IMPACT OF ETHANOL EXPANSION ON THE CATTLE FEEDING INDUSTRY

A Thesis

by

ERIN DALEY

Submitted to the Office of Graduate Studies at
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2007

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	Joe L. Outlaw
Committee Members,	David P. Anderson
	Jodi Sterle
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ABSTRACT

Impact of Ethanol Expansion on the Cattle Feeding Industry. (May 2007)

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Chair of Advisory Committee: Dr. Joe L. Outlaw

The U.S. has a history of producing surplus corn, but the current and projected growth in ethanol production combined with strong feed and export demand is causing an overall increase in corn utilization. Although livestock feeders are projected to remain the largest users of corn, corn utilization can be reduced if ethanol co-products are used to replace a portion of corn in finishing rations.

The objective of this study was to determine the economic trade-offs for cattle feeders when facing higher corn prices and increasing supplies of ethanol co-products. A stochastic partial budget model was used to determine the impact on the cost of gain when ethanol co-products are substituted into rations at varying inclusion rates. The model was built for all four major cattle feeding states: Texas, Nebraska, Kansas, and Colorado. Ration scenarios were developed for each state, based on the research results of feedlot nutrition and personal communication with feedlot operators. The various scenarios were simulated to determine the impacts of changing corn prices, corn processing costs, cattle performance, and feeding and transportation costs for Wet Distiller's Grains with Solubles (WDGS) on the key output variable, cost of gain.

The model results indicated when 15 percent WDGS (on a dry matter basis) replaces a portion of corn and protein supplement, the simulated cost of gain is lower than the base ration scenario when the feedlot is located within 200 miles of ethanol production. When feedlots are located more than 200 miles from an ethanol plant, Dried Distiller's Grains with Solubles (DDGS) can be fed to lower the cost of gain; therefore, ethanol co-products can be fed to help offset potential increases in corn prices.

The partial budget model is a useful tool for livestock, corn, and ethanol producers who are attempting to determine the impacts of ethanol expansion on corn price and utilization. Policy makers can also benefit from the model analysis as they face decisions in the future regarding ethanol and farm policy alternatives.

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the ranch, and for taking care of my horses!

NOMENCLATURE PAGE

Acronym	Definition
ADG	Average daily gain
CB	Corn Belt: includes Nebraska feedlots
CGF	Corn gluten feed
CP	Central Plains: includes Kansas feedlots
DDGS	Distiller’s dried grains with solubles
DM	Dry matter
DMI	Dry matter intake
Feed:Gain	Pounds of feed per pound of gain
HMC	High moisture corn
NP	North Plains: represents Colorado feedlots
PCC	Professional Cattle Consultants
SFC	Steam flaked corn
SP	South Plains: includes Texas feedlot
WCDGS	Wet corn distiller’s grains with solubles
WDGS	Wet distiller’s grains with solubles
WSDGS	Wet sorghum distiller’s grains with solubles

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CHAPTER I

INTRODUCTION

It is difficult to say whether by-products led to cattle feeding, or cattle feeding provided a market for by-products. Around the turn of the century, sugar mills, whiskey distilleries, and cottonseed oil mills produced by-products that were fed to cattle. “Before railroads and refrigeration, livestock and corn whiskey were about the only ways many farmers could market their grain. The livestock could walk to market, and whiskey was worth the transportation expense (Ball 1992).” From the time cattlemen started “cattle feeding”, by-products have been utilized to reduce the cost of gain, especially in the finishing ration. From cottonseed hulls, to beet pulp and brewer’s grains, the cattle feeding industry has incorporated all sorts of by-products into their feedlot rations. With the current expansion of the ethanol industry, another by-product feed, or co-product of ethanol production, distiller’s grains, is becoming more available to livestock feeders.

Cottonseed oil mills, cheap land, and a mild climate brought cattle feeding to Texas. Cattle were fed cottonseed meal and hulls, corn, and molasses by hand from mule-drawn wagons. Initially Texas cattle were shipped to the corn belt to be finished, and finally processed in Chicago. Following the introduction of hybrid grain sorghum and silos to store excess feed, Texas cattle feeders were able to finish their own cattle.

This thesis follows the style of the *American Journal of Agricultural Economics*.

Hybrid grain sorghum when combined with irrigation increased sorghum yields by 40 percent. Further technological advancement led to the use of the steam-flaking process to make the abundant grain sorghum a more efficient feedsource. In 1962, the Panhandle area became the leader in the “Age of Giant Feedyards”, as unprecedented 30,000-head capacity yards were built (Ball 1992). Texas remains the number one cattle feeding state to this day.

Over the years, the cattle feeding industry has spread from the corn belt throughout the nation, with each area having its own specific competitive advantages. The top four cattle feeding states are Texas, Nebraska, Kansas, and Colorado. Nebraska and Kansas grow surplus grain while Texas and Colorado are corn deficit states. Texas and Colorado use the railroad system to secure corn supplies from the midwest to meet their feed demands. As ethanol production continues to explode, especially in the midwest- primarily utilizing corn as a feedstock- the impact on the top four cattle feeding states remains largely undetermined.

Passage of the Energy Policy Act of 2005 has stimulated the already rapid expansion in the ethanol industry with over 34 new plants under construction. Currently, 97 ethanol plants in 20 states have a combined production capacity of nearly 4.5 billion gallons per year (RFA 2006). Ethanol production is expected to expand beyond the federally mandated 7.5 billion gallon Renewable Fuel Standard (RFS). Predicted demand for ethanol production exceeding the RFS is driven by high oil prices and the phase-out of Methyl Tertiary-Butyl Ether (MTBE) as a fuel additive. At its current growth rate, ethanol production will reach 7 billion gallons and consume 2.6 billion bushels of corn per year by 2010, which is roughly 26 percent of a normal corn crop (Baker and Zahniser 2006). Therefore, livestock feeders (the largest corn users) will likely see higher corn prices as they compete with ethanol plants in the corn and grain sorghum markets. Higher corn prices will increase the cost of feedlot rations, unless ethanol co-products can replace corn and other feeds at a lower price. For each bushel of corn used for ethanol production, more than 17 pounds of feed, Distillers Dried Grains with Solubles (DDGS), are produced. Increasing supplies of DDGS and other ethanol co-products used for livestock feed will likely result in lower prices for these alternative feed sources.

Ethanol production consumes the grain's starch, but the protein, minerals, fat, and fiber are concentrated during the production process to produce a highly valued and nutritious livestock feed. For dry mill ethanol plants, which make up the majority of production, most feed is dried and sold as DDGS. Approximately 20-25 percent of the feed is fed as Wet Distillers Grains with Solubles (WDGS). The WDGS contains approximately 65 percent water, and is shipped locally, reducing energy input costs for ethanol plants (RFA 2006).

Extensive economic studies have not been completed to show how feedlots can benefit from the increased production of distillers grains (DG). However, there are many potential advantages from feeding ethanol co-products. Cost effectiveness, added palatability, increased moisture in dry diets, improved feed intake and efficiency, additional non-starch digestible energy (100-120 percent that of corn on dry matter basis), decreased incidence of acidosis, and increased protein content of the diet are all predicted benefits of feeding DG. These attributes are discussed in further detail in Chapter II, and more importantly, they are evaluated on an economic level in Chapters III and IV.

As ethanol and corn demand increase, the supply of the ethanol co-product, distillers grains (DG) will increase as well. Therefore substitution of DG for corn and soybean meal (SBM) in livestock rations will likely occur. Feedlot diets typically contain a small amount of roughage (such as alfalfa); a protein, mineral and vitamin supplement; and corn. Corn typically comprises 80 to 85 percent of the diet. When DG are fed, they replace the protein in the supplement but primarily replace corn as the source of energy (Erickson 2006). The substitution of DG into livestock diets requires nutritional analysis, but there are also many economic implications that have not been researched. Although some economic analysis has been completed on a national level, this study will further determine the potential changes in ration costs and compositions as DG replaces corn and SBM in livestock rations for the primary cattle feeding areas of Texas, Nebraska, Colorado, and Kansas.

Objectives

The primary objective of this research is to evaluate the potential impact of increasing ethanol production on the beef cattle feeding industry. Potential cost savings through the feeding of ethanol co-products will be identified using a partial budget analysis.

Geographic differences and specific regional implications for beef cattle feedlots in the top four cattle feeding states; Texas, Nebraska, Kansas, and Colorado will be analyzed. Implications for the feed deficit states; Texas and Colorado will be compared with corn exporting states that have abundant ethanol production; Nebraska and Kansas.

The regional differences in feedlot equipment and ration composition that are further affected by the feedlot's proximity to ethanol production will be included in the analysis. The two primary ethanol co-products from the dry-milling production process; wet distiller's grains with solubles (WDGS) and dried distillers grains with solubles (DDGS), will be evaluated as proportional substitutes for energy (corn) and protein (soybean meal) in representative region-specific rations.

The final objective is to analyze the changing cost of gain when the feedlot is located 25, 60, 100, or 200 miles from ethanol production. Cost of gain for feeding two dietary inclusion rates of WDGS compared to the control ration will be estimated including the additional transportation costs for WDGS.

Justification

Future economic implications of the potential tradeoff between corn and ethanol co-products in feedlot rations have not been extensively analyzed. Feed is the single most costly component of finishing cattle, where feed costs often represent 70 to 80 percent of the total cost of gain. It takes approximately 55 bushels of corn to raise a feeder calf to harvest, where every pound of beef produced requires 5.6 pounds of corn (USMEF 2006), so reduced availability that creates increasing corn prices have a significant affect on feed costs. When distiller's grains are fed they replace a portion of the corn as well as any supplemental protein, like soybean meal, potentially reducing ration costs (Erickson 2005).

Projections by the Food and Agricultural Policy Research Institute (FAPRI) and the USDA show that corn prices are expected to increase over the baseline period (2006-2015), with ethanol production as the single most important factor driving the rise in prices. Corn used for ethanol production will soon outpace corn exports and will result in corn diverted from exports to ethanol. Even as livestock and poultry production expand over the next few years, projected increases in corn prices will contribute to a decline in feed and residual use of corn (Westhoff 2006). At the same time, increasing use of ethanol co-products could offset the decline in feed use of corn, as they are substituted into livestock rations. These co-products are available at varying levels of moisture and nutrient content, and replace other ration ingredients besides corn, so there are many variables for consideration when determining economic impacts.

There have been numerous studies on the nutritional aspects of distiller’s grains (DG), from the ethanol dry-milling process, but for the most part, the specific regional economic aspects of feeding DG have not been considered. Currently the majority of livestock feeders have not added DG to their feed rations. Cattle feeders who are feeding DG are adding the co-product at 10 to 15 percent of the ration on a dry matter basis, depending on their location relative to the ethanol plant. Nutritional research has shown optimum inclusion rates for WDGS ranging between 25 and 35 percent of ration dry matter (Vander Pol et al., 2006b) in Eastern Nebraska, while Daubert et al. (2006) found optimal levels between 8 and 16 percent for cattle fed in Kansas**.** Texas studies have shown less favorable results from including DG in steam-flaked corn (SFC) based feedlot rations (Cole et al. 2006). Differences in cattle performance are generally attributed to variations in co-product quality and nutrient content and varying energy values of corn from different processing methods in the base ration. Regardless of differing cattle performance results, as ethanol production uses more of the total corn supply, cattle feeders will have additional incentives to feed more ethanol co-products as they become more available and potentially at lower prices.

According to the Renewable Fuels Association (2006), in 2005 approximately 75 to 80 percent of distiller's grains were fed to ruminant animals (dairy and beef cattle), but swine (18-20 percent) and poultry (3-5 percent) consumption has been increasing as new research has shown nutritional benefits for monogastrics. While 9 million metric tons of distiller's grains were produced in 2005 (up from 3.6 million metric tons in 2002), there are estimates that the supply of DG will reach 12 to 14 million metric tons by 2012 (RFA 2006). According to FAPRI, corn co-product use in 2005/06 will surpass feed and residual use of wheat, sorghum, barley, and oats combined, and increase by an additional 10 million metric tons by 2015/16 (Westhoff 2006).

Analysis by Doering and Hurt (2006) showed, at the local level, individual livestock producers "may well feel impacts" from bio-fuel production greater than the national average estimates, depending upon the particular situation of their state or region. "A large bio-fuel processing presence in an area may well increase corn or soybean prices above the national average change and disrupt existing marketing and transportation logistics." At the national level, a more gradual adjustment is expected, which can also change with changes in energy policy. A supply response is also expected where higher corn prices and relatively steady soybean prices could cause a shift in corn to soybean crop rotations from the current 50-50 split to 60 percent corn and 40 percent soybeans. Larger supply responses are expected within 50 miles of an ethanol plant. Doering and Hurt (2006) also predict that low feed grain prices and substantial farm program subsidies will limit the shift of soybean acres to corn acres. Supply response must be considered when estimating corn price changes as demand increases with ethanol expansion. Analysis in this study will include prices for both traditional feed ingredients and co-products in determining a price relationship between the various ration components.

CHAPTER II

REVIEW OF LITERATURE

This literature review is organized among several primary areas of research:

- Profitability and risk in cattle feeding
- Breakeven and partial budget analysis
- Various topics regarding ethanol production and the production process as it relates to DG
- Corn processing differences
- Previous economic research
- Impacts of feeding on manure management costs
- Market outlook
- Statewide analysis and background
- Nutritional aspects of WDGS and DDGS

Profitability and Risk in Cattle Feeding

Like all agricultural producers, cattle feeders face substantial economic risks through highly variable net returns. Monthly average returns to finishing yearling steers in Kansas feedlots ranged from a loss of $175 per head to a profit of $120 per head between 1990 and 1998 (Mark, Schroeder, and Jones 2000). Although variability of fed cattle and feeder cattle prices have greater impacts on cattle feeding profitability than corn prices; corn price, feed conversion, and average daily gain explained 65, 27, and 2 percent of cost-of-gain variability (Albright, Schroeder, and Langemeier 1994). For both steers and heifers, fed cattle price has the largest impact on profit per head, followed by feeder cattle prices, corn prices, feed conversion, interest rates, and average daily gain.

In general, as placement weight increases, feeder cattle prices impact profitability more while corn prices, interest rates, and animal performance influence profitability less. Feeder cattle prices impact profitability more for spring and fall placements and corn prices typically have the largest influence on profits for third quarter placements. Feed conversion influences profitability more for winter placements while ADG has a greater impact on profits for late winter/early spring placements (Mark, Schroeder, and Jones 2000).

In this study, it will be assumed that steers are placed on feed in October at 600 pounds and in May at 750 pounds. Cost of gain for the two weight groups will be compared to determine whether adding ethanol co-products (and changing feed costs and compositions) has a greater effect on lighter weight placements. October and May and the corresponding in-weights were chosen based on the National Agricultural Statistics Service’s Cattle on Feed Report (USDA/NASS 2006). These months have the highest number of placements for feeder cattle under 600 pounds (October) and 700-799 pounds (May). In their analysis of derived demand for cattle feeding inputs, Arnade, Mathews, and Jones (2005) found one pattern of placing lighter (under 600-pound), just weaned feeder calves in the fall for longer term feeding, and a second pattern of placing heavier feeder cattle in the spring (off wheat pasture) for shorter feeding periods. These results are consistent with the months and in-weights assumed in this study.

Breakeven and Partial Budget Analysis

Breakeven budgeting is one of the most useful management tools available to cattle feeders and feeder cattle producers. One of the most common goals of breakeven budgeting is to determine the breakeven purchase price for feeder cattle. Unfortunately, a large number of unknown variables exist in the breakeven budget. Breakeven budgeting is used to evaluate the affect of changes in cattle or feed prices on expected profit margins, where expected cost of gain is a key piece of information. Cost of gain is the average cost of each additional pound of weight gained by an animal after it has been placed on feed (Anderson and Trapp 2000).

Cost of gain has many components including: yardage fees, veterinary charges, and interest, but its largest component is actual feed cost. Although feedlot rations contain many ingredients, corn, by volume, is the most important ingredient. Albright, Schroeder, and Langemeier (1994) determined that over 60 percent of the variability in cost of gain in two Kansas feedlots could be attributed to corn price variability. Ignoring miscellaneous expenses such as yardage, veterinary expenses, and interest, cost of gain (COG) can be expressed by the following equation:

$COG = RC*CONV$,

Where RC is ration cost given in dollars per pound, and CONV is the feed conversion rate (pounds of feed/pound of beef gain). Changes in cost of gain are not directly proportional to changes in corn price for three reasons cited by Anderson and Trapp (2000). First, substitution will occur between corn and other feeds as corn prices vary. Second, changes in the price of corn will lead to changes in the weight of cattle being placed on feed (Marsh 1999). Changes in placement weight will, in turn, affect slaughter weight, and will indirectly influence cost of gain due to its effect on feed conversion efficiency. Finally, cost of gain will not be as responsive to changing corn prices if feedlots maintain inventory or forward contract their corn purchases.

This paper will primarily focus on the feed substitution affect on cost of gain, where co-products will replace corn and protein supplements (like soybean meal) in feedlot rations. A partial budget analysis will be used to focus on changing feed and feeding costs. Arnade, Mathews, and Jones (2005) found feeder cattle costs constitute the largest cost share of cattle feeding costs, with feed costs as the next largest cost. Numerous studies are cited in their research with inconsistent correlations between feeder cattle prices and feed prices. For clarity, this study will focus on the feed cost of gain, with the hotel assumption, where feeder and fed cattle prices are not considered. With the hotel assumption, the cattle feeder does not own the cattle on feed, but provides a service and adds value to the cattle through pounds of gain.

Variety of Ethanol Co-Products Available

The co-products from wet and dry mill ethanol processing plants have substantially different nutrient contents and feeding characteristics which require separate consideration in economic analyses. Ethanol expansion is primarily occurring in the dry mill industry, where many new ethanol plants have dryers, but will likely produce WDGS to reduce natural gas drying costs when in close proximity to animal feeding. WDGS has a short useful life and spoils quickly due to its high water and fat content.

The minimal 3 to 6 day shelf life of WDGS limits its use and can add extra preservation and storage costs to the feed product. The excess water weight (up to 70 percent water) adds significantly to transportation costs, limiting the profitable feeding radius around the ethanol plant. For instance, a ton of WDGS may contain up to 1,300 pounds of water, which must be hauled to and handled at the feedlot. Although the extra moisture in the ration has a positive effect on cattle performance, the increased handling and transportation costs are significant considerations (Erickson 2006).

Wet-mill ethanol plants produce a variety of co-products, but cattle feeders primarily use wet corn gluten feed (WCGF). WCGF is lower in protein and fat than distiller's grains and its energy is primarily derived from highly digestible fiber. *Sweet Bran*®, Cargill's brand of WCGF, is produced at their wet-mill ethanol plants in Blair, Nebraska and Eddyville, Iowa (Blackford 2006). Over the last several years feedyards in the Southern Plains have been using *Sweet Bran*® as an energy and protein source, replacing a portion of the steam-flaked corn (SFC) and supplemental protein in feedlot rations (Cole et al. 2006). Pelleted corn gluten feed is also utilized in the Southern Plains. This paper will not specifically evaluate *Sweet Bran*® because the majority of ethanol production and expansion is occurring in the dry mill industry (RFA 2006).

Ethanol Production Processes

The variety of ethanol co-products are a result of two different production processes, dry milling (mash distillation) and wet milling. In dry milling, the grain is cleaned and ground dry to reduce the particle size and the entire kernel is used in fermentation. The wet milling process removes the maximum amount of starch from the kernel by first adding water to the grain and allowing it to steep so the starch can be removed. The starch is then converted to dextrose for further refining, and is used to convert enzymes or is fermented to produce amino acids, organic acids, gums, and other products (Weigel, Loy, and Kilmer 1997b).

The dry and wet milling processes produce substantially different co-products. The primary co-products from dry milling are distiller’s grains and carbon dioxide, while wet mills produce a variety of co-products, including gluten feed and meal and corn oil. Although corn is the primary grain used in ethanol production, other cereal grains can be used. For instance, Kansas uses more grain sorghum than corn in their dry mill ethanol plants, where grain sorghum has essentially the same value as corn in ethanol production. If several grains are used in the milling process, the greatest percentage of cereal used must be named in the co-products (Weigel, Loy, and Kilmer 1997a). Co-products from both dry and wet milling processes have important nutritional and financial implications for the livestock feeding industry. Figure 2.1 shows the basic schematic of the wet milling industry resulting in wet or dry corn gluten feed. Figure 2.2 outlines the dry milling process, with WDGS and DDGS as the final co-products.

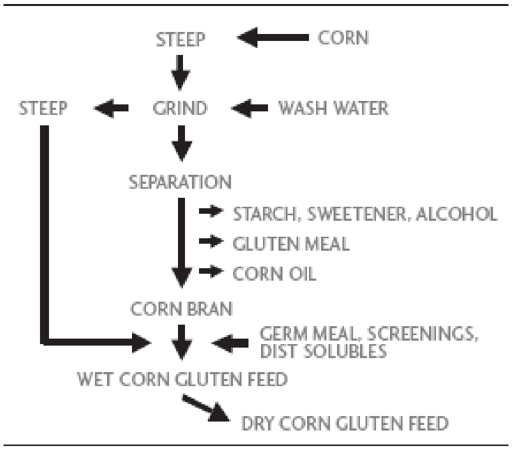


Figure 2.1 Corn wet-milling process

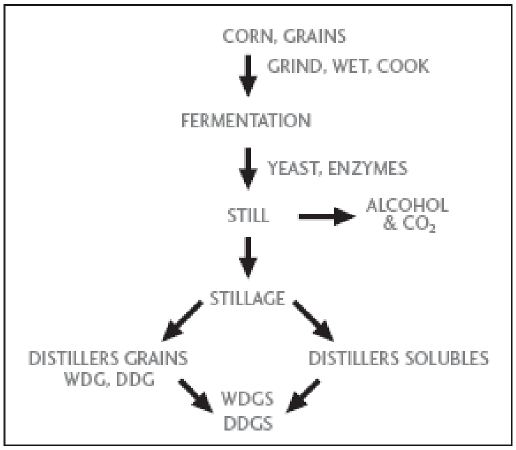


Figure 2.2 Corn dry-milling process

As ethanol producers become more innovative and move toward energy independence and more sustainable production systems, the co-products could be used to provide green energy to power the plants. Some ethanol plants are already burning the solubles or thin stillage to power their plants instead of adding them back to the DDG (DDGS without the solubles) (Kotrba 2006). Other plants are pumping their stillage into anaerobic digestion tanks, bypassing the evaporating and drying process that creates distiller's grains. In an effort to become fossil fuel free, the plants can lessen feedstock and energy risks while providing a solution for the expected distiller's grains glut when an additional 3 billion gallons of ethanol per year enter the market. Anaerobic digestors allow plants to bypass the distiller's grains handling system. The feedstock can be diverted to or from the anaerobic digestor at any time depending on market conditions (Nilles 2006).

Changing ethanol production processes and resulting co-products make it difficult to forecast the price and supply of DDGS and WDGS. Some ethanol plants are de-germing corn before beginning the ethanol production process. De-germing corn and eliminating the solubles in DDGS both alter the nutrient composition of the co-products. The resulting co-products often have lower fat content and therefore lower energy values (Blackford 2006). As cattle feeders consider alternative ration ingredients, it will be important to consider both price and feeding value of ever-changing ethanol co-products.

Dry Mill Expansion: Ethanol Plant Processing Margins

Processing margins are the sum of revenues on ethanol and co-products less the expenditures on corn inputs, all expressed in terms of one bushel of corn processed. Margins are an effective measure for comparing processing costs (labor, utilities, and capital) that are stable per unit of input processed. The wet-mill margin includes revenues from its three primary co-products, corn gluten feed, corn gluten meal, and corn oil. The dry-mill margin uses co-product revenues from DDGS. Otto and Gallagher (2003) used an ethanol price for Bettendorf, Iowa, an average corn price for North Central Iowa, and co-product prices from data sources in Illinois and Indiana. Margins for the wet and dry mills exceeded $3 per bushel of corn in the early 1980s but then declined to the $1.50 to $2.00 range by the mid 1990s. Recently the range has been closer to $3.00 per bushel. A typical range for the sum of operating and annual capital costs is $1.60 per bushel to $1.80 per bushel. High margin values indicate a market signal for expansion (Otto and Gallagher 2003).

Further analysis of the difference between the wet and dry mill margins (the wet-dry differential) indicated the market benefit of a wet-mill expansion instead of a dry-mill expansion. Wet-mill expansions will probably occur when the return difference exceeds the corresponding higher cost of the wet-mill plant. Until then, the industry favors dry-mill expansion (as evidenced by dry-mills comprising the majority of ethanol plant construction). Higher processing and capital costs (about $0.18/bu) for the wet mills have limited wet-mill expansion. The increasing efficiency of dry mills has also prompted an increase in dry-mill construction (Otto and Gallagher 2003). Therefore, in this study we will analyze co-products from the dry-milling process.

Value of Ethanol Co-Products

Distiller's grains are the primary co-product in ethanol production. A variety of decisions regarding the production and marketing of distiller's grains are very important to the ethanol producing plant. With large quantities of distillers grains produced each day, the ethanol plant's profitability is impacted by their ability to sell the co-products. The share of the total ethanol plant revenue typically attributed to the sale of DDGS ranges from 15 to 20 percent. If DDGS is priced at $80 per ton and baseline corn at $2.20 per bushel ($78.57/ton); a decline in DDGS price from the baseline level of $80 per ton to $70 per ton would reduce net returns for a 40 million gallon per year ethanol plant by $149,237 for each decline of one dollar per ton of DDGS (Tiffany and Eidman 2003). Therefore, distiller's grains are not just a by-product of ethanol production, but a valuable co-product.

The proximal location of the ethanol plant to the corn supply and further to livestock feeding facilities assists in a plant's ability to market the DG. An ethanol plant producing 30 million gallons of ethanol per year produces about 94,000 tons of dried DDGS per year, or nearly 270 tons every day. On the livestock feeding end this equates to 180,000 head of livestock eating three pounds each day to consume all the DDGS produced from that plant. DDGS is slowly making its way into feedlot rations, where the current recommended daily maximum intake is 10 pounds, with most rations only incorporating about 3 pounds per head per day. Research from the University of Nebraska-Lincoln, South Dakota State University, and Iowa State University has shown the suggested feeding level for DG products ranges from 15 to 35 percent of beef diets on a dry matter basis. The primary markets for DDGS have been dairy and beef cattle, but promising markets exist for poultry and swine (Coltrain 2001).

DDGS Compared to WDGS

Ethanol plants can cut natural gas use in half by producing WDGS. This significantly reduces the costs of the facility (some plants are not even including a dryer when constructing the plant). There is more risk involved when plants only produce WDGS because transportation costs at 35 percent dry matter content limit the feeding radius. Therefore plants producing WDGS have an economic incentive to contract out their sales of WDGS to nearby livestock feeders. As local markets become saturated, plants will likely begin drying more of the DG produced so it can be shipped to an area without ethanol production. The amount of WDGS produced can also be seasonal, depending on the number of cattle on feed in the local area throughout the year. For instance, in the summer months when there are fewer cattle on feed in Eastern Nebraska, the ethanol plants produce more DDGS which is shipped to more distance markets (Erickson 2006). The local feeding radius for WDGS has not been fully evaluated, especially from the cattle feeder's point of view. "The precise relationship between the level of byproduct in the diet and both the feeding value and economic value remains elusive (Klopfenstein 2001)." Analysis in this paper will consider feeding WDGS at feedlots located 25, 60, 100, and 200 miles from an ethanol plant.

DDGS is lower in energy (about 93 percent the energy of WDGS). The drying process drives off some of the energy containing ethers, as well as making some of the fiber less digestible. Other than differences in dry matter content, the chemical composition of the two distiller's products is similar. Distiller's grains contain 10-15 percent fat (oil), 40-45% neutral detergent fiber, 30-35 percent crude protein, and 5 percent ash on a dry matter basis (NRC 1996). DDGS is typically fed as a protein supplement (6-15 percent of diet on DM basis), however the drying process appears to reduce the energy value. When fed at higher levels (>15 percent), the co-product is primarily an energy source, replacing corn grain. WDGS is more often fed at higher levels in the diet to supply both protein and energy. While drying costs significantly increase the commodity price for DDGS (pricing it relative to SBM and corn and significantly higher than WDGS), the increased transportation and potential storage costs are the economic disadvantages of feeding WDGS. When DDGS is priced on an energy basis (relative to corn), the expected improvement in animal performance is not large enough to offset the increased ration cost associated with higher inclusion levels (Klopfenstein 2001).

Inconsistency

Ethanol plants use different ratios for their blend of condensed solubles to the grain fraction in DDGS production. Some ethanol plants add all the condensed solubles produced to the grain fraction, while others may add substantially less before the drying process. Distillers solubles have a much different nutrient composition than the grain portion, so differing ratios of ingredients have a large impact on the varying nutrient content of DDGS. At least one ethanol plant is attempting to burn most solubles produced as a fuel source for the plant (Dudley-Cash 2005).

Some of the dry-mill ethanol plants use modified production processes to produce ethanol, which alter the composition of the DDGS. Some plants use cookers to add heat for fermentation and thus use fewer enzymes in the fermentation process. Heating may reduce amino acid digestibility, making the plants that use more enzymes and do not rely on cookers to facilitate fermentation more desirable for DDGS production. Some ethanol plants partially de-germ the corn before fermentation, lowering the fat content (and corresponding energy value) of DDGS produced (Dudley-Cash 2005).

The greatest variation in WDGS is its dry matter content, which can alter ration formulations. The sulphur content in WDGS can also fluctuate as plants use sulphuric acid during the ethanol production process to control pH problems. This results in an increase in sulphur content of WDGS. If feedlot water supplies contain a significant amount of sulphur, increasing sulphur in the ration can have negative affects on cattle performance and health. Contracting WDGS supplies with an ethanol plant can help guarantee a consistent supply of WDGS (Erickson 2006).

Standardized DDGS

There has been discussion in the industry regarding standardization of DDGS composition. The U.S. ethanol industry consists of a few very large producers and many small, independent ethanol plants. The smaller plants primarily oppose standardization because they are exploring new uses for DDGS in search of niche markets to gain a competitive edge. Although DDGS is not graded, subjective color evaluation can be used to detect digestible lysine content. “Golden” DDGS can have a $20 to $30 per ton premium over darker DDGS supplies due to the implied correlation between color and digestible amino acid content (Dudley-Cash 2005).

Previous Economic Studies

Perrin and Klopfenstein’s (2001) research at the University of Nebraska used a combination of experimental results, survey data and market prices to demonstrate the average value of feeding wet corn gluten feed compared to the dried product. The average calculated value of the WCGF was $130 per ton of dry matter during the 1990’s, compared to the alternative value as dried feed of $93 per ton. The approach of this study was to estimate the feed value of WDGS and WCGF (based on the value of the feeds for which they substitute) and to subtract from that, the value of the co-products in their next best use, which is their value as dried feeds adjusted for drying costs. Survey data and plant production estimates were used to determine the total feeding amount for these products. Perrin and Klopfenstein (2001) also analyzed the distribution of benefits between the processor and the cattle feeder, dependent on the price charged for the co-products.

The estimated opportunity cost of selling the feed as a dried co-product was subtracted from the imputed value to determine the net benefit of feeding the wet co-products. The opportunity cost for a given year was the market price of the dried feed less an estimated $20 per ton of dry matter for drying costs. To further estimate the distribution of this net benefit between cattle feeders and corn processors, the average delivered price of wet byproducts was used, as determined from survey responses from 183 feedlot operators in Nebraska.

Perrin and Klopfenstein's (2001) results, showed one ton of WDGS on a dry matter basis primarily replaced 0.03 tons of alfalfa hay and 49.8 bushels of dry rolled corn and had a total value of $140.03 per ton, when these traditional ingredients were valued at average 1992-99 prices. Using an average feeding value of $140 per ton, the opportunity cost of the dried feed was $118 per ton, for an average net benefit of $22 per ton. Delivered price averaged $107, indicating an average gain of $32 per ton to feeders, and a $10 per ton loss to processors. Over the following two years, processors received a positive $5.77 per ton benefit. This indicates over the first few years, sales were lower than the processor's opportunity cost to establish the market.

Haugen and Hughes (1997) analyzed the economic implications of feeding different levels of wet corn gluten feed in a 1,000-head capacity North Dakota beef feedlot. A model that integrated the feeding trial data with economic input and output prices was used to determine the economic returns for each ration. All variables were held constant except the feed cost and quantities, using corn price levels of $2.00, $2.50, and $3.00. The wet corn gluten feed price was calculated at 37.5 percent of the corn price per ton on a wet basis. Transportation costs were included for a 50 mile zone at $3.50 per ton where each truck could haul 25 tons. This calculates to $0.0018 per pound for transportation and it was assumed that the WCGF was used as it was delivered (only short-term storage on a concrete slab was available).

The different percentages of WCGF in the feedlot rations resulted in significantly different net returns due to changes in gross margin (based on pounds gained per animal), feed costs, operating margin, hauling costs, shrink, and death loss. Many factors influenced the net return, including biological effects of the ration measured as gain per day and feed efficiency. The 56 percent ration (as compared to 0, 28, and 85 percent WCGF) showed a high economic return per head for each corn price and the best biological effect. The feed ingredients in the control ration are not included in the report, and therefore it is unclear what corn processing method is utilized. The small size of the feedlot also limits further application of this study.

Vander Pol et al. (2006b) conducted an economic comparison for cattle fed 0, 10, 20, 30, 40, and 50 percent WDGS in DRC/HMC-based rations. Corn was evaluated using a 10-year average price, with either a $0.05 or $0.10 increase in price per bushel to represent the higher basis on corn near an ethanol plant. WDGS prices were estimated at

95 percent of the price of corn at the ethanol plant. Transportation costs were assumed to be $2.50 per loaded mile based on a 25 ton (as is) load.

