does not grow as rapidly in the fall as do turnips, so it may not contribute significantly to the forage quality of the cover crop mix in November, but might contribute more in February and/or March.

The researcher's experience with cover crop production supports the temporal aspects of cover cropping. Winter oats have a higher rate of growth in the fall than winter rye. Thus, a cover crop mixture containing a high percentage of winter oats will be ready for grazing sooner than a mixture containing a high percentage of winter rye. Spring oats and oilseed radishes do well in the fall, but are unlikely to routinely overwinter in most areas in Kansas and Missouri, so they should be grazed by late December. Rye and hairy vetch make most of their growth in the spring, so delaying grazing on fields with these cover crops yields more forage. Temporal growth rates should be considered by producers or advisors when selecting species to include in the cover crop mixture and which fields to sow to a particular mixture. The temporal variation in the rate of biomass production of various cover crop species affects the value of the cover crop used for grazing.

Economic factors to be considered when developing production cost estimates for use of cover crops include fencing, labor, water, land lease rates, hay and cattle price cycles. This study focuses on the 90-150 day winter period from mid-November to mid-March. During this period, cattle market prices tend to drop to seasonal lows (December and January) before recovering in February and March. Sewell et al. (1993) investigated backgrounding cattle and discovered that 400-500 pound steers bought in the October to

December timeframe and sold as 600-800 pound feeder cattle netted about $62 per CWT for 200 pounds of gain (about $124 per animal). They also found that the value of gain per pound in the winter was 18 cents higher than for summer gains. They acknowledged that winter gains cost more than summer gains, as well. Animal weight gains from cover crop grazing might have a comparable cost to summer pasture when the preponderance of the establishment cost is accounted for as a cost to the crop production operation.

### 1.2 Soil Health and Grazing Cover Crops

There are many definitions of what soil health is. Kibblewhite et al. (2008) define soil health as: "a healthy agricultural soil is one that is capable of supporting the production of food and fiber, to a level and with a quality sufficient to meet human requirements, together with continued delivery of other ecosystem services that are essential for maintenance of the quality of life for humans and the conservation of biodiversity." Doran and Zeiss (2000) define soil health as a soil's capacity "to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health." Kibblewhite et al. (2008) consider soil health to be integrated into a larger functional system referred to as "ecosystem services". In this regard, soil health must be considered not just as a medium for producing food and fiber, but for its role in carbon sequestration, nutrient cycling, and water cycling, among others. Agricultural soils are disturbed soils; tillage, planting, fertilization, pest management, and harvesting operations all disturb the soil and the soil environment to some extent. Magdoff (2001) states that soil health is "influenced by every aspect of soil and crop management."

Soil health should be considered when determining the economics of grazing cover crops. According to Sere et al. (1995) grasslands are responsible for producing 27% of the world's milk and 23% of the world's beef. This suggests that crop ground is used to produce 73% and more than 77% of the world's supply of milk and beef, respectively. Some of this crop ground might be sown in non-grass forage crops, such as alfalfa. The preponderance of this crop ground is likely used to produce corn for silage or grain, soybeans for protein and oil, or cereal grains for feed. All of these cropping systems can have cover crops integrated into them under the right circumstances. Therefore, all crop ground has the potential to be cover-cropped and potentially grazed by animals to increase meat, milk, and fiber production. By growing a cover crop, biomass is added to the crop field during the "off-season". This promotes soil health by continuing to feed the soil organisms that dwell in these fields during the non-cash cropping season.

### 1.3 Cattle Production and Cover Crops

Late fall and winter are periods of the year when forage production is often limited in Missouri and Kansas. Grazing livestock often requires either supplemental feed (hay and/or concentrate) or deferred pasture (stockpiled forage) during this time. Cover crop production provides another readily available feed source for grazing livestock. Pasture-based forage generally becomes limiting starting between November 15 and December 15 depending upon seasonal precipitation, location, and fall temperatures. This results in a 90-150 day period (ending in mid-March) in which supplemental feeding is generally required. This winter period can affect animal performance. Many cattle producers in the region calve in the springtime to take advantage of the flush of new grass growth. Other cattle producers calve in the fall to take advantage of a surge of forage growth normally observed in late summer and into the fall, when temperatures and precipitation are often optimal for cool-season grass production. Yet, regardless of which calving season is used, cattle performance is susceptible to winter conditions. Hight (1968) and Greenwood and Cafe (2007) both report that nutritional limitations can reduce calf performance. This reduction can occur either directly on calf growth during or after weaning, or indirectly through the cow by producing lower birthweight calves. Cover crop grazing may be able to raise the plane of nutrition for many pre- and post-weaning calves and cows that are in lactation or late gestation.

In a study using meat goats, Lema et al. (2007:89) compared animal performance on winter pastures of triticale and rye to a KY31 tall fescue control. They reported that "net energy, total digestible nutrients, relative feed value, Ca, Mg, K and P contents" were statistically higher in the triticale and rye forages. Mature female goats (does) grazing KY31 tall fescue (*Lolium arundinaceum* (Schreb.)) showed a decline in weight over the course of the study, whereas does grazing either triticale or rye gained weight after they were acclimated to the forage (after about one month) (Lema et al. (2007:94-103). This demonstrates that maintaining animals in better body condition through the winter can be done more easily on cereal grasses than on tall fescue grass found in pastures throughout the region.

What is the forage value of typical cover crops? If the forage value of pasture and dried forage declines over the winter months, do cover crops potentially increase the nutrition available to grazing animals? A Progressive Dairyman article by Boylen (2016) addresses the first question. She interviewed Jim Paulson of the University of Minnesota who had recently done a study on the forage value of cover crops. The article reported the forage value of 20 cover crop species and of these 20, six are suitable for late fall and winter cover crop use. The six cover crop species of interest for fall and winter grazing are: kale, turnip, crimson clover, forage oats, annual ryegrass, and tillage radish. These had crude protein (CP) percentages of 23.2, 17.2, 20.4, 16.6, 21.7, and 22.4, respectively. Their total digestible nutrients (TDN) values were 65.2, 67.9, 63.6, 62.2, 60.6, and 68.3, respectively. Dry matter (DM) yields per acre ranged from 2.4 tons for annual ryegrass to 1.36 tons for kale, with the average of the six being 1.71 tons DM/acre. Barry (2013) reported forage brassicas were highly digestible and had metabolisable energy values higher than most pasture grasses and legumes.

Paulson's data clearly shows that cover crops can have excellent forage value (quality) and be productive. With an average CP value of 20.25% and an average TDN value of 64.6%, grazing animals would not likely require protein supplementation, and if sufficient forage was available the TDN values would likely ensure maintenance of body condition score and available net energy for growth (Boylen, 2016).

Many producers graze corn stover to manage residue and to reduce hay feeding requirements. Leask and Daynard (1973:515) reported that corn stover had a protein content of 4.5%. They also found that the digestibility of the stover (*InVitro* dry matter disappearance (IVDMD)) declined at a rate of 1.5% per week. Clearly, corn stover is a low quality forage that doesn't improve with age. Sowing corn fields to cover crops to be grazed over winter increases the nutritional value of the field and likely increases the rate of animal gain, maximizing the more valuable winter pound gain observed by Sewell et al. (1993).

Another concern to crop producers is, does grazing cover crops impact the follow-on cash crop? Cicek et al. (2014) investigated this under organic production systems. They found that soil phosphorus and potassium were unaffected by grazing and nitrate nitrogen ($NO_3 – N$) actually increased significantly in grazed plots when compared to ungrazed plots.

**1.4 Research Focus**

The purpose of the research was to assess the economic potential of using cover crops for forage and grazing. The study area for this project was the humid region of the lower Midwest, centered on Missouri, and incorporating parts of eastern Kansas in preparing grazing budgets. The scenarios investigated in this research were: 1) a mixed crop and livestock producer who owns a herd of cattle and has both dry or pregnant cows and weaned calves available to graze corn stover and cover crops; 2) a crop farmer who leases out a corn stover and cover crop field to a livestock producer (and who may or may not provide value added services to the livestock producer); 3) a crop farmer who purchases stocker cattle for the purpose of grazing the cover crop and corn stover; and 4) an integrated operation with crops and cattle where cover crops are not grown and hay is fed to cattle during the winter months. Each of these scenarios had different budgets, risks, and profit potentials. The research aimed to address the risks and profit potentials for each scenario.

**1.5 Conclusion**

The introduction has focused on setting the stage for determining the economic value of establishing cover crops to enhance soil health, and potentially grazing the cover crops as a management methodology. The next chapter focuses on reviewing the literature that relates to economic factors of cover crop production and subsequently grazing the cover crop. It looks at some economic aspects of ecosystem services and the value of these services. Chapter 3 consists of the methodology used to perform the assessment of the economic value of using cover crops as forage and for grazing. It includes the development of the cost factors used in the analysis. Chapter 4 presents the results of the analysis and the discussion of the results. The analysis focuses on purchase/sell decisions to determine profitability of retaining or purchasing cattle for the purpose of grazing cover crops. The conclusions are presented in Chapter 5.

# CHAPTER II: LITERATURE REVIEW

This chapter seeks to set the stage for the analysis by establishing the importance of cover crops for soil stabilization and soil health, resting cool season grass pastures, and establishing the cost of feeding hay during winter months. Studies involving the grazing of cool season cereal grasses and broadleaf plants were reviewed to establish realistic rates of average daily gain when grazing them as a cover crop. Cover crop termination methods were reviewed and the risks of cover cropping and grazing cover crops examined and presented.

## 2.1 Soil Health

The majority of US agricultural croplands are left "naked" for four to six months each year following the main crop harvest and prior to the planting and establishment of the next season's main crop. Leaving our croplands without a vegetative cover for this period of time can result in significant erosion and loss of biological activity in the soil. Pimentel et al. (1995:1119) looked at the environmental and economic costs of soil erosion and the benefits of conservation measures using a model of the erosion effects on the productivity of crops. Using data developed by other researchers as the basis of their model, they determined that soil erosion occurs at the rate of 17 tons per hectare per year which translates into an average loss of "75 mm of water, two tons of organic matter and 15 kg of nitrogen" being lost from each hectare of cropland per year. They extended their calculations to determine the impact after 20 years of unchecked erosive activity and concluded that, over that period of time, 2.8 cm of topsoil would be lost. This, they stated, translated into a predicted 7% decline in cropland productivity. When we consider that by 2050 we will need to feed two billion more people from less agricultural land than is currently supporting the present population, the effect of soil erosion becomes more significant. From an economic perspective, Pimentel et al. (1995) estimated that erosion would cost approximately $196 per hectare, or approximately $98 per acre, to replace the water holding capacity and nutrients lost. The authors did not consider the biological activity impacts in their estimates. This prediction supports the need for widespread adoption of cover crops and other conservation practices, whether grazed or not.

**2.2 Grasslands and Resting Cool Season Pastures**

Much of the agricultural land used in the world is grassland. Grasslands are critical assets for much of our global livestock production. But many grasslands have been converted into cropland to meet man's needs for food. Recently researchers have looked at grasslands ability to sequester atmospheric carbon and store it as soil carbon. Changing grassland management can increase the carbon concentration in the soil and can have a positive impact on soil organisms that are active in the soil (Contant 2001). Changing from native land cover to improved pastures increased the soil carbon content in a number cropping regions (mostly in former rainforest areas), as did the application of inorganic fertilizer or manure to grassland (Contant 2001).

