RISK ANALYSIS OF TILLAGE AND CROP ROTATION ALTERNATIVES WITH WINTER WHEAT FOR SOUTH CENTRAL KANSAS

by

MATTHEW J. PATCHA

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Approved by:

Major Professor
Dr. Jeffery R. Williams

Abstract

This study examines the economic profitability of reduced-tillage and no-tillage systems for corn, soybeans, and grain sorghum production in annual rotation with winter wheat, and monoculture wheat and grain sorghum in south-central Kansas. Net returns to land and management per acre for each of 13 production systems are calculated several different ways. Net returns are calculated using the 10-year average yield for each crop, the average crop price from 2009, and 2009 input prices. A distribution of net returns is also calculated using the actual historical yields and crop prices from 1997 to 2006 and 2009 input prices. This process is repeated, except average crop prices from 2006, 2007, 2008 and 2009 are now used. Finally, net returns are calculated using simulated yield and price distributions based on actual historical yields, four historical monthly price series, and 2009 input costs.

Overall, the reduced-tillage wheat-soybean systems (RTWS) have the greatest net returns for each of the net return distributions. No-tillage wheat-soybean (NTWS) generally has the second highest net returns. Stochastic Efficiency with Respect to a Function (SERF) is used to determine the preferred management strategies under various risk preferences. SERF analysis indicates that RTWS is the system most preferred by all producers, regardless of their level of risk aversion. NTWS is typically the second most preferred system to RTWS. Using historical annual prices for 1997 to 2006 and the simulated monthly prices series for 2006 to 2009 and 2007 to 2009 to calculate the net return distributions, managers with higher levels of risk aversion prefer reduced-tillage wheat-grain sorghum (RTWG) over no-tillage wheat-soybean (NTWS). Sensitivity analysis shows that as the price of glyphosate falls, no-till systems become relatively more profitable. SERF analysis using the historic yields, 2006 to 2009 simulated monthly prices, and 2009 input costs with reduced glyphosate prices indicate that NTWS would

be the system most preferred by producers at all levels of risk aversion. RTWS closely follows NTWS as the next preferred system with those conditions also for all levels of risk aversion.

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CHAPTER 1 - Introduction

1.1 Overview

Children in Russia handpicked the first seeds of the famous hard red winter wheat, known as Turkey Red, which eventually led to wheat production in Kansas. The children were part of Mennonite colonies preparing to emigrate from the steppes of Russia to the prairies of America to escape religious persecution. In 1874, the Mennonite immigrants landed in New York. Within a month of landing, most of the immigrants traveled to the now-Kansas counties of Reno, Harvey, Marion and McPherson, where the Santa Fe railroad was offering thousands of acres on good terms. It was there that they planted the first of the great crops of hard Turkey Red wheat; which with its derivatives have made Kansas the granary of the nation (Walter, 2000).

Over a century later, hard red winter wheat is still the principal crop grown in south-central Kansas. Approximately 51 percent of all the harvested crop acres in a 13 county area of south-central Kansas in 2007 were wheat acres (USDA - NASS, 2008). Producers in this area have typically used conventional tillage. The glossary of soil science terms from the Soil Science Society of America (SSSA, 2008) website defines conventional tillage as any primary or secondary tillage operation that usually leaves less than 30 percent plant residue cover on the soil surface after completion of the tillage sequence. This type of tillage can lead to a decrease in soil quality and overall productivity because of soil erosion and moisture loss. As a result, there has been a change in federal farm programs to help prevent this problem.

In January of 1990, producers were required to develop conservation plans to reduce soil erosion to remain eligible for farm program benefits under the 1985 Food Security Act and subsequent farm legislation. These plans had to be implemented no later than Jan. 1, 1995 (U.S. Congress – F.A.C.T. Act, 1990). Following this was the passing of the incredibly important FAIR Act, better known as the 1996 Farm Bill. The 1996 Farm Bill had a tremendous impact on agricultural producers nationwide. The 1996 Farm Bill removed the connection between income support payments and farm prices and, in turn, provided seven annual fixed – but declining – production flexibility contract payments. This change allowed producers to receive government payments largely independent of farm prices; whereas before deficiency payments were totally dependent on farm prices (Young and Shields, 1996).