Scenarios were compared for feedlots surrounding the plant, and within 30, 60, and 100 miles of the plant. Costs accounted for include: extra feeding costs resulting from handling rations with higher moisture contents, as well as corn bushel price and transportation depending on distance from the ethanol plant. Increased return was based on energy value (relative to corn, Vander Pol et al. 2006c) of WDGS at each level fed.

The results showed the optimum inclusion rate for feedlot producers is 30 to 40 percent of diet dry matter when feedlots are within 30 miles of the ethanol plant. As the distance increases from the plant to the feedlot, the optimum inclusion of WDGS decreases to between 20 and 30 percent. This comparison suggests that WDGS can be fed at higher levels than the current industry inclusion rate; however, the optimum inclusion is dependent on more than just the energy value of WDGS. Factors such as WDGS price, cattle performance, distance from the plant, and corn price influence the economic optimum inclusion amount (Vander Pol et al. 2006b). Figure 2.3 shows the economic return for the various WDGS dietary inclusion rates when the feedlot is located at the plant, and 30, 60, or 100 miles from the plant.

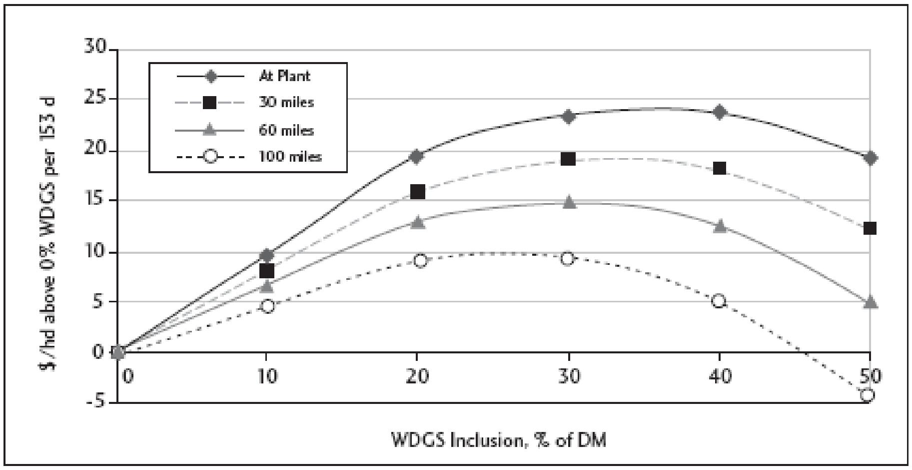


Figure 2.3 Economic returns from feeding WDGS when fed at 0 to 50 percent of diet dry matter (Vander Pol et al. 2006b)

Note: WDGS is Wet Distillers Grains with Solubles and DM is Dry matter

Corn Processing Methods: Costs and Benefits

Corn is the primary ration ingredient for which DG is substituted. It is therefore important to understand the costs and benefits of the corn processing methods most commonly utilized. Starch is the primary energy component of corn, so optimal starch utilization is critical to improving feedlot cattle performance. Corn is approximately 72 percent starch, and many methods of processing have been employed in an attempt to improve its utilization by livestock. Processing methods vary in form and cost, and in their most basic form consist of: treating corn with heat, moisture, time, and/or mechanical action (Huntington 1997).

The Processes

Dry-rolling corn is accomplished by passing whole shelled corn through a rollermill. The steam-flaking process includes exposing corn to steam before passing it through a set of rollers. Early harvest and ensiling high-moisture corn is another common processing method in Eastern Nebraska, for instance, where corn is harvested near the feedlots. High moisture corn (HMC) is ground or rolled and stored in oxygen-limiting structures (like trench silos with cement floors and walls) at 25 to 32 percent moisture (Macken, Erickson, and Klopfenstein 2006).

Feedlot rations and feed management are largely based on the corn processing method utilized, where methods differ between regions depending, primarily, on corn prices. The most common corn processing methods, from least to most intensive, are: dry rolling, early harvest high moisture ensiling, and steam flaking (Macken, Erickson, and Klopfenstein 2006). Steam flaking corn results in the highest energy value relative to the other corn processing methods. Steam flaking is also the most costly processing method, with higher fixed and variable costs than dry rolling or high moisture ensiling (Macken, Erickson, and Klopfenstein 2006; and Cooper et al. 2001). Steam flaking is primarily utilized in corn deficit areas, like the Texas panhandle (Cole et al. 2006) and Eastern Colorado to maximize the feed energy value of corn. In locations where corn is available at lower basis prices, i.e. Eastern Nebraska, feedlots use the less expensive, less intensive processing methods (dry rolling and high moisture ensiling). Variables such as corn price, feed efficiency response, energy cost, and feedlot size determine economic returns for corn processing (Macken, Erickson, and Klopfenstein 2006).

Corn grain contains on average, 61 percent starch, 3.8 percent oil, 8 percent protein, 2.2 percent fiber, and 16 percent moisture. The dry milling ethanol production process uses fermentation of the corn starch to produce ethanol, concentrating all the other constituents of corn in the remaining co-products (Trenkle 2006). While cattle feeders use corn processing to improve availability of the high starch content of corn, and thereby increase the energy value of corn, the ethanol production process removes corn starch to produce ethanol.

WDGS generally has higher energy values relative to corn on an equal dry matter basis, ranging from 120 to 180 percent of corn's energy v alue, with a quadratic decrease as WDGS inclusion rates increase from 0 to 50 percent of diet dry matter. The relationship found by Vander Pol et al. (2006c) is shown in figure 2.4, where WDGS energy values are compared to those of DRC. The higher energy value is a function of improved feed efficiency, partially due to the high fat content found in WDGS (Vander Pol 2006c). DDGS typically has energy values equal to or greater than corn, but lower than WDGS. Protein degradation and availability of protein and energy from dry distiller's grains will vary depending upon temperature of the dryers. Distiller's grains dried at higher temperatures will be less digestible (Trenkle 2006). When DDGS and WDGS replace steam-flaked corn, which has a higher energy value than dry-rolled corn, the affects on cattle performance differ with the intensity of the corn processing method (Vander Pol 2006a).

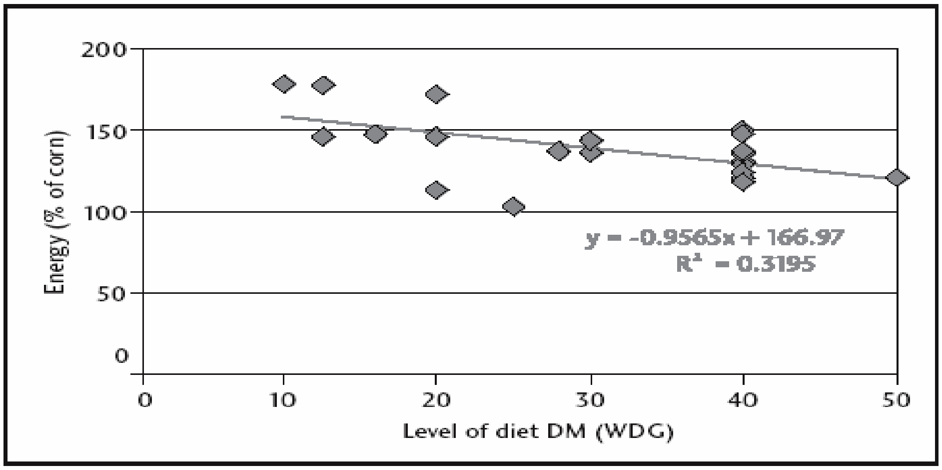


Figure 2.4 Energy content of WDGS when replacing corn at 0 to 50 percent of diet dry matter (Vander Pol et al. 2006c)

As corn processing makes starch more available, incidences of subacute acidosis can also increase, having a detrimental affect on cattle performance. The energy in distiller's grains comes from highly soluble fiber and fat instead of starch. This causes a slower rate of fermentation in the rumen and lowers the risk of subacute acidosis which may improve cattle performance (Vander Pol et al. 2006a). Corresponding changes in cattle performance are measured through average daily gain, feed efficiency, and dry matter intake. For instance, Vander Pol et al. (2006a) found cattle receiving WDGS combined with dry rolled and/or high moisture corn had higher average daily gains when compared to those receiving WDGS in steam-flaked corn based rations. Although the reasons for these results are not explicitly explained in the literature, steam flaked corn has a higher energy value than dry rolled or high moisture corn, so replacing it with WDGS is not as beneficial as replacing dry rolled corn with WDGS. The results from various studies involving corn processing methods combined with ethanol co-products are important for further economic analysis of how different regions can best incorporate ethanol co-products into feedlot rations (Erickson 2006).

Galyean and Lemon (2006) conducted a study to determine the optimal dietary concentration of WDGS in steam-flaked corn-based finishing diets. They also compared the feeding value of sorghum-based wet distiller's grains, or WSDGS with corn-based wet distiller's grains, or WCDGS. The importance of the steam-flaked corn ration for this research is that the Texas cattle feeding industry predominately feeds steam flaked corn, and sorghum is also available in the area. Galyean and Lemon found a linear decrease in ADG as the dietary concentration of WSDG increased. Unlike previous studies (Larson et al. 1993; Ham et al. 1994; and Lodge et al. 1997) which reported improved feed efficiency in cattle fed distiller's grain, they found a linear increase in the feed to gain ratio, meaning poorer feed conversion, with increasing WSDG concentrations. These results also differ from those of Daubert et al. (2005), who fed steam-flaked corn based diets containing WSDG to heifers. Peak performance occurred at the 8 and 16 percent inclusion rates and performance decreased significantly with higher distiller's grains concentrations. Lodge et al. (1997) also found a decrease in ADG and feed efficiency for cattle fed a higher concentration of dried sorghum distiller's grains (40 percent of a dry-rolled corn ration, DM basis). Galyean and Lemon did not find a statistically significant difference in performance between the cattle fed sorghum and corn based wet distiller's grains.

Drouillard et al. (2006) compared the feeding value of wet and dry distiller's grains in steam-flaked corn based diets and also evaluated the roughage value of distiller’s grains. To test the difference between wet and dry distiller’s grains, the trial rations included 15 percent (DM basis) wet or dry sorghum distiller’s grain with solubles (WDSG or DSDG) and wet and dry corn-based distiller’s grains. Roughage value was evaluated by feeding wet sorghum distiller’s grain with 0 and 6 percent alfalfa hay (where steam flaked corn replaced alfalfa in the 0 percent hay ration). Drouillard et al. found distiller’s grains with solubles derived from sorghum and corn have comparable nutritional values. Likewise, wet and dry distiller’s grains had similar feeding values. Removal of alfalfa hay from wet and dry sorghum-based distiller’s grains rations adversely affected dry matter intake, average daily gain, and final body weight. Depending on alfalfa prices, the removal of alfalfa, or substitution of a lower-quality forage, when feeding distiller’s grains, might result in a lower-cost ration with similar cattle performance. Current studies at the University of Nebraska are evaluating the effects of replacing alfalfa with corn stalks in rations containing WDGS. The high protein content of wet and dry distiller’s grains could eliminate the need to feed alfalfa as a protein source in rations containing DG, resulting in ration cost savings (Erickson 2006).

Feeding Costs and Methods

Currently, ethanol production has not come online in Texas, but as of May 2006, four plants in Texas were scheduled to begin construction. WDGS will likely be produced by these ethanol plants because of their close proximity to feedlots and dairies. Wet co-products are not as easily incorporated into steam-flaked corn-based rations compared to DRC and HMC-based rations. Feeding WDGS in a feedlot system with feed mills and steam flaked corn, like those in the Southern Plains, presents major issues. Nebraska studies have shown less favorable effects from feeding WDGS with SFC than with DRC or HMC (Vander Pol et al. 2006a). The nutritional benefits, as well as corn processing cost trade-offs need further analysis.

Feeding equipment used for processing and feeding dry rations (using steam-flaked corn) are significantly different from equipment used to handle Nebraska's wet rations. In Nebraska ration ingredients are placed in Roto-mix® mixer-delivery box trucks using front end loaders and rations are then mixed in the trucks on the way to the feed bunks. When feed mills are used at feedlots to produce steam-flaked corn based rations, the typically dry ingredients are mixed in the feed mill and then loaded directly onto the feed trucks. Therefore no mixing occurs on the feed trucks. If WDGS were incorporated into these types of rations, it could not be mixed in the feed mill because of its high water content (Erickson 2006). Roto-mix® trucks might have to be purchased to handle the WDGS.

Texas panhandle feedlots are also much larger than the average Eastern Nebraska feedlot, leading to additional considerations for the management of co-products (Cole et al. 2006). Larger feedlot size compounded with additional feeding time required due to excess water weight from wet co-products leads to more trade-offs for analysis. Depending on the increase in corn prices and proximity to ethanol production, if WDGS is available at enough of a discount to corn, the additional equipment, labor, and handling costs could be offset by the cost savings from replacing a portion of the more expensive corn with WDGS.

For cattle feeders located further from ethanol production, DDGS could be an economical feed source, where handling, storage, and transportation costs are lower than for WDGS. The dry co-product could be mixed in the feed mills and therefore requires less extra handling costs and equipment changes for Texas feeders. Feedlot nutrition studies have shown that DDGS should be fed at lower inclusion rates than WDGS, and generally limited to 15 percent of the ration on a dry matter basis for maximum cattle performance (Drouillard et al. 2006). At inclusion rates greater than 15 percent, ration mixing problems can occur because the high fat content of DDGS can inhibit flow-ability. Also, at the 15 percent inclusion rate, DDGS replaces dietary protein sources, but at higher inclusion rates it would compete with cheaper energy sources (Erickson 2006).

Macken, Erickson, and Klopfenstein (2006) compared dry-rolled (DRC), early harvest and ensiling high-moisture (HMC), and steam-flaked corn (SFC) processing methods for 5,000 and 20,000-head capacity feedlots. Processing costs were determined to be \$1.58, \$4.71, and \$9.57/t (metric ton; DM basis) for DRC, HMC, and SFC, respectively, for the 5,000-capacity feedlot. Economies of scale were evident as costs were lower for the 20,000-capacity feedlot at \$0.81, \$3.07, and \$6.23/t (metric ton; DM basis) for DRC, HMC, and SFC, respectively. Using these economic calculations in an 85 percent corn diet (DM basis), feed efficiency would need to improve by 6.1 percent and 4.2 percent for feeding SFC compared with feeding DRC in a 5,000-head capacity and 20,000-head capacity feedlot, respectively, to be of economic value. Variables such as corn price, feed efficiency response, energy cost, and feedlot size determine economic returns for corn processing.

Natural gas cost comprised 29 and 45 percent of the cost to flake corn for the 5,000 and 20,000-head feedlots, respectively. If natural gas prices increase, corn price may also increase, and therefore increase the natural gas breakeven price (Macken, Erickson, and Klopfenstein 2006). Higher corn prices make steam-flaking more economically feasible, explaining its use in feed deficit areas.

One limit to Macken, Erickson, and Klopfenstein's (2006) analysis is their use of 5 year average prices for corn ($2.05/bu for western Nebraska corn), natural gas ($5.04/ thousand cubic feet; 1998-2002 average for commercial sector in Nebraska), and electricity ($0.056/kwh; 1998-2002 average for the commercial sector in Nebraska) prices. The diet used to determine dietary cost as a function of corn processing method was 85 percent corn, 7 percent alfalfa hay, 5 percent supplement, and 3 percent tallow (DM basis). The costs of the ration ingredients were 95.51/t (metric ton) for corn ($2.05/bu), $93.70/t of alfalfa hay, $275.58/t for supplement, and $286.60/t for tallow (DM basis). Using these prices and ration ingredients, Macken, Erickson, and Klopfenstein (2006) found that feeding SFC generated economic return in both the 5,000-head and 20,000-head capacity feedlots compared with feeding HMC or DRC. Feedlots in the Southern Plains are generally larger than those in the Northern Plains and therefore capitalize on economies of size as they spread the costs of steam-flaking over a larger number of cattle.

Impacts of Feeding on Manure Management Costs

Another cost consideration when feeding distiller's grains is manure handling. The high phosphorus (P) concentration in many co-products are less of a concern for cattle feeders in the northern Great Plains than those in the southern Great Plains because northern cattle feeders have more access to corn acres for spreading the increased concentrations of P in manure (Cole et al. 2006). Kissinger et al. (2006) developed an economic model to evaluate the cost and value of manure distribution. The model evaluates cost and value of manure distribution with different dietary P, feedlot size, application time, land availability and crops grown, and equipment. Costs of handling manure before hauling are not included, as they are not a function of manure P content.

Feedlots ranged in size, from 2,500-head to 25,000-head one-time capacities to determine phosphorus excretion amounts from cattle fed diets with varying levels of phosphorus content. The dietary crude protein and phosphorus content increased as ethanol co-products were fed at higher percentages of the ration (ranging from 0 to 40 percent inclusion rate on a dry matter basis). The dietary P requirement for feedlot cattle has been estimated at 0.16 percent of the ration dry matter (Erickson et al. 2002), while rations normally contain much higher P levels. For instance, Kissinger et al.'s (2006) analysis included rations containing 0.29 percent to 0.49 percent dietary P, corresponding with 0 percent co-product to 40 percent co-product inclusion rates.

Fifty percent of the land surrounding the feedlot was assumed to be available for spreading manure. If dietary P was 0.49 percent of diet DM, then distribution costs were \$0.90, \$1.20, and \$2.75 greater for a 2,500, 10,000, and 25,000 head feedlot, respectively, compared to the lowest dietary P of 0.29 percent (Kissinger et al. 2006). There are limitations in applying these costs to Texas feedlots, because in this study manure nutrient value was used to offset the increased distribution cost, assuming land availability. Larger feedlot size and smaller amounts of adjacent land available for manure spreading increase the costs for Texas manure management (Cole et al. 2006). As dietary P increases, distribution costs increase depending on size of feedlot and land availability.

Implications of Increasing Ethanol Production for Agriculture

Urbanchuk (2005) showed that an 8 billion gallon Renewable Fuel Standard (RFS) would require the use of an additional 2.374 billion bushels of corn for ethanol production and an estimated 310 million bushels of soybeans for biodiesel production by 2012. Although this represents significant increases in corn used for ethanol production, only a small impact was predicted for livestock feed costs. Exports were expected to moderately increase due to increased export demand but would be constrained by increasing domestic use. Some soybean and cotton acres would likely shift to corn production (Urbanchuk 2005). The current profitability of soy-diesel is not as favorable as that for ethanol (the biodiesel blending and distribution system is not as well developed). Therefore land is more likely to be pulled from soybean acres into corn production (Doering and Hurt 2006).

Urbanchuk (2005) also predicted increased supplies of DDGS would result in favorable prices for DDGS which would also restrain the growth in prices for SBM and other protein feeds. Although numbers of livestock on feed are expected to increase from 2005 to 2012, feed demand for corn is expected to grow slowly, showing adequate supplies of competing feeds.

McNew and Griffith (2005) analyzed the impact of twelve ethanol plants that opened from 2001 to 2002 for their impact on local grain prices. On average, corn prices increased by 12.5 cents per bushel at the plant site, and some positive price response occurred up to 68 miles from the plant. Of particular interest was farmers' interest in ethanol plant ownership. They noted two primary incentives for farmer investment; the outlook for potential profit from increasing ethanol demand combined with a history of declining real grain prices, and the belief that increased demand for corn will raise local grain prices. Even if the ethanol plant itself makes zero profit, the increased corn prices would benefit the farmers in the area.

Corn prices near ethanol plants reflect transportation costs, and therefore the price impact varies spatially across the region around the ethanol plant and the terminal market. When considering one terminal market as the only demand center before the opening of the ethanol plant, producers who continue to ship to the terminal market still receive a positive price impact as a result of the ethanol plant. Demand for grain from the ethanol plant reduces the amount of grain shipped to the terminal market, and in turn raises regional corn prices. Producers who ship to the ethanol plant receive an even greater price increase because of lower transportation costs (as long as the ethanol plant is closer in location than the terminal market) (McNew and Griffith 2005). With the expected increase in corn prices and increase in co-product supplies, livestock feeders located near ethanol plants will face trade-offs between changing ration ingredients and costs of feed and feeding.

FAPRI's (2005) study shows slight increases in grain prices for livestock feeders. At the same time, corn price increases as does net farm income, but at a lower-than-expected rate due to decreasing government farm payments (lower loan deficiency payments and counter cyclical payments). If we produce 7 billion gallons of ethanol, projected corn prices increase 10-15 cents/bu and government payments decrease, leaving net farm income nearly unchanged. Livestock feeders, as well as ethanol producers, must pay the higher prices for corn, where government payments used to make up the difference between the loan rate and/or target prices. Corn production is also expected to increase between 600 and 650 million bushels a year (an increase of approximately 4 million corn acres), in response to increased corn demand, up to 2012. FAPRI (2005) also predicts decreases in corn exports, feed consumption (of corn), and corn stocks to offset the increasing corn demand resulting from ethanol expansion.

Commodities other than corn are also affected by the increased demand for corn. Soybean meal prices are expected to decline by 10 percent as the supply of corn co-products (substitutes for soybean meal) increase and therefore enter the market at a lower price. FAPRI's (2005) projected DDGS production increases from 8 million tons in April 2005 to over 18 million tons by 2012. Poultry producers are expected to benefit from the cheaper protein sources and therefore production will increase and poultry products will be offered at a lower price relative to beef. Pork production, like beef and dairy, will face higher feeding costs, as they require a less protein-dense diet than poultry rations.

FAPRI’s (2005) model does not account for fluctuations in natural gas prices (in the ethanol production and DDGS drying process). DDGS prices are estimated as a function of corn price, SBM price, and DG production. The equation does not directly include transportation costs, storage costs, or potential costs as a result of inconsistent co-products. The difference in costs associated with WDGS compared to DDGS is another important aspect not covered in FAPRI’s (2005) analysis. Furthermore, predictions show minor effects of ethanol production on livestock feeders, but regionally there will be greater impacts and these have not been estimated. The FAPRI (2005) study notes that livestock feeders located further from ethanol plants could be adversely affected by ethanol production as they face the increased cost of corn and do not benefit from the decreased price of co-products because of the high transportation costs of transporting DG. These specific implications within the states of Texas, Nebraska, Kansas, and Colorado are analyzed in this paper.

In Ferris and Joshi’s (2004) analysis of the impacts of an increase in fuel-ethanol demand on agriculture and the economy showed an uncertain effect on livestock producers, since higher corn prices increase feed costs, while lower DDGS and SBM prices reduce feed costs. The economics of corn ethanol supply depended on the prevailing federal and state subsidies, and changes in prices of gasoline, corn, and DDGS. Therefore the net effect on retail prices of meat, poultry, milk, and oil were also uncertain. They projected that agricultural commodity prices would increase more dramatically in the short run followed by more moderate increases due to expanded acres in grain production. Increased use of ethanol fuel would likely benefit farmers, while improving urban air quality, and contributing to energy security by marginally reducing the dependence on imported oil.

Market Outlook

Cattle Cycle

Increasing ethanol production comes at a time when costs for feed, purchased livestock, seed, repairs, and interest payments are also increasing (with energy prices accounting for much of the story as evidenced by record-breaking fuel and fertilizer costs) (FAPRI 2006). Cattle prices have reached their peak for this cycle, as producers continue to expand in response to the attractive industry returns. Cattle prices are projected to decline in 2006 with increasing domestic supplies of beef. The cattle cycle hit its low inventory in 2004 with close to 95 million head. Cattle supplies will continue to grow through 2012, with the peak of this cattle cycle near 103.5 million head.

Ethanol Production

Food, seed, and industrial (FSI) use of corn and grain sorghum is expected to increase nearly 19 percent in 2006/07 over the previous year and equal 30 percent of total use. Corn use for ethanol is expected to increase 34 percent in 2006/07 following a 21 percent year-over-year increase in 2005/06. Monthly ethanol production reported by the Department of Energy was record-high at 302,000 barrels per day in February 2006.

Prices were also strong as ethanol replaced MTBE, creating tight supplies and transportation problems (Baker and Allen 2006).

Ethanol prices at the plant typically exceed those of unleaded gasoline. The 51 cent per gallon tax benefit for ethanol makes it competitive at the pump. Both gasoline and ethanol prices are projected to decline slightly between 2006 and 2012. At the same time, corn prices are projected to increase, decreasing gross margins for ethanol producers. Cattle feeders could suffer from higher corn prices as well, depending on the impact from increasing ethanol co-products. Since increased ethanol production translates into a greater supply of co-products, primarily distillers grains, the impact of higher corn prices is moderated with the use of co-products as an alternative feed source. Estimated domestic feed use of corn co-products now exceeds that of wheat, sorghum, barley, and oats combined (FAPRI 2006).

Figure 2.5 shows the predicted increase in ethanol and corresponding DDGS and corn gluten feed (CGF) production. As shown in figure 2.6, ethanol production has already outpaced FAPRI’s (2006) baseline projections.

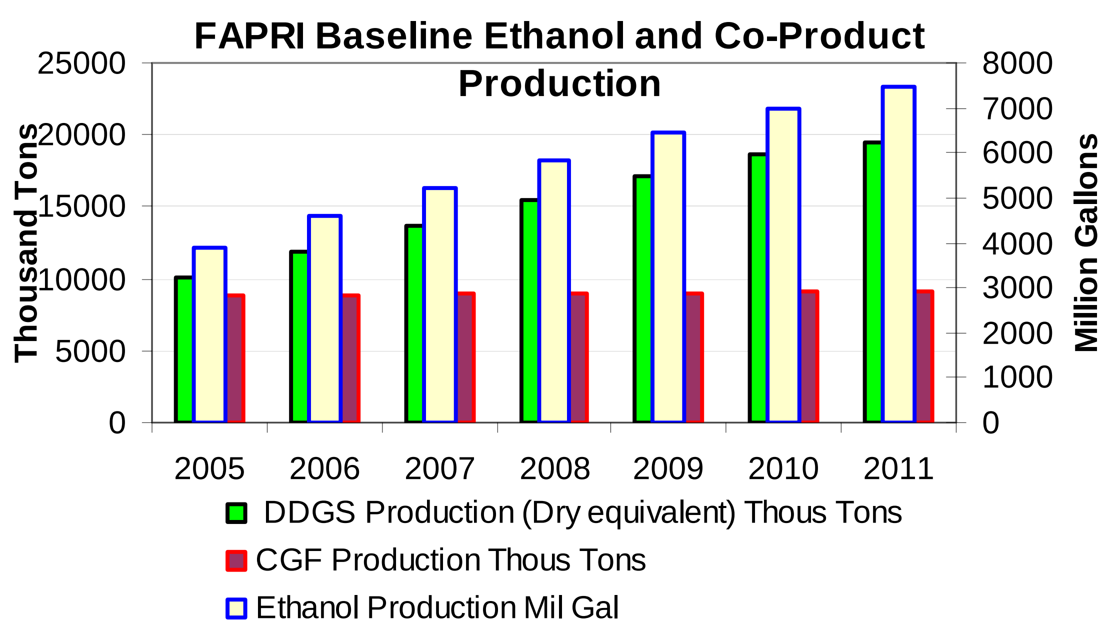
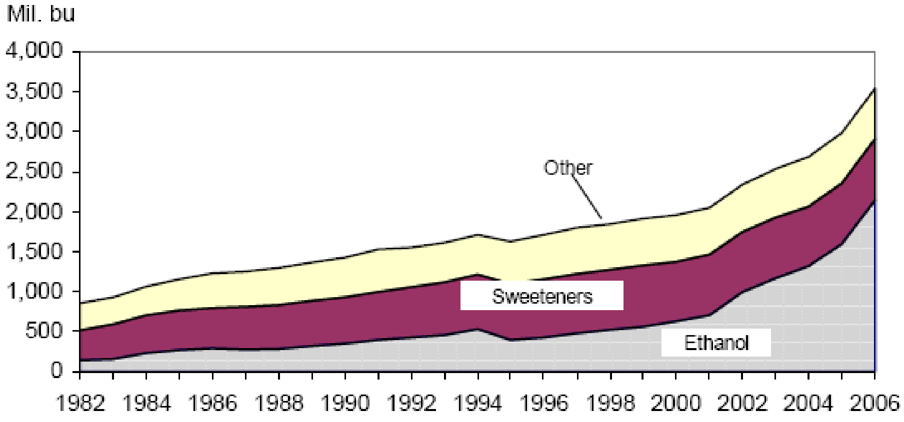


Figure 2.5 Ethanol and corresponding DDGS and CGF forecasted production (FAPRI, 2006)
Note: DDGS is distiller's dried grains with solubles and CGF is corn gluten feed.

Figure 2.6 shows the increasing use of corn for ethanol, predicted at 2.5 billion bushels in 2006/07. Total food, seed, and industrial (FSI) use is projected at 3,545 million bushels, up from 2,985 million bushels expected in 2005/06, with ethanol production driving the year-over-year increase.

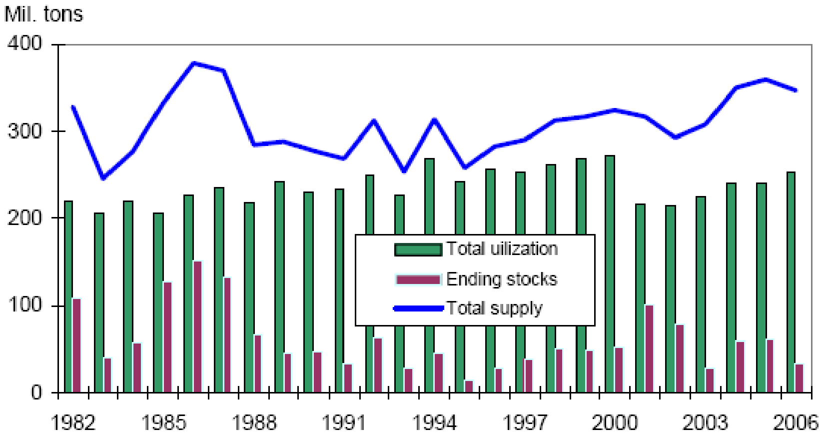


Note: Other includes starch, beverage alcohol, cereals and other products, and seed.
Source: Economic Research Service, USDA, The Feed Grain Data Delivery System.

Figure 2.6 U.S. food, seed, and industrial use of corn

Feed Grain Supply and Utilization

Total feed production for 2006/07 is projected at 283 million tons, down from 299 million in the previous marketing year. Fewer harvested acres for corn, sorghum, and barley along with increased utilization results in predicted lower ending stocks regardless of higher trending yields. Food, seed, and industrial use is projected at 96 million tons, up from 82 million tons in 2005/06. Exports are expected to rise from 57 million tons in 2005/06 to 60 million tons in 2006/07. Feed and residual use is expected to decline 2 million tons in 2006/07 to 158 million (Baker and Allen 2006). Figure 2.7 shows the total utilization, ending stocks, and total supply of feed grains in the U.S. Although ending stocks are predicted lower in 2006, total supply still exceeds total utilization.



Source: World Agricultural Outlook Board (*WASDE*).

Figure 2.7 U.S. feed grain supply and utilization

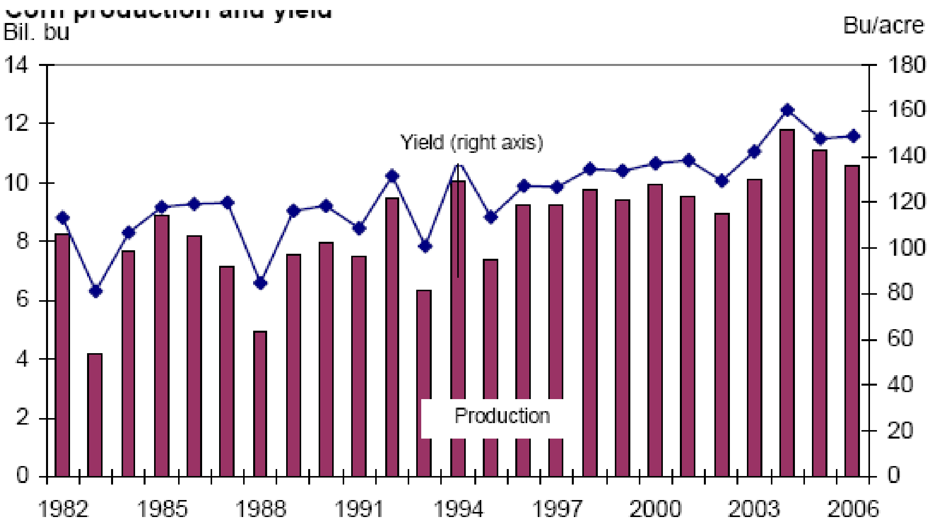
Feed and residual use per grain consuming animal unit (GCAU) is projected at 1.74 tons in 2006/07, down from 1.78 tons a year earlier. Record total GCAUs are projected to be up 1 percent to 93 million, even though supplies of domestic cattle on feed are constrained by heifer retention. Beef production is expected to be 26.8 billion pounds, up from 26.3 billion a year earlier, while pork production and poultry production are expected to increase by 2 percent from 2006 (Baker and Allen 2006). Ethanol co-products likely make up the difference in lower feed and residual use with a higher number of GCAUs.