A possible advantage of grazing cover crops is to afford perennial pastures a period to rest and recover from seasonal grazing pressure. Riesterer et al. (2000) looked at seasonal yield distributions of cool season grasses after winter defoliation. They found that December defoliation reduced the spring groundcover when compared to defoliation in October. The difference in groundcover was 9%, which does not seem to be significant. However, a 9% reduction in groundcover means a 9% or greater increase in the soil surface being exposed to erosive conditions. Thus, removing cattle from permanent pastures in the November to early December timeframe and moving them to crop fields that are producing cover crops may result in increased soil surface cover on and lower erosion losses from permanent pastures. Dowling et al. (1996) found that resting pastures containing perennial grasses resulted in an increase in the perennial grass content and a decrease in the weed content of the pasture.

Rotational grazing of pastures is seen as a way to maintain high-quality pastures by applying the appropriate number of animal units and then removing them to avoid overgrazing of the pastures. An Illinois study looked at cattle performance and forage characteristics on continuous and rotationally grazed systems. The investigators reported that rotationally grazed pastures had significantly higher stocking rates than pastures grazed continuously. The rotational paddocks were rested for 30 days between grazing sessions. They found that rotational grazing increased beef production per hectare by allowing them to increase stocking rates while maintaining average daily gains and forage quality (Bertelsen et al., 1993). Another study, conducted in the western United States in a region that contains native grasses, did not show any impact of rotational grazing (Hart et al., 1988). It is possible that these researchers did not see any differences due to insufficient grazing pressure being applied. Scanlan et al. (2011) found that resting pastures for six months resulted in improved pasture conditions and production. This finding further supports the concept of removing animals from grazing permanent pastures and moving them to fields having cover crops and crop residue. Resting permanent pastures allows the plants to regenerate root and shoot mass.

Poore et al. (2000) investigated the use of stockpiled fescue to reduce the costs of beef cattle production. They found a cost-benefit of strip grazing stockpiled fescue over feeding hay of approximately $0.50 per head per day. This suggests that grazing fields containing cover crop and crop residues has the potential to have lower overall costs than feeding hay to overwinter cattle.

### 2.3 Grazing Cool Season Grasses

A common practice of livestock producers is to plant a cool season grass into existing warm season pastures to extend the fall or winter grazing season. Often the grasses chosen to fill this need are annual ryegrass or cereal grasses such as oats and rye. These grasses are often sown by drilling the seed into closely clipped pastures that are then rested from grazing for six to eight weeks to give the annual cool-season grasses an opportunity to grow. A study by McCartney et al. (2008) investigated the grazing of beef cattle on cool season cereals. They found that cattle performed well when grazing on these grasses and that the forage quality was sufficient to over-winter pregnant cattle. An Arkansas study revealed that beef cattle had the highest average daily gain on wheat-annual ryegrass pastures (Beck et al., 2005).

### 2.4 Grazing Cool Season Broadleaf Forages

An Australian study looked at grazing spring canola (a brassica) and concluded that early-season grazing of spring canola had no effect on yield (Kirkegaard et al., 2012). This suggests that a fall planted cover crop such as spring oats could be sown in a field to be planted to spring canola to provide spring grazing. It also suggests that spring oats and winter canola may be able to be used in a grazing system if the winter canola is planted early and attains sufficient vegetative size to ensure a high probability of winter survival. It further intimates that winter canola may be reasonable for grazing in the early spring.

Turnips, tyfon, and rape are other brassicas that can be used for grazing. In a study using lambs, Koch et al. (2002) observed that these brassicas provide high quality forage for lambs. They also remarked that seeding into a double seedbed not only facilitates the timely establishment of the *Brassica* spp. crop, it both reduces the cost of production and provides grazing lambs with a source of dry matter. Koch et al. (2002:3) also noted that fall planting date is “probably the biggest factor in the productivity of turnips and other brassicas” when used for grazing of the cover crop.

Thompson and Stevens (2012) conducted a study using 250 Friesian x Jersey dairy cows to determine if grazing the animals on Swedes or kale would maintain their body condition scores. They discovered a highly significant difference in body condition scores between cows fed Swedes (4.67) and kale (4.45) at the end of a five-week grazing period. The initial body condition score was 4.3, so grazing either the Swedes or kale resulted in maintenance of body condition score over the experimental period. Edwards et al. (2014) found similar results for body condition scores grazing Friesian x Jersey dairy cows on fodder beets, kale and a kale-oat forage system. Over an eight week study period, average body condition scores improved by 0.76 for the fodder beets, 0.66 for the kale and 0.76 for the oat and kale mixture. Hence, including certain broadleaf species in the cover crop seeding mixture can contribute to the value of the cover crop for grazing.

The taproot of some brassicas and other broadleaf species can quickly penetrate to lower soil horizons (B and upper C on more shallow soil profiles) to mine nutrients and return them to the foliage where grazing animals can consume them.  Nutrient mining contributes to nutrient sequestration.  This can be especially significant in the sequestration of nitrogen to prevent it from leaching into groundwater sources.  Sarrantonio (edited by Clark, 2007) points out that cover crops can also cycle potassium and calcium, preventing them from moving into lower horizons of the soil profile in soil water.  The tap-rooted cover crop species may also improve soil characteristics by penetrating traffic and plow pans to improve soil drainage.

**2.5 Grazing Cover Crops**

Franzluebbers and Stuedemann (2008) investigated the effects of grazing cover crops on soil properties. They found that grazing cover crops had little effect on soil bulk density, a measurement of soil compaction. They determined that water infiltration was reduced by grazing cover crops over not grazing the cover crops, but concluded that cover crop grazing did not cause any significant damage to the soil.

Aasen et al. (2004) looked at strip grazing spring cereals, field peas and mixtures from a perspective of forage yield and nutritive value. They found that field peas provided sufficient protein to support lactating cows. Field pea and cereal grass mixtures had higher protein concentrations than cereal grasses alone. When evaluating the economic advantages of mono-cropped cereals versus the mixtures containing peas, they concluded that there was little benefit to the mixtures.

Hight (1968) looked at the plane of nutrition provided to cows in late gestation and through the lactation period on offspring at weaning. Cows on a high plane of nutrition weaned all calves born alive (34), cows moved to a low plane of nutrition after parturition weaned 97% of calves born alive (31 of 32), cows moved from a low plane of nutrition to a high plane following parturition weaned 81% of calves born alive (26 of 32), and cows maintained on a low plane of nutrition during late gestation and throughout their lactation period weaned 82% of calves born alive (27 of 33). Death losses from various causes were noted by the author. Several animals died of starvation at or near birth. Greenwood and Cafe (2007) observed that calves subjected to either prenatal or pre-weaning growth retardation may ultimately attain carcass weights equal to calves not subjected to retarded growth, but at an older age. These studies suggest, for both spring and fall calving operations, maintaining dams on a high plane of nutrition produces both healthier and growthier calves. The higher nutrition level found in cover crops can contribute to maintaining a high plane of nutrition throughout the late fall and winter period when high quality pasturage is frequently unavailable. Faster growing animals may increase net returns by achieving marketing weights sooner and possibly being in better condition when historic cattle prices rebound in the late winter and early spring.

### 2.6 Economic Value of Corn Stover

Corn stover has different economic value depending on marketing avenues available to the corn producer. In central Missouri and Kansas, the markets for corn stover have not yet developed where harvesting corn stover as a bioenergy product is a viable alternative for most producers. Several companies, led by Ameren Missouri, are trying to develop “biocoal” from Missouri corn stover (Brownfield, 2015). The companies envision farmers raking and baling the stover, then hauling it to collection facilities. An Iowa State University study estimated the cost of baling and hauling stover to a cellulosic ethanol plant at between \$52 and \$91 per ton, depending on the efficiency of the operation (Johnson, 2014). Edwards (2014b) compared corn stover harvesting system costs between livestock and biofuel. Stover was baled and hauled in both harvesting systems. He calculated that harvesting for livestock use had a \$1.60/ton advantage over biofuel if the farmer owned the equipment and a \$3.65/ton advantage for livestock use if the stover is custom baled. In-field harvesting of stover by livestock is likely to be more cost advantageous than biofuel harvesting and possibly cost advantageous to baling and hauling for livestock use. Fence construction/deconstruction and water hauling for livestock grazing cover crops are labor intensive activities that may negate some of the cost advantages.

Iowa State Extension (Edwards, 2014a) estimates that corn stover can replace up to 25 pounds of hay per day, giving the corn stover a value of $18.75 per acre. Leask and Daynard (1973) report that stover declines in dry matter digestibility over time from a high of 52% at physiological maturity of the grain at the rate of 1.5% per week. They did not determine at what point dry matter digestibility stopped declining or changed its rate of decline past their three-week trial period. They also reported that the protein content of the stover averaged 4.5%. The feed value of corn stover actually consumed by cattle is likely to be higher than Leask and Daynard (1973) report due to their values being the averages of all plant residue (stover) components (stalk, leaves, husk and shank). They did not account for the value of corn cobs or incompletely shelled cobs and spilled grain left in the field. While the feed value of corn cobs is limited (Ochetim, 1993 and Bell, 1949), they do provide some digestible dry matter, and if grain is attached, energy to grazing animals. Bell (1949:3) reported that the nutritional value of corn cobs to be low, "Corn cobs usually contain about 32 percent fiber, about 2 percent total protein and little mineral matter. Chemically, they analyze slightly inferior to oat straw." Ochetim's (1993) nutritional values for cobs were very similar at 32.5 % fiber, 2.5% protein, and he added that cobs had a gross energy value of 2,550 kcal/kg. Personal observation of cattle grazing corn stover with cover crops suggests that the animals eat the more nutritious parts of the stover (leaves and husks) preferentially to the stalks.

A high percentage of the stalks remain after grazing is ceased, although they are often broken due to trampling. One advantage of grazing corn stover is the mechanical damage done to the stalks by the cattle increases the rate at which they decompose. Today's corn hybrids tend to have genetic traits resulting in sturdier stalks to avoid lodging and reduce corn borer damage. These traits make the stalks more difficult to break down before the coming planting season. The trampling action of the cattle while grazing facilitates breaking stalks and working them into the soil where they can be more readily broken down by soil organisms. One producer told the author that his fields were mellower following cover crop grazing because the percentage of stalks remaining vertical was greatly reduced. He said that this made planting easier. This anecdote is supported by Sorenson (2016) who stated that removing some residue prevents spring planting issues of residue affecting seed placement. Wyoming farmer Mike Baker was quoted by Smith (2016:53), 'We are nearing 200 bushel an acre, so we have a lot of corn residue to harvest through the cows.' Baker leases his corn ground for residue grazing and estimates that his fields provide 500 to 600 animal unit months (AUM) per year.

Cattle grazing crop residue may provide agronomic benefits to the follow on crop by reducing the density of residue per acre and the potential of residue to interfere with proper seed placement. With more farmers investing in precision planting technology and equipment, grazing the residue, with or without cover crops, may become a more common practice.

**2.7 Cover Crop Termination**

By definition, a cover crop is a crop that is grown between main crops and without the expressed intent of harvesting the crop. It is not uncommon for some cover crops to persist long enough to have a grain crop taken off in the late spring or early summer, either by design or due to weather-related soil issues. Cover crop termination can be challenging. In Missouri and Kansas corn planting occurs around April 15th annually, full season soybean planting normally follows one or two weeks behind corn planting. For cover crops, this equates to a planned termination date in the vicinity of March 15th. Allowing 30 days from cover crop termination to planting gives the crop producer adequate time to perform spring tillage (if performed), fertilize, and apply herbicide. It also gives the cover crop time to completely die and begin the decomposition process. The time from termination to planting can range from 0 days when the main crop is planted directly into the cover crop prior to its termination, to more than 30 days. Krueger et al. (2011) studied cereal rye termination dates and its effect on corn production in Minnesota. They found that rye terminated 21-30 days prior to planting had no influence on corn biomass, while rye harvested as forage two days before corn planting had a negative impact on corn biomass development.