This farm bill also eliminated the annual acreage idling programs, allowing farmers the freedom to plant any crop, regardless of their previous base-acreage constraints. For farmers in south-central Kansas, this meant they were no longer required to grow only wheat. The farm bill also ensured the continuation of soil and water conservation in several ways. For producers to receive payments or loans on program commodities, they were required to enter into a production flexibility contract for the period of 1996 to 2002. This contract mandated producers' compliance with the existing conservation plans set forth in the 1985 bill for the farm, wetland provisions and planting flexibility provisions. The 1996 Farm Bill also started a conservation program called the Environmental Quality Incentives Program (EQIP). EQIP was authorized $1.3 billion over the seven years of 1996 to 2002 to provide technical, educational and cost-share assistance/incentive payments to crop and livestock producers for implementing management practices that protected soil and water resources (Young and Shields, 1996). The EQIP program was later reauthorized in the 2002 Farm Bill to work as a voluntary conservation program for farmers and ranchers who promote agricultural production and environmental quality as compatible national goals (USDA - NRCS, 2009).

Research in the area of conservation, coupled with strong outreach programs, has helped producers meet their conservation plans. Farm equipment manufacturers and improvements to tillage equipment designs over the last decade have facilitated the transition from conventional to conservation tillage. Producers can now choose between any number of different tillage practices and have the knowledge to understand their effects on the environment.

One of the primary goals of any producer is to maximize net returns. However, all producers know that responsible stewardship of the land is the only way to protect the longevity of their operations. Producers now have to decide what tillage operation, as well as what crop rotation; can meet both of these needs.

1.2 Statement of the Problem

Prior to the widespread use of herbicides that began in the 1940s, tillage was the only way to destroy/prevent unwanted vegetation. Tillage can be defined as the mechanical manipulation of the soil profile for any purpose. In agriculture, a list of purposes might entail modifying soil conditions, managing crop residues or weeds, and/or incorporating chemicals for crop protection (SSSA, 2008). For years, tillage practices remained very much the same. It was typical to have a sequence of operations, such as plowing and harrowing, to produce a fine seedbed and to remove weeds and previous crop residue.

Tillage leaves the field uniform and weed-free, creating a seedbed that is easy to plant into. Additionally, tillage helps increase soil temperature, which allows for earlier planting and better germination. Tilling the field, breaks apart any compacted areas or crusting on the surface, allowing for better water infiltration and seed placement (Mannering and Griffith, 1985).

Tillage does have drawbacks. The primary problem that results from tillage is soil erosion. The lack of residue on the soil surface leaves the soil unprotected and vulnerable to wind and water erosion. Erosion caused by water creates several problems. First is the problem of sedimentation. This occurs when the soil is moved by water from the desired place (farmer's field) to an undesired place, such as a river, pond or edge of the field. In addition to losing valuable topsoil, the potential for ground or surface water contamination exists. Pesticides can bind to soil aggregates, so that when runoff occurs, chemicals can contaminate water sources, reducing water quality (Doran and Parkin, 1994).

The removal of surface residue by tillage can also diminish soil quality. The presence of surface residue is important because it increases water infiltration and keeps the soil surface from crusting. Surface residue also reduces evaporation of valuable moisture stored in the soil. The residue acts as an insulator for the soil, keeping the soil temperature low and the soil moisture level high. Although retention of soil moisture is often desirable, it can also be problematic for farmers. The combination of a wet spring and a field with a heavy residue cover can delay farmers at planting. Additionally, the lower the soil temperature, the slower the rate at which seeds will germinate. This can result in slow seedling emergence and inhibited plant growth early in the season (Mannering and Griffith, 1985).

One way to decrease soil erosion and prevent the aforementioned problems is to practice conservation tillage. Conservation tillage can be described as any planting or tillage system that results in the maintenance of at least 30 percent coverage of the soil surface by plant residues (SSSA, 2008). As mentioned before, the benefits of maintaining some level of crop residue on the soil surface includes reduced soil erosion, increased soil moisture retention, and reduced fuel, labor and machinery costs. Furthermore, utilizing conservation tillage methods can reduce some of the need for terraces, grassed waterways, contour farming and drainage tile that are typically used in a conventional tillage system to control water erosion.