Corn

In spite of continued strong domestic demand for corn, corn prices are still lower in 2005/06. Higher production costs and reduced prices and yields have resulted in a sharp decline in corn producer net returns, outweighing larger loan deficiency payments and counter cyclical payments. Predicted higher corn prices in 2006/07 will not likely offset the high costs of nitrogen fertilizer and other inputs, but will put stress on cattle feeder's profit margins. In 2006/07, corn producer margins may narrow further, as the effects of lower LDPs and higher production costs outweigh increases in market prices. Later in the baseline, rising prices and yields increase returns and encourage producers to plant more corn. Furthermore, projected increasing soybean returns after 2006/07 will not be sufficient to keep producers from shifting their acres to corn production (FAPRI 2006).

Forecasted beginning 2006/07 corn stocks are 2,226 million bushels, up from 2,114 million the previous year. Ending 2006/07 stocks are projected at 1,141 million bushels, down from 2,226 million a year earlier. Total corn supply is expected to be 12,786 million bushels, down 450 million from the previous year. Total corn utilization is projected at a record 11,645 million bushels, up from 11,010 million bushels a year earlier. Increased ethanol production is the major factor behind the increased utilization, but exports are also predicted to increase by 125 million over the 2005/06 level. The resulting season average corn prices are expected to be $2.25 to $2.65 per bushel for the 2006/07 marketing year, compared with $1.95 to $2.05 in 2005/06 (Baker and Allen 2006).

Figure 2.8 shows corn production and yield, with yield trending higher in 2006/07. USDA forecasted a 1.1 bushel per acre increase in yield (to 149 bushels per acre), which is above trend due to the accelerated corn planting in the spring of 2006.

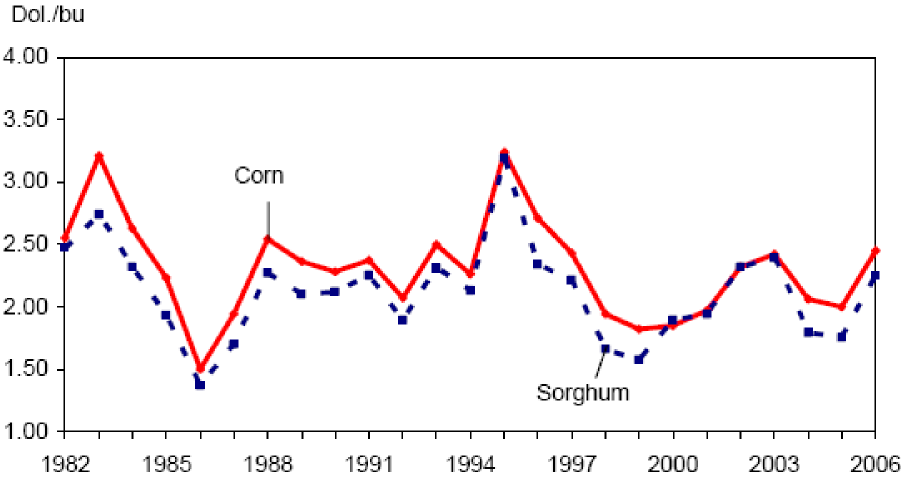


Source: National Agricultural Statistics Service, USDA-NASS Quick Stats and World Agricultural Outlook Board (*WASDE*).

Figure 2.8 U.S. corn production and yield

As Good (2006) noted, a reduction in corn acreage and corresponding increase in soybean acres planted in 2006/07 seems contrary to market signals. Domestically, continued expansion in the use of corn for ethanol production is projected at 2.5 billion bushels in 2006/07 (Baker and Allen 2006). Assuming a trend corn yield in 2006, the increase in corn used for ethanol during the 2006/07 marketing year may be equivalent to production from more than 2.5 million acres (Good 2006).

There are contradicting forecasts for domestic feed use in 2006/07, with USDA predicting a one percent decrease in consumption per grain consuming animal unit (GCAU). Good (2006) estimates domestic feed and residual use of corn during the 2006/07 marketing year will grow with corresponding expansion in beef, pork, and poultry production. A modest 2 percent increase in feed use would equal 120 million bushels. The potential increase in feed use of corn might be limited by increased production of co-product feeds from the ethanol industry (Good 2006). Therefore a portion of the increased corn demand for ethanol will be shared by the feed industry's demand for the co-products of ethanol production, where ethanol co-products replace corn and soybean meal. Lower forecasted ending stocks, from decreased production and record-level use for all four feed grains; corn, sorghum, barley, and oats suggest higher feed prices. Figure 2.9 shows the increasing prices for corn and sorghum (Baker and Allen 2006).



Source: World Agricultural Outlook Board *(WASDE)*.

Figure 2.9 Annual average farm price for corn and sorghum

The expected increase in consumption of U.S. corn during the 2006-07 marketing year can be supported from inventories of the 2005 crop if acreage does not decline and the U.S. average yield is near trend. Large declines in acreage, or a shortfall in the average yield, will result in a decline in ending corn stocks. However, the stocks-to-use ratio will decline regardless of the supply response, as nominal stocks decline and use increases. If corn consumption increases as expected, more U.S. corn acreage will eventually be needed, even with higher trending yields (Good 2006).

Figure 2.10 shows feed and residual use of corn only slightly lower beyond 2006, while fuel alcohol use and exports increase over the baseline period. As total corn utilization increases, ending stocks decline according to FAPRI's (2006) predictions.

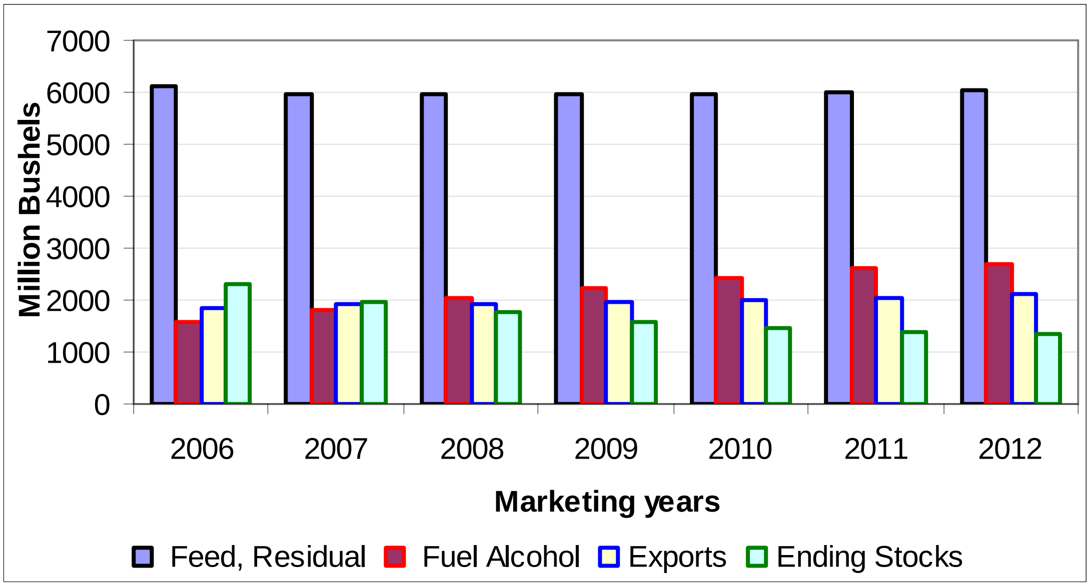


Figure 2.10 Baseline projections for corn supply and utilization (FAPRI, 2006)

Soybean Meal

Domestic consumption of soybean meal increases throughout the baseline in response to low meal prices and growth in poultry and livestock production. Soybean meal exports are projected to remain relatively stable. Increased biofuel production will likely strengthen soybean oil prices while meal prices are weakened by competition from corn co-products. Soybean acreage is expected to increase to 73.2 million acres in 2006, at the expense of corn. After 2006, stronger demand growth for corn than for other crops results in increases in corn acreage and fewer acres planted to soybeans. Declining prices for soybeans weigh on cottonseed prices, in spite of a reduction in cottonseed production (FAPRI 2006).

Record large crops in South America and slower growth in consumption of U.S. soybeans compared to corn indicate market incentives to move acres into corn production. Domestic SBM consumption for livestock feed should occur at a rate equal to the growth in corn consumption, as both feedsources can be replaced by ethanol co-products. Exports of U.S. soybeans will be supported by growing Chinese demand, but will face competition from South America (Good 2006).

Sorghum and Hay

Sorghum acres planted have declined sharply in recent years, and will likely continue this trend. Returns have not been competitive with other crops, partially due to increases in production costs (FAPRI 2006). Kansas and Texas, leading sorghum production states, could see higher sorghum prices with increasing ethanol production.

Total sorghum utilization is expected to decrease from 400 million bushels to 365 million bushels in 2006/07, due to lower feed and residual use and declining exports. Food, seed, and industrial use is expected to increase from 55 million bushels in 2005/06 to 60 million bushels, as some ethanol plants will utilize sorghum as an alternative feedstock. The 2006/07 season average sorghum price is projected at $2.05 to $2.45, up from $1.70 to $1.80 in 2005/06 (Baker and Allen 2006).

Increasing cattle numbers contribute to the modest projected growth in hay disappearance, while hay area remains mostly stable. Due to tighter supplies, hay prices rise in 2005/06, with increasing demand and competition with other crops for land (FAPRI 2006). The simple average of all hay prices from May 2005 to April 2006 was $98.18 per ton, compared with $92.41 during the same period a year earlier. Prices are expected to remain strong through 2006/07 with high livestock numbers, dry pasture and range conditions, and low hay stocks (Baker and Allen 2006).

From the cattle feeder's point of view, higher hay prices will contribute to tighter margins. Cattle rations must contain around 5 percent roughage on a dry matter basis. However, if DG are added to the ration, a lower quality forage can be substituted for alfalfa, due to the higher protein and fiber content of DG. Perrin and Anthony (2005) studied the impact of ethanol expansion by 50 percent on Nebraska agriculture. In this study, the substitution of WDGS into feedlot rations could reduce alfalfa use in feedlots by as much as 16 percent, with an 18 percent reduction in alfalfa price. Already, Nebraska feedlots feeding wet co-products have been able to substitute other roughages for alfalfa, with total reduction of about 10 percent (Perrin and Anthony 2005).

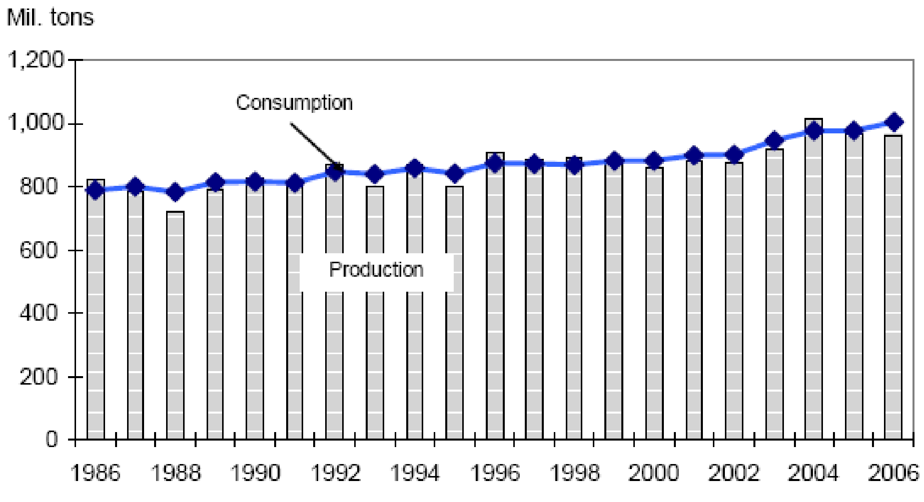
Exports

The export market represents an opportunity for new market growth as DDGS production expands along with ethanol production. In 2004, the U.S. ethanol industry exported approximately one million metric tons of DDGS, with the largest importers being Ireland, the United Kingdom, Europe, Mexico, and Canada (RFA 2006). On the other hand, corn exports are projected to show little growth as corn prices rise between

2006 and 2010. Corn exports will likely increase in later years when prices level off. Projected ethanol use of corn outstrips corn exports in 2007/08 (FAPRI 2006).

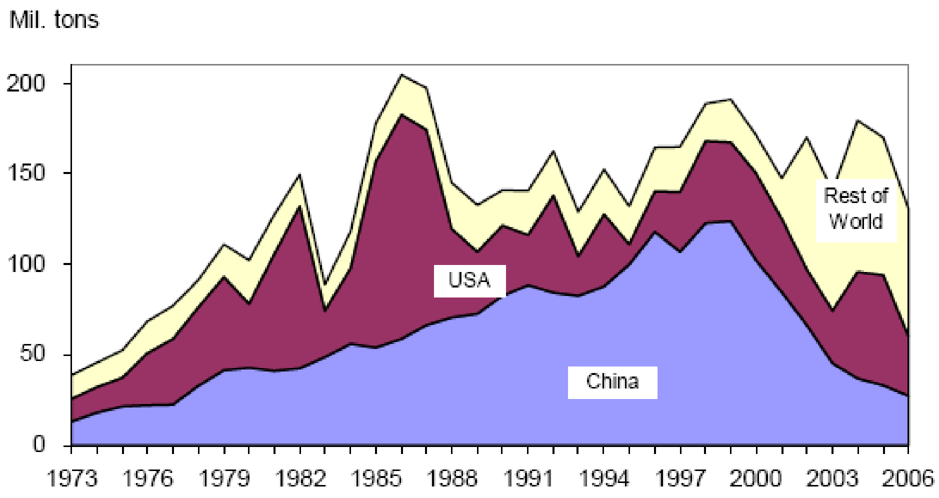
Corn export demand projections might improve due to production shortfalls in Argentina, and decreasing Chinese exports. China will likely become less of a competitor and eventually a net importer of corn, but at an unknown rate. The U.S. could easily experience an increase from 150 million bushels in export demand with reduced competition from China in the years ahead. A probable 225 million bushel increase in U.S. corn exports next year would be equivalent to about 1.5 million acres (Good 2006). Reduced exports from South Africa and less competition from feed-quality wheat will further enhance the export demand for U.S. corn (Baker and Allen 2006).

Figure 2.11 shows world coarse grain production and consumption while Figure 2.12 shows global ending corn stocks (Baker and Allen 2006).



Source: Foreign Agricultural Service, USDA, Production, Supply, and Distribution (PS&D).

Figure 2.11 World coarse grain production and consumption



Source: Foreign Agricultural Service, USDA, Production, Supply and Disribution (Distribution (PS&D.

Figure 2.12 Global ending corn stocks

State-Wide Studies: Analysis and Background

For decades, U.S. and Iowa corn growers have faced excess production and government farm programs designed to avoid surplus supplies. Expanding ethanol production could change corn allocation significantly. If U.S. corn acreage remains at its 2003 level, the amount of corn available for export is expected to decline from about 2.1 billion bushels in 2004-2005 to about 900 million in 2008, a 57 percent decline in potential U.S. corn exports (Wisner and Baumel 2004). Supply and demand response to increased corn prices were not accounted for in Wisner and Baumel’s analysis.

Wisner and Baumel’s (2004) basic assumption was that Iowa livestock and poultry feeders and wet and dry corn millers will bid a high enough price for corn to purchase the required amount to feed all of the Iowa animals and to keep the Iowa processing plants operating at capacity. The data show that Iowa corn consumption for ethanol production is expected to increase 557.8 million bushels, or 222.8 percent between 2003 and 2008. Corn yields were assumed at the long-run trend level each year.

Corn fed to all Iowa livestock is expected to decline slightly from 483 million bushels in 2003 to 481 million bushels in 2008. A combination of the changing mix of animals and the substitution of DDGS for 45 million bushels of corn accounts for the decrease in corn fed to livestock. Iowa grain processing plants are expected to produce 5.6 million to 6.7 million tons of DDGS in 2008. Iowa livestock producers are expected to consume 2.2 million tons, with the remaining 3.4 to 4.5 million tons being sold to animal feeders in other states and/or exported abroad. The unanswered questions are where the excess DDGS will be sold and how it will be transported (McVey, Baumel, and R.N. Wisner 2005).

Nebraska

New technologies and irrigation resources made Nebraska's grain production grow faster than any other major producing state during the 1970's and 1980's. The resulting relatively cheap grain inspired growth in the cattle feeding and grain processing industries. Corn processing plants were established when research showed a market for feeding the processing byproducts directly to the expanding numbers of finishing cattle. With affordable inputs and an output market, transportation and processing costs were reduced by about $0.17 per bushel processed (or about 5 percent of the total cost of ethanol production), as co-products didn’t have to be dried and shipped to distant markets (Perrin and Klopfenstein 2001).

Perrin, Weller, and Isom (2005) attribute Nebraska’s comparative advantage in ethanol production to the large number of cattle on feed within the state. In Nebraska, wet corn co-products are fed to about 75 percent of feeder cattle, at low rates that could be increased substantially. Therefore a large potential market exists for wet corn co-products within the state. Perrin, Weller, and Isom (2005) believe other Corn-Belt states have smaller potential markets for wet co-products.

When Perrin and Anthony (2005) considered the impacts of doubling ethanol production in Nebraska, they estimated the percentage of cattle being fed some co-products would increase from 75 percent to over 80 percent (with a 25 percent increase in feeding rate), and a 6 percent increase in the total number of cattle fed. They predicted co-product based rations would reduce the cost of beef production, leading to average gains for cattle feeders of between \$0.01 and \$0.02 per pound of beef produced. Increasing co-product production would lead to increased cattle feeding within Nebraska and bidding up feeder calf prices by nearly \$8/cwt. Other states would supply a majority of these feeder calves, as nearly two-thirds of Nebraska feeders come from out of the state (Perrin and Anthony 2005).

Erickson (2005) found the Nebraska feedlot industry is using about 15 to 20 percent inclusion rates for co-products. He predicted that WDGS was being fed to about 35 to 40 percent of the feedlot cattle in the state. WCGF from the wet milling plants in Columbus and Blair is fed to another 30 to 35 percent of Nebraska feedlot cattle. On average, if the feedlot is feeding WDGS at 20 to 40 percent of the diet (dry matter basis) and is within 100 miles of the plant, feeder returns are $15 to $25 per animal fed for 150 days. If the price of corn is increased by $0.05 per bushel as demand from ethanol plants increases, returns to cattle feeders decrease by $3 per animal. A 10 cent increase in corn price decreases returns by $6 and so on, but net return to cattle feeders still ranges from $9 to $19 per animal. These benefits are a result of a cheaper feed source as well as increased cattle performance measured by average daily gain and feed efficiency (Erickson 2005).

Nebraska Ethanol Production

Nebraska currently has 12 ethanol plants, producing more than 575 million gallons of ethanol each year, and requiring nearly 300 million bushels of grain for the production process. This makes ethanol production the third largest use of Nebraska corn. A market that barely existed twenty five years ago has grown to become a significant factor in the profitability of Nebraska farmers. It is estimated that ethanol production adds 5 cents to 8 cents per bushel of corn in areas near an ethanol plant. Grain sorghum is also used as a feedstock in Nebraska ethanol production (Nebraska Ethanol Board 2006). Figure 2.13 shows the ethanol plants in operation (green dots) and under construction (brown dots) in Nebraska.

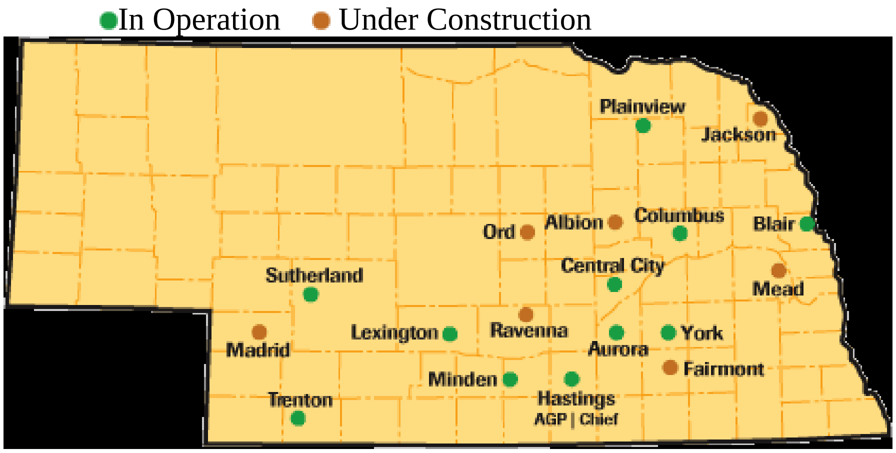


Figure 2.13 Nebraska ethanol production plants in operation and under construction (Nebraska Ethanol Board 2006)

Ethanol production continues to explode in Nebraska, where approximately 11 new plants are in the planning stages (McElroy et al. 2006). These new plants could produce nearly 600 million gallons of ethanol per year, doubling current production within the state.

Nebraska Corn Production

Nebraska, the “Cornhusker State”, is the third largest corn-producing state in the nation. Nebraska’s corn production has fluctuated from 1.01 billion bushels (yield: 126 bu/acre) in 2000 to 940 million bushels (yield: 128 bu/acre) in 2002 and a new record production and yield of 1.3 billion bushels (yield: 166 bu/acre) in 2004. Production was lower in 2005, at 1,270,500 thousand bushels with average yield of 154 bushels per acre (USDA/NASS 2006). Table 2.1 shows Nebraska corn utilization within the state as well as domestic and international exports (Nebraska Corn Board 2006).

Table 2.1 Nebraska Corn Utilization

Corn Utilization within Nebraska:	Million Bushels	% of total corn production
Processing	309	36
Other Feeding	1	0.09
Dairy	4	0.37
Poultry	13	1
Hogs	62	6
Beef	199	19
Net Leaving State		
Domestic	383	36
International	96	9
Processing Components		
Dry Mill Ethanol	136	
Wet Mill Ethanol	103	
Other	70	

Note: Data available at: http://www.nebraskacorn.org/necornfacts/cornutilization.htm

Nebraska Feedlot Rations

Nebraska finishing rations commonly contain high moisture corn or dry rolled corn, or some combination of the two as the primary ingredients. Table 2.2 shows feedlot nutrition research rations from the University of Nebraska. WDGS replaces a portion of the corn as well as urea in the diet (Erickson 2006).

Table 2.2 Nebraska Beef Finishing Ration Components

		DG=WDGS inclusion level on DM% basis				
Ingredient	**CONTROL**	**10DG**	**20DG**	**30DG**	**40DG**	**50DG**
High Moisture Corn	45	40	35	30	25	20
Dry Rolled Corn	45	40	35	30	25	20
WDGS	0	10	20	30	40	50
Alfalfa hay	5	5	5	5	5	5
Dry supplement	5	5	5	5	5	5
Fine ground corn	1.04	1.78	2.07	2.35	2.61	2.66
limestone	1.45	1.55	1.57	1.55	1.53	1.51
urea	1.29	0.66	0.44	0.21	0	0
potassium chloride	0.45	0.42	0.39	0.36	0.33	0.31
salt	0.3	0.3	0.3	0.3	0.3	0.3
calcium sulfate	0.24	0.06	0	0	0	0
Tallow	0.13	0.13	0.13	0.13	0.13	0.13
trace mineral premix	0.05	0.05	0.05	0.05	0.05	0.05
rumensin-80 premix	0.016	0.016	0.016	0.016	0.016	0.016
thiamine	0.013	0.013	0.013	0.013	0.013	0.013
vitamin A-D-E premix	0.01	0.01	0.01	0.01	0.01	0.01
Tylan-40 premix	0.009	0.009	0.009	0.009	0.009	0.009

Note: Ingredients are as a percent of the total ration, on a DM (dry matter) basis.

Kansas

Kansas Ethanol Production

Seven dry mill ethanol plants are currently in operation in Kansas with a capacity of about 170 million gallons. Kansas production creates a market for 65 million bushels of sorghum and corn (Kansas Grains 2006). At least three new Kansas plants are being planned, with two intending to use a closed-loop system where anaerobic digesters will be used to convert cattle manure to energy to run the ethanol plant and the WDGS will be fed to the cattle. Corn and grain sorghum will be the primary feedstocks. These new plants could add over 160 million gallons of ethanol per year, nearly doubling Kansas ethanol production (McElroy et al. 2006).

Kansas Corn Production

According to January 2006 USDA statistics, Kansas corn production in 2005 totaled a record 465.8 million bushels. This record production is 33.8 million bushels over 2004’s previous record of 432 million bushels. Planted area was 3.65 million acres, up 550,000 acres from planted area in 2004. Acreage harvested for grain, at 3.45 million acres, was up 570,000 acres from the area harvested in 2004 (Kansas Grains 2006).

Kansas Feedlot Rations

Table 2.3 shows the ration compositions for a feedlot finishing trial with differing levels of WDGS fed to heifers. This control ration is representative of Kansas feedlots that are not currently feeding ethanol co-products.

Table 2.3 Kansas State University Feedlot Finishing Rations

Composition of Diets Fed to Heifers During the Final 58 Days of Feedlot Finishing

Ingredient	**Percent of Ration Dry Matter**					
Flaked corn	83.6	76.9	70.3	63.6	56.1	48.1
Alfalfa hay	7	7	7	7	7	7
Wet distiller’s grains w/solubles	---	8	16	24	32	40
Soybean meal	3.4	2.4	1.3	0.7	---	---
Rumensin/Tylan/MGA premix a	2.5	2.5	2.5	2.5	2.5	2.5
Limestone	1.5	1.5	1.5	1.5	1.5	1.5
Urea	1.2	0.84	0.48	0.12	---	---
KCl	0.47	0.49	0.52	0.54	0.55	0.55
Salt	0.31	0.31	0.32	0.32	0.33	0.33
Vitamin/mineral premix b	0.14	0.14	0.14	0.13	0.13	0.13

a Formulated to provide 300 mg/day Rumensin, 90 mg/day Tylan, and 0.5 mg/day MGA.
b Formulated to provide 0.1 ppm cobalt, 8 ppm copper, 0.5 ppm iodine, 48 ppm manganese, 0.25 pm selenium, 48 ppm zinc, and 1000 IU/lb vitamin A in the diet dry matter.
Note: Data from Daubert et al., 2006.

Texas

Texas Ethanol Production

There are five ethanol plants in various planning stages in Texas. The proposed plants have a combined production capacity of around 300 million gallons per year, and will use corn and grain sorghum as their primary feedstocks. Cattle manure and cotton gin waste is planned to power at least one of the plants in Hereford, Texas. The ethanol plants will rail in corn, as well as utilizing locally produced grain sorghum and corn (McElroy et al. 2006).

Texas Corn and Sorghum Production

Texas ranks number 12 in corn production and number 2 in sorghum production in the nation. In 2005, 2ll million bushels of corn were harvested from 1.85 million acres with an average yield of 114 bushels per acre. The average Texas corn price was $2.50 per bushel. Sorghum had about the same harvested acres, but a much lower average yield of 60 bushels per acre, and an average price of $3.85 per cwt (NASS 2005). Most of the corn and sorghum produced in Texas are sold as livestock feed. As a corn deficit state, Texas also imports corn from the Midwest to meet the feed demand of the livestock industry.

Cattle on Feed

Texas ranks number one in cattle on feed, and Figure 2.14 shows the top four cattle feeding states with 2006 inventory.

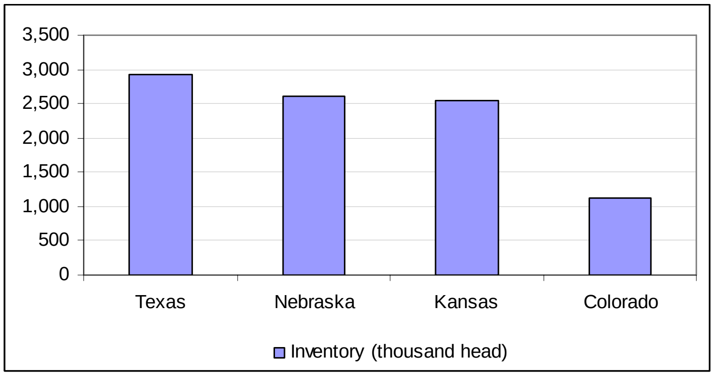


Figure 2.14 Top 4 states cattle on feed 2006 inventory (USDA/NASS 2006)

Texas (Panhandle) Feedlot Rations

Texas finishing rations primarily contain steam-flaked corn and a combination of cottonseed hulls, meal, and cotton burrs. Rations may also contain corn silage as a roughage source. Alfalfa is not as common in the Panhandle region as in the other states, especially in the recent drought years. Table 2.4 contains trial ration ingredients for a study by Galyean and Lemon (2006) at Texas Tech University.

Table 2.4 Texas Panhandle Finishing Rations (Galyean and Lemon 2006)

Ingredient		Treatment diets			
	Control	5% WSDGS	10% WSDGS	15% WSDGS	10% WCDGS
SFC	75.4	73.9	70.68	65.72	71.03
WSDGS	0	5.37	10.7	15.97	0
WCDGS	0	0	0	0	10.2
Cottonseed hulls	7.62	7.59	7.56	7.53	7.6
Molasses	4.25	4.23	4.22	4.19	4.24
Tallow	3.06	3.05	3.04	3.02	3.06
Urea	1.01	1.01	0.77	0.25	0.81
Cottonseed meal	5.86	1.97	0	0	0
Limestone	0.26	0.35	0.52	0.81	0.53
Supplement	2.54	2.53	2.52	2.5	2.52

Note: SFC is steam-flaked corn, WSDGS is wet sorghum distillers grains plus solubles and WCDGS is wet corn distiller;s grains with solubles; all ingredients are as a percent of total ration on a DM (dry matter basis).

Colorado

Colorado Ethanol Production

Colorado has three ethanol plants producing a total of 91.5 million gallons of ethanol per year (OEMC 2006). There are four new ethanol plants on the horizon for Colorado, potentially producing 350 million gallons of ethanol per year. At least one of the 100 MMgy plants plans to use cattle manure to create syngas fuel to power the plant (McElroy et al. 2006). All of the plants will be located in the northeast region of Colorado, where the most corn is grown and cattle are fed. Corn will be the primary feedstock, and will primarily be railed in from the Midwest.

Colorado Corn Production

Colorado produced 140.5 million bushels of corn in 2005, with an average yield of 148 bushels per acre, and an average price of $2.25 per bushel (USDA/NASS 2006). Also a corn deficit state, Colorado imports feed grains from the Midwest.

Colorado Feedlot Rations

Table 2.5 contains examples of Colorado feedlot rations, formulated on a dry matter basis.

Table 2.5 Colorado Beef Finishing Rations

25% WDGS	0% WDGS
62 % Dry Rolled Corn	82 % Flaked Corn
25 % Distillers Grain (WDGS)	
7 % Hay	11 % Hay
6 % Dry Protein	7 % Dry Protein
90 Mg Tylan	90 Mg Tylan
360 Mg Per Head Per day Rumensin	360 Mg Per Head Per day Rumensin

U.S. and Regional Data and Charts

Figure 2.15 shows the increase in cattle on feed in the U.S. for 2006 compared with 2005 and 2004 numbers. Cattle on feed inventory on June 1, 2006 was up 4 percent compared to June 1, 2005.

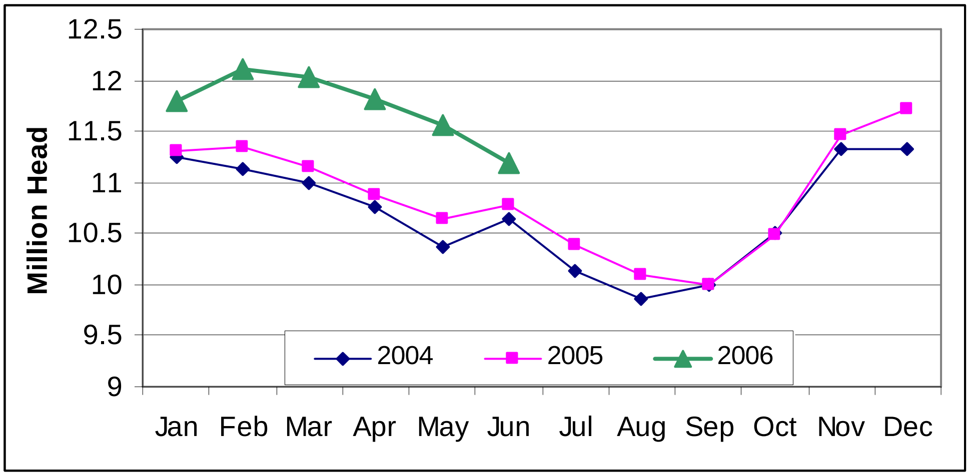


Figure 2.15 U.S. cattle on feed, 1000+ capacity feedlots
Source: USDA Cattle on Feed Report, June 23, 2006

Figure 2.16 shows the regional historic total cost of gain for each region from historic data collected by the Professional Cattle Consultants (PCC), a private feedlot consulting company. High corn prices in 1996 are reflected in the high cost of gain during that time. Currently, the Corn Belt has the lowest total cost of gain for 750 pound steers placed on feed in May, while the Southern Plains have the highest total cost of gain.