Allelopathic compounds can be released by some cover crops or their residue (cereal rye for example) and these compounds can be more influential on the germination of certain main crops. Price et al. (2008) determined that extracts of some common cover crop species inhibited radicle elongation in cotton and radish when compared to a water control. The inhibition was greater in radish than cotton. This observation could be a species effect or a seed size effect. Another study found that wheat straw inhibited the emergence of sunflower and tomato (Boz, 2003). Flail mowing and incorporating *Brassicaceae* cover crops was found to greatly affect the germination of muskmelons direct seeded 7 days after cover crop termination. Muskmelon stand establishment was less than 50% of the control stand (Ackroyd and Ngouajio, 2011). Usually, corn and soybeans are not significantly impacted by allelopathic compounds released by cover crops.

Another argument for delaying planting after cover crop termination is to allow for sufficient decomposition of the cover crop to occur to release organic nutrients. A Canadian study showed that most crop residues have an initial rapid decomposition in the first 4-5 weeks after termination (Lupwayi et al., 2004:408). It is during this initial period when proteins, amino acids, and soluble sugars are consumed by decomposing organisms and within a short period of time released into the soil.

For purposes of this thesis, the steer grazing termination date was set at March 15th. A producer might decide to graze cover crops longer if conditions warrant longer grazing. Producers can also decide to make hay or silage from residual cover crop biomass after the steers have been removed.

Cover crops can be terminated by several means or combination of means. Organic producers favor the use of a roller crimper. This is a steel drum fitted with steel bars (blades), in either a straight or spiraled pattern, which is pulled across the field and knocks down the cover crop while the steel bars crimp the stem of the plants to crush the vascular system of the plants (Ashford and Reeves, 2003).

Herbicide termination is the most popular method of terminating the cover crop, with glyphosate being the most common herbicide used. Paraquat can be added to glyphosate to enhance the burn-down. Roller crimping and then spraying the cover crop was shown to be effective by Price et al. (2009) and Ashford and Reeves (2003). Both research teams concluded that herbicide application rates could be reduced when termination was coupled with roller crimping. Ashford and Reeves determined that roller crimping was most effective when done after the cereal grain reached anthesis. This stage of plant growth may occur too late in the season for use in terminating the cover crop 30 days prior to the optimum corn planting date in Missouri and Kansas. Balkcom et al. (in Clark, 2007) state using a roller crimper to terminate the cover crop may not be effective on small weeds. They also caution against using reduced rates of non-selective herbicides in terminating cover crops due to the possibility of contributing to the development of herbicide resistance in weeds.

Other methods can be employed when weather or field conditions do not cooperate with terminating the cover crop as anticipated. These methods include grazing, removal of the forage for silage or as hay, mowing, and harvesting the grain. For the purposes of this thesis it was assumed that the cover crop was terminated after grazing and on time through the use of herbicides.

## 2.8 Risks

Planting a cover crop is not without risk. The primary risk of a cover crop is production risk. Production risks come at cover crop seeding and termination, and to the follow-on main crop. Weather variables are the by far the largest risk factor, but fall harvest timing and spring planting timing are significant risk factors. When the cover crop is sown as part of a grazing plan, market price risk (livestock) becomes a risk factor to be managed. These risks are examined in more detail in the following sub-sections.

### *2.8.1 Cover Crop Production Risks*

Fall harvest timing impacts the sowing and development of the cover crop. Corn is usually shelled prior to soybean harvest on most farms in Missouri. Biomass accumulation in winter-killed fall cover crops such as spring oats and oilseed radish benefits from an earlier corn harvest and subsequent cover crop sowing. The cover crop “cocktail” can have a more diverse species mixture when sowing is in late August or early September. As time passes, the diversity of the cover crop mixture narrows as potential species are removed from consideration due to environmental constraints present within the southern reaches of the Northcentral region. Timely cover crop sowing can affect availability of the crop for grazing. Oats and turnips are often more productive in the fall, whereas cereal rye has its greatest growth in the late winter and early spring. Biomass production is impacted by weather. Timely rain events (after sowing and periodically thereafter) contribute to biomass production. Late sowing might limit grazing until later in the winter or suppress stocking rates due to limited biomass production. Cover crops compete with winter annual weeds for biomass production. Grazing cover crops may enable weed seeds to germinate and become established. Using the management intensive grazing (MIG) approach to grazing limits weed production, because the cover crop is given the opportunity to regrow.

When terminating a cover crop, a producer incurs potential risks from weather and field conditions that may not be conducive to timely termination of the cover crop impacting production of the cash crop. Not only can delayed cover crop termination impact planting the main cash crop, but it could also impact the insurability of the main cash crop. The USDA Risk Management Agency has established four cover crop termination zones for the US (USDA/RMA, 2015). Missouri and SE Kansas are in zone 4, which provides the greatest flexibility for cover crop termination relative to main crop insurability. The eastern third of Kansas (less the SE Corner) is in zone 3, while the western two-thirds of the state are in zone 2. Zones 3 and 2 have progressively more restrictive cover crop termination requirements to assure insurability. This could be a factor explaining why some farmers who should adopt cover crops do not do so. Cover crops may not fit into some farmers' risk management plans.

Balkcom et al. (in Clark, 2007) point out that cover cropping also has the potential to increase pest risks to the main crop. They caution producers to consider avoiding cover crops that might serve as alternate hosts to pests of the follow-on main crop.

A study by Arbuckle et al. (2015) examined Iowa farmers' decision making processes with regards to cover crop adoption. They concluded that farmers who believe that the benefits of cover cropping outweigh the risk tend to adopt cover crops for their operations. Also noted was a tendency for operators of more diverse farms, including livestock, were more likely to integrate cover crops into their operations. Arbuckle et al. (2015:1) stated in conclusion, "A lot of emphasis is rightly placed on the benefits of cover crops, but the study results indicate that helping farmers learn how to manage and minimize potential risks might lead to more adoption."

Another production risk is nitrogen fertilization following cover crops. Leguminous cover crops can add nitrogen to soils allowing corn farmers to take a nitrogen credit for the amount of nitrogen presumed to be added by the cover crop. A case study by Larson et al. (1998:172) suggests that farmers having "a wide range of risk-averse and risk-seeking behavior" may not reduce nitrogen applications following a leguminous cover crop, such as hairy vetch. They added that extremely risk-averse farmers tended to exclude winter legumes from their cover crop system. While there may be nitrogen risk rewards from planting leguminous cover crops ahead of corn, the variability of organic nitrogen availability throughout the growing season combined with the typically tight margins on corn production suggest that applying nitrogen at rates to support typical corn yields is a risk management strategy.

Bergtold et al. (2016) suggest that the ultimate economic value of cover cropping in a given year is determined by cover crop input costs and cash crop yields. They add that unrelated events such as weather also impact positive or negative economic outcomes. Long-term production risk reduction may be enhanced through the use of cover crops if, over a period of time, modulation in cash crop yields is reduced and become more predictable.

### *2.8.2 Cash Crop Production Risks*

The market risks associated with cover crops are largely associated with impacts on the following cash crop. Cover crops can impact the cash crop by delaying planting time, tying up available nutrients, reducing water availability, and possibly releasing alleopathic substances that affect the germination and seedling development.

Delayed planting of the cash crop can occur in wet years when the cover crop cannot be terminated in a timely manner or at the right stage of growth. Any delay in planting date from the optimal planting date for the area is likely to result in a yield reduction or the need to change to a shorter season hybrid (Lauer et al., 1999). Delaying cover crop termination increases biomass production and can lead to a greater increase in soil organic matter content over time, but it can reduce main crop yields in any given year. This risk factor will have its greatest impact in years where climatic conditions are such that short cover crop termination and planting windows exist during the months of March, April and May.

Cover crop termination can result in a temporary reduction in nutrient availability to supply the germinating and juvenile main crop. Even a short term reduction in nutrient availability at planting can manifest itself in lower crop yields at the end of the season. The nutrient of most concern is nitrogen. Ott and Hargrove (2009) report that taking nitrogen credits for leguminous cover crops is a matter of a producer's risk tolerance. They reported that risk-neutral producers using hairy vetch as a cover crop applied 50 pounds of nitrogen per acre for the succeeding crop. Risk averse producers preferred to add no supplemental nitrogen when using hairy vetch. Lu et al. (2003:25) conducted an economic analysis of sustainable cropping systems and found that the "highest gross margins were attained by a cover crop-based system with zero nitrogen inputs". Terminating the cover crop 15 to 30 days prior to planting of the main crop is a risk management strategy for ensuring ample nutrient availability to the germinating seed and developing seedling. Balkcom et al. (in Clark, 2007) recommend cover crop termination 2-3 weeks prior to planting to allow the cover crop to desiccate sufficiently to facilitate either tillage or planting operations.

Cover crops can reduce the amount of moisture in the soil available to the main crop in years when seasonal moisture is limiting. In most parts of Missouri, this is not generally an issue. However, in Kansas it can be an issue. There are always trade-offs in using cover crops. While cover crops may remove much needed moisture, the crop residue provides a barrier to soil moisture loss under no till cropping systems. A study by Silva (2014) demonstrated that the cover crop species and termination method played a significant role in subsoil moisture depletion. She found that subsoil moisture content was lower over time for cereal grains compared to leguminous cover crops, and roller crimped terminated cover crops compared to mowed cover crops.

Lastly, there is evidence that some cover crops can release compounds that are alleopathic. This is a beneficial trait for weed suppression, but may have an impact on germinating corn and soybean seeds as well. Terminating the cover crop 2-3 weeks prior to main crop planting is a risk reduction strategy for alleopathic cover crop management (Balkcom et al., in Clark, 2007). However, one successful cover crop management strategy is to no-till plant the main crop and roller crimp the cover crop either immediately after main crop planting. The alleopathic risk to corn and soybean production appears to be limited and a may be factor of the degree of cover crop biomass present at time of termination.

### 2.9 Conclusion

Cover crops have many benefits (soil health, nutrient sequestration, and soil conservation) and some significant risks (termination, alleopathy, and biomass production). Grazing cover crops can be used as a means to rest permanent pasture in integrated livestock-crop farming operations. The literature showed resting permanent pasture to be beneficial to pasture health. Grazing cover crops can maintain the body condition scores of cattle during the winter period. As suggested by Hight (1968), maintaining cows on a higher plane of nutrition improves the calf crop and the number of calves weaned, while Greenwood and Café (2007) found that maintaining cows and calves on a high plane of nutrition resulted in faster growing calves that reached market weights faster than calves subjected to poor nutrition. Grazing cover crops can offer a high plane of nutrition and provide producers with the economic benefits described by Hight, and Greenwood and Café.

The risks of cover crop use are, for the most part, manageable. Weather is a risk factor to crop production regardless of the presence of a cover crop or not. Alleopathic properties of certain cover crop species can be managed by managing cover crop termination-planting intervals.

The objective of the literature review was to establish a logical, fact-based prospective for the research. The focus of the literature was broad, encompassing many aspects of cover crop production and considerations when contemplating grazing cover crops. The framework established in the literature review is built upon in the Methodology (Chapter 3).

# CHAPTER III: METHODOLOGY

This chapter presents the rationale for performing this study through the presentation of appropriate cost data used to determine the baseline costs for grazing a cover crop grown among corn stover. It presents the rationale for using each of these cost factors to develop baseline costs for each of the four scenarios. The four scenarios used in the study are presented and discussed in detail. Lastly, the chapter discusses sources of the data so that potential users of the outcomes of the study can adjust the cost factors to meet local and temporal prices.

The economics of using cover crops for winter grazing of cattle was determined from secondary data sources. The data was collected on costs of fencing, providing water, managing the cattle, transportation, and interest on capital. An enterprise budgeting approach was taken to assess the economic value of grazing cover crops. The rationale for this was to create a tool to enable users to update pricing data to provide an aid for real-time decision making.