Several conservation tillage practices are in use today. The first system, stubble mulch, leaves 30 percent or more of the surface covered with crop residue (SSSA, 2008). This can be accomplished by the use of tillage equipment such as disks, field cultivators, V-blades, harrows, etc. In this study, the above tillage practices will be considered reduced tillage (RT) operations. This type of tillage is good for building organic matter by mixing in plant residue or manure. This type of tillage is still better than conventional tillage because more than 30 percent residue cover is left on the surface reducing the potential for keep erosion. One downfall associated with reduced tillage is the number of tillage passes made across a field. Multiple tillage operations or passes lead to soil compaction and higher labor, fuel and machinery costs.

The second commonly used conservation tillage practice is ridge till. Ridge till can be described as a tillage system in which ridges are formed atop the planted row by cultivation; the ensuing row crop is planted into the ridges formed the previous growing season (SSSA, 2008). This also could be classified as a reduced tillage operation, but this tillage method was not used in this experiment. Ridge till is useful for reducing herbicide costs, since any weeds in the seed furrow are physically eliminated, so herbicides have to be applied only as a band across the crop. Similar to ridge till is strip tillage (also not used in this experiment), where the tillage operation is performed in isolated bands separated by bands of soil essentially undisturbed by the tillage equipment.

The third and final tillage system is no tillage (no-till). As the name implies, no tillage of the soil occurs and the crop is planted directly into the previous crop's residue. No-till offers a number of potential benefits. Not tilling the soil ensures that there is plant residue on the surface to slow erosion. No-till also allows the soil to retain more moisture than other tillage practices because the residue on the soil reduces evaporation and keeps soil temperatures lower (Mannering and Griffith, 1985). This extra moisture may be enough to allow a farmer to plant another crop, rather than leave a field to fallow. Lastly, no-till should reduce labor, fuel and machinery costs.

Although conservation promises many benefits, some concerns exist that need to be addressed. Conservation tillage, especially no-till, has dramatically increased the amount of chemicals applied to fields each year. This has created several problems. First, the cost savings from the lack of tillage operations may become offset by the increase in cost of chemicals used. Another problem that can result from an increase in pesticide use is the runoff of chemicals into surface water or leaching into groundwater sources. Perhaps most important is the concern over weeds becoming resistant to current herbicides.

According to Peterson (1999), resistance to triazine herbicides has been confirmed in Kansas in kochia, redroot pigweed, common water hemp, Palmer amaranth and downy brome. Resistance to acetolactate synthase (ALS)-inhibiting herbicides also has been confirmed in kochia, Russian thistle, common water hemp, Palmer amaranth, common cocklebur, shattercane and common sunflower. Possibly the biggest future concern by producers will be weeds that are resistant to glyphosate. Scientists have now identified nine glyphosate-resistant weed biotypes in the United States, some of which include Palmer Amaranth and common water hemp, which have already shown resistance to triazines and ALS inhibitors (Moore, 2010).

Several key management strategies can help producers keep herbicide-resistant weed problems in check. These include crop rotation, rotating herbicide modes of action used, changing tank-mixes of herbicides, and cultivation. Crop rotation reduces weed pressure, which helps producers lessen their reliance on herbicides; however, the most common change producers make is either an addition to their tank mix or switching to different herbicides. For many Kansas farmers changing herbicides or tank mixes is an easier fix than trying to find another crop rotation. In addition to keeping herbicide resistant weeds at bay, crop rotation is essential for maintaining optimum plant health. Proper crop rotation helps keep insect and disease problems at a minimum (Peterson, 1999).

When residue is left on the soil surface year-round, one potential problem is more weed seeds, insects and diseases (Mannering and Griffith, 1985). If not properly controlled, any one of these three threats can cause serious harm to the next crop. For example, wheat yields can suffer if a field is left as continuous wheat, due in part to toxic effects of the previous year's residue on the next planting. This problem is also believed to occur in continuous row-crop rotations as well.

Many insects can thrive and cause serious damage if given the ability to complete life cycles in a continuous crop rotation (Mannering and Griffith, 1985). A perfect example of this would be the corn rootworm in a field left to continuous corn. Crop rotation breaks up this cycle that would otherwise be beneficial to the insect's life cycle; keeping insect problems from ballooning. This is yet another reason for the yield advantage gained from rotations versus monocultures. With conservation tillage, rotation is important as a means of disease and insect control and has a direct effect on yield and input costs.