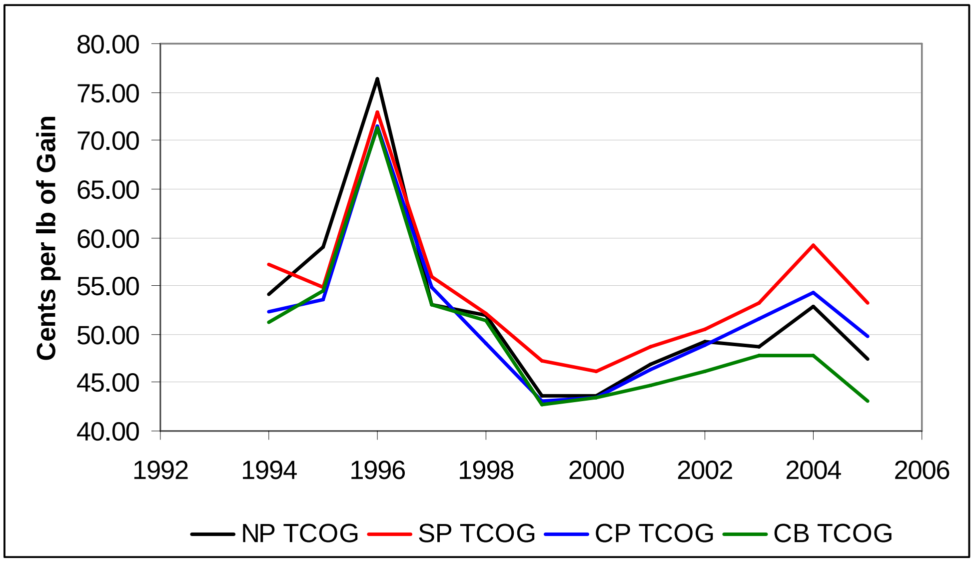


Figure 2.16 Total cost of gain (TCOG) from PCC data for 750 pound steer placements by region

Note: North Plains (NP) represents Colorado feedlots, South Plains (SP) contains Texas feedlots, Central Plains (CP) includes Kansas feedlots, and Corn Belt (CB) includes Nebraska feedlots. PCC data is from close-out month of September, where May is the estimated placement month.

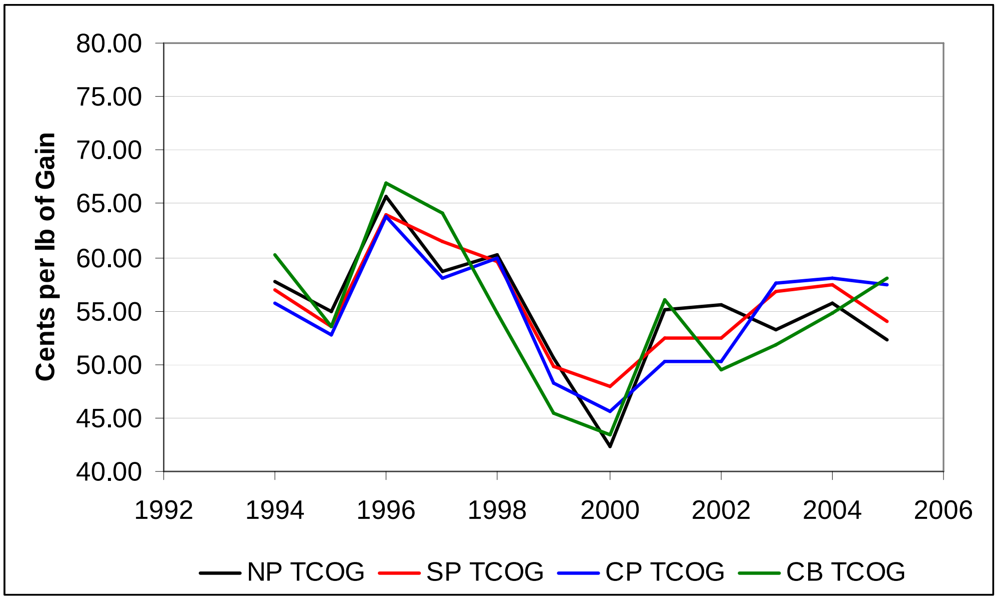


Figure 2.17 Total cost of gain (TCOG) from PCC data for 600 pound steer placements by region

Note: North Plains (NP) represents Colorado feedlots, South Plains (SP) contains Texas feedlots, Central Plains (CP) includes Kansas feedlots, and Corn Belt (CB) includes Nebraska feedlots. PCC data is from close-out month of April, where October is the estimated placement month.

Figure 2.17 shows total cost of gain for steers placed at 600 pounds, with October as the estimated placement month. The overall trend in this data is similar to those placed at 750 pounds, but in recent years, the Corn Belt and Central Plains have faced a higher total cost of gain. Total cost of gain includes veterinary costs, which are typically higher for lighter weight placements. Adverse weather conditions for fall placements can also lead to increased veterinary costs, increasing the total cost of gain. Figures 2.18 and 2.19 show the regional veterinary costs for 600 pound and 750 pound placement weights, respectively. Veterinary costs are in dollars per head, and are significantly higher for steers placed at lighter weights and in the northern feedlots, with higher chances for adverse weather conditions.

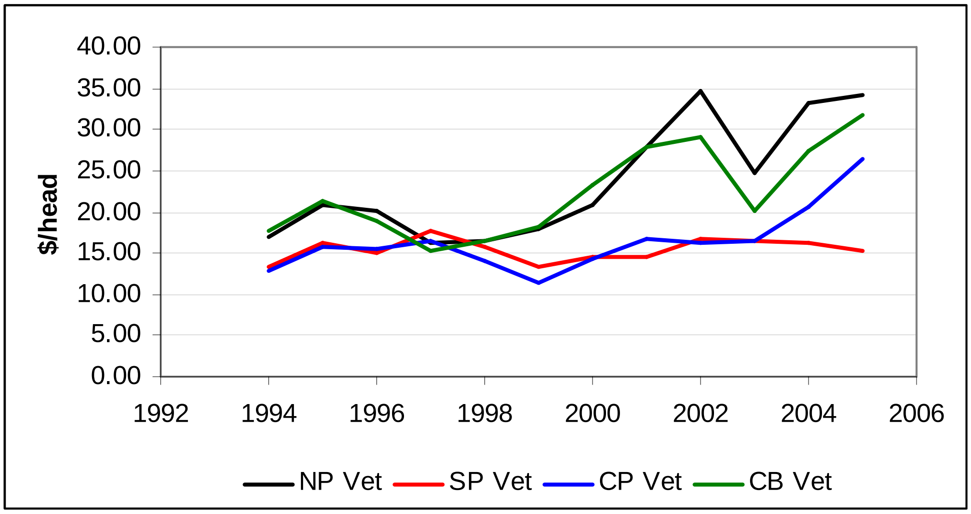


Figure 2.18 Veterinary costs for 600 steers placed on feed in October
Note: See note on page 67 for description of regions.

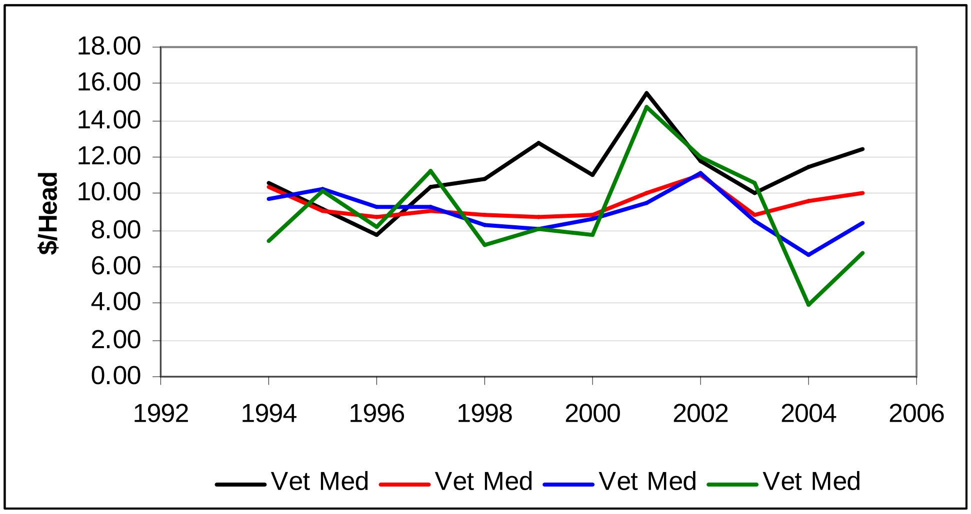


Figure 2.19 Veterinary costs for 750 pound steers placed on feed in May
Note: See note on page 67 for description of regions.

The correlation between total cost of gain and corn prices can be seen by comparing figure 2.20 with figures 2.16 and 2.17.

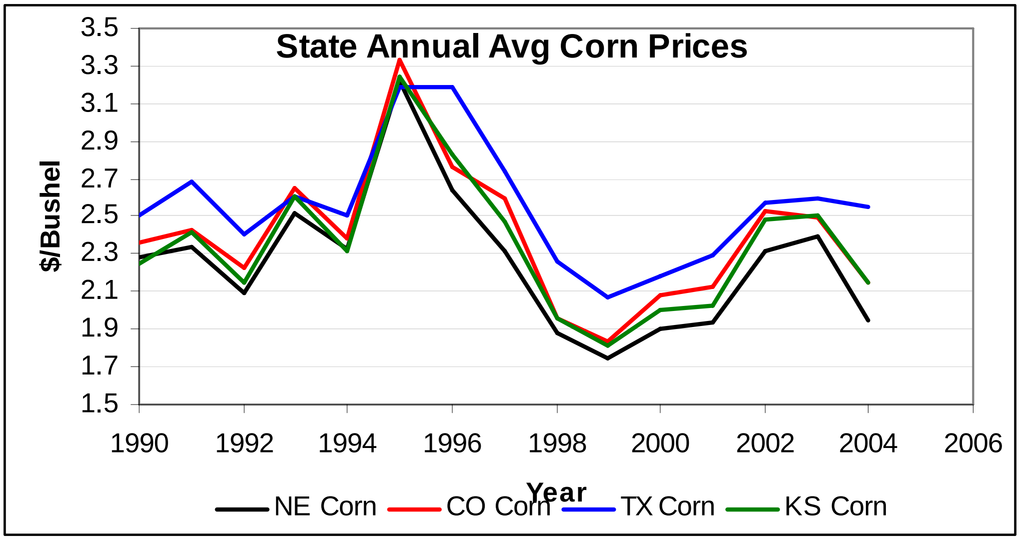


Figure 2.20 State annual average corn prices (USDA/NASS 2006)

Risk Factors in Ethanol Production and Price Correlation

Coltrain, Dean, and Barton (2003) found relatively high correlation between prices of ethanol and unleaded gasoline (correlation: 0.58), but in reality the relative supply and demand for each are also significant drivers in their price patterns. Ethanol and natural gas prices also move together with a correlation of 0.49. The price of ethanol is driven more by the energy market than the agricultural commodity market (i.e., sorghum and corn) as indicated by their significantly uncorrelated relationship (correlation: 0.17).

Distiller’s grains, on the other hand, are closely related to the agricultural feedstock commodity market where the correlation between sorghum and DDGS is 0.74. Since DDGS is an output and sorghum is an input this positive correlation implies that as price increases for sorghum, the price of DDGS produced will also increase- lowering the risk in ethanol production. Sorghum is comparable to corn as an input cost and produces a similar DDGS product. The value of DDGS to the ethanol producer is about 1/6th the value of the ethanol produced (Coltrain, Dean, and Barton 2003). This is further emphasized in Figure 2.21, where the correlation between DDGS and the input feedstock is shown by the negative value of the co-product. This study is useful in further determining the relationship between co-products and other feed ingredients. The correlation between natural gas prices and feed ingredients has further implications when considering the cost savings from dry rolling corn compared to steam flaking corn, especially when incorporating WDGS into the ration

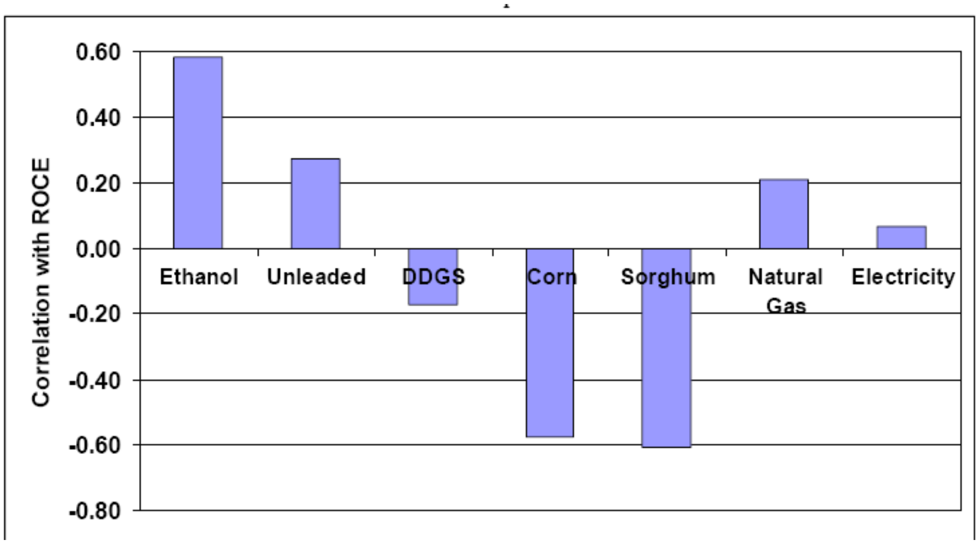


Figure 2.21 Correlation between return on common equity and various input and output factor prices associated with ethanol production (Coltrain, Dean, and Barton, 2003)

Nutritional Aspects of WDGS and DDGS

Although this paper focuses on implications for the cattle feeding industry, this section provides an overview of the nutritional attributes of ethanol co-products for the entire livestock feeding industry. The brief nutritional analysis helps to explain why WDGS and DDGS are primarily fed to ruminants, but are increasingly being utilized in pork and poultry production.

The nutritional attributes of DDGS for dairy and beef cattle include high levels of bypass protein and a highly digestible combination of fiber and fat, making DDGS a highly desirable ingredient for ruminant diets. DDGS can be a substitute for corn or SBM in ruminant rations, but DDGS protein is of lower quality than SBM so DDGS should be priced between corn and SBM (Urbanchuk 2005). There may be fewer off-feed incidents when feeding distillers grains than when feeding corn even though they contain similar amounts of energy. This should increase the feeding value of ethanol co-products, from a nutritional point of view. Ethanol is produced from the starch in corn, so the energy in DG comes from digestible fiber and fat instead of starch. Ruminal starch fermentation is more likely to result in acidosis, laminitis, and fatty liver, so the removal of starch results in a valuable feed product (Schroeder 2003).

The limitations of DDGS are its low level of amino acid content, especially lysine and tryptophan, giving SBM the advantage in protein quality. At a higher percentage of the diet (>50 percent), additional fat limits the inclusion of DG in feedlot rations (depending on the fat content in the rest of the diet). The high phosphorus content of DDGS can also be a concern for cattle feeders. Increasing regulations for phosphorus levels in manure can increase the costs of feeding a high phosphorus diet. The cost of supplementing calcium (CA) must also be considered, and at what level CA must be supplemented. Beef cattle rations need a calcium to phosphorus ratio of 1:1 to 1.5:1 otherwise the negative effects include a potential for water belly steers as well as increased phosphorus levels in manure (Shurson and Noll 2005).

The phosphorus in DDGS comes primarily from the solubles that are mixed back in during the drying process. Therefore, phosphorus levels can vary depending on the percent of solubles in DDGS. Phosphorus is a valuable mineral, especially for cattle on high forage diets. Corn distiller's based livestock supplements are now being manufactured to take advantage of the phosphorus and other minerals found in condensed distillers solubles. New products are constantly being developed by the ethanol and feeding industries to capture new markets and get the most return for ethanol co-products (Shurson and Noll 2005).

High sulphur levels are another concern when feeding large amounts of DDGS. Ethanol plants often add sulphur during the distillation process to aid in pH control. If DDGS has a high sulphur content, thiamin should be supplemented, especially if water sources also contain sulphur (Erickson 2006).

Dairy

The general recommendation for dairy producers is feeding up to a maximum of 20 percent of ration dry matter (DM) as distillers grains. When converted to typical feed intakes for lactating cows, this is about 10 to 12 pounds of DDGS or 33 to 37 pounds of WDG per cow per day. Higher levels of DDGS may be fed depending on the amount of corn silage and alfalfa in the ration. With a greater amount of alfalfa, less DDGS is needed to fulfill the protein requirement. On the other hand, when corn silage makes up a greater percent of the ration, more DDGS may be incorporated (replacing most or all of the SBM and corn in the normal grain mix). If WDG is fed with high levels of corn silage, high water content will likely limit total dry matter intake (for WDG>20% DM). Excess feed protein is likely with 30 percent DG in the diet, unless corn silage and/or grass hay are the primary forages utilized (Schroeder 2003). This study does not consider the economics of valuing DG as an energy or protein source, where depending on price it could feasibly replace part of the alfalfa or corn silage in the ration.

Most research has focused on DG as an alternative protein for SBM, but in addition to their protein content, corn co-products are also an excellent energy source. The valuable energy is attributed to the high content of digestible neutral detergent fiber (40-45 percent NDF) and fat in DG. This makes DDGS a potential replacement for dietary starch, where the additional digestible fiber causes a reduction in ruminal acidosis occurrences. Even though DDGS has high fiber content, it only contributes 15 percent physically effective fiber to the diet because of the small particle size. Therefore, NDF from long particles is necessary to stimulate rumination health (i.e. forages) (Schroeder 2003).

According to Schroeder (2003), some factors to consider when feeding DG to dairy cattle are: 1) a proper ratio of forage sources to reduce dietary crude protein (avoid CP greater than 18 percent), 2) supplemental sources of lysine if corn silage comprises the majority of the forage, 3) avoid adding excessive fat to the diet (avoid fat greater than 6 percent), and 4) avoid excessive excretion of nitrogen and (or) phosphorus. Again, economic factors are largely ignored.

Schroeder's (2003) analysis cites recent research from the University of Nebraska comparing the feeding of wet and dry DG where virtually no differences in feed intake or milk production were found. Meanwhile, on-farm observations indicate that there may be an advantage to feeding WDGS when the other ration ingredients are dry because of improved ration palatability. Similar nutritional aspects make cost efficiency the primary factor in choosing whether to feed wet or dry DG. Cost efficiency differences are found primarily in transportation, storage, and handling costs. DDGS can be stored for extended periods of time, can be shipped greater distances more economically and conveniently than WDGS, and can easily be blended with other dietary ingredients. On the other hand, WDGS saves the ethanol plant drying costs, and these savings are passed on to the livestock feeder (Shroeder 2003). Some studies have also shown that WDGS increases feed efficiency (and therefore decreases the cost of gain).

Feeding distillers grains to lactating dairy cows can increase milk yield above diets consisting of SBM, especially when supplemented with ruminally protected Lysine and Methionine. Milk protein yield and percentage increase with amino acid supplementation, while milk fat yield and percentage are generally unaffected by diet (Nichols et al. 1998). Economic efficiency was not considered in this study.

While dairy cows require 0.38 percent phosphorus in their daily ration, the standard diet contains 0.40 percent, and a diet including 30 percent WDGS contributes

0.50 percent P. (A standard diet consists of 50 percent of a 1:1 mixture of alfalfa and corn silage plus a concentrate with soybean meal and corn. The 30% corn distillers diet replaced a portion of both the forage and concentrate with WDGS.) Crude protein, RUP3 (rumen undegradable (escape) protein) and calcium are constant between diets--all equal to the requirement (Shroeder 2003).

Swine

Monogastrics can also be fed DDGS, as a substitute for corn, SBM, and dical phosphate. The swine industry is the fastest growing sector of DDGS use in the U.S. (Shurson, Noll, and Goihl 2005). Excess P in DDGS makes it more favorable for swine and poultry because of their higher P requirements, where DDGS can at least partially replace dical phosphate in monogastric rations (Neutkens 2002).

As the swine industry moves toward applying manure based on a phosphorus standard rather than nitrogen, producers will be willing to pay more for ingredients like DDGS. Fermentation releases the phytate phosphorus in corn, which makes phosphorus more available to the pig. Although it is not mentioned in the literature, there is potential for marketing DDGS with different levels of solubles (P content) as ethanol plants move toward more specialized and differentiated co-products (Neutkens 2002).

At a typical 10 percent inclusion rate for grow-finish rations, 200 lb. of DDGS, plus 3 lb. of limestone, will replace 177 lb. of corn, 20 lb. of SBM and 6 lb. of dicalcium phosphate resulting in feed cost savings of $0.19/ton. This savings is an advantage over a typical corn-SBM diet containing 3 lb. of synthetic lysine/ton. The inclusion rate can go to 20 percent, with the higher amino acid digestibility values found in DDGS, plus 80 percent phosphorus availability, without compromising performance. The 10 percent fat content of DDGS limits use levels over 20 percent, due to possible reductions in pork fat quality. The high fiber content in DDGS is another limiting factor in monogastric diets, but only at the higher inclusion rates, while product inconsistency is perhaps an even greater limiting issue (Neutkens 2002).

DDGS can also be fed to sows. Gestating animals can receive up to 40 percent DDGS and lactating sows up to 20 percent in the diet. DDGS can be extremely cost effective in a swine diet, where the savings come primarily from the reduction in dicalcium phosphate. If phytase is added with the DDGS, the need for inorganic phosphorus can be reduced by 70 percent. Beyond the economics, diets are adjusted for health issues, so the cost advantage over SBM may be insignificant. DDGS may have more health benefits for swine than have been fully discovered at this point. “One theory is the high amount of insoluble fiber in DDGS (42 percent vs. 4.7 percent for corn and 13 percent for SBM) pushes feed through the digestive system faster, preventing pathogens from attaching to the gut wall. The other unique thing about DDGS is it contains a lot of spent yeast, which may have special nutraceutical properties (Neutkens 2002).”

According to Shurson (2003) DDGS has traditionally been used more in the dairy industry, so it has been valued more for its by-pass protein content than its energy value. As a swine producer, valuing DDGS for its cost per pound of protein compared to other ingredients will undervalue its energy and phosphorus value while overvaluing protein. Phosphorus is the third most expensive nutrient in swine diets therefore one of the main advantages of feeding DDGS is its relatively high available phosphorus content. Based on economic importance, the three primary nutrient categories in swine diets are energy, amino acids, and phosphorus. Shurson, Noll, and Goihl (2005) cite research at the University of Minnesota that has shown DDGS (from modern dry mill plants) has a high metabolizable energy (ME) value (1,527 kcal/lb.) that is comparable to corn (1,550 kcal/lb.). When using high quality, “new generation” DDGS, virtually no supplemental fat is required to maintain the desired dietary energy levels in typical corn-soybean meal diets (Shurson, Noll, and Goihl 2005).

When determining the value of DDGS, amino acid content must be considered, especially the most variable amino acid in DDGS, lysine. The higher the lysine in DDGS, the more SBM it can replace in the diet. Previous studies have shown lysine levels vary from 0.63 percent to 0.90 percent (average 0.73 percent), where much of the variation is related to the normal variation in the corn source. The importance of lysine content can be seen when the value of DDGS is calculated on a total lysine basis versus DDGS formulated on a digestible lysine basis. Using total lysine and total phosphorus approach, adding 200 lb. of DDGS to a typical early grower diet (1,486 kcal ME/lb., 1.0 percent lysine, 0.55 percent P) will replace 162 lb. of corn, 36 lb. of 44 percent SBM, and 5 lb. of dicalcium phosphate. The resulting feed cost savings are $1.40/ton of complete feed over a typical corn-SBM diet (with 3 lb. of synthetic lysine) (Shurson 2003).

Calculating cost savings based on digestible nutrients, instead of total amount, results in less cost savings from adding DDGS. More corn would be replaced (177 lb.), less SBM (19 lb.), and more dicalcium phosphate (7 lb.). The cost savings are reduced to $0.62/ton because more corn is replaced and relatively less SBM compared to the replacement based on total amino acid content. Therefore, one could afford to pay an additional $6.20/ton for DDGS ($91.20) using the digestible amino acid method, and break even with the cost of the typical diet. On the other hand, using total amino acids, one could afford to pay an additional $14/ton for DDGS ($99/ton) (Shurson 2003).

Adding phytase with DDGS can eliminate the need for additional dicalcium phosphate in swine diets, when diets are formulated using an available phosphorus method. Diet cost will be increased slightly ($0.11/ton) compared to feeding a typical corn-SBM diet containing 3 lb. of synthetic lysine and no phytase. Beyond the cost increase, feeding DDGS and phytase is still an economical way to significantly cut phosphorus levels in manure. Least-cost diet formulation typically has not incorporated ingredients to decrease nutrient excretion as there has been little or no economic (or regulatory) incentive to do so (Shurson 2003). As hog producers begin to face new stringent environmental quality standards and phosphorus manure regulations, the benefits of feeding DDGS for its phosphorus availability become extremely important.

Markham (2005) found that DDGS is primarily a corn replacer but trends very closely with SBM prices. The Lysine limiting characteristic of corn is multiplied by three in DDGS but synthetic lysine is cheap and readily available (due to increased imports from China). This makes DDGS a cheap feed source for monogastrics, especially as a substitute for oilseed proteins. Inclusion of DDGS in ruminant diets has little effect on oilseed protein consumption. Monogastrics, on the other hand, can be fed DDGS in place of oilseed proteins with the supplementation of synthetic lysine.

Pork producers have also found DDGS enhances gut health, and reduces the need to use antibiotics and medications, and again lowers costs. This also benefits consumer relations and the pork producer's image as they move away from medications and toward a more natural product.

With all the supposed positive implications for swine feeders, the question remains, why aren't pork producers feeding more DDGS? Although not directly cited in the literature, the best explanation is inconsistency of DG products and distance between swine operations and ethanol plants. Most pork producers who are feeding DG are using WDG, and therefore must be located near an ethanol plant. The inconsistency issue is extremely important to swine operations because their rations are carefully calculated, especially grower-finisher diets, and a slight change in chemical composition alters many ration ingredients. If each shipment of DG varies in nutritional quality, the costs of incorporating DG outweigh the potential cost saving benefits of the additional ingredient.

The value of DDGS for monogastrics depends on the process used by ethanol plants. New enzyme technologies (to increase ethanol production efficiency) could increase the crude protein by removing the germ and/or bran from corn prior to fermentation, and removing phosphorus prior to producing DDGS. As crude protein increases, other nutrients must decrease in concentration. For instance, an increase in crude protein is at the expense of fat and phosphorus in the high protein DDGS. A reduction in fat will substantially reduce the energy value for swine and poultry, not to mention the lost benefit of cost savings from the reduced phosphorus advantage of DDGS. Since about 50 percent of the diet cost savings of using DDGS in swine diets is due to the reduced need for inorganic phosphorus supplementation, the large reduction in phosphorus content in high protein DDGS will make it less valuable than the "typical" DDGS in swine diets (Shurson, Noll, and Goihl 2005).

Poultry

Corn DDGS can supply a significant amount of energy, amino acids, and phosphorus to poultry diets. DDGS has similar benefits for poultry as are shown for swine, where phosphorus availability is greater than that of corn. The sodium content of corn DDGS can range from 0.01 to 0.48 percent averaging 0.11 percent, therefore dietary adjustments for high sodium content may be necessary to avoid wet litter and dirty eggs. Corn DDGS also contains xanthophylls which has been shown to significantly increase egg yolk color when fed to laying hens, and increase skin color of broilers when included at levels of 10 percent of the diet. Diets should be formulated on digestible amino acid values for DDGS, especially for lysine, methionine, cystine, and threonine. Current maximum dietary inclusion levels for corn DDGS are 10 percent for meat birds and 15 percent for chicken layers. Diets should also be formulated by setting minimum acceptable levels for tryptophan and arginine due to the second limiting nature of these amino acids in corn DDGS protein (Shurson, Noll, and Goihl 2005).

"Rapid supply growth, improved quality, slow export growth, increased freight costs, sound nutritional research, and dependable nutrition information will force more

DG into all rations. Gut health concerns, P manure regulations, and close geographic proximity to supply has and will continue to increase consumption of DDGS in mongastric rations at the expense of oilseed protein (Markham 2005)."

Summary

Overall, ethanol co-products are an increasingly important factor of profitability for both livestock feeders and ethanol producers. As more corn is demanded for ethanol production, livestock feeders will face higher corn prices. At the same time, ethanol co-product supplies will increase, and likely decrease prices for the alternative feed ingredient. Ethanol producers face the decision of drying their distiller's grains, and incurring significant natural gas costs, or selling the co-product wet, as WDGS. Of course the demand for WDGS by livestock feeders will also determine how much WDGS is produced compared to the amount sold as DDGS.

It is important to understand the economically feasible amount of WDGS and DDGS that can be fed in livestock rations, as well as the feasible distance that WDGS can be hauled from an ethanol plant to the feedlot. Of course many assumptions must be made when modeling the cost effectiveness of WDGS and DDGS in livestock rations, and these assumptions are discussed in chapter III.

CHAPTER III

METHODOLOGY AND ASSUMPTIONS

This analysis will consist of a partial budget cost of gain analysis using feedlot rations from the four major cattle feeding states. The budgets were analyzed using stochastic simulation to determine the potential differences in cost of gain with respect to changing ration ingredients. Feedlot ration ingredients are expected to change with the increased availability of ethanol co-products as well as the increase in corn prices. This analysis will evaluate cost of gain for various ration ingredient scenarios, where base scenarios are compared to alternative scenarios where ethanol co-products replace a portion of the corn in each ration.

Data

Historical data was used to develop a partial budget model for beef feedlots. The partial budget includes ration costs and feeding (yardage) costs representing feedlots in Colorado, Kansas, Nebraska, and Texas. Ration costs are a function of stochastic ingredient prices as well as ration composition and cattle performance (dry matter intake). Historical data from *Feedstuffs* was used to estimate ration ingredient prices including: corn, soybean meal, DDGS, alfalfa, cottonseed meal and hulls, tallow, urea, and molasses. Historic feedlot data from the Professional Cattle Consultants (PCC), a private feedlot consulting company, was used to estimate feed efficiency, average daily gain, dry feed conversion, daily dry matter intake, veterinary/medical expenses, and other key variables for each region. Yardage and feeding costs were estimated from industry averages found in the literature, and from PCC data.

Changes in cattle performance resulting from feeding two different levels of WDGS and one level of DDGS were estimated by adjusting historical average daily gain, feed efficiency, and dry matter intake (from PCC data) by the results found in feedlot nutrition studies from the University of Nebraska-Lincoln, Kansas State University, and Texas Tech University. Results from research by these universities account for the regional changes in cattle performance with the corresponding ration composition when incorporating distiller's grains. Manure management costs correlated with feeding WDGS (and corresponding increases in dietary phosphorus levels) were estimated from Kissinger et al.'s (2006) results.

Feed costs are estimated for a base ration, and both wet and dry distiller's grains at two dietary inclusion rates in a total of four rations for Texas and Nebraska, and seven rations for Colorado and Kansas, where steam-flaked corn based rations are compared to dry-rolled corn based rations. The base and alternative rations were developed based on previous feedlot nutrition research in each region, as well as personal communication with feedlot operators and researchers. Costs for each region's base ration reflect corn processing costs (steam flaking or dry rolling), local feed prices, and feedlot management (yardage) costs. Steam flaking and dry rolling corn processing costs are estimated from Macken, Erickson, and Klopfenstein's (2006) results, with adjustments for current regional natural gas and electricity prices. Natural gas and electricity price data were obtained from the Department of Energy (USDOE 2006).

Cattle on feed placement weights and inventory data were obtained from the National Agricultural Statistics Service State Statistics (USDA/NASS 2006) database.

Trucking costs obtained from the Agricultural Marketing Service Grain Transportation 1st Quarter 2006 Report, were used to estimate the costs of hauling WDGS (USDA/AMS 2006). The North Central Region contains Nebraska and Kansas, the Rocky Mountain Region represents Colorado, and the South Central Region includes Texas.

Methods

- Stochastic simulation using Simetar® for partial budget analysis of each feedlot region, with cost of gain as the key output variable. Simetar® is an Excel add-in useful for simulating the performance of key variables within economic models (Richardson 2005).
- Scenario and sensitivity analysis of changing ration components, costs, and feedlot location with respect to ethanol production.

Stochastic Simulation

Stochastic simulation adds risk to a deterministic model. Instead of deterministic results, or point estimates, the stochastic model simulates a sample of values for each key output variable (KOV). The sample of values represents an estimate of the variable’s probability distribution which can be used by a decision maker in a risky environment. Risk is incorporated for variables that are not known for certain, but are assumed to have a known probability distribution. In stochastic models, variability within the historic data is included as risk when estimating the parameters for the probability distributions of the stochastic variables. A stochastic model is simulated 100 to 500 times using randomly selected values for the risky variables to estimate the probable outcomes for the KOVs (Richardson 2005).

Cattle Assumptions

The partial budget analysis will use the hotel assumption, where the cattle feeder does not own the cattle, but provides a service through adding pounds of gain to cattle. Another major assumption is that only steers are fed, allowing more accurate cattle performance estimates. PCC steer close-out data will be used for the specific placement weights. PCC data is reported in the close-out month, so placement date was estimated by subtracting the days on feed from the close-out month. USDA Cattle on Feed report placement weights and inventory data were used to determine in-weights to be used in the partial budget analysis. Simetar®'s seasonal index function was used to determine which months have the greatest number of cattle placed on feed for two weight groups: under 600 pounds and 700 to 799 pounds, for each region, using a 10 year average for 1996-2005. The determined placement month for 750 pound steers was May and a large number of 600 pound steers are placed on feed in October. The two weight groups and corresponding months were used to account for seasonal cattle performance and feed cost differences when determining whether changing ration costs and compositions have different implications for lighter (fall) versus heavier weight (spring) placements.

Regional PCC data was analyzed to determine correlation between placement weight and date and cattle performance, measured by average daily gain and feed efficiency. Correlation between in-weights and days on feed were also estimated from regional PCC data. Out-weight fluctuates with average daily gain as a function of historic regional data correlated with in-weight, and then adjusted for cattle performance as a function of ration composition from feedlot nutrition studies. In-weight and days on feed are constant for each region and represent historic placement data.