## 3.1 Scenarios Used for Developing Budgets

### *3.1.1 Rationale for Scenarios*

The four scenarios used in this research were selected to represent the most likely situations in which grazing cover crops might be considered and provide a control scenario for comparison. The control is a scenario in which the producer owns the cattle and maintains them for the winter period on permanent pasture by feeding hay and supplement. The cost/benefit for the traditional method of maintaining cattle through the winter provides a baseline to compare the cost/benefit of the other three scenarios. Each scenario is explained in the following subparagraphs.

*3.1.2 Integrated Enterprise with Owned Livestock and Cover Crops on Crop Fields*

The operator owned both the cropland and cattle. The operator managed a 50 cow cow-calf operation and calves in the spring. Calves were weaned in September at an average weight of 450 pounds. Moving cattle to cover crop fields made use of corn stover and cover crop for winter grazing while resting permanent pastures. Fencing was purchased. Water tanks were assumed to be on-hand. Rotational grazing was used. Steers (20 and 31, respectively) and open/cull cows (3) grazed the cover crops for either 90 or 120 days. Steers and cull cows were sold at the time of removal from the cover crop. Pregnant cows either remained on permanent pasture or grazed another cover crop field and were not considered in the budget calculations.

*3.1.3 Cropping Enterprise with Cover Crops on Crop Fields with Livestock Purchased*

The operator owned the cropland, but had no integrated livestock enterprise. Cattle were purchased specifically to graze corn stover and cover crops and were sold at 90 or 120 days. November purchased steers were sold in February (90 days) or held to March (120 days). December purchased cattle were sold in March. Fencing and watering supplies were purchased and each was assessed to have a five-year life. Steers were purchased at a distance of 100 miles and shipped to the farm. Cattle were purchased at weights between 300 and 500 lbs.

*3.1.4 Cropping Enterprise with Cover Crops on Crop Fields with Grazing Lease*

The crop operator sowed the cover crop, fenced the field and provided livestock services to a lessee granted grazing rights. Grazing period was 15 November to either 15 February or 15 March. The land owner was paid a management fee of $0.875 per head per month. Smith (2017) states that leasing per head per month is the most common way of leasing cover crop grazing fields.

### *3.1.5 Integrated Enterprise with or without Cover Crops, Hay Fed to Supplement Available Permanent Pasture*

In this scenario, no cover crop was grazed. The operator maintained a 50 cow cow-calf operation on permanent pasture and cropped 100 acres of corn. Pasturage was supplemented with good quality hay for 90 or 120 days. The operator calves in the spring. All 50 offspring were fall weaned at 450 pounds and all are steers. Costs of carrying cows through the winter on pasture and supplemental good quality hay and concentrate were not considered in the analysis. For comparison to the other scenario results, only 31 steers were used in the 90-day analysis and 25 in the 120-day analysis. Also included were three cows. The average daily gain (ADG) used in the analysis for this group of animals was fixed at one pound per day regardless of the ADG used in the analysis of the other scenario groups. The expected gain of cattle overwintered on hay with concentrate was discussed with a colleague who is a cattle producer. This colleague confirmed the author's assessment that one pound of gain per day was reasonable to assume (Shanks, 2017: personal communication). An opportunity cost of $1781.25 per hundred acres was assessed for the value of corn stover not sold or fed to reduce the cost of feeding hay.

## 3.2 Model Assumptions and Budgeting

For purposes of this study, the costs of establishing and terminating the cover crop were allocated to the cropping operation and not included in the cost/benefit analysis of grazing cover crops. The justification for this assumption is grazing the cover crop is a value-added opportunity. Many producers establish cover crops and do not offer them for grazing. Unless grazed, the entire cost of establishing and terminating the cover crop is allocated to the cropping operation. Individual producers may elect to allocate a portion of their costs of establishing a cover crop to the cover crop grazing enterprise costs.

Cattle prices (Tables 3.2a and b) were obtained from historical cattle prices by averaging the historical monthly prices for each month in a five month period beginning November 1992 and ending March 2011 (Schulz, 2016; McKinley and Griffith, 2012). Pricing data for 2016/17 was obtained from monthly reports published in Progressive Cattleman (Anonymous, 2016).

Steer weights used to establish price averages for this study ranged from 300 lbs. to 800 lbs. Cow weights were set at 1000 lbs. at purchase/start and 1100 pounds at sell/end. Because body condition scores of the cows were unknown, it was assumed that the average cattle would be likely to gain approximately 1 pound per day. The analysis included prices for cattle purchased at 300 to 500 lbs. and sold at 390 to 800 lbs. based on historical average cattle prices between 1992 and 2011, and 2016/2017 cattle prices at Joplin Regional Stockyards (MO) reported in the November through March issues of Progressive Cattleman. Reported price ranges were averaged (Anonymous, 2016). Two sets of price data were used as a means of determining if long-term historical average prices or recent average prices were better able to represent expected net returns. When the study began, cattle prices were at historically high levels. Omitting the prices in the years of historically high prices was thought to provide a more accurate reflection of the historical average prices. As the study progressed, cattle prices have receded from their apex to more "normal" price levels. The 2016/2017 price data was available for cattle sales at a stockyard within the study region; a benefit not available from the sources of the long-term average price data.

Rate of gain in pounds per day can have an influence on the profitability of any livestock operation. The rate of gain over time is referred to as the average daily gain (ADG). For scenarios one and two, five rates of ADG were used to vary the sell weights of the cattle. The ADG rates used in this study for scenarios one and two are: 1.5, 1.75, 2.0, 2.25, and 2.5 lbs. per day. The ADG rate used for scenario four is 1.0 lbs. per day (Shanks, 2017). The total gain for each ADG rate and grazing duration is shown in Table 3.1.

**Table 3.1. Average Daily Gain and Total Gain by ADG Rate and Grazing Period Duration.**

| Average Daily Gain Rate | Total Gain By Grazing Period Duration | |
|---|---|---|
| Lbs./day | 90 Day Gain | 120 Day Gain |
| 1 | 90 | 120 |
| 1.5 | 135 | 180 |
| 1.75 | 157.5 | 210 |
| 2 | 180 | 240 |
| 2.25 | 202.5 | 270 |
| 2.5 | 225 | 300 |

Grazing management of the cover crops was based on a management intensive grazing (MIG) strategy where cattle were moved to new forage every 2-4 days. A MIG strategy was selected to minimize compaction, maximize forage quality available to the animals, and to allow for potential regrowth of the cover crop after grazing. Selecting a MIG strategy added to the costs of fencing and management.

Fencing costs (Table 3.2) were based on purchasing high-tensile wire for the perimeter fence, polywire for interior cross fencing and a solar charger capable of energizing five miles of fence. Fence post requirements were based on a design of installing steel t-posts every 100 linear feet and plastic step-in posts every 10 linear feet.

Pricing data was obtained from prices at MFA Cooperatives and Tractor Supply Company. Corner braces/tensioners consist of waste concrete blocks and priced locally.

Watering cost factors (such as water tanks) (Table 3.4) were obtained from one or more internet sources and represent costs at the time budgets were developed. Water consumption rates were based on 10 gal/day for dry cows and 8 gal/day for steers (Pfost et al., 2007).

Both fencing and watering materials were assumed to have a five year life. A 15% annual replacement rate for fencing materials was included in the cost budget to cover replacement of fencing materials due to breakage and loss. Fence mending supplies were included in the miscellaneous line item for fencing.

The field size used in this study for all scenarios was set at 100 acres. This size field was selected to enable the best fit of the number of cow and steers to the field. Because of variability of corn stover and cover crop biomass production coupled with a lack of published information on calculating stocking rates for corn stover, a conservative approach was taken to setting initial stocking rates. The stocking rate for the 90 day grazing period was 34 animals (three cows and 31 steers); stocking rate for the 120 day grazing period was 28 animals (three cows and 25 steers) (Redfearn and Bidwell, undated; Stalker et al., 2015; Minyard, 1975). Adding the cows to the scenario was based on the author's observations of steer behavior with and without cows present during the conduct of a 2012-2014 NRCS funded demonstration project. Without cows in the grazing mix, steers tended to be easily agitated and not respect the electric hot wire dividing grazing paddocks. With cows, the steers tended to remain calmer and respected the hot wire better.

Daily water requirements were determined using a NRC table cited by Rasby and Walz (2011) using an average temperature of 60ºF. Cows require 8.0 gal/day and steers require 9 gal/day (assumes a 600 lb. steer). Two 700 gallon stock tanks were purchased at a cost of $270 each[1] to provide sufficient water storage capacity for a minimum of two days. Two tanks were purchased so that one tank could be placed in the paddock of the field currently being grazed, the other in the next paddock scheduled for grazing. This was done so that cattle could be moved without concern for the need to move the water tank simultaneously with the animal move.

## 3.3 Data Specifics

### *3.3.1 Cattle Prices*

Three primary sources were used to determine cattle prices used in the analysis. The 1992-2011 average cattle pricing information used to generate the average cattle prices for this period came from an Iowa State University publication, Ag Decision Maker (Schulz, 2016) and a University of Tennessee Extension publication, Seasonal Prices for Tennessee Feeder Cattle and Cows (McKinley and Griffith, 2012). The average prices were calculated using the average price data for each month of interest (November through March), summing the average prices within each month and weight class across the years, and determining the average of the historical prices. The 1991-2011 range was selected for two primary reasons: the long-term data was available, and the data avoided the 2012-2014 period when cattle prices were exceptionally high. The author believed that the 2012-2014 price averages might skew the long-term average prices. These averages are shown in

[1] Price based on January 2017 price advertised by MFA cooperative in Missouri.

**Table 3.2 Historical Average Cattle Prices (1992-2011) per CWT by Type and Weight Class**

| | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|
| **Cow** | 43.60 | 44.49 | 46.19 | 48.59 | 49.83 |
| **Steer** | | | | | |
| **300-400 lb** | 106.07 | 109.2 | 110.38 | 114.19 | 115.8 |
| **400-500 lb** | 95.38 | 97.48 | 99.32 | 103.60 | 105.79 |
| **500-600 lb** | 104.08 | 104.86 | 106.16 | 109.88 | 113.01 |
| **600-700 lb** | 120 | 161 | | | 139 |
| **700-800 lb** | 96.15 | 96.22 | 94.02 | 93.61 | 93.70 |

*** Prices represent average prices per CWT from 1992 to 2011**

Sources: Schulz, 2016; McKinley and Griffith, 2012

The 2015-2017 pricing information came from Progressive Cattleman's Market Watch (Anonymous, 2017). The Market Watch reports weekly sale price ranges for 23 livestock markets throughout the country. For purposes of this analysis the pricing data for the Joplin Regional Stockyard was used. Two prices were generally reported for each weight class, a high and low price. High and low prices were averaged to obtain the prices shown in Table 3.3.

**Table 3.3 Average Cattle Prices (2016/17) per CWT by Type and Weight Class at Joplin Regional Stockyard**

| | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|
| **Cow** | 55.00 | 55.00 | 59.00 | 65.00 | 60.50 |
| **Steer** | | | | | |
| **300-400 lb** | 154.00 | 178.50 | 163.50 | 150.00 | 180.00 |
| **400-500 lb** | 145.50 | 157.50 | 164.50 | 165.50 | 168.00 |
| **500-600 lb** | 132.00 | 138.50 | 152.00 | 152.00 | 156.50 |
| **600-700 lb** | 120.50 | 124.50 | 137.00 | 138.50 | 139.00 |
| **700-800 lb** | 120.00 | 123.50 | 132.50 | 128.50 | 128.50 |
| **800+** | 116.00 | 126.50 | 129.50 | 123.50 | 121.00 |

* Progressive Cattlemen - Prices for Joplin Regional Stockyard, Nov 2016 to March 2017

### *3.3.2 Land Lease Price and Fees*

The rental value of crop residue ground is presented in Table 3.3. Rental value was determined using the average rental price per acre obtained from the Kansas State University publication *2015 Leasing Arrangements Survey* (Wick, 2016). The data was obtained from five counties in the Post Rock Extension District in North Central Kansas. Rental prices ranged from $5-$25/acre for crop residue, with the five county average established to be $9/acre. The cost factor used in the budget was $9/acre or $900 per 100 acre field.