As stated before, winter wheat is a primary component of many cropping systems in south-central Kansas; however, the adoption of conservation practices, such as no-till make it possible for producers to raise more row crops because soil moisture is conserved. Now, producers have more to consider when deciding what crop rotations and tillage practices to use.

For many years, a typical cropping system for south-central Kansas would involve one or two crops and a fallow period. An example of this type of rotation could be wheat harvested in June and then immediately planted again in October. After the second harvest, the producer could leave the ground fallow through the winter and plant sorghum the next spring. The traditional choices would have been wheat and grain sorghum since they are less sensitive to moisture stress than corn and soybeans. However, the demand for soybeans and corn has greatly increased over the last 10 years with the advent of renewable fuels. This increase in demand has left producers trying to balance the right amount of wheat acres with the right amount of row crops (Claassen, 2009).

Due to the climatic conditions of south-central Kansas, wheat continues to be the predominant crop planted in the area. However, research conducted in the Great Plains area has shown no-till systems increase fallow water storage efficiency (McGee et al., 1997), as well as grain water-use efficiency, when combined with greater cropping intensification (Peterson et al., 1996; Farahani et al., 1998). It is also worth mentioning that a more intensive rotation with summer crops generally has resulted in greater return than a traditional wheat-fallow system (Dhuyvetter et al., 1996). This research suggests that using conservation practices, such as no-till, allows producers the choice to forgo the fallow period and immediately plant another crop due to the moisture savings gained from not tilling the field.

With that in mind, the primary focus of the agronomic research was to determine if wheat can be grown after a row crop successfully without a fallow period and to examine how wheat yields respond to different tillage and crop rotations. It is the goal of this analysis to determine which tillage system and rotation with winter wheat will provide the greatest net return and least variability of net returns for producers in the central Great Plains area. Further economic analysis is necessary to evaluate the tradeoffs between tillage practices and crop rotations and their respective affects on potential crop yields and overall net returns.

1.3 Objectives of the Study

This study examines the economic profitability of 13 reduced-tillage and no-tillage systems for corn, soybean and grain sorghum production in an annual rotation with winter wheat and monoculture wheat and grain sorghum in south-central Kansas. Table 1.1 lists the description of each cropping system. The analysis will indicate which tillage system and rotation provides the greatest net return and least variability of net returns. Additionally, the analysis will evaluate which system farm managers would prefer under different levels of risk aversion. Specific study objectives are as follows:

1. Identify tillage and cropping systems that are technologically feasible for south-central Kansas.

2. Collect yield data from agricultural experiment station research for each tillage system and cropping rotation.

3. Collect historical price data from the Kansas Agricultural Statistics Service.

4. Determine the tillage and field operations for each of the cropping systems based on experiment station practices that correspond to the experimental yield.

5. Construct enterprise budgets for each cropping system.

6. Develop net return distributions using enterprise budgets, costs, and historical yield and price information for each tillage and crop rotation system.

7. Determine potential risk by examining standard deviation of yield, prices and net returns for the respective tillage and cropping systems.

8. Use Stochastic Efficiency with Respect to a Function (SERF) techniques to evaluate which system and rotation would be selected by managers with different risk-aversion preferences.

1.4 Study Area

The focus of this study was on south-central Kansas. All yield and input data for this study was collected at the Harvey County Experiment Field near Hesston, Kansas. Harvey County is located in the Central Great Plains Winter Wheat and Range Land Resource Region (LRR). The county is further subdivided into two major land resource areas (MLRA): Central Kansas Sandstone Hills and Great Bend Sand Plains. The area landscape is nearly level to gently sloping (USDA-NRCS, 2006). Figure 1 shows a county map of Kansas with a star indicating the location of the research field.

Agriculture is the primary industry of the study region. Diversified dry-land operations make up the majority of the farms in the area. The primary crop grown on most operations is winter wheat. Grain sorghum, soybeans and corn are the predominant crops occupying the majority of the remaining crop acres. Additional crops grown in the area include alfalfa, sunflowers and a small amount of oats. Livestock is also raised in the area, primarily beef cattle. Other livestock operations in the area include dairy, swine and poultry (USDA - NASS, 2008). Table 1.2 shows the total acres planted to winter wheat, grain sorghum, soybeans and corn in the study area, as well as the total harvested acres of all the crops grown in the area for 2008 (USDA, NASS, 2008).