Numbers of cattle placed on feed for May and October are representative of regional feedlot size and number of placements for the given months. Costs in the partial budget model are calculated on a per head basis. Assumptions for corn processing costs and manure handling costs are based on 25,000 head one-time capacities. WDGS investment costs are estimated based on 25,000 to 35,000 head one-time capacities.

Stochastic Variables

WDGS price information is generally not available, so WDGS prices were estimated as a percentage of the local corn basis at the ethanol plant. To estimate the ethanol plant's corn basis, a $0.15 per bushel premium was assumed for corn within 25 miles of an ethanol plant, representing the increased demand for corn (Vander Pol et al. 2006b). WDGS prices were estimated as 95 percent of corn price, on an equal dry matter basis, with WDGS having a dry matter content of 35 percent and corn at 85 percent dry matter. The equation for WDGS pricing is based on previous studies (Vander Pol et al. 2006b) and personal communication with cattle feeders and ethanol producers in eastern Nebraska. WDGS dry matter content can vary, but will be assumed at 35 percent.

Corn, soybean meal, cottonseed meal, sorghum, alfalfa, molasses, urea, yellow grease, and DDGS prices will be estimated from monthly data from 1996 to 2006. For May placements (150 days on feed), monthly prices were averaged for May through September. October placements are assumed to be on feed for 200 days, so monthly prices for October through April the following year were averaged from 1996/97 to 2005/06. The historic feed price averages, based on feeding period, were then estimated as stochastic variables with multivariate empirical (MVE), truncated normal, and truncated empirical distributions using Simetar®. PCC cattle performance data were also estimated as MVE distributions. Table 3.1 contains the variables used in the model.

Table 3.1 Exogenous and Endogenous Variables in Colorado, Kansas, Nebraska, and Texas Models

Exogenous Stochastic	**Exogenous Deterministic**
PCC Data	Steers Placed
Average Daily Gain	Purchase Weight
Feed:Gain	Days on Feed
Dry Matter Intake	Yardage
Vet/Med Costs	Manure hauling
Feedstuffs Data	**Endogenous Stochastic**
Corn	Total feed
Soybean Meal	Total Gain
Cottonseed Meal	Out-weight
Cottonseed Hulls	Total cost of feeding
Corn Gluten Feed	Corn Processing Costs
DDGS	Transportation of WDGS
WDGS	WDGS Feeding Costs
Alfalfa pellets	**WDGS Investment Costs**
Corn Silage	Roto-mix
Urea	Front end loader operator salary
Yellow Grease	Roto-mix driver salary
Molasses	Repair, Maintenance, Insurance
	Fuel

Simple regression analysis was used to test for trend by analyzing the t-statistics. After testing for trend, significant correlation between the variables was determined using Simetar®'s Correlation Matrix function and again analyzing the critical t-statistics. The MVEMPIRICAL function in Simetar® was used to simulate the correlated variables. The MVEMPIRICAL function uses as input the matrix of historic data and the corresponding means for the random variables. The result is an array of MVE correlated random values for the variables. If an MVE distribution is not used, correlation between variables will be ignored in simulation, and the model will over or under estimate the mean and variance of the key output variables (Richardson 2005).

The empirical distribution was used because there were too few observations to estimate the parameters for the true distribution. Usually 20 or more observations are required to prove conclusively that a distribution is normally distributed, and only 10 observations were used in this model. The empirical distribution has a finite minimum and maximum based on observed values, and the shape of the distribution is defined by the data. Parameters for the empirical distribution are the sorted values of the observations and the cumulative probabilities for the sorted values (Richardson 2005).

Variables that were not correlated were estimated as truncated normal or truncated empirical distributions. Truncated normal distributions were estimated using historic means, standard deviation of the historic data, the minimum and maximum values from the historic data, and a uniform standard deviate (USD). The Simetar® function for truncated normal distributions is:

=TNORM (Mean, Std Dev, Min, Max, USD)

Normality tests used to ensure normal distributions of the data estimated as truncated normal random variables include: the Kolmogornov-Smirnoff, Chi-Squared, Cramer-von Mises, Anderson-Darling, and Shapiro-Wilks. For the Chi-Squared test, 20 intervals were used and the null hypothesis of normal distribution was tested based on approximate p-values. For each variable that was estimated as a truncated normal distribution each normality test resulted in a failure to reject the null hypothesis that the distribution is normally distributed.

For those variables that were not normally distributed, the empirical distribution was used. The parameters for truncated empirical distributions include an array of sorted random variables (S_i), cumulative probabilities for the S_i values, including the end points of zero and one, USD, and the minimum and maximum for the distribution. The Simetar® function for truncated empirical distributions is:

=TEMPIRICAL ((S_i, F(S_i), Min, Max, USD)

Each random variable was validated using Simetar®'s hypothesis test, comparing two means, to ensure the stochastic variables replicated the mean and variance of the corresponding historic variables. T-critical values were used to fail to reject the null hypothesis that the two means and variances were equal for each simulated variable and the historic data. The stochastic feed ration costs and cattle performance estimates were then incorporated into the partial budget model to project risk based impacts of DG inclusion on cattle feeding cost of gain.

Alternative Ration Scenarios Incorporating DDGS and WDGS

Base regional ration ingredients were adjusted to incorporate DDGS at 15 percent of the diet dry matter and WDGS at 15 and 30 percent of the diet dry matter. DDGS and WDGS primarily replace corn and the protein supplement (soybean meal, cottonseed meal, or urea). Previous feedlot nutrition studies were used to determine ration adjustments for the incorporation of distiller's grains.

If steam-flaked corn (SFC) is used in the base ration, an alternative scenario replaces steam-flaked corn with dry rolled corn (DRC) and WDGS at the two inclusion rates. Corn processing costs were adjusted, reflecting the elimination of natural gas costs with use of the dry-rolling process. An asterisk in the following equations indicates a stochastic variable.

Ration costs= DMI*, Feed Price* for each ration ingredient

DMI= Average Daily Gain* X Feed:Gain*

Potential costs for changes in infrastructure or equipment were accounted for to more adequately determine whether cost savings exist for feeding DRC with WDGS. Additional costs include investment in Roto-Mix® mixer/delivery box trucks, labor costs for Roto-Mix® drivers and front end loader operators, as well as fuel, insurance, and maintenance costs. The costs are correlated with the WDGS inclusion rate, where a 15 percent inclusion rate would require half the labor and fuel of the 30 percent WDGS inclusion rate. One Roto-Mix® truck is included in the investment costs for both the 15 and 30 percent WDGS scenarios. These costs were estimated based on personal communication with cattle feeders in the Texas Panhandle (Sartwelle 2006).

Additional costs for WDGS storage were not included. Feeding WDGS within 3 to 5 days eliminates the need to include costs for bagging or adding preservatives to the wet co-product.

WDGS costs are a function of: stochastic corn price, transportation cost, fuel, labor, insurance, maintenance, investment, manure handling, and stochastic cattle performance (average daily gain, total feed intake).

Total Cost of Gain= (Yardage + Vet/Med + WDGS costs + Corn Processing + Feed Costs)/Total Gain

Increased feeding time and handling costs were also estimated based on the increasing amount of weight hauled to the feedlot and fed each day when incorporating WDGS. The feed cost equation estimated by Vander Pol et al. (2006b) was used to determine the percentage increase in feeding costs for each inclusion rate of WDGS. The percentage increase in feeding costs is calculated from the change in as-fed feed when incorporating WDGS as compared to the base ration. An industry average feeding cost of $0.085 per head per day is used as the basis feeding cost.

Cattle performance was also adjusted for the DDGS and WDGS inclusion rates. The regional average daily gain, dry matter intake, and feed efficiency from the PCC data was adjusted by the percentage change found in feedlot nutrition studies. The feedlot nutrition studies utilized have ration components comparable to those in the model scenarios, ensuring an accurate performance adjustment.

Scenario and Sensitivity Analysis

The partial budgets were simulated using scenario analysis in Simetar® to determine whether changing ration components, costs of components, and feed handling/processing costs change the economics of feeding wet and dry distiller’s grains. Table 3.2 contains the scenarios used in the Colorado and Kansas models. The rations ending with KSU were estimated from Daubert et al. (2005). The rations ending with NE were estimated from Vander Pol et al. (2006).

Table 3.2 Scenarios for Colorado and Kansas Models, Expected Value

As is feed lbs/day	Base	15% DDGS/SFC KSU	15% WDGS/SFC KSU	30% WDGS/SFC KSU	30% WDGS/SFC NE	15% WDGS/DRC	30% WDGS/DRC NE
Total Corn	**20.15**	**17.47**	**17.22**	**13.87**	**15.34**	**16.92**	**15.60**
Flaked corn	**20.15**	**17.47**	**17.22**	**13.87**	**15.19**	**0.00**	**0.00**
Dry Rolled corn	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**16.92**	**15.44**
Ground Corn	0.00	0.00	0.00	0.00	0.15	0.00	0.16
Alfalfa hay	**1.41**	**1.42**	**1.40**	**1.64**	**1.31**	**1.86**	**1.38**
DDGS	**0.00**	**3.51**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
WDGS	**0.00**	**0.00**	**8.99**	**19.22**	**18.02**	**8.99**	**18.96**
Soybean meal	0.97	0.00	0.00	0.00	0.00	0.00	0.00
Fat	0.00	0.00	0.00	0.00	0.02	0.03	0.02
Rumensin/Tylan	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Limestone	0.41	0.64	0.64	0.32	0.30	0.00	0.32
Urea	0.30	0.11	0.11	0.00	0.00	0.00	0.00
KCl	0.00	0.00	0.00	0.12	0.10	0.00	0.11
Salt	0.00	0.00	0.00	0.07	0.06	0.00	0.07
Vitamin/min	0.00	0.00	0.00	0.03	0.01	0.00	0.02
Premix	0.00	0.00	0.00	0.00	0.64	1.27	0.67
Premix total	0.41	0.64	0.64	1.06	1.12	1.27	1.18
Total lbs Feed/head/day	**23.24**	**23.14**	**28.35**	**35.79**	**35.80**	**29.07**	**37.13**
ADG (lbs/day)	**3.18**	**3.19**	**3.11**	**3.00**	**3.59**	**4.07**	**4.05**
DMI (lbs/day)	20.60	20.90	20.30	18.80	20.40	19.50	22.60
Adjusted DMI May	21.12	21.27	20.97	20.22	21.02	20.57	22.12
Adjusted DMI Oct	19.52	19.67	19.37	18.62	19.42	18.97	20.52
Feed:Gain (DM)	6.49	6.54	6.53	6.96	5.76	6.53	5.68

Note: DDGS: distiller's dried grains with solubles; WDGS: wet distiller's grains with solubles; SFC: steam flaked corn; ADG: average daily gain; DMI: dry matter intake; Feed:Gain is pounds of feed per pound of gain.

Table 3.3 Scenarios for Texas Model, Expected Value

As is feed lbs/day	**0% WDGS**	**15% DDGS**	**15% WDGS**	**30% WDGS**	**15% WSDGS TTU**
Total Corn	16.81	14.73	14.48	12.60	14.26
Flaked corn	**16.81**	**14.73**	**0.00**	**0.00**	**14.26**
Dry Rolled corn	**0.00**	**0.00**	**14.48**	**12.60**	**0.00**
Corn silage	**2.27**	**2.27**	**2.31**	**1.73**	**0.00**
Alfalfa hay	0.33	0.33	0.34	0.22	0.00
DDGS	**0.00**	**3.28**	**0.00**	**0.00**	**0.00**
WDGS	**0.00**	**0.00**	**8.67**	**17.31**	**8.42**
Corn Gluten Feed	**2.32**	**1.99**	**2.02**	**2.02**	**0.00**
Soybean meal	0.00	0.00	0.00	0.00	0.00
Cottonseed hulls	0.83	0.66	0.67	0.00	1.54
Cottonseed meal	0.00	0.00	0.00	0.00	0.00
Molasses	0.91	0.00	0.00	0.00	1.02
Fat (yellow grease or tallow)	0.50	0.50	0.51	0.31	0.56
Rumensin/Tylan/MGA premix	0.00	0.00	0.00	0.00	0.56
Limestone	0.35	0.35	0.35	0.35	0.15
Urea	0.36	0.30	0.30	0.12	0.05
KCl	0.06	0.06	0.06	0.06	0.00
Salt	0.00	0.00	0.00	0.00	0.00
Premix	0.40	0.30	0.31	0.20	0.47
Premix total	1.11	0.94	0.96	0.68	1.18
Total lbs Feed/head/day	**25.14**	**24.76**	**30.03**	**34.93**	**27.03**
ADG (lbs/day)	**3.68**	**3.70**	**4.07**	**4.05**	**3.09**
DMI (lbs/day)	20.09	20.10	20.82	20.75	17.25
Adjusted DMI May (lbs/day)	19.87	19.87	20.23	20.20	18.45
Adjusted DMI Oct (lbs/day)	18.68	18.68	19.04	19.01	17.26
Feed:Gain (dry matter basis)	4.63	4.60	4.72	4.75	5.64

Note: WDGS: wet distiller’s grains with solubles; DDGS: dried distiller’s grains with solubles; WSDGS: wet sorghum distiller’s grains with solubles; ADG: average daily gain; DMI: dry matter intake; Feed:Gain is pounds of feed per pound of gain.

The base scenario used in the Texas model was estimated from personal communication with cattle feeders from the Texas Panhandle (Sartwelle 2006). As shown in table 3.3, SFC is fed in the base scenario, the 15 percent DDGS scenario, and the 15 percent WSDGS TTU scenario. DRC is fed in the 15 and 30 percent WDGS scenarios. The 15 percent WSDGS TTU ration and corresponding cattle performance are estimated from research by Galyean and Lemon (2006). The 15 and 30 percent WDGS rations were estimated by primarily substituting DRC for SFC in the base scenario and replacing a portion of the DRC with WDGS. Cattle performance, specifically ADG, for the 15 and 30 percent WDGS rations was estimated from Vander Pol et al. (2006a).

Nebraska ration scenarios, located in table 3.4 were estimated from Vander Pol et al. (2006a,c). All Nebraska rations contain DRC, and the 30 percent WDGS DRC:HMC contains a combination of DRC and HMC. A DDGS scenario was not included for the Nebraska analysis, as it was assumed that all feedlots will have access to WDGS.

Table 3.4 Scenarios for Nebraska Model, Expected Value

As is feed lbs/day	**Base**	**15% WDGS/DRC**	**30% WDGS/DRC**	**30WDGS DRC:HMC**
Total Corn	**23.94**	**19.61**	**15.82**	**16.88**
Flaked corn	0.00	0.00	0.00	0.00
Dry Rolled corn	**23.67**	**19.13**	**15.66**	**7.64**
High Moisture Corn	0.00	0.00	0.00	9.08
Ground Corn	0.27	0.48	0.16	0.16
Corn silage	0.00	0.00	0.00	0.00
Alfalfa hay	**1.29**	**1.25**	**1.40**	**1.36**
DDGS	0.00	0.00	0.00	0.00
WDGS	**0.00**	**9.62**	**19.24**	**18.77**
Molasses	0.00	0.00	0.00	0.00
Fat	0.03	0.03	0.02	0.02
Rumensin/Tylan	0.00	0.00	0.00	0.00
Limestone	0.34	0.35	0.32	0.31
Urea	0.30	0.12	0.00	0.00
KCl	0.11	0.09	0.11	0.10
Salt	0.07	0.07	0.07	0.07
Vitamin/mineral	0.00	0.00	0.02	0.02
Premix	0.08	0.03	0.68	0.66
Premix total	0.79	0.58	1.09	1.06
Total Feed/head/day	**26.15**	**31.17**	**37.67**	**38.19**
ADG (Average daily gain, lbs/day)	**3.65**	**4.09**	**4.05**	**3.91**
DMI (Dry matter intake, lbs/day)	24.00	24.85	22.60	21.50
Adjusted DMI May	23.14	23.57	22.44	21.89
Adjusted DMI Oct		0.12	0.11	0.07
Feed:Gain (DM)	6.52	6.08	5.68	5.61

Note: WDGS: wet distiller’s grains with solubles; DRC: dry rolled corn; HMC: high moisture corn; DDGS: distiller’s dried grains with solubles; Feed:Gain is pounds of feed per pound of gain.

Sensitivity analysis will include the following changes in the above scenarios:

- Changes in cattle performance (based on previous nutrition studies and correlated with DG inclusion rate and corn processing method)
- Corn price as a function of proximity to ethanol production

- Transportation costs for WDGS inclusion for feedlots located 25, 60, 100, and greater than 200 miles from an ethanol plant at both 15 and 30 percent inclusion rates

Sensitivity Elasticity Analysis

The sensitivity of the key output variable (KOV), cost of gain, with respect to changes in corn price, total gain, transportation costs, WDGS feeding costs, and WDGS investment costs were analyzed using Simetar®'s sensitivity elasticity analysis option in the simulation engine. Sensitivity elasticities for 15 and 30 percent WDGS inclusion rates are compared. Sensitivity elasticities quantify the average percent change in a KOV resulting from a one percent change in the exogenous variable X (Richardson 2005).

Summary

The partial budget stochastic simulation model was built for all four states to incorporate specific ration scenarios representative of each region. The model was not designed to forecast future costs of gain, but to estimate the marginal changes in cost of gain when feeding WDGS and DDGS. The model evaluates changes in transportation costs for WDGS and corn price basis when feedlots are located at varying distances from ethanol production. Specific investment, feeding, and manure handling costs correlated with WDGS inclusion are also estimated to more accurately determine the changes in cost of gain when feeding ethanol co-products.

CHAPTER IV

RESULTS

Results from the partial budget cost of gain analysis from the Colorado, Kansas, Nebraska, and Texas models are discussed in this chapter. For simplicity, only figures containing results from October placements will be included in this chapter. The model output for May placement analysis results are included in the appendix, and are similar to the results for October placements.

Results from the model analysis are primarily based on the KOV, cost of gain. The major components of cost of gain, as well as specific costs associated with feeding WDGS will also be explained in this chapter. Each model was built with flexibility for WDGS transportation costs, corn basis adjustments, and WDGS investment costs to account for the economic impacts of ethanol production through changing ration ingredients.

Cumulative distribution function (CDF) graphs, created using Simetar®, are used to show the least cost rations, based on cost of gain. The CDF graphs include the 500 simulated iterations for each scenario of the model output. Cost of gain is on the x axis with corresponding probability values on the y axis. When seeking the minimal cost of gain, one will prefer the rations farthest to the left of the CDF graph. The base scenario cost of gain will be slightly lower than historical averages because not all cost are included in the partial budget analysis. It is also important to note that WDGS and DDGS inclusion rates are on a dry matter basis.

Colorado Model Results

Seven ration scenarios were included in the Colorado model, as previously discussed in Chapter III. The seven scenarios account for different ration ingredients and corresponding cattle performance when feeding WDGS and DDGS at varying inclusion rates, compared to the base ration. In most cases, cost of gain is lowest for the ration scenario including 15 percent WDGS fed with DRC. Figure 4.1 shows the 15 percent WDGS/DRC ration as the least cost of gain scenario, with 30 percent WDGS/DRC as the next lowest cost of gain alternative ration. The distributions do not cross, so at all probabilities the 15 percent WDGS/DRC ration is preferred to minimize cost of gain.

There are many assumptions under which this is the preferred ration. The model assumptions are discussed in Chapter III, but three model specifications should also be noted for these results. First, in this case the feedlot is located at the ethanol plant, where no transportation costs are included for WDGS. Second, the corn price basis is a positive $0.15 per bushel to account for the increase in corn demanded by the ethanol plant. The $0.15 per bushel premium for corn also increases the cost of WDGS because the WDGS is priced at 95 percent of the price of corn (on an equal dry matter basis). Finally, investment and feeding costs, as explained in Chapter III, are included for feeding WDGS.

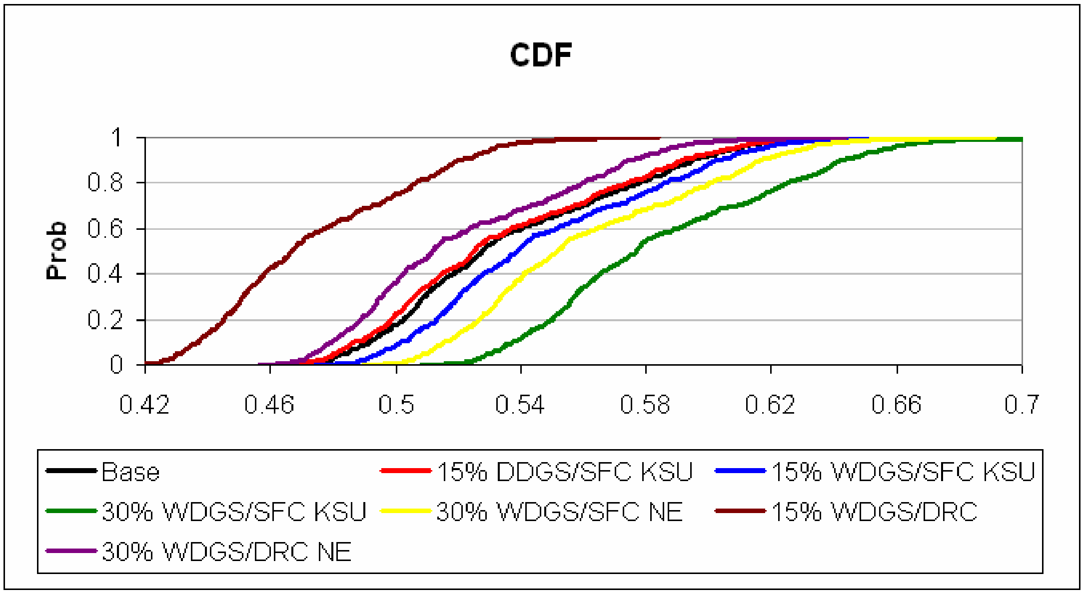


Figure 4.1 Colorado cost of gain for feedlots located at an ethanol plant
For definitions, see Nomenclature Page, page vi.

The rations with the highest cost of gain are those where 30 percent WDGS is fed in a steam-flaked corn based ration. These rations are based on studies from the University of Nebraska (Vander Pol et al., 2006a) and Kansas State University (Daubert et al. 2005). The major cost difference between the 30 percent WDGS/DRC and 30 percent WDGS/SFC scenarios is cattle performance, specifically ADG, where the total pounds gained are lower for the cattle fed WDGS/SFC than those fed WDGS/DRC based rations. Steam-flaking costs are also much higher than dry-rolling costs, increasing the cost of gain in the WDGS/SFC rations.

When feedlots are located further from ethanol production, WDGS transportation costs are included in the cost of gain. At a distance of 25 miles from an ethanol plant, the 15 percent WDGS/DRC ration still has the lowest cost of gain, as shown in figure 4.2, but the 30 percent WDGS/DRC ration is no longer the second lowest cost of gain scenario. It is difficult to determine whether the base scenario, 15 percent DDGS/SFC, or 30 percent WDGS/DRC is the next best alternative.

Table 4.1 shows the WDGS costs for feedlots located 25 miles from ethanol production, including all costs except actual feed costs for the WDGS ration scenarios. Transportation costs are included for hauling the WDGS 25 miles, and are shown as total trucking costs, trucking costs per head, and per pound of gain. The 15 percent WDGS/DRC scenarios include total WDGS costs of $0.04 to $0.05 per pound of gain for WDGS inclusion (excluding the actual feed costs). Approximately $0.07 per pound of gain for the 30 percent WDGS scenarios is attributed to WDGS costs. Table 4.1 shows a variety of cost breakdowns for the inclusion of WDGS in DRC and SFC-based rations to emphasize the transportation, feeding, and investment costs associated with the co-product.

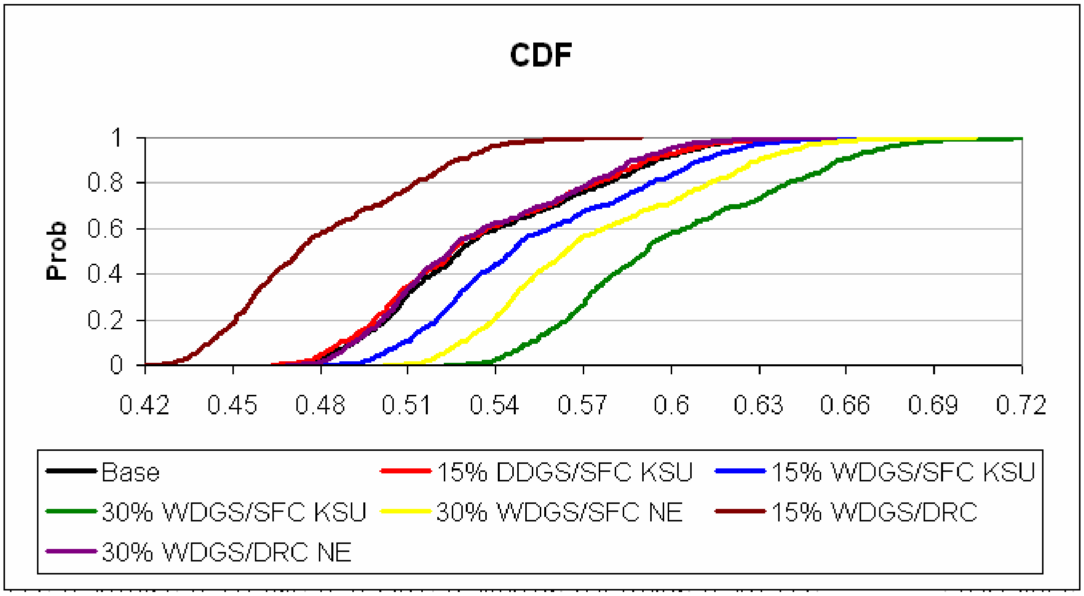


Figure 4.2 Colorado cost of gain for feedlots located 25 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

Table 4.1 WDGS Costs for Colorado October Placements at Feedlot Located 25 Miles from Ethanol Plant

	15% WDGS/SFC KSU	30% WDGS/SFC KSU	30% WDGS/SFC NE	15% WDGS/DRC	30% WDGS/DRC NE
tons WDGS	24908.65	51081.30	49945.87	24394.36	52774.44
Truckloads WDGS	996.35	2043.25	1997.83	975.77	2110.98
Total Trucking	109598.05	224757.74	219761.81	107335.19	232207.52
Trucking Cost/head	3.65	7.49	7.33	3.58	7.74
Trucking cost/lb gain	0.006	0.013	0.012	0.006	0.013
Loads of WDGS per day	4.98	10.22	9.99	4.88	10.55
% increase in feeding costs	0.22	0.48	0.54	0.22	0.60
feeding cost/head/day	0.10	0.13	0.13	0.10	0.14
Feeding cost/head	20.73	25.09	26.18	20.81	27.26
Labor $/truckload for Days On Feed	34.41	33.56	34.32	35.14	32.48
Labor costs/head	1.14	2.29	2.29	1.14	2.29
Repair, Maintenance, Insurance, Fuel/head	0.39	0.59	0.59	0.39	0.59
Manure Handling	4.30	4.30	6.70	4.30	6.70
Total WDGS Costs/head	**30.21**	**39.76**	**43.08**	**30.23**	**44.58**
Total Gain	588.34	577.34	636.34	684.34	682.34
WDGS Costs/lb gain	**0.05**	**0.07**	**0.07**	**0.04**	**0.07**

Note: 30,000 Cattle on feed for 200 days, expected value
For definitions, see Nomenclature Page, page vi.

For a better understanding of the total cost of gain, Figures 4.3 and 4.4 show total costs and total gain, the two components of total cost of gain where:

Total Cost of Gain= Total Costs/Total Gain

Total costs in figure 4.3 are for feedlots located 25 miles from ethanol production, and include a $0.15 corn basis and WDGS investment costs. While scenarios including WDGS have the highest total costs, the WDGS/DRC scenarios also have the highest total gain. Sensitivity elasticities are also included in this chapter and further explain the significance of total gain in the KOV, cost of gain.

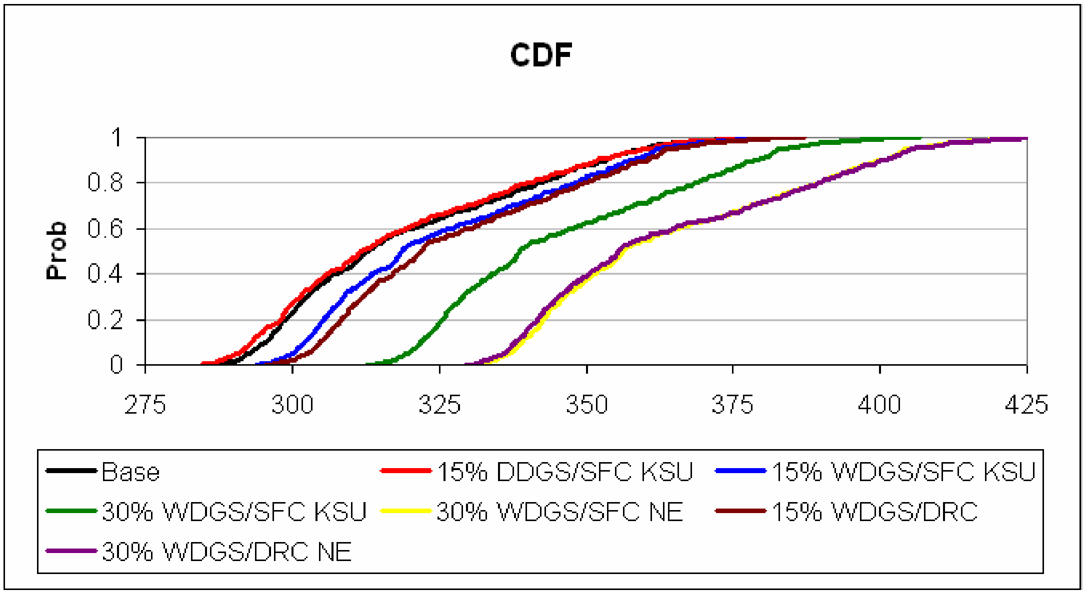


Figure 4.3 Colorado total costs for feedlots located 25 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

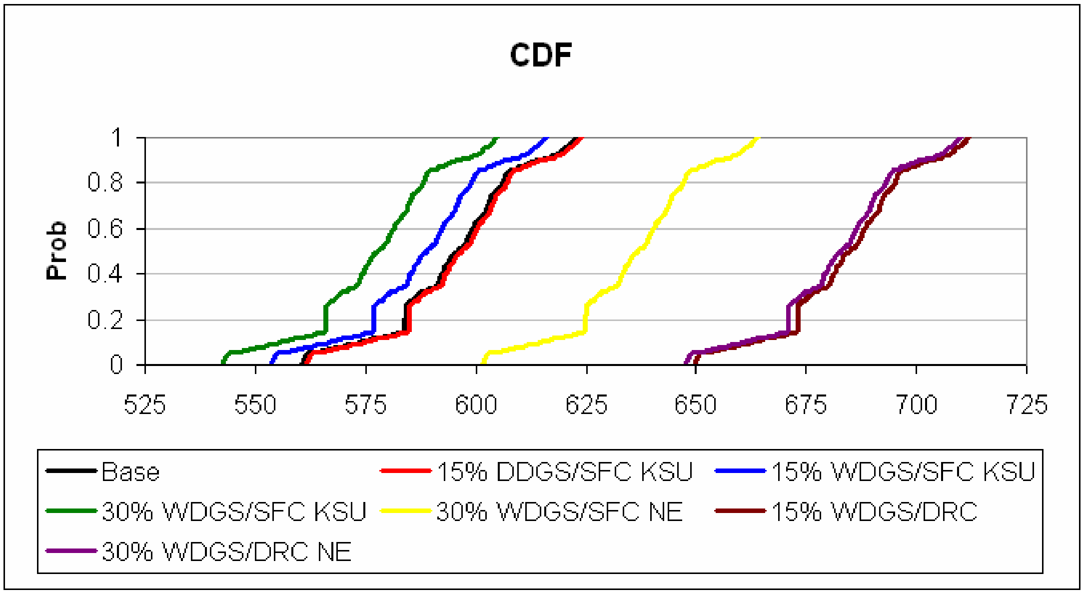


Figure 4.4 Colorado total gain for October placements on feed for 200 days
For definitions, see Nomenclature Page, page vi.

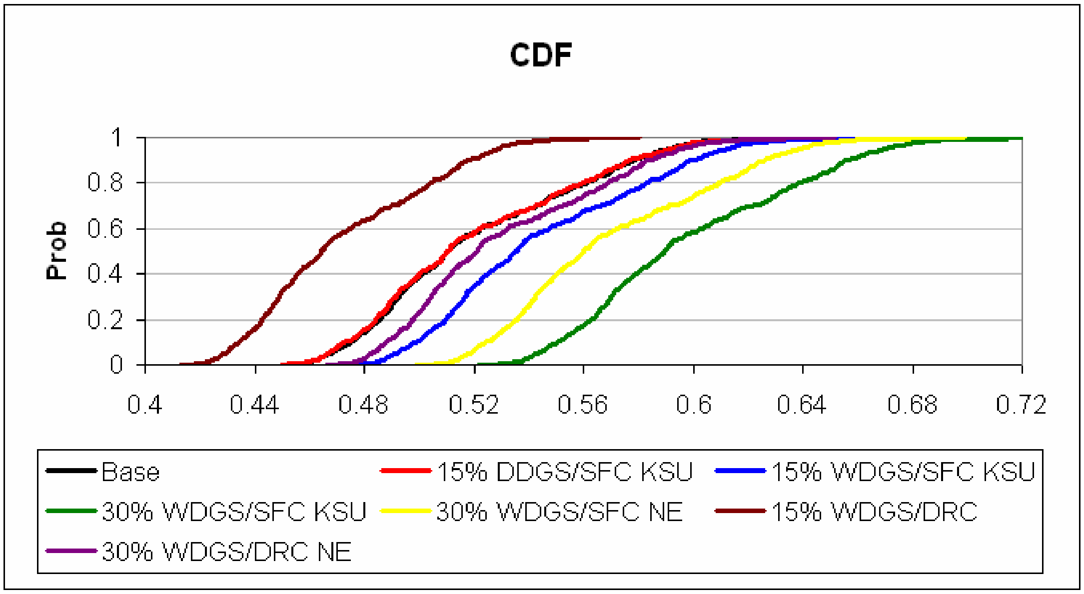


Figure 4.5 Colorado cost of gain for feedlots located 60 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

Feedlots located 60 and even 300 miles from ethanol production could still lower their cost of gain by feeding 15 percent WDGS/DRC, as shown in Figures 4.5 and 4.6 respectively. The next best alternatives are 15 percent DDGS/SFC and the base ration scenario. The 30 percent WDGS/DRC ration is now clearly not preferred as a cost-minimizing scenario. Those rations combining SFC with WDGS remain the highest cost of gain alternatives.