The management fee for the landowner providing services to the crop residue renter (fencing, water, and daily chore management) was derived from information provided in an article in the April 2016 edition of "The Progressive Farmer". The article discussed renting corn acres for grazing in Nebraska. Corn residue ground was leased on per acre basis with a per head per day management fee. The article reported management fees ranging from $0.50 to $1.25 per head per day (Sorensen, 2016). The budget used the average of this range, $0.875/head/day. An opportunity cost of 85% of the daily per head management fee was assessed to account for costs associated with labor, fuel, and miscellaneous expenses associated with providing the service.

**Table 3.4 Land Lease Income (Cost) and Management Fees**

| | | Unit Cost | Quantity | Total Cost |
|---|---|---|---|---|
| Crop Residue/Acre | $ | 9.00 | 100 | $900.00 |
| Livestock Mgmt Fee | $ | 0.875 | 34 head | $2677.50 |
| (per head/day) | $ | 0.875 | 28 head | $2940.00 |

*3.3.3 Watering Costs*

Costs of watering material were obtained from a local farm supplier retail outlet (MFA Cooperative) and various online sources. The prices represent competitive prices for the water tanks and other supplies at the time they were obtained (January 2017) and are displayed in Table 3.5.

Costs of hauling water were based on a haul distance of five miles each way and a labor estimate of 1.5 hours of labor per trip (Borman and Bedell, 2008). Iowa and Missouri sources estimated the cost of hauling water one mile is $0.01 per gallon (Pfost et al., 2007 and Wells, 1995). Two 700 gallon water tanks were selected to minimize the number of refill trips. Water consumption was determined to be 278 gallons per day for 31 steers and 3 cows, and 230 gallons per day for 25 steers and 3 cows (Pfost et al., 2007). It was assumed that each water tank was filled to 650 gallons and refilled with 100 gallons of water remaining in the tank. Each tank provided approximately 2.5 days of water between refills. Water hauling costs were not included in the calculations for Scenario 4. It was assumed that there was an existing watering system.

**Table 3.5 Watering Material and Labor Costs per 100 Acre Field**

| Item | Unit Cost | Quantity | Total Cost | Annual Cost |
|---|---|---|---|---|
| Stock Tanks, 700 gal | $ 325.00 | 2 | $ 650.00 | $216.67 |
| Water Tank, 1500 gal | $ 2,500.00 | 1 | $2,500.00 | $833.33 |
| Misc Supplies | $ 150.00 | 1 | $ 150.00 | $ 50.00 |
| Labor | $ 12.00 | 12 | $ 432.00 | $144.00 |
| **Total Watering Material and Labor Costs** | | | $3,732.00 | **$1,244.00** |

### *3.3.4 Fencing Costs*

The fencing system design used to establish fencing costs was based on a design the author was familiar with from a 2012-2014 NRCS funded cover crop grazing demonstration project on which the author was the project director. For this analysis, the perimeter fence was a single strand of high tensile wire supported by step in posts every 10 linear feet and a steel t-post every 100 linear feet. Tension on the fence in corners was provided by large concrete blocks (each block is 2 ft high by 2 ft deep by 6 ft long and weighing between 2000 and 4000 lbs., source: www.modernconcreteproducts.com). Blocks were set behind the corner posts and tied to the posts with wire. Gates were constructed from electrified gate handles. Interior fences were polywire supported similarly to the perimeter fencing. Wire reels were used to facilitate rolling the polywire and moving it to a new location. Three polywire reels with approximately 2100 feet of wire per reel were used to enable cattle to be moved from an existing paddock into a new paddock. A solar charger was used to electrify the perimeter and interior fencing. Grounding rods and a battery for the fence charger were included in the cost estimate. Erecting and removing the fence was estimated to take 32 hours of labor at $12 per hour. The summary of the costs allocated to fencing are presented in Table 3.6.

**Table 3.6 Fencing Costs per 100 Acre Field**

| Item | Unit Cost | Quantity Req'd | Cost/100 A | Annual Costs* |
|---|---|---|---|---|
| Steel T- Posts | $ 3.69 | 265 | $ 977.85 | $ 325.95 |
| Step-In Posts | $ 2.00 | 3776 | $ 7,552.00 | $ 2,517.33 |
| High Tensile Wire | $ 110.00 | 7 | $ 770.00 | $ 256.67 |
| Poly Wire | $ 29.00 | 3 | $ 87.00 | $ 29.00 |
| Misc Hardware | $350.00 | 1 | $ 350.00 | $ 116.67 |
| Concrete Blocks | $ 50.00 | 4 | $ 200.00 | $ 66.67 |
| Grounding Rods | $ 18.00 | 3 | $ 54.00 | $ 18.00 |
| Fence Charger (Solar) | $ 650.00 | 1 | $ 650.00 | $ 216.67 |
| Battery | $ 100.00 | 1 | $ 100.00 | $ 33.33 |
| Wire Reels | $ 81.00 | 3 | $ 243.00 | $ 81.00 |
| Labor | $ 12.00 | 32 | $ 384.00 | $ 384.00 |
| **Total Fencing Costs** | | | $11,367.85 | **$ 4,045.28** |

Material costs amortized over three-year period

### *3.3.5 Hay Feeding Costs*

For ease of calculation, it was assumed that all hay fed was purchased and that the hay purchased was of good quality. Another assumption was that the cost of hay fed per day would be constant ($1.64) without regard to steer weight. Cost of feed per day per cow was determined from a Missouri Extension publication (Carpenter, 2014) and it includes the cost of 2.3 lbs. of supplement added to the ration. It was also assumed that supplement consumption by steers would equal that of cows. These costs are displayed in Table 3.7.

**Table 3.7 Hay Feeding Costs**

| | |
|---|---|
| Hay/ton (Good Quality) | $95.00 |
| Hay Cost/Day/Cow | $1.64 |
| 90 Days | $5,018.40 |
| 120 Days | $5,510.40 |

### *3.3.6. Miscellaneous Costs*

Rental of a portable corral was included as a miscellaneous cost. Often these corrals are available for rent from the local cooperative or cattlemen’s association. The analysis uses a fee of $100 per use, with two uses per season. Not included in the costs used in the analysis was a portable weighing chute or livestock scale. However, a scale could be rented or purchased for use in managing the sale of grazing cattle. Portable livestock scales for purchase cost in the vicinity of $1000 for models that can be placed in the bottom of a squeeze chute.

### *3.3.7 Corn Stover Value*

An acre of corn produces about 4,800 lbs. or 2.4 tons of stover. Edwards (2014b) estimated the value of corn stover at $72/ton or $172.80/acre. He further estimated that each acre of corn stover could replace 25 pounds of hay per day and gave this a value of $18.75/acre based on hay costing $95 per ton. Thus, the value of corn stover from a 100 acre corn field is $1781.25 and it replaces 25,000 pounds of hay over a 100-day period. The amount of hay replaced equates to 25 1,000 lb round bales that do not need to be produced or bought, stored, and moved. Carpenter and Schmitz (2014) estimated the average cost for good quality hay was $95/ton. At $47.50 per bale ($95/ton) to purchase, grazing corn stover can reduce hay costs $5,937.50 per year. For analysis of scenario 4, it is assumed that good quality hay was available on the farm and was assigned an opportunity cost of $47.50 per bale.

### *3.3.8 Transportation Costs*

The cost of transporting livestock was included in cost estimates. Transportation costs were determined for each scenario and each starting and ending weight using a freight calculator (The Cattle Range, 2017). Mileage to the field was dependent upon the scenario. For scenario 1, the assumption was that cattle were moved 10 miles from their home pasture to the field. Scenario 2 assumed that the cattle were purchased 100 miles from the field and trucked in. No transportation costs to the field were assessed for scenarios 3 and 4, since in scenario 3 the lessee had the responsibility for transportation and in scenario 4, no cattle were moved to the field. Transportation off of the farm or field was assumed to be 25 miles to the sale facility. This outbound charge was assessed in scenarios 1, 2, and 4, but not for scenario 3 (lessee's responsibility). The transportation charges are presented in Table 3.8.

**Table 3.8 Transportation Costs by Scenario and Number of Animals Into and Out of Cover Crop Grazing Field**

| Scenario | # Head | In | | | Out | | | |
|---|---|---|---|---|---|---|---|---|
| | | 300 lb. | 400 lb. | 500 lb. | 500 lb. | 600 lb. | 700 lb. | 800 lb. |
| 1 | 31 | $1.05 | $1.05 | $1.05 | $2.62 | $2.62 | $2.62 | $2.62 |
| | 25 | $1.30 | $1.30 | $1.30 | $3.25 | $3.25 | $3.25 | $3.25 |
| 2 | 31 | $10.48 | $10.48 | $10.48 | $2.62 | $2.62 | $2.62 | $2.62 |
| | 25 | $13.00 | $13.00 | $13.00 | $3.25 | $3.25 | $3.25 | $3.25 |
| 3 | 31 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| | 25 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| 4 | 31 | $0.00 | $0.00 | $0.00 | $2.62 | $2.62 | $2.62 | $2.62 |
| | 25 | $0.00 | $0.00 | $0.00 | $3.25 | $3.25 | $3.25 | $3.25 |

Source: The Cattle Range, Freight Calculator accessed 18 July 2017 at http://www.cattlerange.com/Tradin-tools/Freight-Calculator/Freight-Calculator.htm
Transport Distances In: Scenario 1, 10 miles; Scenario 2, 100 miles; Scenarios 3 and 4, 0 miles.
Transport Distances Out: Scenarios 1,2, & 4, 25 miles; Scenario 3, 0 miles.

### *3.3.9 Economic Opportunity Costs*

Economic or opportunity costs were included in the cost calculations. Land lease income foregone was included as costs for scenarios 1, 2, and 4. The land lease cost factor used was $9.00 per acre or $900 for a 100-acre field. Operating interest was charged against the cost of purchasing cattle in scenario 2, and for not selling in scenarios 1 and 4. The interest rate used was 2.875% per annum. The rate was obtained from the USDA FSA website (2017) and was for operating loans. The cost of not selling corn stover ($172.80/acre) was assessed for all scenarios.

### 3.4 Conclusion

This chapter has presented the rationale and data used in the development of enterprise budgets used in the economic analysis of grazing cover crops in corn stover.

# CHAPTER IV: RESULTS

This chapter presents the results of the analysis of the enterprise budgets developed to determine the economic value of grazing cover crops and corn stover by cattle. The initial analytical outcomes are discussed. The initial stocking rates were determined to be too low to support a profitable enterprise with a positive net return regardless of average daily gains, grazing duration, or month in which the start prices were determined. A secondary analysis was performed on scenarios one and two using three stocking rates. The results of the secondary analysis are also reported and discussed in this chapter.

The chapter begins with a brief review of each of the scenarios and a short discussion of the outcomes for each scenario. Then the results of the initial analysis are discussed, followed by the results of the secondary analysis.