1.5 Soils found in the Study Area

The soils found in Harvey County can be classified into eight different soil associations. A soil association is an area in which different soils occur in a characteristic fashion. Two soil associations cover most of the county; these are the Irwin-Rosehill-Clime and Ladysmith-Goessel associations. Both the Irwin and Ladysmith soil associations belong to the soil order Mollisol (Soil Survey Staff, 2009).

Mollisols are considered soils of grassland ecosystems. They are characterized by a thick, dark surface horizon. This horizon is very fertile because of the high organic matter that results from the breaking down of plant roots. The soil of the entire experiment field in this study is classified as a Ladysmith silty-clay loam. According to the National Resource Conservation Service (NRCS) web soil survey the "Ladysmith soil series consists of very deep, somewhat poorly drained, very slowly permeable upland soils formed in fine textured sediments." These soils typically occur in the Central Loess Plains. Slopes in the Great Plains area vary immensely from gently rolling flat lands to the larger hills found in areas such as the Flint Hills; however, the Ladysmith soil series is usually found where the land is level to gently sloping with slopes ranging from 0 to 3 percent (Soil Survey Staff, 2009).

The Ladysmith soil profile can be broken down into several main horizons, or layers, of soil. According to the NRCS, the top 10 inches of the Ladysmith soil profile are classified as silty clay loam. The next horizon usually ranges from 10-45 inches deep and is classified as silty clay. The third horizon ranges from 45-60 inches and is also silty clay. As mentioned before, each of these layers is a dark grey color. The darkness of the soil color is a primary indicator of the level of organic matter in the soil, the darker the soil the higher the organic matter content. The water table for the Ladysmith soil series typically beings at greater than 80 inches. These soils are known to have slow water permeability, but runoff is also low because of the gentle slope of the land. This soil is well suited for growing most crops. According to the NRCS web soil survey results, the Ladysmith soil series accounts for nearly 24 percent of all Harvey County land.

Officially, the Ladysmith soil has a capability class of 2s. Land that is classed as 1-4 is considered arable land fit for farming, with class 1 being the best. Classes 5-8 are deemed unworthy of being farmed and are typically left as pasture, rangeland, forestland and/or wildlife habitat. The Ladysmith soil in this study is classified as a class 2, which means it exhibits some moderate limitations that restrict the choice of plants or that require moderate conservation practices. The subclass for this Ladysmith soil is represented by a lowercase s. This means the soil is limited mainly because it is shallow, droughty or stony. This limitation is slight and does not keep the soil from being prized as excellent soil for the cultivation of crops (Soil Survey Staff, 2009).