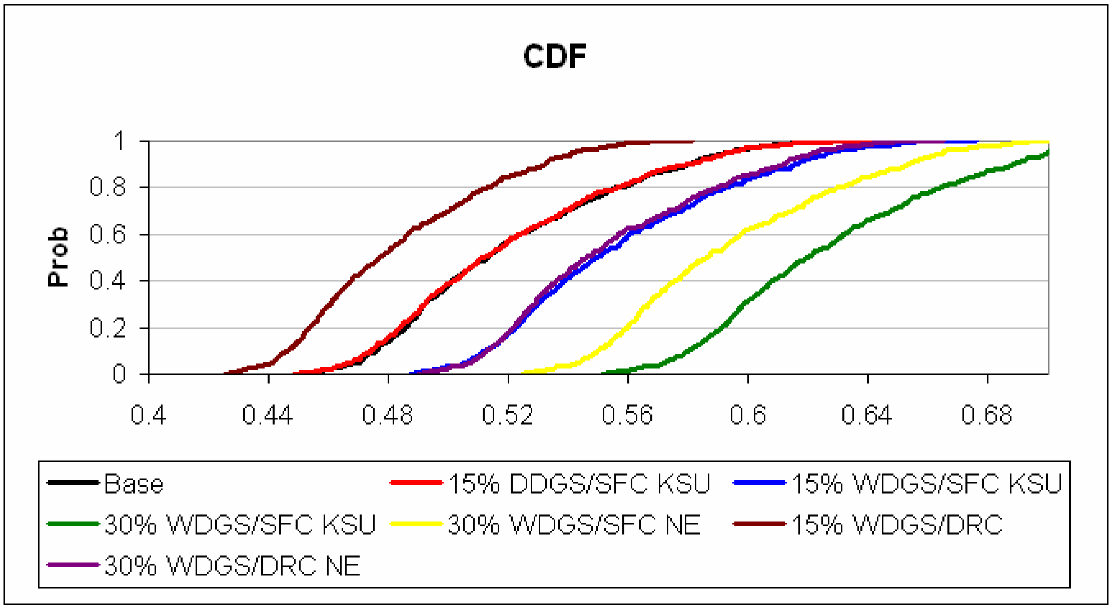


Figure 4.6 Colorado cost of gain for feedlots located 300 miles from an ethanol plant For definitions, see Nomenclature Page, page vi.

Table 4.2 WDGS Costs for Colorado October Placements at Feedlot Located 300 miles from Ethanol Plant

	15% WDGS/SFC KSU	30% WDGS/SFC KSU	30% WDGS/SFC NE	15% WDGS/DRC	30% WDGS/DRC NE
tons WDGS	24908.65	51081.30	49945.87	24394.36	52774.44
Truckloads WDGS	996.35	2043.25	1997.83	975.77	2110.98
Total Trucking	451344.69	925593.24	905019.09	442025.83	956272.80
Trucking Cost/head	15.04	30.85	30.17	14.73	31.88
Trucking cost/lb gain	0.022	0.045	0.044	0.022	0.047
Loads of WDGS per day	4.98	10.22	9.99	4.88	10.55
% increase in feeding costs	0.22	0.48	0.54	0.22	0.60
Feeding cost/head/day	0.10	0.13	0.13	0.10	0.14
Feeding cost/head	20.73	25.09	26.18	20.81	27.26
Labor $/truckload for Days On Feed	34.41	33.56	34.32	35.14	32.48
Labor costs/head	1.14	2.29	2.29	1.14	2.29
Repair, Maintenance, Insurance, Fuel/head	0.59	0.59	0.59	0.59	0.59
Manure Handling	4.30	4.30	6.70	4.30	6.70
Total WDGS Costs/head	**41.80**	**63.12**	**65.92**	**41.58**	**68.71**
Total Gain	588.34	577.34	636.34	684.34	682.34
WDGS Costs/lb gain	**0.07**	**0.11**	**0.10**	**0.06**	**0.10**

Note: 30,000 Cattle on feed for 200 days; expected value

Table 4.2 shows the transportation costs for WDGS when hauling the co-product 300 miles from the ethanol plant to the feedlot. The increased cost of transportation when compared to the feedlot located 25 miles from an ethanol plant is approximately \$0.02 and \$0.05 more per pound of gain for 15 and 30 percent WDGS inclusion rates respectively. The 15 percent WDGS/DRC ration still has the lowest cost of gain at a distance of 300 miles from ethanol production, where total WDGS transportation costs per head for the feeding period are approximately \$14.73, compared with \$3.58 for feedlots located 25 miles from the WDGS source. WDGS transportation costs for the 30 percent WDGS inclusion rates are about twice as much as those for the 15 percent inclusion rates, on a per head basis.

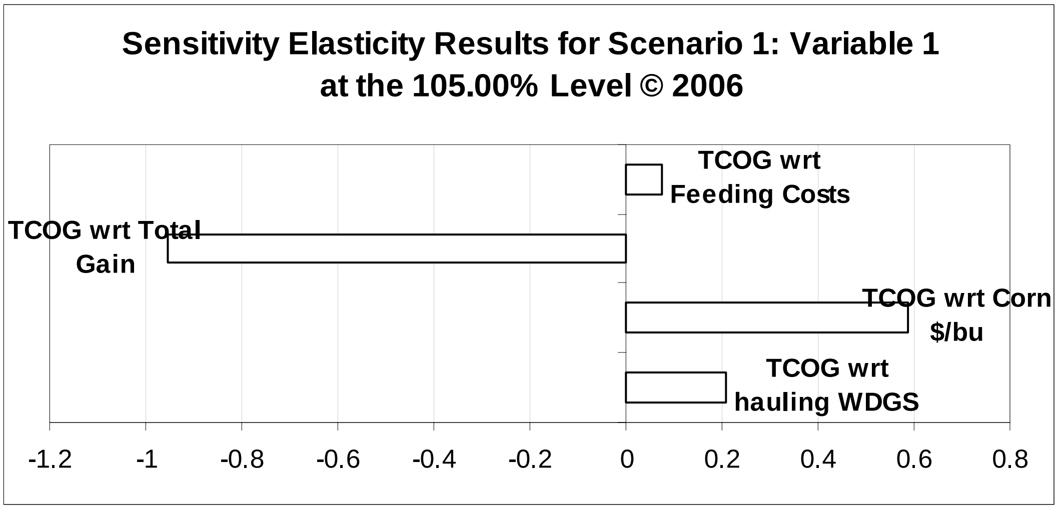


Figure 4.7 Colorado total cost of gain (TCOG) sensitivity elasticity analysis results

Sensitivity elasticities quantify the average percentage change in cost of gain (TCOG) with respect to a one percent change in the following variables: WDGS transportation costs (hauling WDGS), corn price, total gain, and the additional costs associated with feeding WDGS (feeding costs). Sensitivity elasticities are like elasticities, but they quantify the average percentage change in cost of gain to a one percent change in the exogenous variables. Simetar® calculates sensitivity elasticity values by simulating the model for the base value of each exogenous variable to be tested. Next Simetar® changes one exogenous variable at a time by a 5 percent change and simulates the model. The sensitivity elasticity values are calculated for each exogenous variable across all iterations (Richardson 2005). The sensitivity elasticity values are the bars in Figure 4.7.

Figure 4.7 shows that total gain and corn price have the largest impact on cost of gain, respectively. These results are for October placements, fed 30 percent WDGS/DRC in a feedlot located 100 miles from ethanol production. Total gain has the largest sensitivity elasticity, where a one percent change in total gain would result in a 0.95 percent reduction in the cost of gain. Nearly a one to one relationship makes sense because we are essentially simulating free gain. On the other hand, a one percent increase in the price of corn will lead to a 0.59 percent increase in the cost of gain. A one percent increase in the cost of transporting the WDGS would result in a 0.21 percent increase in the cost of gain and a one percent increase in feeding costs (for WDGS) would raise the cost of gain by 0.07 percent. Sensitivity elasticity analysis for the base scenario would indicate cost of gain increasing by around 0.7 percent with a one percent increase in corn price. The greater impact of corn price on cost of gain in the base scenario is due to corn price constituting a larger percent of the cost of gain when no WDGS is included in the ration.

Kansas Model Results

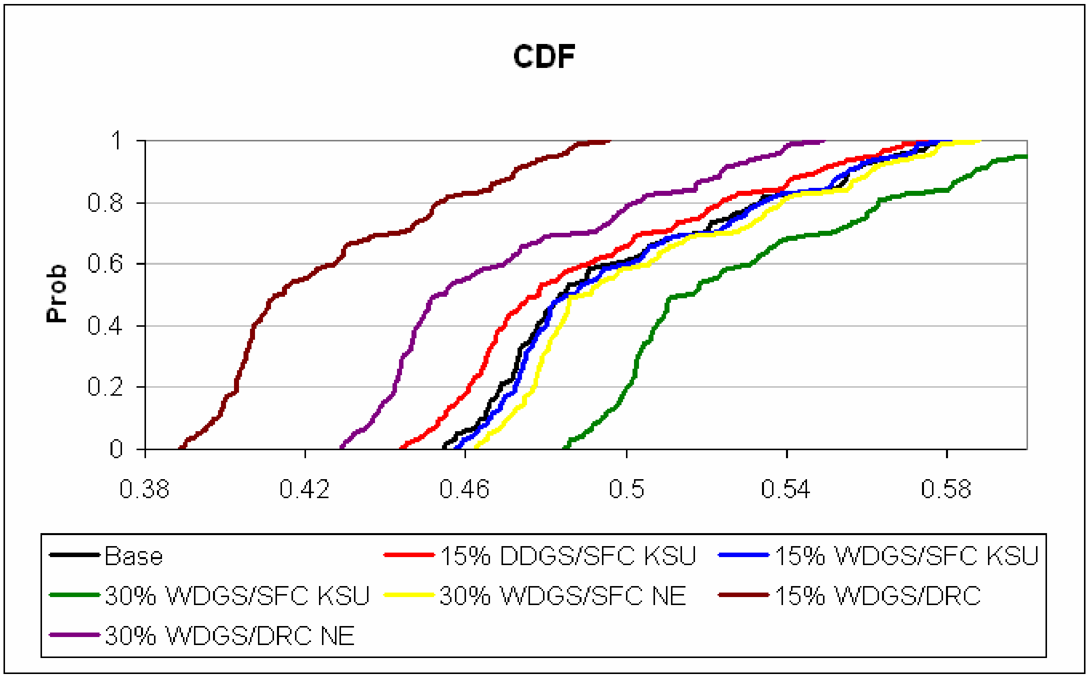


Figure 4.8 Kansas cost of gain for feedlots located at an ethanol plant
For definitions, see Nomenclature Page, page vi.

Kansas results are similar to those from the Colorado model, with the same ration scenarios used in the analysis. Like the Colorado results, only the output for October placements will be included in this chapter, with May results in the appendix. The 15 percent WDGS/DRC ration scenario had the lowest cost of gain in nearly all scenarios. As shown in Figure 4.8, 15 percent WDGS/DRC followed by 30 percent WDGS/DRC are the least cost of gain ration scenarios at each level of probability. These results are for feedlots located at an ethanol plant, including a $0.15 corn basis and WDGS investment costs.

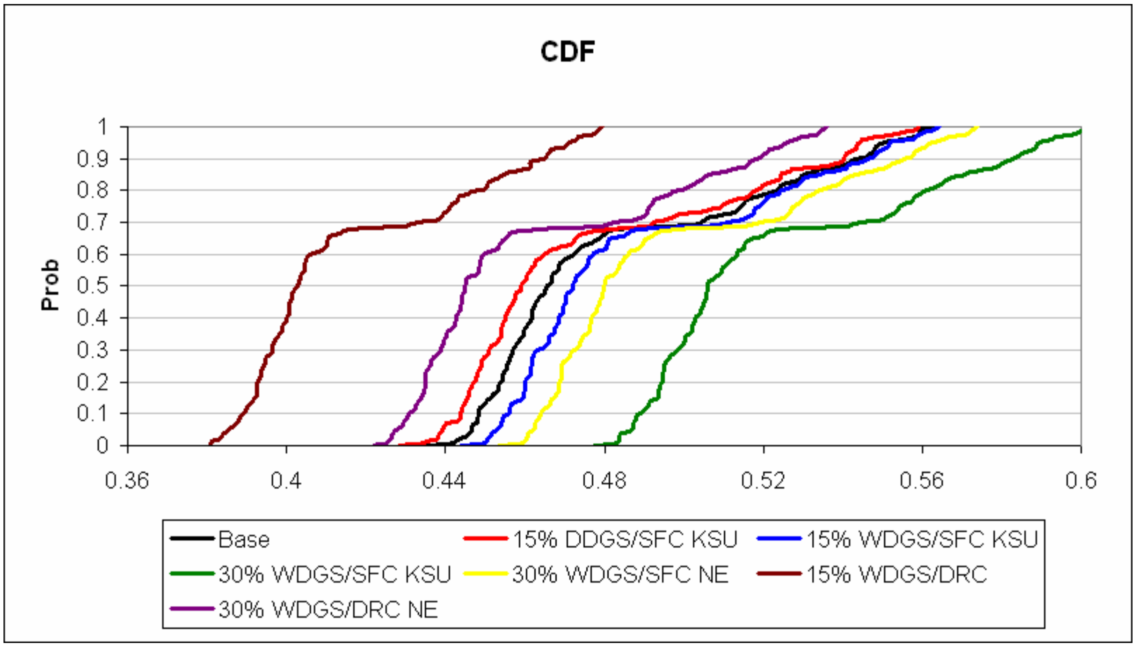


Figure 4.9 Kansas cost of gain for feedlots located 25 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

The results for a feedlot located 25 miles from ethanol production are nearly the same as those for the feedlot located at an ethanol plant, as seen in figure 4.9. When WDGS must be hauled 100 miles to the feedlot, as shown in figure 4.10, the 15 percent WDGS/DRC ration still has the lowest cost of gain, but the 30 percent WDGS/DRC scenario becomes less feasible. It is difficult to determine the difference between the 30 percent WDGS/DRC ration and the base and 15 percent DDGS/SFC rations.

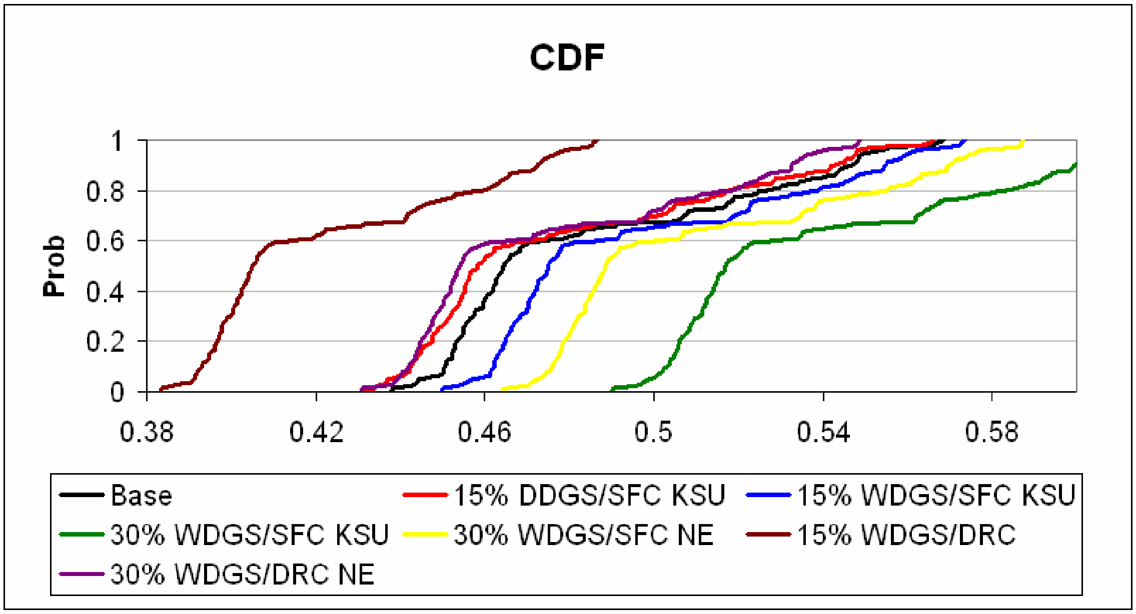


Figure 4.10 Kansas cost of gain for feedlots located 100 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

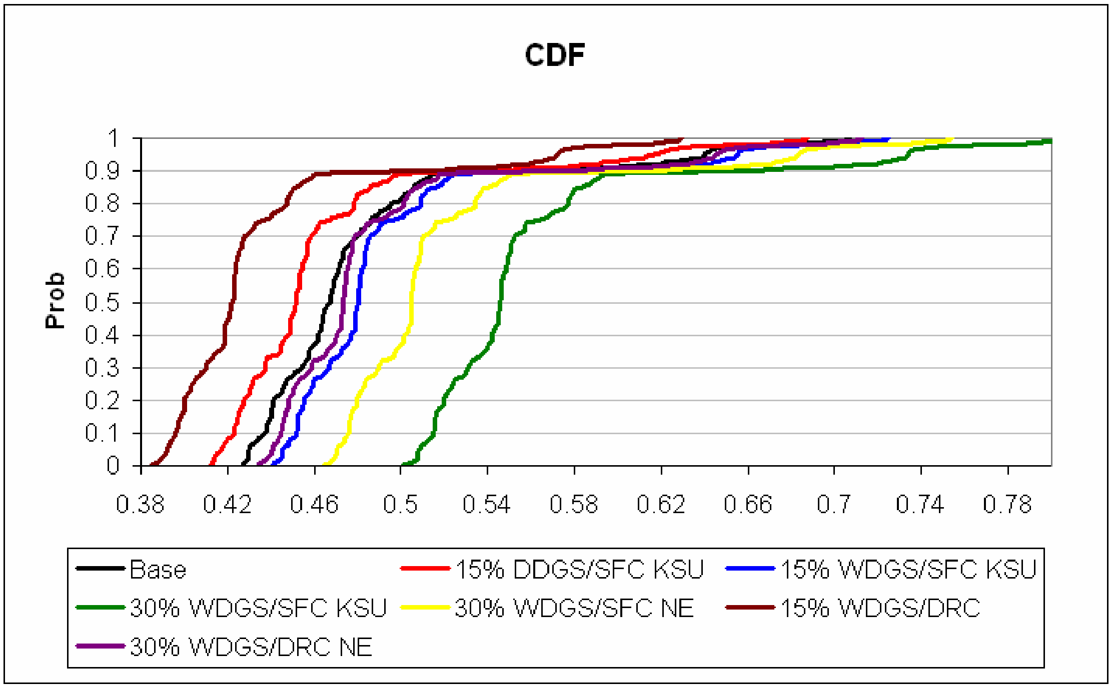


Figure 4.11 Kansas cost of gain for feedlots located 200 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

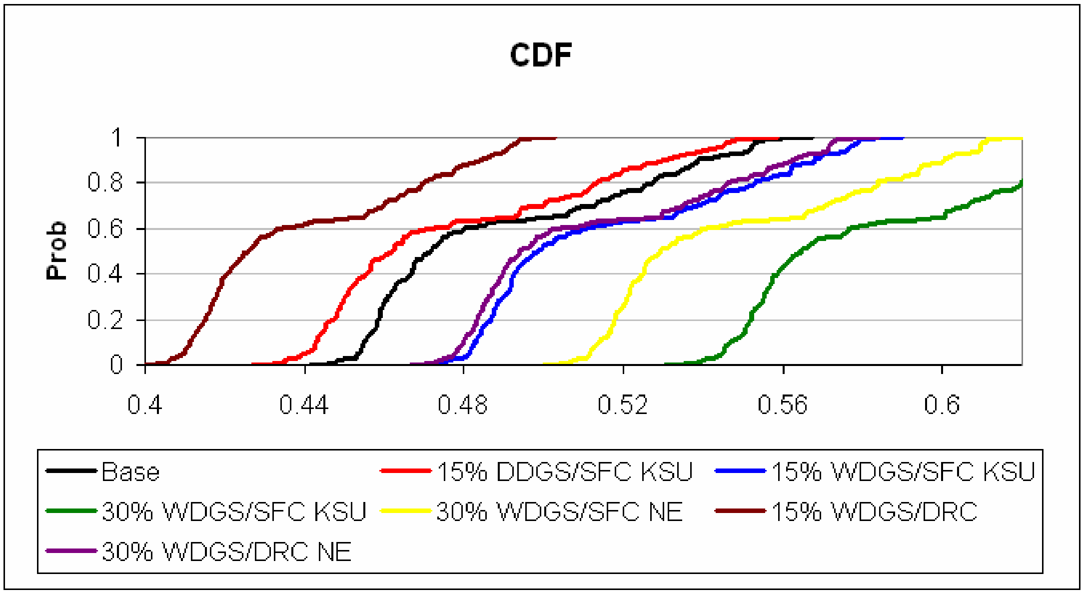


Figure 4.12 Kansas cost of gain for feedlots located 300 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

Even when a feedlot is located 200 to 300 miles from ethanol production, WDGS can be fed at the 15 percent inclusion rate, as shown in figures 4.11 and 4.12. The 15 percent DDGS/SFC ration is the next least cost of gain alternative, followed by the base ration for both the 200 and 300 mile locations. In summary, depending on the distance from ethanol production, Kansas cattle feeders can likely lower their cost of gain by incorporating WDGS or DDGS at the 15 percent inclusion rate (dry matter basis).

Nebraska Model Results

Nebraska results are also similar to those discussed previously in this chapter. Although only four ration scenarios are compared in the Nebraska model, the 15 percent WDGS/DRC ration still has the lowest cost of gain in most cases. Nebraska ration composition and corresponding cattle performance are estimated from University of

Nebraska feedlot nutrition research (Vander Pol et al. 2006a,c). Figure 4.13 shows the 15 and 30 percent WDGS/DRC rations respectively as the lowest cost scenarios. This CDF shows the results for a feedlot located at an ethanol plant and costs include a $0.15 corn basis. Again, only results from the October placements will be included in this chapter.

At a distance of 25 miles from ethanol production, Nebraska cattle feeders feeders can still feed 15 percent WDGS/DRC at the lowest cost of gain, and the 30 percent WDGS/DRC has a similar cost of gain to the base scenario. When comparing figures 4.13 and 4.14, the increasing costs of transportation for WDGS are evident, as the 30 percent WDGS/DRC ration becomes less optimal when the feedlot is located 25 miles from an ethanol plant.

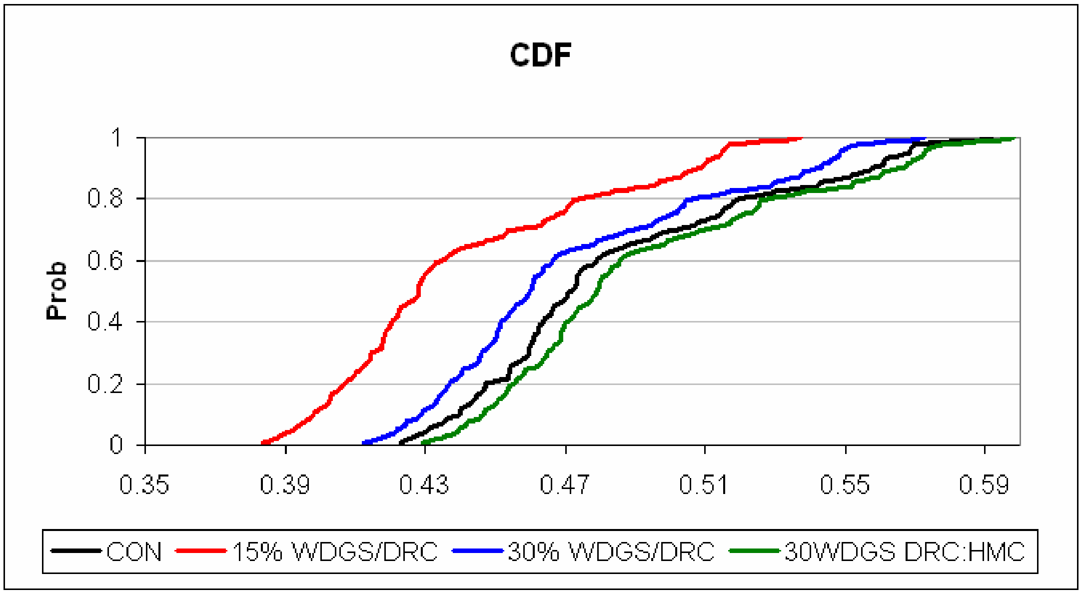


Figure 4.13 Nebraska cost of gain for feedlots located at an ethanol plant
For definitions, see Nomenclature Page, page vi.

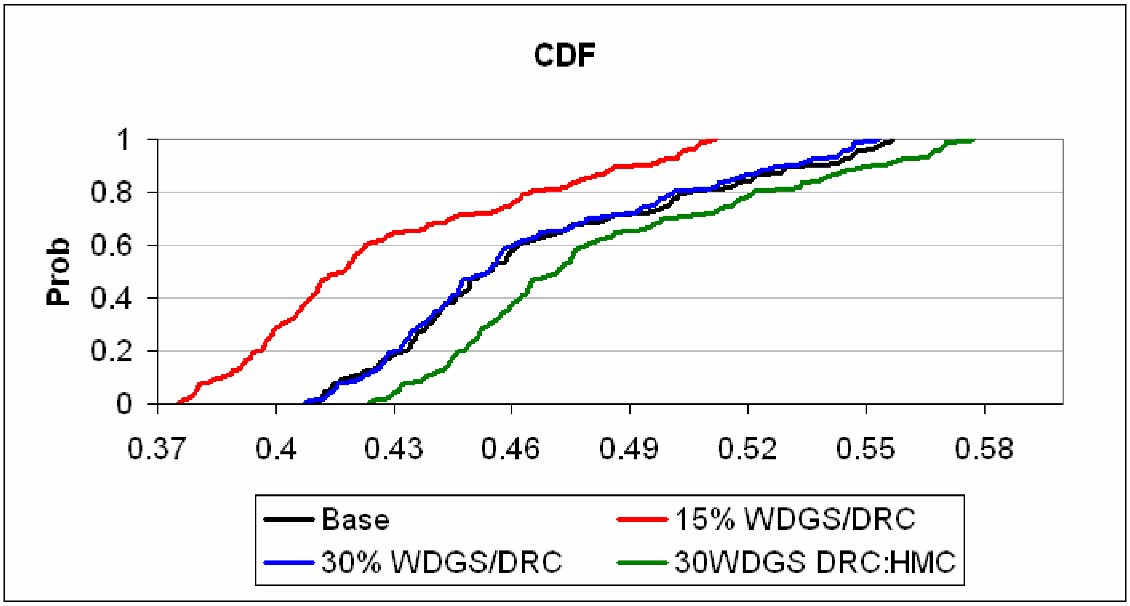


Figure 4.14 Nebraska cost of gain for feedlots located 25 miles from an ethanol plant For definitions, see Nomenclature Page, page vi.

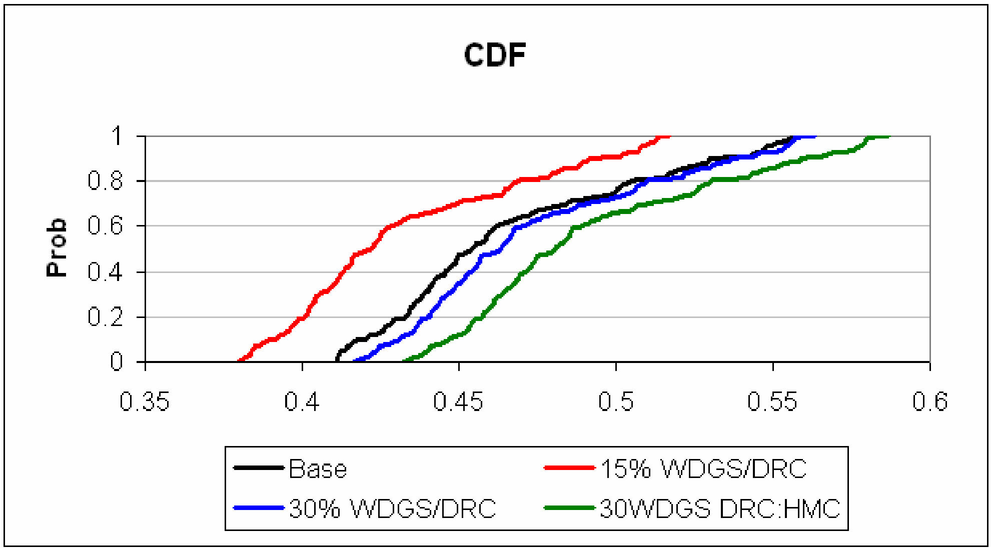


Figure 4.15 Nebraska feedlots located 60 miles from an ethanol plant For definitions, see Nomenclature Page, page vi.

When transporting WDGS 60 miles, the 30 percent WDGS/DRC scenario is no longer preferred over the base scenario, but the 15 percent WDGS/DRC remains the least cost of gain option, as seen in figure 4.15. The results for Nebraska feedlots located 60, 100, and 200 miles from ethanol production are similar. At each distance from ethanol production, WDGS can be fed at 15 percent dry matter to obtain the lowest cost of gain. The base ration of DRC has the second lowest cost of gain at all three locations proximal to ethanol production.

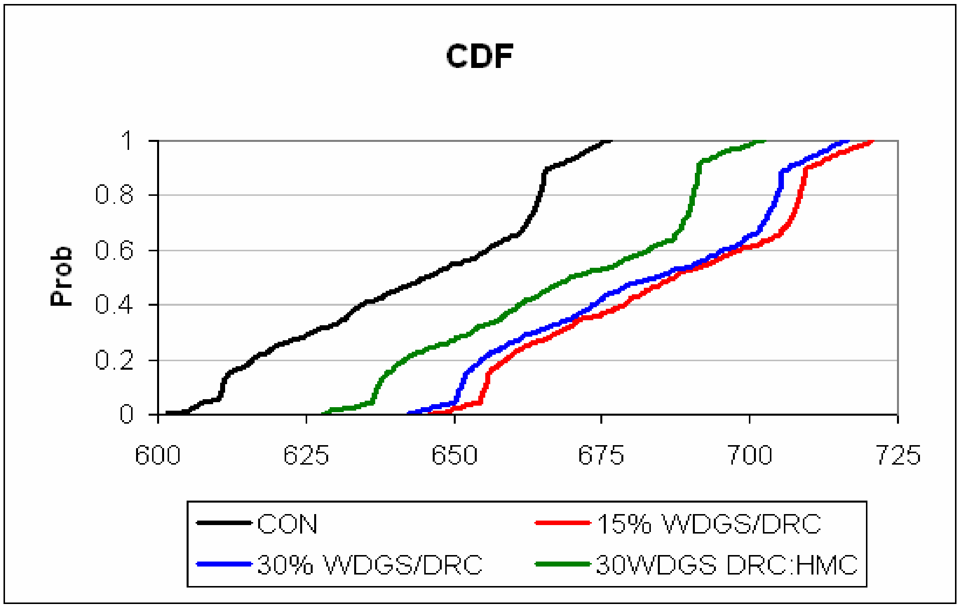


Figure 4.16 Nebraska total gain for October placements
For definitions, see Nomenclature Page, page vi.

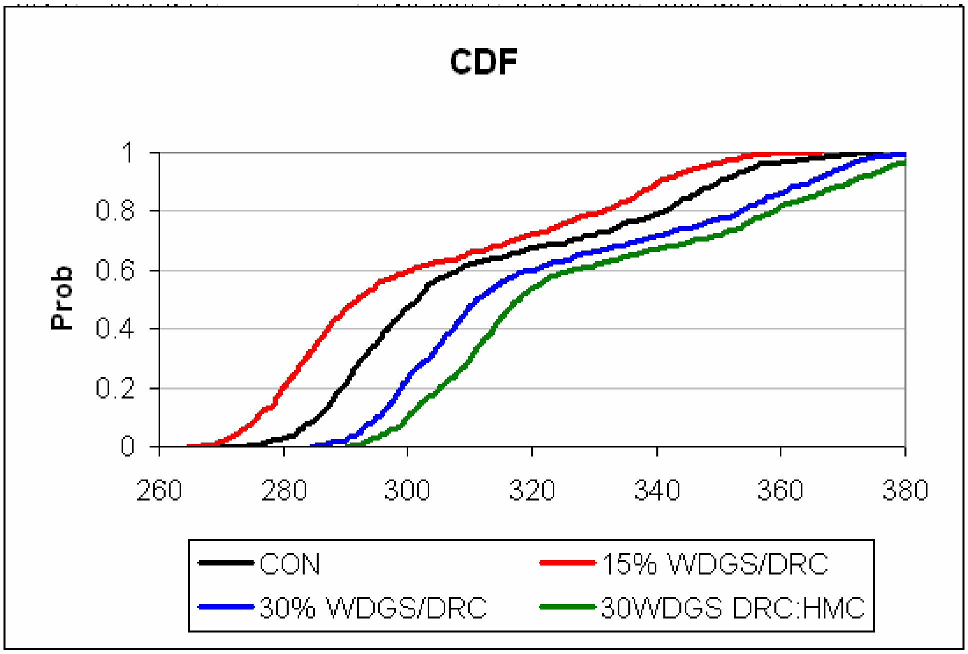


Figure 4.17 Nebraska total costs per head for feedlots located at an ethanol plant
For definitions, see Nomenclature Page, page vi.