## 4.1 Scenario Review

There were four scenarios used in this study. The scenarios had grazing durations of either 90 or 120 days. Cattle start weights were established as 1000 lbs., with end weights established as 1100 lbs. Steer start weights ranged from 300 to 500 lbs., with end weights ranging from 390 to 800 lbs. End weights were dependent upon ADG and grazing duration. Since the ADG of the scenario four was fixed at 1.0 lb/day, the weight gains for this scenario were held constant within a starting weight category. Scenario three was fee-based and independent of cattle prices. For scenario three to have a positive net return, the fees collected for leasing the land and providing management services had to be greater than the cost of providing the services and the value of harvesting the corn stover in bales for sale to cattle producers.

### 4.2 Initial Results

The results of the initial analysis using either 34 animals or 28 animals in the cover crop grazing scenarios or feeding hay and concentrate in scenario four all produced negative net returns regardless of grazing duration, start month, or average daily gains. One exception occurred in scenario four where a positive net return of $375 was realized when 500 lb. steers were grazed for 120 days with a November start month using the historical average prices. Net returns for scenario 4 were negative when the 2016/2017 average prices were used, although the net returns tended to be less negative than when the historical average prices were used (Table 4.1). Representative net returns for scenarios one, two and four are displayed in Appendix A.

Scenario three had costs of $15,626.30 for 90 days of leased grazing and providing management services and costs of $17,630.28 for 120 days of leased grazing and providing management services. The respective incomes based on leasing the 100 acre field for $900 and providing management services at the rate of $0.875/hd/day were calculated to be $3,577 and $3,840. The management services fee was assessed a cost of 90% of the fee ($2276 and $2499 for the 90 and 120 day grazing periods, respectively). The costs assessed against the management fee was for labor, and fuel and depreciation for the vehicle used to perform the management task. The negative net return for this enterprise was determined to be ($12,048.81) and ($13,790.28) for the 90 day and 120 day lease periods, respectively.

If management services were eliminated or reduced, the net returns from scenario three would change. If no management services were provided, only the $900 in land rent would be income. The value of the corn stover is $172.80/acre, so simply leasing the land at $9/acre would result in a negative net return of $163.80/acre. If the management service did not include providing the fencing or water transport, the reduction in costs would improve the net returns for scenario 3. The risk of not providing some level of management service is the risk of not finding a lessee willing to lease the land in a non-competitive environment.

### 4.3 Discussion of Initial Results

Reflecting upon the initial results, two factors appear to be most responsible for the net negative returns observed. The first factor was the cost. The major cost drivers of scenarios one, two, and three, other than the value of livestock, are fencing and water hauling. Reviewing the results in Appendix A suggests that a reduction in the cost factors for fencing and/or water hauling might result in positive net returns under some situations. Reducing the same costs may also contribute to the net returns in scenario three becoming less negative. Given the assumptions used in the analysis, that the fencing was bought new and no water source was closer than 10 miles, cost reductions would need to be based on individual producer situations.

The other factor that appears to be influencing the net returns is the stocking rates. As stated in Chapter 3, a conservative approach was taken to stocking rates. The literature varied greatly on stocking rates (Ward, 1978; Drewnoski et al., 2016). Without knowing the biomass of the stover and cover crops available, a conservative approach to stocking rates seemed like a reasonable starting point for the analysis. Fencing costs are not impacted by stocking rate, assuming that the perimeter of the field must be fenced. If smaller areas of the field's perimeter were fenced and the perimeter fence moved, the cost saving would likely be minimal when labor costs to move the fencing are considered. Even transportation costs are not greatly increased when stocking rate increases. Watering costs and some costs associated with moving animals to a new paddock are variable costs that are stocking rate dependent. Thus, increasing stocking rates may provide a positive net return for the cover crop in corn stover grazing enterprise for scenarios one, two, and three.

**Table 4.1 Net Returns for Scenario 4 Using Average Historical and 2016/2017 Prices.**

| Start Weight (lbs.) | Start Month/Duration | Ave. Hist. Price Net Return | 2016/2017 Average Price Net Return |
|---|---|---|---|
| 500 | November/90 days | (4673) | (967) |
| | November 120 days | 375 | (1154) |
| | December 90 days | (4221) | (1307) |
| 400 | November/90 days | (4698) | (1193) |
| | November 120 days | (7302) | (2498) |
| | December 90 days | (4625) | (2460 |
| 300 | November/90 days | (4652) | (4451) |
| | November 120 days | (11314) | (2131) |
| | December 90 days | (4748) | (3267) |

### 4.4 Analysis of Higher Stocking Rates

After analyzing the outcomes of the initial analysis, a secondary analysis was designed to determine if increase stocking rates would provide a positive net return for the enterprise. Scenarios one, two, and three were included in the secondary analysis. This analysis had three outcomes: the effect of increasing stocking rates on the net returns for scenarios one and two; the effect of increasing stocking rates on the net return for scenario three; and determining a breakeven management fee for scenario three.

Three stocking rates were selected: 50, 75, and 100 steers per 100 acre field. Average daily gains were either 2.5 or 2.0 lbs. Start months were either November or December, with 90 day or 120 day grazing periods for the November start dates, and a 90 day grazing period for the December start date. Animal start weights were either 400 or 500 lbs. No cows were included in this analysis. Only the 2016/2017 pricing data was used in this analysis.

#### *4.4.1 Effect of Increasing Stocking Rates on Net Returns for Scenarios 1 and 2*

The results of the effect of increasing the stocking rates on net returns for scenarios one and two are displayed in table 4.2. The results will be discussed by scenario, start month and start weight.

##### *4.4.1.1 Scenario 1*

The net returns for a 90 day grazing period were positive for 75 and 100, 400-pound steers with a November start month. Net returns from 500 pound steers starting at the same time were positive at an ADG of 2.0 with 75 animals and stayed positive with 100 animals, regardless of ADG. Net returns from the 120 day grazing period were more sensitive to ADG effects on sale prices. The 400 pound steers showed net negative returns with the exception of 100 animals starting in November and gaining 2.5 pounds per day, whereas, the 500 pound steer group showed positive net returns in all but one situation, 75 animals gaining 2 pounds per day. The December 90 day group of animals only produced positive net returns when 100 steers were gaining two pounds per day regardless of start month.

#### *4.4.1.2 Scenario 2*

The net returns for the 90 day group started in November were negative when only 50 animals were in the group. With 75 animals, the 400 pound steers produced a positive net return at both ADG's rates, whereas the 500 pound steers only showed a positive net return at 2.0 lbs. ADG. Increasing the stocking rate to 100 animals resulted in positive net returns for both weight groups at each of the ADG rates. For the animals started in December, only the 100 animals with an ADG rate of 2.0 lbs./day produced a positive net return.

#### *4.4.1.3. Discussion of Scenarios 1 and 2*

The results of the effects of increasing stocking rates show that there is an interaction between stocking rate, rate of average daily gain, and start month. Increasing stocking rate generally led to higher net returns. When looking at the net returns displayed in table 4.2, it becomes evident that controlling cost factors may lead to more positive net returns for the enterprise.

There is also an interaction between rate of grazing duration, ADG and sale price. Having a fixed grazing duration can work against net returns at higher ADG rates. As an animal moves into the next higher weight price category, the risk of a lower net return increases. Periodic weighing of animals when moving between paddocks might reduce the price risk by allowing producers to market animals before they move into the next weight price category. Weighing is a practice that can help producers determine the ADG rate at a particular time and allow them to set target dates for marketing animals. The cost of a portable livestock weighing system is between $1500 and $2500. Such a system would be of benefit to producers with higher cattle numbers and could also be useful in tracking animal performance over a period, determining correct dosages of vaccines, anthelmintics, and other medications, and other management decision support tasks.

**Table 4.2 Effects of Increasing Stocking Rates on Net Returns of Scenario 1 by Grazing Period, Start Month, and ADG, Using 2016/17 Cattle Prices**

| Net Returns by Start Weight, Grazing Period and ADG | | | | | |
|---|---|---|---|---|---|
| **NOV 90 Days** | | **Start Weight** | | | |
| **# Animals** | **ADG** | **400 lbs.** | | **500 lbs.** | |
| **50** | 2.5 | -2835.82 | | -3463.85 | |
| | 2 | | -2037.07 | | -2955.1 |
| **75** | 2.5 | 317.865 | | -706.15 | |
| | 2 | | 1515.85 | | 56.97 |
| **100** | 2.5 | 3389.45 | | 2133.38 | |
| | 2 | | 4986.95 | | 3150.88 |
| **NOV 120 Days** | | | | | |
| **50** | 2.5 | -3438.04 | | 1988.33 | |
| | 2 | | -6503.04 | | 1133.33 |
| **75** | 2.5 | -656.75 | | 625.75 | |
| | 2 | | -5254.25 | | -657.25 |
| **100** | 2.5 | 2206.56 | | 3916.56 | |
| | 2 | | -3923.44 | | 1911.88 |
| **DEC 90 Days** | | | | | |
| **50** | 2.5 | -5096.82 | | -5100.53 | |
| | 2 | | -3739.67 | | -4421.78 |
| **75** | 2.5 | -3073.77 | | -3161.17 | |
| | 2 | | -1906.74 | | -2143.05 |
| **100** | 2.5 | -4050.65 | | -1139.98 | |
| | 2 | | 2762.45 | | 217.52 |

**Table 4.3 Effects of Increasing Stocking Rates on Net Returns of Scenario 2 by Grazing Period, Start Month, and ADG, Using 2016/17 Cattle Prices**

| **NOV 90 Days** | | | | | |
|---|---|---|---|---|---|
| **# Animals** | **ADG** | **400 lbs** | | **500 lbs** | |
| **50** | 2.5 | -2835.82 | | -3758.45 | |
| | 2 | | -2337.60 | | -3249.7 |
| **75** | 2.5 | -58.7 | | -1000.75 | |
| | 2 | | 1139.42 | | -237.63 |
| **100** | 2.5 | 3094.84 | | 1838.78 | |
| | 2 | | 4986.95 | | 2856.83 |
| **NOV 120 Days** | | | | | |
| **50** | 2.5 | -3733.34 | | -6815.71 | |
| | 2 | | -6798.34 | | -7670.71 |
| **75** | 2.5 | -952.05 | | -5575.61 | |
| | 2 | | -5549.55 | | -6858.61 |
| **100** | 2.5 | 1911.26 | | -4253.49 | |
| | 2 | | -4218.74 | | -5963.49 |
| **DEC 90 Days** | | | | | |
| **50** | 2.5 | -5391.42 | | -6766.05 | |
| | 2 | | -3443.92 | | -6087.3 |
| **75** | 2.5 | -3450.21 | | -3455.77 | |
| | 2 | | -528.96 | | -2437.65 |
| **100** | 2.5 | -1427.16 | | -1434.58 | |
| | 2 | | 2467.84 | | -77.08 |

#### *4.4.1.4. Effect of Increasing Stocking Rates on Net Returns for Scenario 3*

Increasing stocking rates increased the income generated for scenario three as shown in Table 4.4, but net returns remained significantly negative. The greatest income occurred with 100 animals grazing for 120 days, but still resulted in a negative net return of ($6230.28). Therefore, if the landlord provides fencing, watering, and management services to a lessee, the daily management fee has to be greater than $0.875/hd/day to provide a net positive return to the landlord.