Figures 4.16 and 4.17 show the components of the KOV, total gain and total costs. WDGS can be fed at 15 percent of the ration dry matter to increase total pounds of gain, as seen in figure 4.16 and decrease total costs, in figure 4.17, making it the least cost of gain ration. Feedlots located greater than 200 miles from ethanol production can still feed 15 percent WDGS at a lower cost of gain than the base ration, according to the Nebraska model results.

It is important to note that cattle feeders in eastern Nebraska are feeding WDGS at inclusion rates greater than 15 percent of ration dry matter (Erickson, 2006). The Nebraska model could be adjusted to value WDGS at less than 95 percent the price of corn, and more WDGS inclusion rates could be evaluated in addition to the 15 and 30 percent scenarios. Changing these variables and adding scenarios could provide a more accurate estimate of the cost of gain for eastern Nebraska cattle feeders.

Texas Model Results

Texas results are also similar to those previously discussed for the other states. When located at an ethanol plant, 15 or 30 percent WDGS can be fed with DRC to decrease cost of gain when compared to the base, 15 percent DDGS/SFC, and 15 percent WDGS/SFC rations. Figure 4.18 shows the results for cost of gain when located at an ethanol plant, with a $0.15 corn basis and WDGS investment costs included in the total costs. It is important to note, as discussed in Chapter III, the Texas base scenario and the 15 percent WSDGS TTU scenario include SFC, while the 15 and 30 percent WDGS rations include DRC instead of SFC. The 15 percent WSDGS TTU ration is based on feedlot nutrition research by Galyean and Lemon (2006) from Texas Tech University. The other rations scenarios are estimated from personal communication with cattle feeders from the Texas Panhandle (Sartwelle 2006).

SFC costs more to process than DRC, due to the use of natural gas, which increases total costs for both the base and 15 percent WSDGS TTU scenarios. In addition, ADG for cattle fed 15 percent WDGS with SFC is lower than for cattle fed 15 percent WDGS with DRC. Therefore, as shown in figure 4.18, even when feedlots are located at an ethanol plant, the highest cost of gain scenario occurs when WDGS is fed in SFC-based rations instead of DRC-based rations. The WDGS/SFC results are similar to those discussed previously in the Colorado and Kansas models.

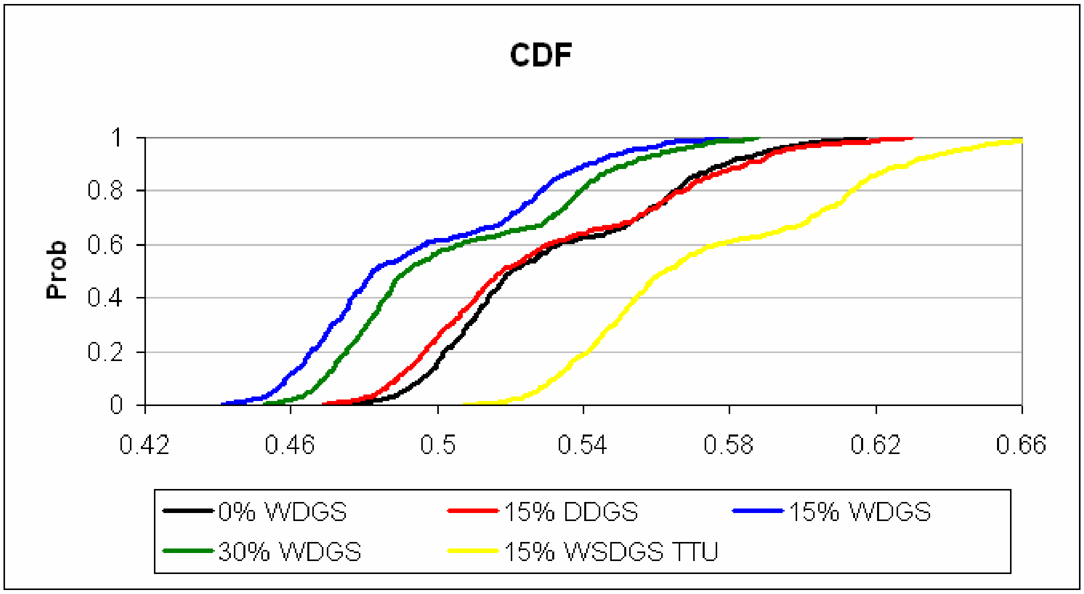


Figure 4.18 Texas cost of gain for feedlots located at an ethanol plant
For definitions, see Nomenclature Page, page vi.

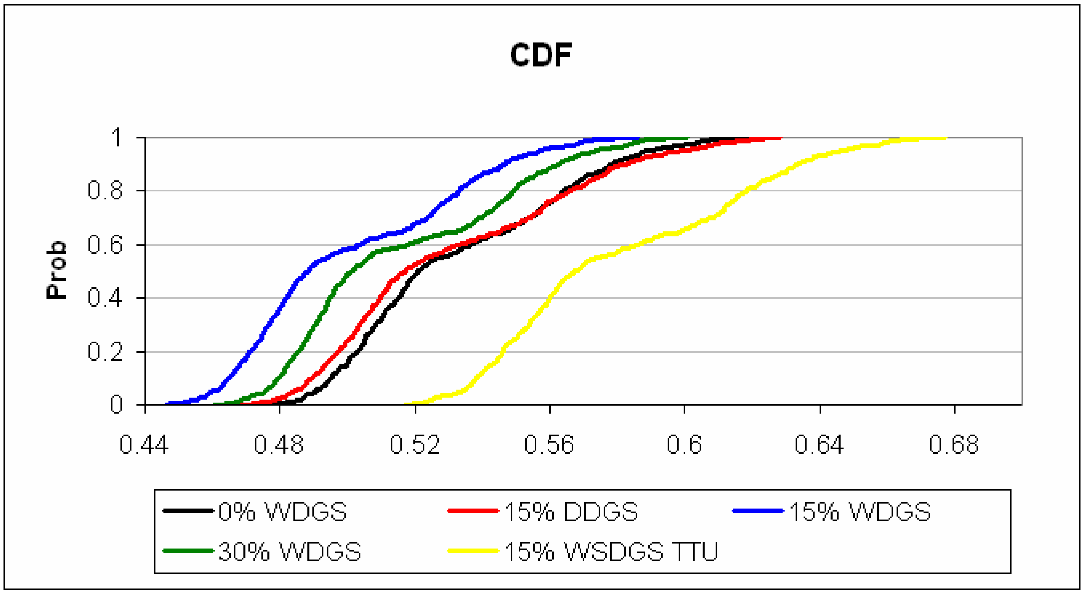


Figure 4.19 Texas cost of gain for feedlots located 25 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

As WDGS has to be hauled greater distances, 25 miles in figure 4.19 and 100 miles in figure 4.20, the 15 percent WDGS/DRC ration still has the lowest cost of gain, and the 30 percent WDGS ration is still a cost-effective option compared to the base, 15 percent DDGS/SFC, and 15 percent WSDGS/SFC rations. At 25 miles from the plant, a $0.15 corn basis is included in the ration costs.

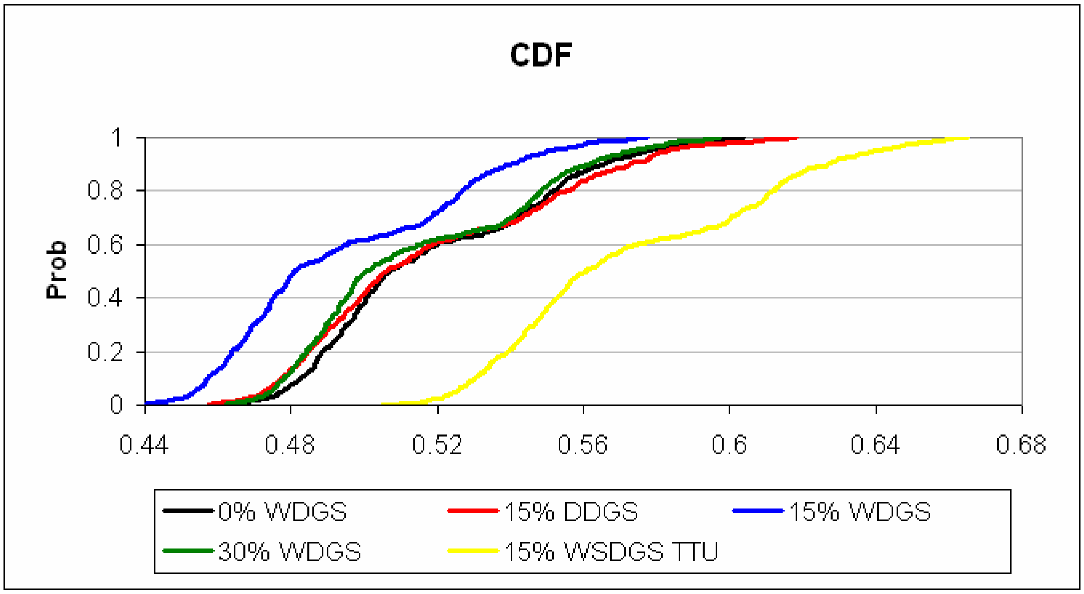


Figure 4.20 Texas cost of gain for feedlots located 100 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

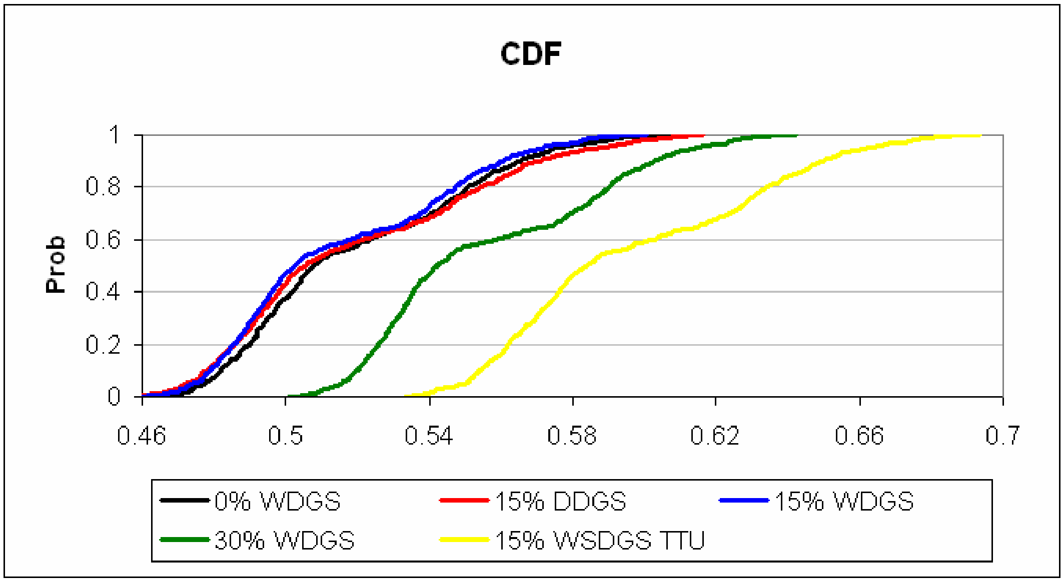


Figure 4.21 Texas cost of gain for feedlots located 300 miles from an ethanol plant
For definitions, see Nomenclature Page, page vi.

When WDGS must be hauled 300 miles from an ethanol plant to a feedlot, it can still be fed at 15 percent of the ration dry matter. As figure 4.21 shows, the 15 percent WDGS ration has a similar cost of gain as the base ration and the 15 percent DDGS ration. At distances greater than 100 miles from ethanol production, the 30 percent WDGS ration would no longer be preferred as a least cost of gain ration.

Summary

Ethanol production and the resulting co-products provide cattle feeders in the top four cattle feeding states an alternative feed ingredient which could potentially lower their cost of gain, from a partial budget analysis. When WDGS is fed with DRC at 15 percent of the ration dry matter, primarily replacing a portion of the DRC, cost of gain savings can range from $7.30 to $2.73 per 100 pounds of gain for cattle feeders located at an ethanol plant (no WDGS transportation costs). Even when transporting WDGS 100 miles, costs per 100 pounds of gain can be decreased by $5.93 to $1.42 depending on which state the feedlot is located. Table 4.3 shows the cost savings from feeding 15 percent WDGS/DRC instead of the base ration in each state, when located at the plant and 100 miles from the ethanol plant. The cost savings are also listed by placement month because those placed on feed in May are on feed for fewer days (fewer total pounds of gain) than those placed at a lighter in-weight in October. Generally cost savings per pound of gain are greater for the October placements as a result of more days on feed and more total pounds of gain per head.

Table 4.3 Average Cost Savings per 100 Pounds of Gain When Feeding 15 Percent WDGS/DRC

	Placements	**At Plant**	**100 miles**
CO	May	$5.46	$3.51
	October	$6.22	$4.43
KS	May	$6.33	$5.05
	October	$7.30	$5.93
NE	May	$4.16	$2.80
	October	$4.44	$3.08
TX	May	$2.73	$1.42
	October	$3.41	$2.24

Note: Cost savings=Average(Base Cost Of Gain-15%WDGS/DRC Cost Of Gain)*100 using the average of 500 iterations
COG=Cost of gain including WDGS investment costs for CO,KS, and TX
At plant costs include $0.15 corn basis

The least cost and second least cost alternatives for each state and placement date are included in Table 4.4. The least-cost scenarios for each distance from ethanol production are included to show the impact of increasing transportation costs for WDGS, as it contains only 35 percent dry matter. The 15 percent WDGS/DRC ration is preferred in all cases. Again the major difference between the 15 percent WDGS/DRC ration and the 15 percent WDGS/SFC rations is the higher ADG when cattle are fed WDGS with DRC. The cost savings from dry-rolling corn instead of using natural gas to steam-flake corn is another significant cost saving aspect of the 15 percent WDGS/DRC scenario.

The next best alternative is either the 30 percent WDGS/DRC ration or the 15 percent DDGS/SFC ration, in most cases. Therefore, if feedlots are located within 200-300 miles of ethanol production, and WDGS is priced at 95 percent the price of corn (on an equal dry matter basis) the co-product is a cost-saving feed ingredient. Feedlot nutrition research has also shown that WDGS improves cattle performance when fed with DRC, so it has benefits on both the cost saving and total gain sides of the cost of gain equation. When feedlots are located greater distances from ethanol production, DDGS can be fed to lower the cost of gain.

Table 4.4 Least Cost of Gain Rations for Each State at Various Distances from Ethanol Production

Nebraska May & Oct		**At plant, $0.15 corn basis**	**25 Miles, $0.15 corn basis**	**60 Miles**	**100 miles**	**200-300 miles**
	1	15% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS
	2	30% WDGS	30% WDGS; Base	Base; 30% WDGS	Base	Base
Texas		**At plant, $0.15 corn basis**	**25 Miles, $0.15 corn basis**	**60 Miles**	**100 miles**	**200 miles**
May	1	15% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS; 15% DDGS
	2	30% WDGS	30% WDGS	30% WDGS	30% WDGS, 15% DDGS; Base	Base
Oct	1	15% and30% WDGS	15% WDGS	15% WDGS	15% WDGS	15% WDGS
	2		30% WDGS	30% WDGS	30% WDGS	15% DDGS; Base
Kansas		**At plant, $0.15 corn basis**	**25 Miles, $0.15 corn basis**	**60 Miles**	**100 miles**	**200 miles**
May	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30% WDGS/DRC; 15% DDGS	15% DDGS	15% DDGS/SFC	15% DDGS
Oct	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30% WDGS/DRC	30% WDGS/DRC; 15% DDGS	30% WDGS/DRC; 15% DDGS; Base	15% DDGS
Colorado		**At plant, $0.15 corn basis**	**25 Miles, $0.15 corn basis**	**60 Miles**	**100 miles**	**200 miles**
May	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	15% DDGS/SFC	15% DDGS	15% DDGS/SFC	15% DDGS
Oct	1	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC	15% WDGS/DRC
	2	30% WDGS/DRC	30%WDGS/DRC; Base; 15% DDGS	Base; 15% DDGS	15% DDGS; Base	15% DDGS; Base

Note: WDGS is fed with DRC in all the above scenarios and DDGS is fed with SFC.

CHAPTER V

CONCLUSIONS

Feed is the single most costly component of finishing cattle, where feed costs often represent 70 to 80 percent of the total cost of gain. It takes approximately 55 bushels of corn to raise a fed calf to harvest, where every pound of beef produced requires 5.6 pounds of corn (USMEF 2006). As ethanol production uses more of the U.S. corn supply, cattle feeders will have to compete with ethanol producers for corn, and likely face higher corn prices. At the same time, the growing supplies of co-products from ethanol production are fed in beef feedlots, specifically DDGS and WDGS. When distiller's grains are fed they replace a portion of the corn as well as supplemental protein, like soybean meal, potentially reducing ration costs (Erickson 2005). Feedlot nutrition studies have shown positive cattle performance results when WDGS and DDGS are fed at 15 and 30 percent of the ration dry matter. Assuming ethanol co-products are priced competitively with corn and cattle performance (ADG) can be improved with the inclusion of WDGS or DDGS, cost of gain could actually be lower for feedlot rations incorporating co-products.

Monogastrics have a more challenging position in the changing corn market, as it is more difficult to incorporate DDGS into pork and poultry rations. Furthermore, WDGS is generally not fed to monogastrics. Ethanol plants prefer to produce WDGS, saving the costs of drying DDGS, so cattle feeders have the advantage of being able to feed WDGS, with positive cattle performance results. While monogastrics consume a much smaller amount of co-products than ruminants, some ethanol plants are designing DDGS products that will be more favorable for monogastric rations. The variety, value, and volume of ethanol co-products are ever-changing as the ethanol industry grows. It is therefore difficult to estimate the future supply, price, and utilization of ethanol co-products.

The primary objective of this research was to evaluate the potential impact of increasing ethanol production on the beef cattle feeding industry. Potential cost savings through the feeding of ethanol co-products are identified using a partial budget stochastic simulation model. The partial budget analysis focuses on changes in ration ingredient costs as well as actual costs of feeding resulting from the inclusion of ethanol co-products, specifically WDGS and DDGS. Stochastic simulation of cost of gain for the major cattle feeding states under different ration scenarios provides insight to the potential impacts of the increasing availability of ethanol co-products. Transportation costs for hauling WDGS, with a composition of only 35 percent dry matter, were also included at differing distances from the feedlot to the ethanol plant.

The partial budget analysis revealed the importance of cattle performance when evaluating the potential cost savings from feeding WDGS. The 15 percent WDGS/DRC ration consistently had the lowest cost of gain when compared to the other scenarios when feedlots were located within 200 miles of ethanol production. On the other hand, the 15 percent and 30 percent WDGS/SFC rations consistently had the highest costs of gain, even when feedlots were located at the ethanol plant. The primary difference between these ration scenarios is the lower ADG when cattle are fed WDGS with SFC instead of DRC. The increased cost of corn processing when steam-flaking corn also results in higher costs for the WDGS/SFC rations. When applying the partial budget results, it is important to note the differences in ADG for each ration.

The partial budget model presented in this paper does not attempt to forecast corn or co-product prices as a result of increasing ethanol production. Stochastic historical feed prices and cattle performance variables for each region are used in the model to determine cost of gain differences between base ration scenarios and ration scenarios including WDGS and DDGS. Simulation of the partial budget model shows that WDGS and DDGS can be fed as cost-saving feed ingredients in the top four cattle feeding states.

Even when accounting for transportation, investment, and feeding costs, when fed at 15 percent of ration dry matter, WDGS can decrease feedlot cost of gain for May (750 pound) and October (600 pound) placements compared to the base scenario. As corn prices rise with the increasing demand from ethanol production, cattle feeders will be forced to pay higher prices for corn. On the other hand, more ethanol co-products will be available in both the wet and dry form, and likely at a lower price than corn. When priced competitively with corn, WDGS and DDGS can improve cattle performance, and through increased ADG decrease the total cost of gain. The partial budget model shows that these co-products will help offset the higher corn prices, as co-products can be fed at a lower cost of gain than the base ration, even for feedlots located 200 to 300 miles from ethanol production.

Future Research

The partial budget cost of gain analysis relies on limited animal science feedlot nutrition studies regarding the use of ethanol co-products in feedlot rations. As seen in the analysis, cattle performance differences can make the difference between alternative scenarios including WDGS as the least and the highest cost rations. Although it may not be ideal to compare various rations against one baseline, it was difficult to harmonize the scenarios due to a regional void in feedlot data involving ethanol co-products. Numerous ethanol co-product feeding trials have been completed in Nebraska, but WDGS feedlot research in Colorado, Kansas, and Texas is limited although feeding trials are currently underway.

Pricing of WDGS and DDGS should also be developed based on regression analysis of the projected supply and demand for feed protein and energy. WDGS was priced at 95 percent the value of corn on an equal dry matter basis in this study because that was the current price relationship being used in the cattle feeding and ethanol industries at the time of this study. Increasing ethanol production, and higher natural gas prices (higher drying costs for the ethanol plant) could increase the supplies of WDGS and likely drive down the prices for the wet co-product. DDGS prices could also change with increasing ethanol and biodiesel production. If both supplies of DDGS and SBM increase, the prices for protein supplements could decrease in the future. On the other hand, strong feed demand worldwide combined with increased ethanol and biodiesel production could increase the price of corn and soybeans, and therefore increase the demand for the co-products as alternative feed ingredients.

The rapidly changing ethanol industry leaves many questions for future research. How much corn will be used for ethanol in the future, or how soon will cellulostic ethanol production become the main source of production? If ethanol plants continue to use corn as their primary feedstock, but change their production processes, ethanol co-products will also change. If the solubles are burned to power the ethanol plant, the remaining feed will have a lower energy value. All of these aspects should be considered in future research and by cattle feeders as they adjust their feeding operations to include ethanol co-products.

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APPENDIX

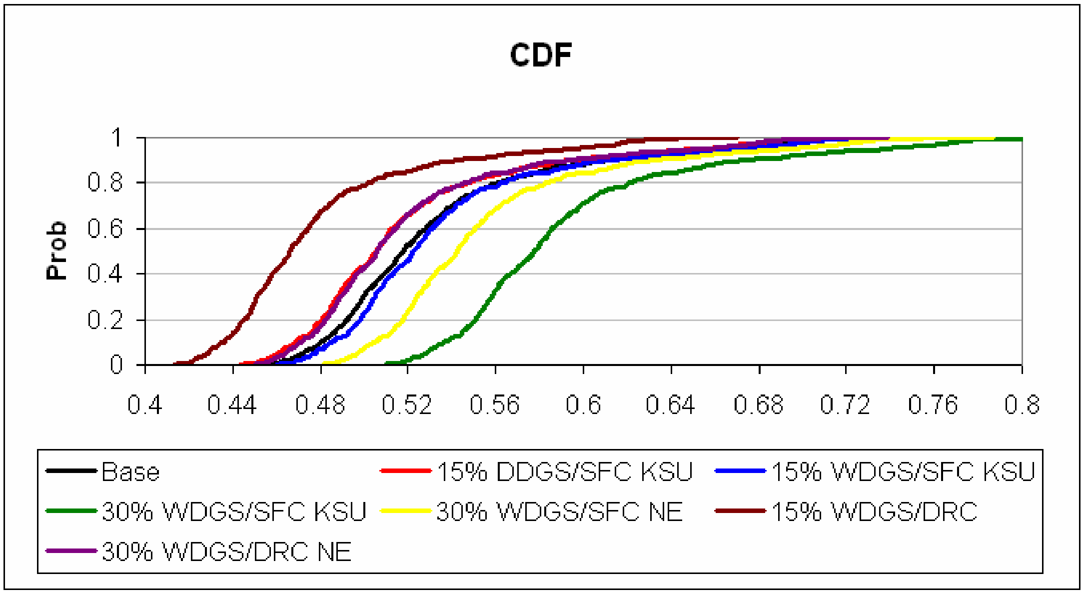

Figure A.1 Colorado cost of gain for feedlots located at an ethanol plant (May)

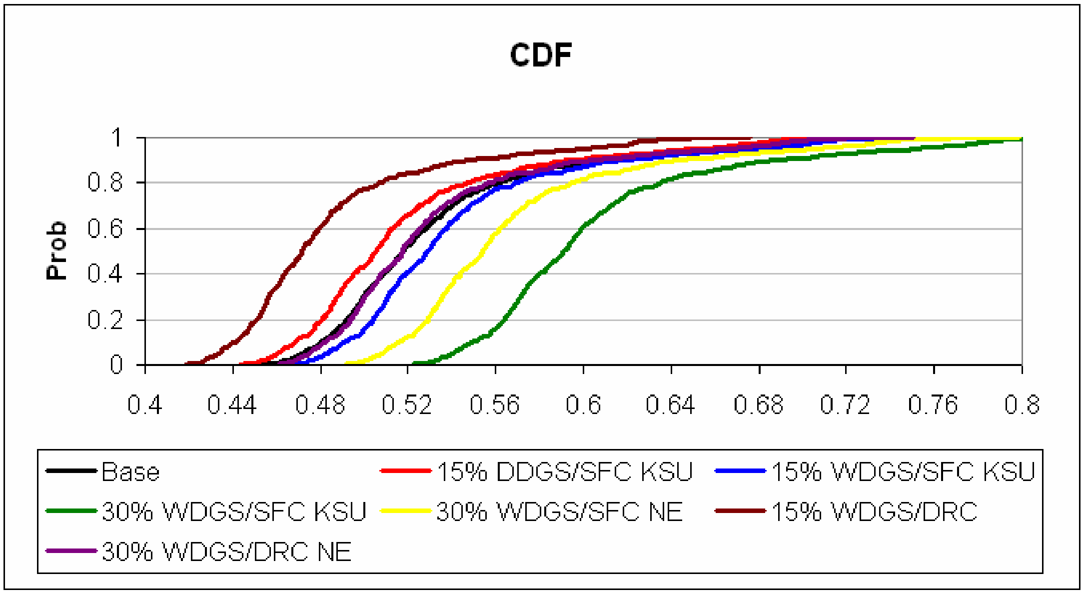

Figure A.2 Colorado cost of gain for feedlots located 25 miles from an ethanol plant (May)

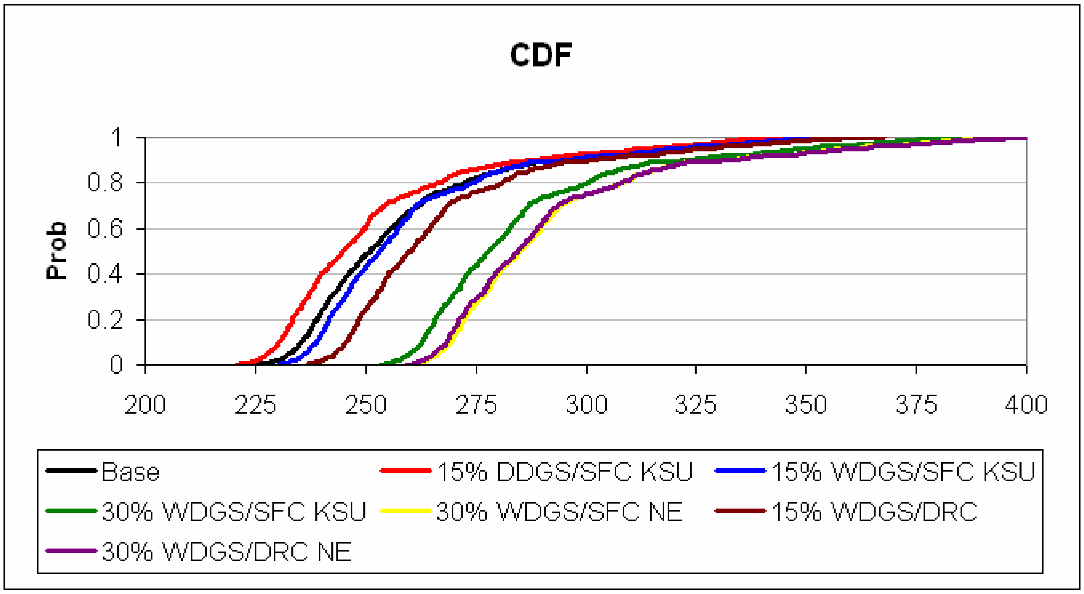

Figure A.3 Colorado total costs for feedlots located 25 miles from and ethanol plant (May)

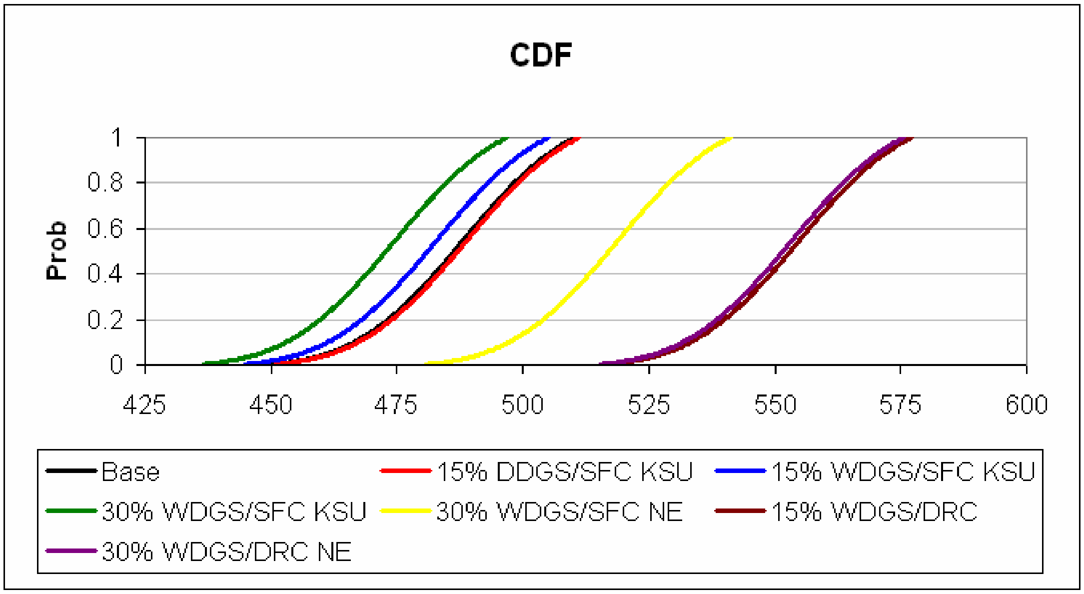

Figure A.4 Colorado total gain for May placements on feed for 150 days

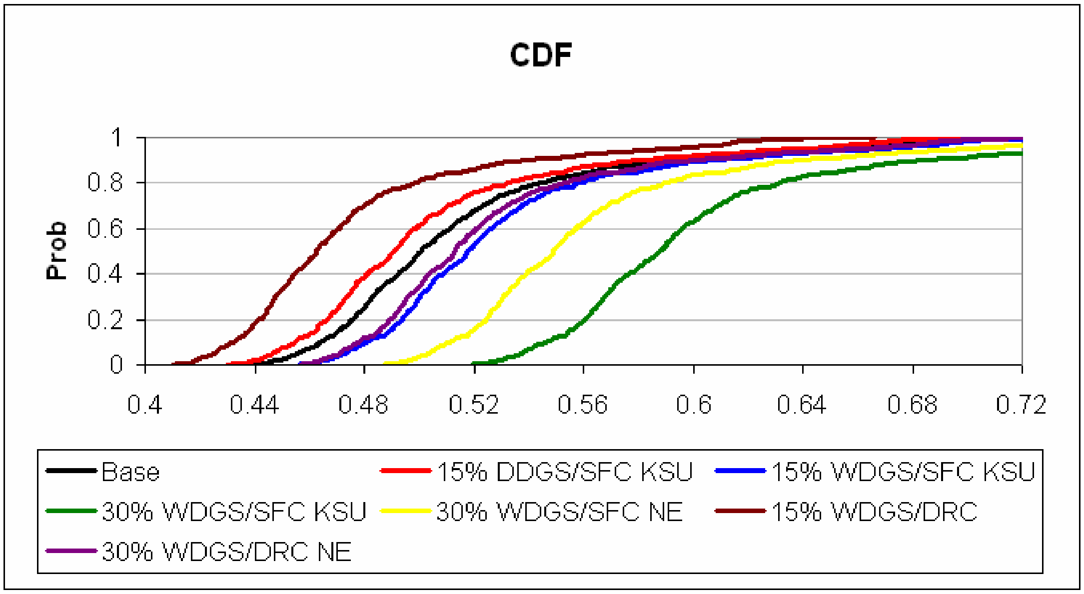

Figure A.5 Colorado cost of gain for feedlots located 60 miles from an ethanol plant (May)