**Table 4.4 Effect of Increasing Stocking Rate on Income for Scenario 3 Using 2016/17 Prices**

| No. of Head | Grazing Duration Days | Income ($) |
|---|---|---|
| 50 | 90 | $ 4,837.50 |
| | 120 | $ 6,150.00 |
| 75 | 90 | $ 6,806.25 |
| | 120 | $ 8,775.00 |
| 100 | 90 | $ 8,775.00 |
| | 120 | $ 11,400.00 |

#### *4.4.1.5. Effect of Increasing Stocking Rates and Management Fees on Breakeven Net Returns for Scenario 3*

Sorensen (2016) reported stover grazing management fees ranged from $0.50 to $1.25 per head per day. The variability in fee prices suggests that there is variability in the management services provided for the fee. In this study the services provided included fencing, watering, and general oversight of herd well-being. Based on the costs for the services provided, a breakeven management fee was determined (Table 4.5) for each stocking density and grazing duration. The breakeven management fee was determined using the costs determined for the grazing period less the $900 land lease, divided by the number of grazing days (number of head times the number of days).

As stocking density and grazing duration increase, the per head cost of the management fee decreases. The management fees reported by Sorensen (2016) suggest that landlords may not be capturing all the costs associated with providing management services to fellow producers releasing their cropland to graze cattle on stover and cover crops. Maximizing stocking rates based on forage availability provides tangible benefits to both the landlord and the lessee. The lessee benefits from a reduction in per head cost in the landlord benefits from a lower per head cost that ensures a positive net return to the enterprise.

**Table 4.5 Management Fees (Per Head Per Day) Required for Breakeven Net Returns for Scenario 3 Using 2016/17 Prices**

| Head | 90 Days | 120 Days |
|---|---|---|
| 50 | $ 3.47 | $ 2.60 |
| 75 | $ 2.32 | $ 1.74 |
| 100 | $ 1.74 | $ 1.30 |

### 4.5 Conclusion

The chapter presented the results and discussion of the analytical outcomes. Based on the original stocking rates, none of the scenarios reliably produced positive net returns from cattle grazing corn stover with cover crops. A stocking rate analysis was undertaken to determine if increasing the stocking rates would result in a positive net return on more reliable basis. The revised stocking rates were set at 50, 75, and 100 animals per 100 acre field and 2.5 and 2.0 lbs./day ADG. The results of the revised analysis showed variability among the outcomes but trended towards more positive net returns with stocking rates of 75 or 100 animals in scenario 1. Positive net returns for scenario 2 were more limited, and found mostly at the 100 animal stocking rate. This suggests that purchasing animals for grazing cover crops may not be profitable at the cost levels used in this analysis. Grazing periods beginning in November tended to produce more positive net returns than those beginning in December.

The management fee structure for scenario three was examined as part of the secondary analysis. Increasing stocking rates alone failed to yield positive net returns when the corn stover and cover crop field was leased for grazing. Further analysis of the data produced breakeven fee amounts based on stocking rates and grazing duration. .

The Excel worksheets used in the analysis are submitted in the accompanying excel documents.

# CHAPTER V: CONCLUSION

This research study was undertaken to determine the economic value of grazing cover crops. The study established the costs associated with fencing around and providing water to a 100 acre corn field into which cover crops had been established for the purpose of providing grazing for cattle. Enterprise budgets were used to project costs and returns of for the cover crop grazing enterprise. Two grazing periods were used for this study, 90 and 120 days. Two starting months were used, November and December, to determine if the timing of grazing the cover crops provided a net return benefit. Four scenarios were used to assess the net returns under different conditions. The scenarios were: an integrated enterprise with owned livestock and cover crops on crop fields; a cropping enterprise with cover crops on crop fields with livestock purchased; cropping enterprise with cover crops on crop fields with grazing lease; and an integrated enterprise with or without cover crops, hay fed to supplement available permanent pasture. Opportunity costs were assessed for interest, land not being leased, and cattle not being sold at the starting month. Transportation costs were added where appropriate.

The results of the initial analysis based on conservative stocking rates failed to produce reliable positive net returns. The reasons for this failure were considered and determined to be largely due to insufficient stocking rate and costs associated with providing water for the animals. A stocking rate analysis was undertaken to determine if increasing stocking rates would increase net return. Stocking rates were set at 50, 75, and 100 steers per 100 acre field. Variable costs were adjusted to reflect the increased number of animals at each stocking rate. Positive net returns were achieved by increasing stocking rates with more reliable positive net returns occurring when the stocking rate was set at either 75 or 100 head. The negative net returns that were observed were much smaller than those observed in the initial analysis and it was concluded that additional positive net returns could be achieved through tighter cost controls. Scenario one had more positive net returns than scenario two, which suggests that owning the animals placed on the corn stover and cover crop field to graze is preferred over scenario two's approach of purchasing the cattle. Again, tighter controls over cost factors, specifically watering costs, might result in not only more positive net returns for scenario one, but also for scenario two.

Scenario three is likely the least risky approach to grazing corn stover and cover crops. By providing management services of purchasing and erecting fencing, and providing water for the animals, overhead costs to the landlord were higher than rental fees, making this enterprise option unprofitable based on the management fee collected for the services rendered. Increasing the stocking rates did not resolve the negative net return conditions observed in the original analysis. Therefore, in order for scenario three to have a positive net return either services must be decreased significantly or a higher management fee must be charged based on stocking rate and grazing duration. Breakeven management fees were determined based on the costs associated with providing the management services previously stated. The breakeven fees showed that management fees need to be based on costs of providing the services and the stocking rates; higher stocking rates resulted in a lower management fee per head.

Scenario four was not included in the secondary analysis because it was unrealistic to assume that by increasing stocking rates on a permanent pasture during a period of time of the year when supplemental forage and concentrate are provided would result in a positive net return. What was not considered as part of the analysis for scenario one was the intangible benefits to permanent pasture by removing grazing pressure from it for 3 to 4 months. The value to livestock operation of resting the permanent pastures is difficult to estimate because many variables contribute to forage production. In general, resting permanent pasture allows the grasses to increase root biomass and store carbohydrates as root reserves, while also promoting shoot growth and tillering.

The research question was to determine if using cattle to graze a crop field consisting of corn stover and supplemented with a winter cover crop was an economically viable enterprise. The results presented suggest that this enterprise can be economically viable under the right conditions. Cattle pricing should follow typical annual cycles so that spring pricing is reasonably predictable based on historical monthly market trends. Stocking rates must be high enough to offset the fixed and variable costs related to fencing and providing potable water for livestock to consume. Producers who are considering leasing their cropland for grazing purposes should establish management fees based on their fixed and variable costs of providing services for which the fee is charged. Locally published management fee rates may not provide sufficient income to produce a positive net return for the enterprise. Integrated operators who choose not to graze or lease their corn stover fields should consider selling the corn stover for use as cattle feed or baling the stover themselves to feed to their own livestock as a substitute for hay. This is in light of the fact that residue management is becoming a greater concern for corn producers as corn grain yields increase. Wilhelm et al. (2011:11) reported that for every ton per acre increase in corn grain yield, stover yield increases about 1700 lbs./acre. Stover management will increase in importance as average corn yields continue to climb. Depending on corn prices, the economic viability of grazing corn residues may be of secondary importance to maintaining the economic viability achieved by consistently high corn yields. As Drewnoski et al. (2016) demonstrated in a long-term study, grazing corn residue can improve subsequent soybean yields in a corn-soybean rotation. Removal of the residue through grazing activities may be the best option, both from an agronomic and economic standpoint, under the right conditions.

Producers who see economic value or agronomic value to grazing cover crops may invest in infrastructure to facilitate the grazing enterprise. Providing buried water lines to frost free watering points within the crop field may reduce overall watering costs, providing greater net returns from the grazing enterprise. Such infrastructure improvements would also likely make purchasing cattle (scenario two) for the purposes of grazing corn stover and cover crops more likely to produce positive net returns. Lastly, providing the infrastructure to water grazing animals would likely allow a landlord to be more competitive for securing a lessee to provide grazing animals to reduce residue on the crop field.

Finally, higher average daily gains may not always result in more net return. As shown in the secondary analysis, they were instances where animals gaining at 2 pounds per day had a positive net return or a higher positive net return than did the group of animals within the same weight class and grazing duration that were gaining at 2.5 pounds per day. The most likely explanation for this is weight category prices. A 500 lb. steer gaining 2 lbs. per day for 120 days gains a total of 240 lbs. If this same animal were to gain 2.5 lbs. per day it would gain 300 lbs. over the 120 day period. Cattle prices tend to be determined in weight range groups, for example 300-400 lbs. Each higher weight range group has a lower price per pound. Therefore, a 740 lb. steer will bring a higher per lb. price than an 800 lb. steer. Producers who want to maximize their net returns from the corn stover and cover crop grazing enterprise may wish to invest in a set of portable livestock scales so that they can periodically weigh the animals and make hold or sell decisions in the field based on individual animal weight gains and market pricing.

The results of this study suggest a need for more research on the economics of corn stover and cover crop grazing. Areas for additional research include: estimating available forage for corn stover and corn stover with cover crops; determining stocking rates to achieve breakeven returns; determining the stocking rate and forage quality interaction; managing gains through stocking rates; and developing a marketing plan based upon ADG and grazing duration.

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## APPENDIX A

**Representative net returns on 300# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using average historical prices**

| **Net Returns-NOV** | | 2.5ADG/300 Buy Wt | | |
|---|---|---|---|---|
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 19,486.51 | $25,619.04 | $ (6,132.52) |
| | 120 | $ 18,595.14 | $26,460.38 | $ (7,865.24) |
| Scenario 2 | 90 | $ 19,486.51 | $25,941.96 | $ (6,455.45) |
| | 120 | $ 18,595.14 | $29,396.27 | $ (10,801.13) |
| Scenario 4 | 90 | $ 14,128.71 | $19,666.19 | $ (5,537.48) |
| | 120 | $ 12,752.34 | $20,763.44 | $ (8,011.10) |
| **Net Returns-NOV** | | 2.25ADG/300 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 18,703.07 | $25,619.04 | $ (6,915.97) |
| | 120 | $ 17,747.60 | $26,460.38 | $ (8,712.77) |
| Scenario 2 | 90 | $ 18,703.07 | $25,941.96 | $ (7,238.90) |
| | 120 | $ 17,747.60 | $29,396.27 | $ (11,648.66) |
| Scenario 4 | 90 | $ 14,128.71 | $19,666.19 | $ (5,537.48) |
| | 120 | $ 12,752.34 | $20,763.44 | $ (8,011.10) |
| **Net Returns-NOV** | | 1.75ADG/300 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 16,280.48 | $25,619.04 | $ (9,338.56) |
| | 120 | $ 15,132.62 | $26,460.38 | $ (11,327.76) |
| Scenario 2 | 90 | $ 16,280.48 | $25,941.96 | $ (9,661.48) |

| | | | | |
|---|---|---|---|---|
| | 120 | $ 15,132.62 | $29,396.27 | $ (14,263.65) |
| Scenario 4 | 90 | $ 14,128.71 | $19,666.19 | $ (5,537.48) |
| | 120 | $ 13,509.92 | $20,763.44 | $ (7,253.52) |

**A2. Representative net returns on 400# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using average historical prices.**

| **Net Returns-NOV** | | 2.5ADG/400 Buy Wt | | |
|---|---|---|---|---|
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 22,892.81 | $27,574.50 | $ (4,681.69) |
| | 120 | $ 200,597.95 | $28,250.05 | $ 172,347.91 |
| Scenario 2 | 90 | $ 22,892.81 | $27,918.68 | $ (5,025.87) |
| Scenario 4 | 90 | $ 14,128.71 | $43,346.05 | $ (29,217.34) |
| | 120 | $ 12,752.34 | $22,424.02 | $ (9,671.68) |
| **Net Returns-DEC** | | 2.5ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 23,539.11 | $27,884.92 | $ (4,345.81) |
| Scenario 2 | 90 | $ 23,539.11 | $41,934.76 | $ (18,395.66) |
| Scenario 4 | 90 | $ 15,306.69 | $22,162.50 | $ (6,855.80) |
| **Net Returns-NOV** | | 2.25ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 22,109.36 | $27,574.50 | $ (5,465.14) |
| | 120 | $ 18,955.93 | $28,250.05 | $ (9,294.11) |
| Scenario 2 | 90 | $ 22,109.36 | $27,918.68 | $ (5,809.32) |
| | 120 | $ 18,955.93 | $31,056.85 | $ (12,100.92) |

| | | | | |
|---|---|---|---|---|
| Scenario 4 | 90 | $ 14,128.71 | $43,346.05 | $ (29,217.34) |
| | 120 | $ 12,752.34 | $22,424.02 | $ (9,671.68) |
| **Net Returns-DEC** | | 2.25ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 22,733.38 | $27,884.92 | $ (5,151.54) |
| Scenario 2 | 90 | $ 22,733.38 | $41,934.76 | $ (19,201.38) |
| Scenario 4 | 90 | $ 15,306.69 | $22,162.50 | $ (6,855.80) |