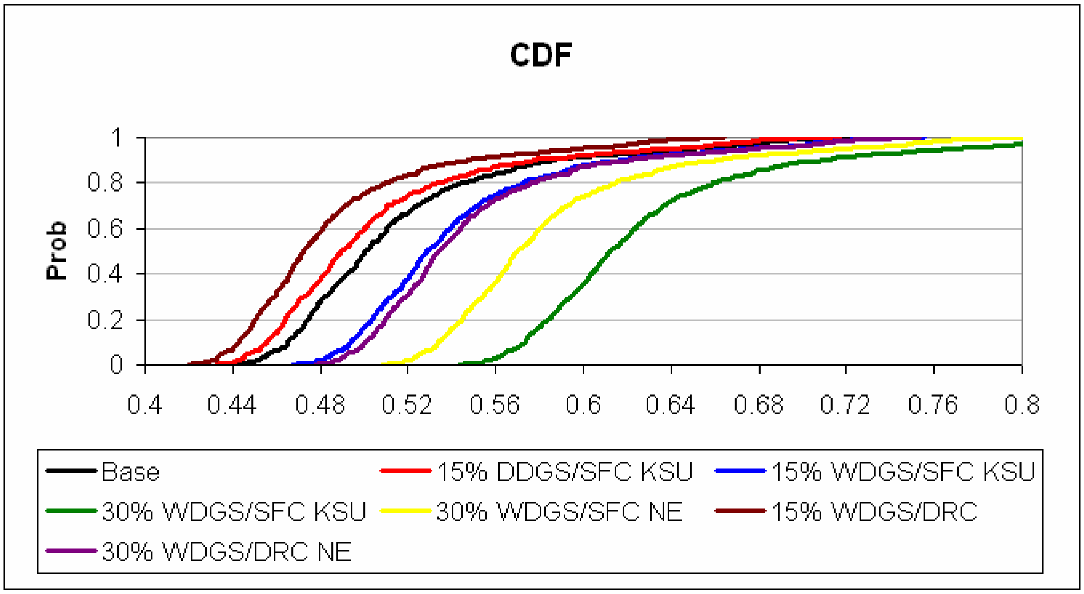

Figure A.6 Colorado cost of gain for feedlots located 300 miles from an ethanol plant (May)

Table A.1 WDGS Costs for Colorado May Placements at Feedlot Located 300 Miles from Ethanol Plant

	15% WDGS/SFC KSU	30% WDGS/SFC KSU	30% WDGS/SFC NE	15% WDGS/DRC	30% WDGS/DRC NE
tons WDGS	16852.63	36037.99	33785.62	16852.63	35553.47
Truckloads WDGS	674.11	1441.52	1351.42	674.11	1422.14
Total Trucking	305369.66	653008.41	612195.39	305369.66	644228.96
Trucking Cost/head	12.21	26.12	24.49	12.21	25.77
Trucking cost/lb gain	0.022	0.047	0.044	0.022	0.047
Loads of WDGS per day	4.49	9.61	9.01	4.49	9.48
% increase in feeding costs	0.22	0.54	0.54	0.25	0.60
feeding cost/hd/day	0.10	0.13	0.13	0.11	0.14
Feeding cost/head (NE eqn)	15.55	19.64	19.64	15.95	20.37
Labor $/truckload for DOF	38.15	35.68	38.06	38.15	36.16
Labor costs/head	1.03	2.06	2.06	1.03	2.06
Repair, Mnt, Insurance, Fuel/hd	0.55	0.55	0.55	0.55	0.55
Manure Handling	4.30	4.30	6.70	4.30	6.70
Total WDGS Costs/head	33.65	52.67	53.44	34.04	55.45
Total Gain	482.8107	474.5607	518.8107	554.8107	553.3107
WDGS Costs/lb gain	0.07	0.11	0.10	0.06	0.10

Note: 25,000 Cattle on feed for 150 days; expected value

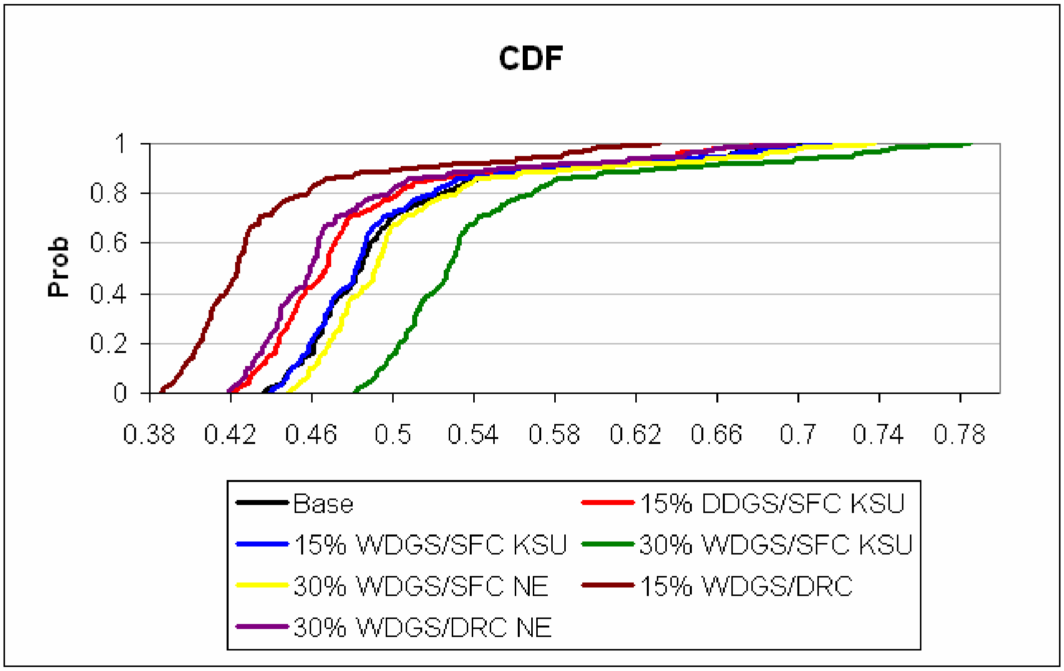

Figure A.7 Kansas cost of gain for feedlots located at an ethanol plant (May)

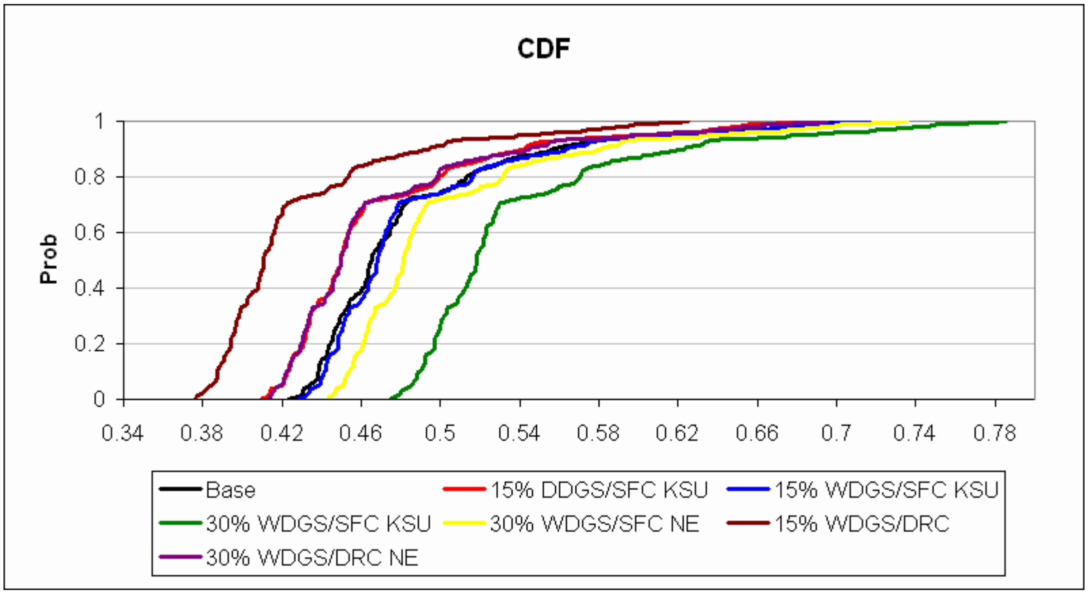

Figure A.8 Kansas cost of gain for feedlots located 25 miles from an ethanol plant (May)

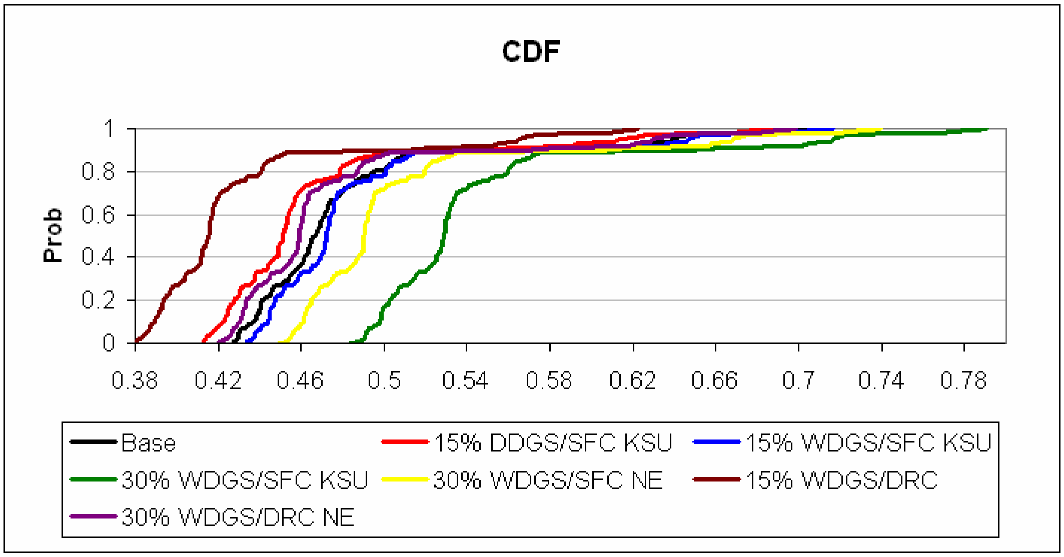

Figure A.9 Kansas cost of gain for feedlots located 100 miles from an ethanol plant (May)

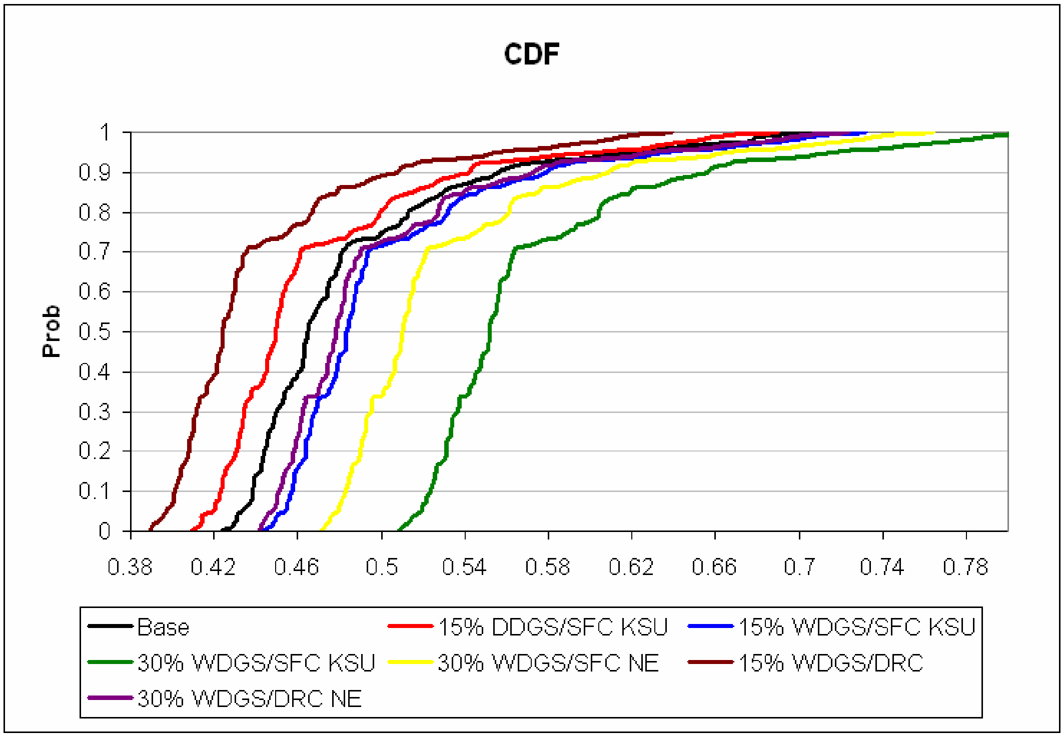

Figure A.10 Kansas cost of gain for feedlots located 200 miles from an ethanol plant (May)

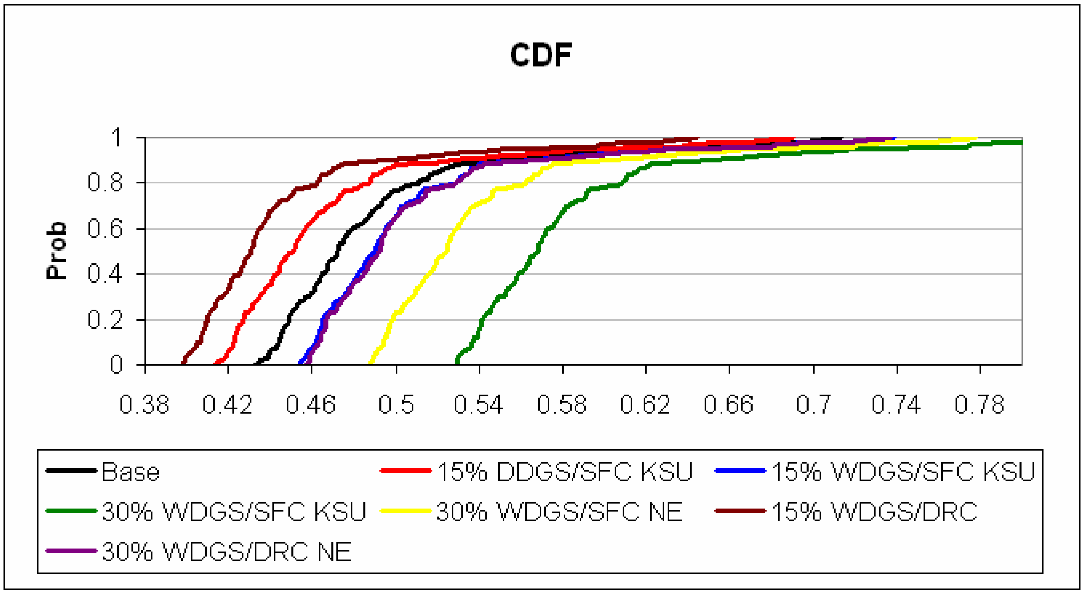

Figure A.11 Kansas cost of gain for feedlots located 300 miles from an ethanol plant (May)

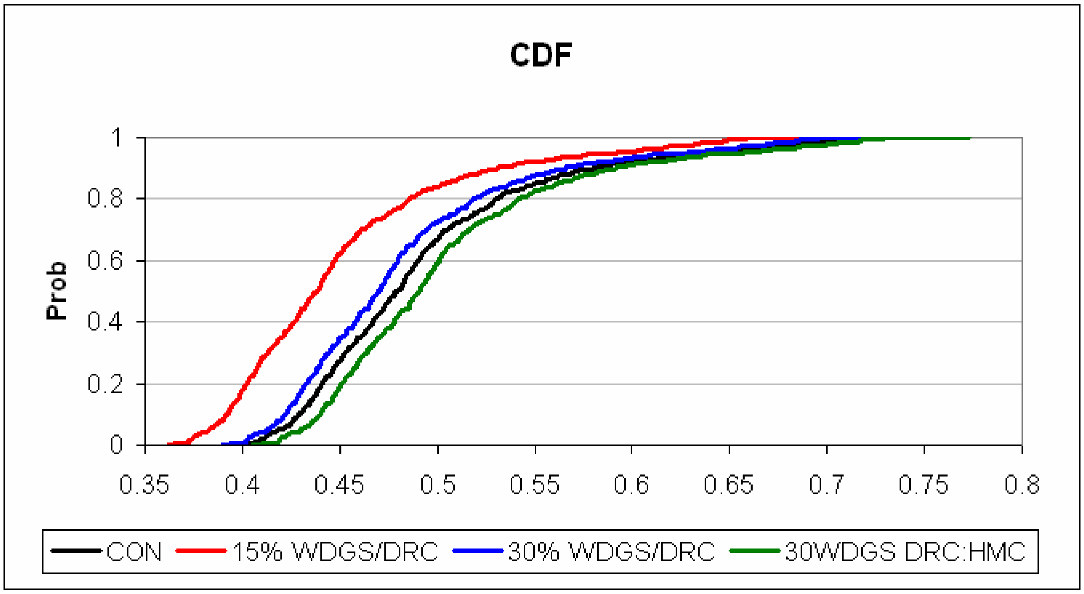

Figure A.12 Nebraska cost of gain for feedlots located at an ethanol plant (May)

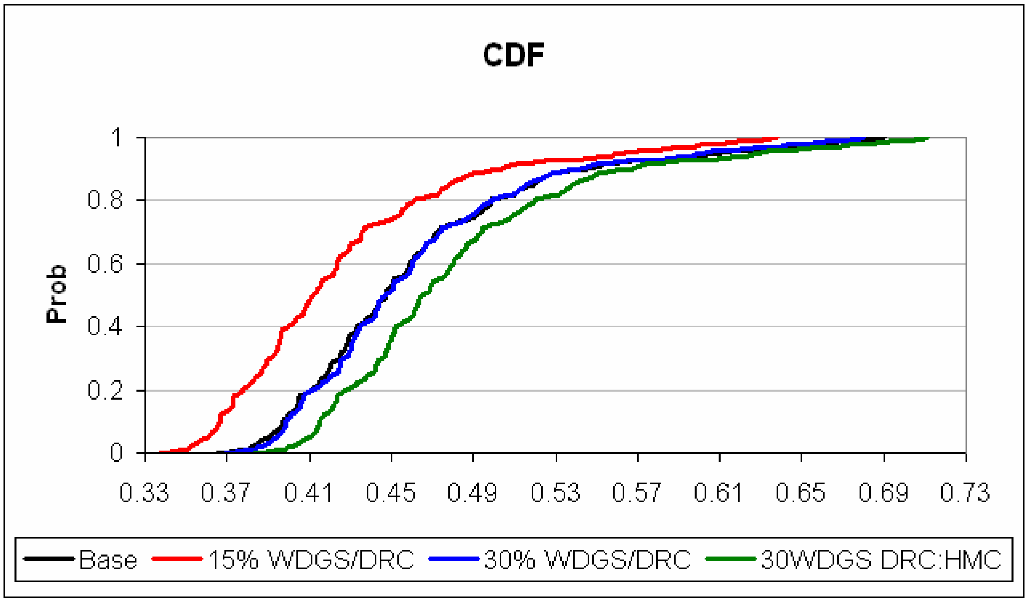

Figure A.13 Nebraska cost of gain for feedlots located 25 miles from an ethanol plant (May)

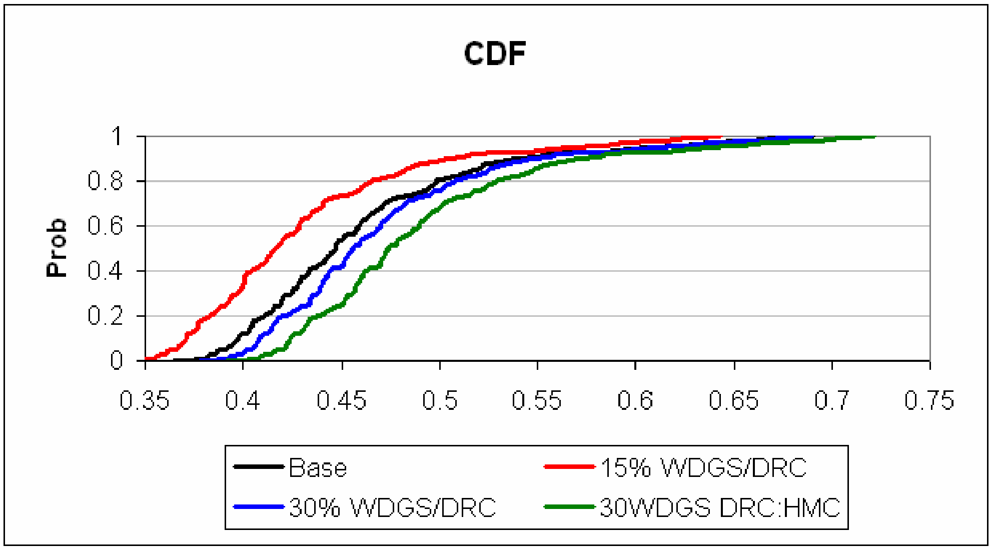

Figure A.14 Nebraska cost of gain for feedlots located 60 miles from an ethanol plant (May)

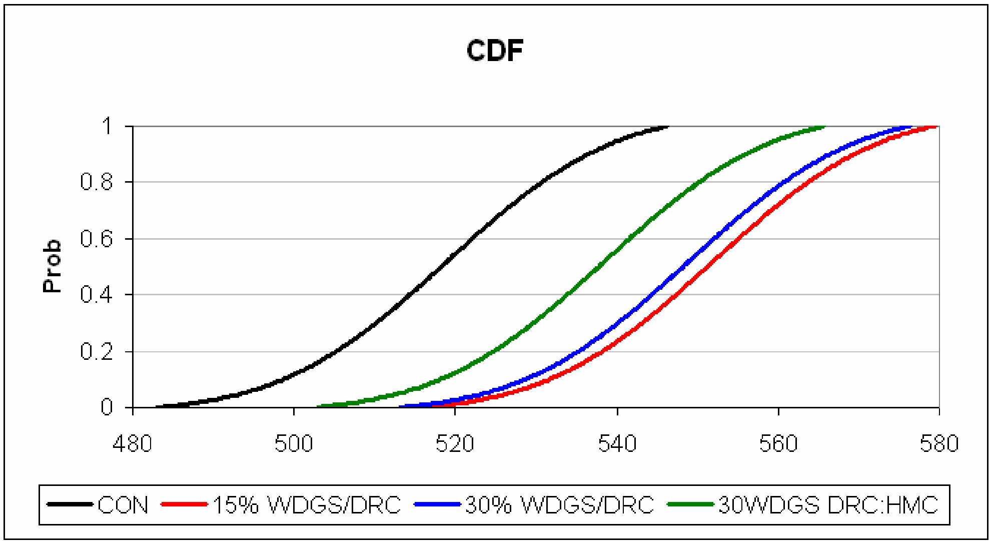

Figure A.15 Nebraska total gain for May placements

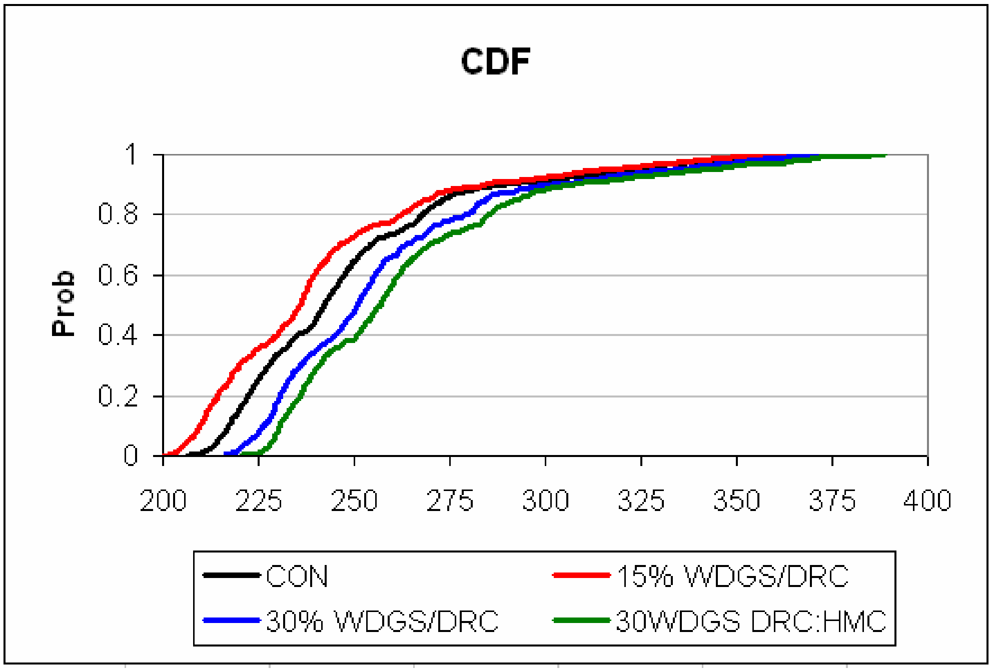

Figure A.16 Nebraska total costs per head for May placements for feedlots located at an ethanol plant

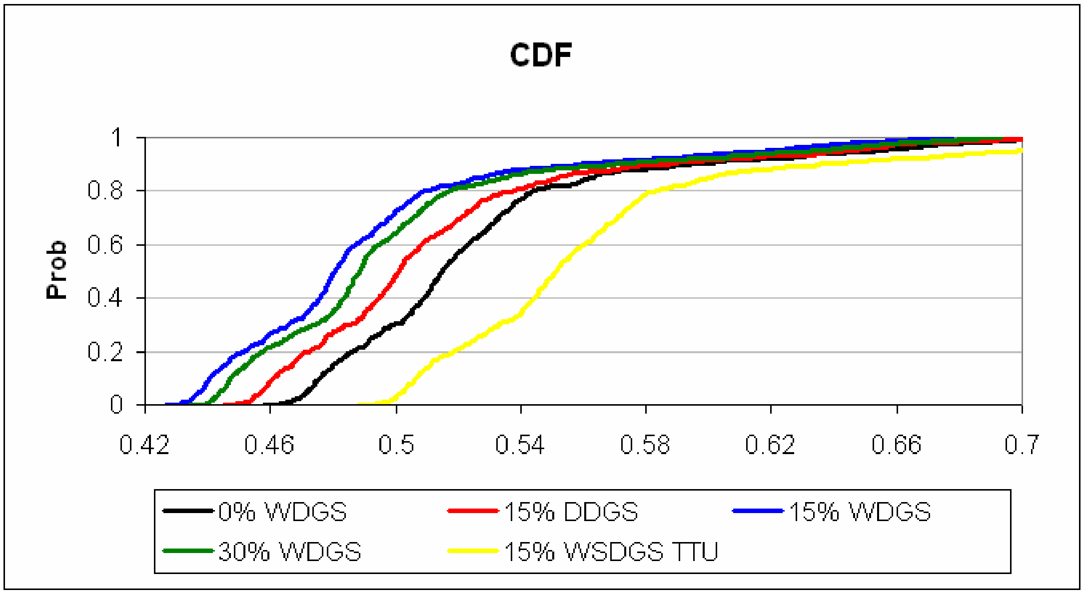

Figure A.17 Texas cost of gain for feedlots located at an ethanol plant (May)

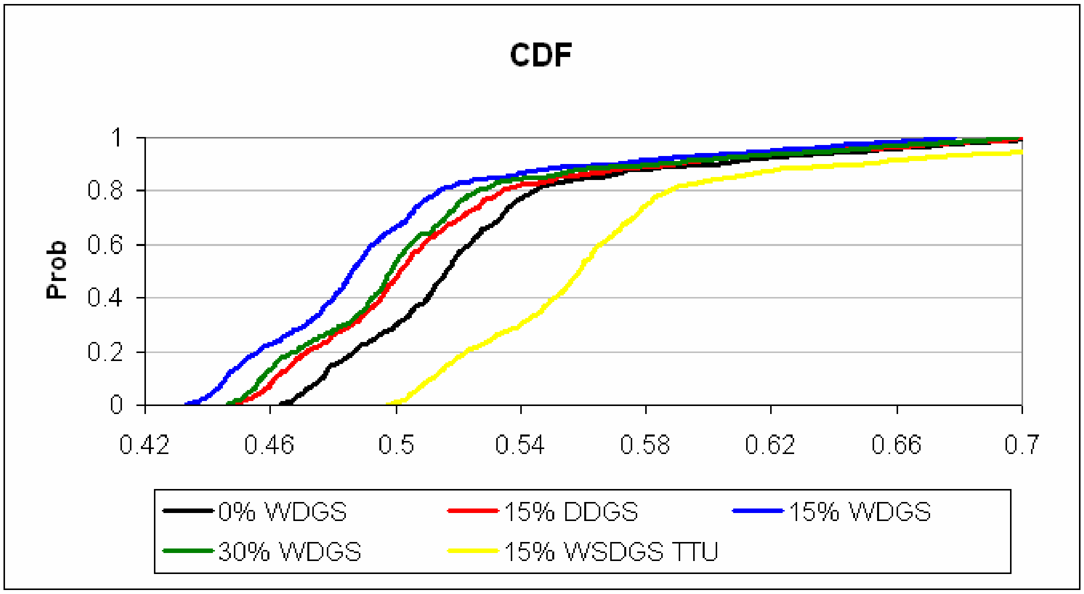

Figure A.18 Texas cost of gain for feedlots located 25 miles from an ethanol plant (May)

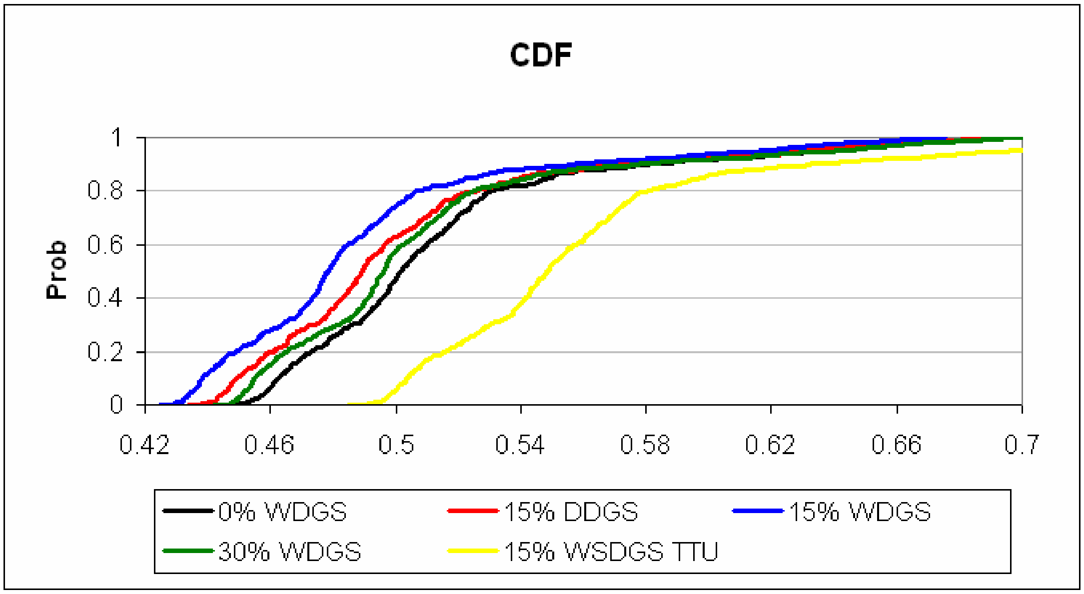

Figure A.19 Texas cost of gain for feedlots located 100 miles from an ethanol plant (May)

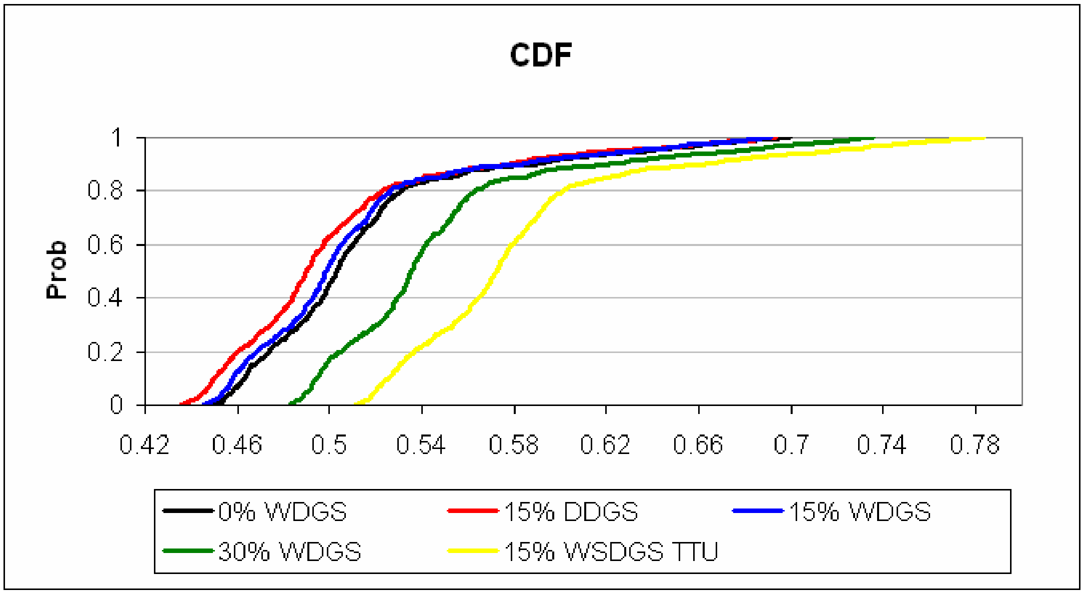

Figure A.20 Texas cost of gain for feedlots located 300 miles from an ethanol plant (May)

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