**A3. Representative net returns on 500# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using average historical prices.**

| | | | | |
|---|---|---|---|---|
| **Net Returns-NOV** | | 2.5ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 22,642.32 | $31,931.68 | $ (9,289.36) |
| | 120 | $ 20,384.39 | $30,946.28 | $ (10,561.89) |
| Scenario 2 | 90 | $ 22,642.32 | $32,254.61 | $ (9,612.29) |
| | 120 | $ 20,384.39 | $31,056.85 | $ (10,672.46) |
| Scenario 4 | 90 | $ 21,700.61 | $26,209.26 | $ (4,508.66) |
| | 120 | $ 23,189.39 | $26,770.26 | $ (3,580.87) |
| **Net Returns-DEC** | | 2.5ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 21,396.35 | $32,080.05 | $ (10,683.70) |
| | | | | |
| Scenario 2 | 90 | $ 21,396.35 | $46,129.89 | $ (24,733.54) |
| Scenario 4 | 90 | $ 21,741.53 | $26,357.63 | $ (4,616.10) |
| **Net Returns-NOV** | | 1.75ADG/500 Buy Wt | | |

| | Period | Total Receipts | Total Costs | Net Returns |
|---|---|---|---|---|
| Scenario 1 | 90 | $ 22,357.46 | $31,931.68 | $ (9,574.22) |
| | 120 | $ 18,276.14 | $30,946.28 | $ (12,670.14) |
| Scenario 2 | 90 | $ 22,357.46 | $32,254.61 | $ (9,897.14) |
| | 120 | $ 18,276.14 | $31,056.85 | $ (12,780.71) |
| Scenario 4 | 90 | $ 14,128.71 | $51,956.01 | $ (37,827.30) |
| | 120 | $ 12,752.34 | $26,770.26 | $ (14,017.92) |
| **Net Returns-DEC** | | 1.75ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 22,726.23 | $32,080.05 | $ (9,353.81) |
| | | | | |
| Scenario 2 | 90 | $ 22,726.23 | $46,129.89 | $ (23,403.66) |
| | | | | |
| Scenario 4 | 90 | $ 15,306.69 | $26,357.63 | $ (11,050.93) |
| | | | | |

**A4. Net returns on 300# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using 2016/2017 average prices at Joplin Regional Stockyards.**

| **Net Returns-NOV 16** | | 2.5ADG/300 Buy Wt | | |
|---|---|---|---|---|
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 29,080.13 | $30,453.02 | $ (1,372.90) |
| | 120 | $ 22,846.50 | $30,870.36 | $ (8,023.86) |
| Scenario 2 | 90 | $ 29,080.13 | $30,775.95 | $ (1,695.82) |
| | 120 | $ 22,846.50 | $31,201.10 | $ (8,354.60) |
| Scenario 4 | 90 | $ 20,280.00 | $24,730.61 | $ (4,450.61) |

| | | | | |
|---|---|---|---|---|
| | 120 | $ 19,636.50 | $23,888.80 | $ (4,252.30) |
| Net Returns- DEC 16 | | 2.5ADG/300 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 27,999.00 | $35,698.46 | $ (7,699.46) |
| Scenario 4 | 90 | $ 30,768.85 | $29,976.04 | $ 792.81 |
| | | | | |
| **Net Returns-NOV 16** | | 2.25ADG/300 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 27,900.11 | $30,453.02 | $ (2,552.91) |
| | 120 | $ 24,297.75 | $30,870.36 | $ (6,572.61) |
| Scenario 2 | 90 | $ 27,900.11 | $30,775.95 | $ (2,875.84) |
| | 120 | $ 24,297.75 | $31,201.10 | $ (6,903.35) |
| Scenario 4 | 90 | $ 20,280.00 | $24,730.61 | $ (4,450.61) |
| | 120 | $ 19,636.50 | $23,888.80 | $ (4,252.30) |
| **Net Returns- DEC 16** | | 2.25ADG/300 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 26,499.53 | $35,698.46 | $ (9,198.93) |
| | | | | |
| Scenario 2 | 90 | $ 26,499.53 | $35,609.38 | $ (9,109.85) |
| Scenario 4 | 90 | $ 30,768.85 | $29,976.04 | $ 792.81 |
| | | | | |

**A5. Representative net returns on 400# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using 2016/2017 average prices at Joplin Regional Stockyards.**

| | | | | |
|---|---|---|---|---|
| **Net Returns-NOV 16** | | 2.5ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |

| | | | | |
|---|---|---|---|---|
| Scenario 1 | 90 | $ 31,025.38 | $34,199.76 | $ (3,174.39) |
| | 120 | $ 26,196.50 | $34,262.56 | $ (8,066.06) |
| Scenario 2 | 90 | $ 31,025.38 | $34,522.69 | $ (3,497.31) |
| | 120 | $ 26,196.50 | $36,194.04 | $ (9,997.54) |
| Scenario 4 | 90 | $ 27,284.45 | $28,477.34 | $ (1,192.89) |
| | 120 | $ 22,341.50 | $29,485.93 | $ (7,144.43) |
| **Net Returns- DEC 16** | | 2.5ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 31,025.38 | $35,698.46 | $ (4,673.08) |
| | | | | |
| Scenario 2 | 90 | $ 31,025.38 | $35,609.38 | $ (4,584.00) |
| Scenario 4 | 90 | $ 30,768.85 | $29,976.04 | $ 792.81 |
| | | | | |

| | | | | |
|---|---|---|---|---|
| **Net Returns-NOV 16** | | 2.25ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 30,109.17 | $34,199.76 | $ (4,090.59) |
| | 120 | $ 26,732.75 | $34,262.56 | $ (7,529.81) |
| Scenario 2 | 90 | $ 30,109.17 | $34,522.69 | $ (4,413.52) |
| | 120 | $ 26,732.75 | $36,194.04 | $ (9,461.29) |
| Scenario 4 | 90 | $ 27,284.45 | $28,477.34 | $ (1,192.89) |
| | 120 | $ 22,341.50 | $29,485.93 | $ (7,144.43) |
| **Net Returns- DEC 16** | | 2.25ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 30,109.17 | $35,698.46 | $ (5,589.29) |

| | | | | |
|---|---|---|---|---|
| Scenario 2 | 90 | $ 30,109.17 | $35,609.38 | $ (5,500.21) |
| Scenario 4 | 90 | $ 30,768.85 | $29,976.04 | $ 792.81 |
| | | | | |
| **Net Returns-NOV 16** | | 2ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 31,340.80 | $34,199.76 | $ (2,858.96) |
| | 120 | $ 25,769.00 | $34,262.56 | $ (8,493.56) |
| Scenario 2 | 90 | $ 31,340.80 | $34,522.69 | $ (3,181.89) |
| | 120 | $ 25,769.00 | $36,194.04 | $ (10,425.04) |
| Scenario 4 | 90 | $ 27,284.45 | $28,477.34 | $ (1,192.89) |
| | 120 | $ 22,341.50 | $29,485.93 | $ (7,144.43) |
| **Net Returns- DEC 16** | | 2ADG/400 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 31,446.20 | $35,698.46 | $ (4,252.26) |
| | | | | |
| Scenario 2 | 90 | $ 31,446.20 | $35,609.38 | $ (4,163.18) |
| | | | | |
| Scenario 4 | 90 | $ 30,768.85 | $29,976.04 | $ 792.81 |
| | | | | |

**A6. Representative net returns on 500# steers and cows grazed on cover crops for 90 or 120 days at average daily gains (ADG) of between 1.0 and 2.5 pounds using 2016/2017 average prices at Joplin Regional Stockyards.**

| **Net Returns-NOV 16** | | 2.5ADG/500 Buy Wt | | |
|---|---|---|---|---|
| | Period | Total Receipts | Total Costs | Net Returns |

| | | | | |
|---|---|---|---|---|
| Scenario 1 | 90 | $ 31,025.38 | $36,635.14 | $ (5,609.77) |
| | 120 | $ 26,196.50 | $36,467.49 | $ (10,270.99) |
| Scenario 2 | 90 | $ 31,025.38 | $36,958.07 | $ (5,932.69) |
| | 120 | $ 26,196.50 | $36,798.23 | $ (10,601.73) |
| Scenario 4 | 90 | $ 29,945.80 | $30,912.72 | $ (966.92) |
| | 120 | $ 23,541.50 | $29,485.93 | $ (5,944.43) |
| **Net Returns-DEC 16** | | 2.5ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 37,318.38 | $37,649.88 | $ (331.51) |
| | | | | |
| Scenario 2 | 90 | $ 37,318.38 | $37,560.80 | $ (242.43) |
| | | | | |
| Scenario 4 | 90 | $ 30,768.85 | $31,927.46 | $ (1,158.61) |
| | | | | |
| **Net Returns-NOV 16** | | 2.25ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 30,109.17 | $36,635.14 | $ (6,525.97) |
| | 120 | $ 26,732.75 | $36,467.49 | $ (9,734.74) |
| Scenario 2 | 90 | $ 30,109.17 | $36,958.07 | $ (6,848.90) |
| | 120 | $ 26,732.75 | $36,798.23 | $ (10,065.48) |
| Scenario 4 | 90 | $ 29,945.80 | $30,912.72 | $ (966.92) |
| | 120 | $ 23,541.50 | $29,485.93 | $ (5,944.43) |
| **Net Returns-DEC 16** | | 2.25ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 36,202.53 | $37,649.88 | $ (1,447.35) |
| | | | | |

| | | | | |
|---|---|---|---|---|
| Scenario 2 | 90 | $ 36,202.53 | $37,560.80 | $ (1,358.27) |
| | | | | |
| Scenario 4 | 90 | $ 30,768.85 | $31,927.46 | $ (1,158.61) |
| | | | | |
| **Net Returns-NOV 16** | | 2.0ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 31,340.80 | $36,635.14 | $ (5,294.34) |
| | 120 | $ 25,769.00 | $36,467.49 | $ (10,698.49) |
| Scenario 2 | 90 | $ 31,340.80 | $36,958.07 | $ (5,617.27) |
| | 120 | $ 25,769.00 | $36,798.23 | $ (11,029.23) |
| Scenario 4 | 90 | $ 29,945.80 | $30,912.72 | $ (966.92) |
| | 120 | $ 23,541.50 | $29,485.93 | $ (5,944.43) |
| **Net Returns-DEC 16** | | 2.0ADG/500 Buy Wt | | |
| | Period | Total Receipts | Total Costs | Net Returns |
| Scenario 1 | 90 | $ 31,446.20 | $37,649.88 | $ (6,203.68) |
| | | | | |
| Scenario 2 | 90 | $ 31,446.20 | $37,560.80 | $ (6,114.60) |
| | | | | |
| Scenario 4 | 90 | $ 30,768.85 | $31,927.46 | $ (1,158.61) |
| | | | | |
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