1.6 Climate of the study area

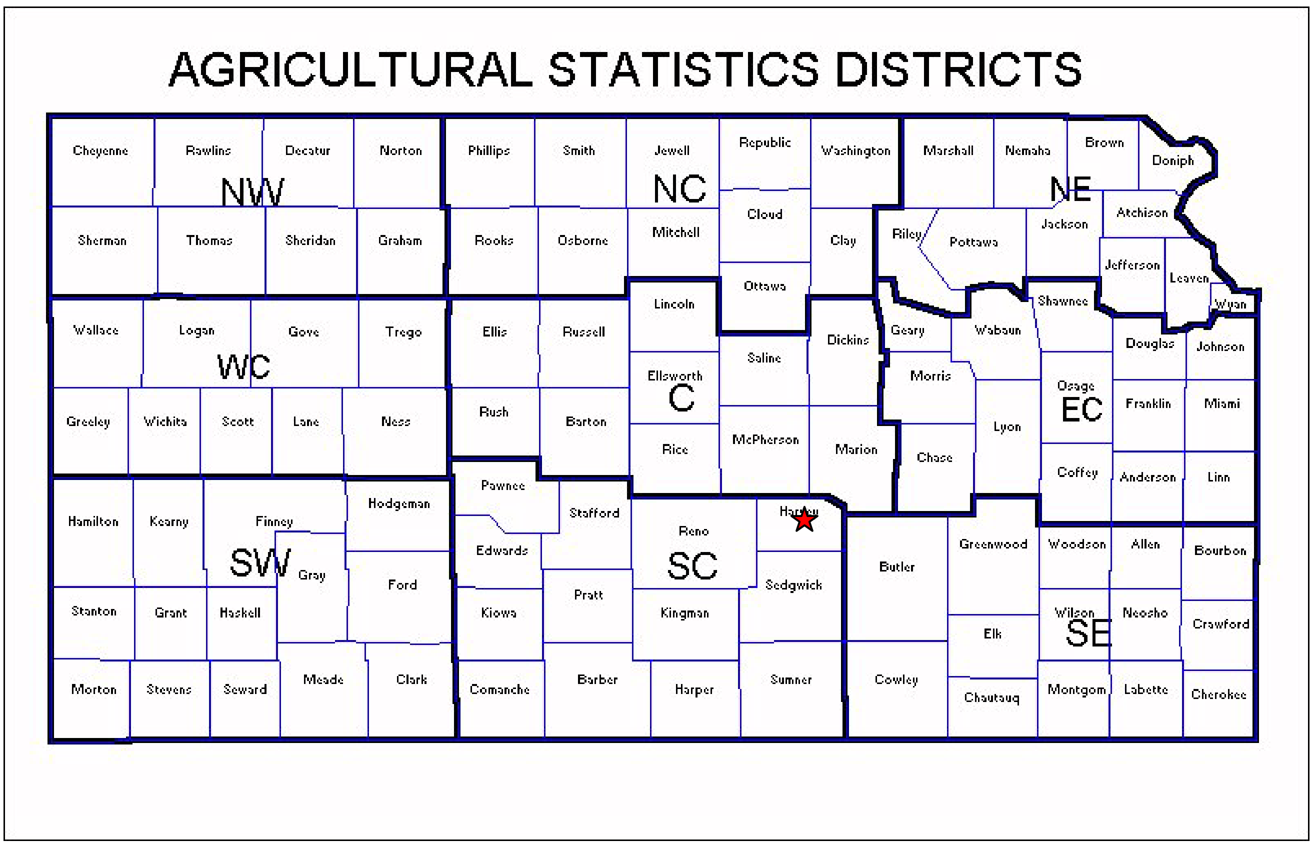
The experiment field is located just outside of Hesston, Kansas, which is in the north-central area of Harvey County. The climate for Harvey County, much like the rest of Kansas, can be described as having a continental climate that is highly changeable. Typically, the winters are cold and drier than northern states. Summers can be hot, with low-to-moderate humidity that is usually accompanied by light to moderate wind movement (5-15 miles per hour).

The State of Kansas lies in an area where it is typical for alternate masses of warm, moist air moving north from the Gulf of Mexico and currents of cold, comparatively drier air, moving from the polar regions of Canada to meet (Flora, 1948). It is due to the collision of these two air fronts that Kansas weather is subject to numerous and, at times, abrupt changes throughout the year.

Annual precipitation for Harvey County averages 35 inches per year (USDA - NASS, 2008). The bulk of this precipitation falls during the growing season (April through October). Showers and thunderstorms can be very intermittent in their occurrence and overall amounts of precipitation. It is common to receive several inches of precipitation in a few hours or days, possibly followed by long dry periods between major rainfall events.

During the growing season, the wind is predominantly from the south. Wind speeds for Harvey County are not available, but National Oceanic and Atmospheric Administration (NOAA) records at nearby Wichita show average wind speeds over the last 48 years to be 12.2 miles per hour. On average, wind speeds for Kansas tend to be lowest from mid July through late November, and gradually increase to their highest speeds in spring (NOAA, 2009).

Figure 1.1. Location of Hesston, KS KSU Experiment Station.



Available online at:
http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/District_Map/distmap.htm

Table 1.1 Cropping Systems.

RTWS	Reduced-till Wheat after Soybean
NTWS	No-till Wheat after Soybean
RTGG-M	Reduced-till Continuous Grain Sorghum
NTGG-M	No-till Continuous Grain Sorghum
RTGG-J	Reduced-till Continuous Grain Sorghum
NTGG-J	No-till Continuous Grain Sorghum
BWW	Burn Continuous Wheat
RTWW	Reduced-till Continuous Wheat
NTWW	No-till Continuous Wheat
RTWG	Reduced-till Wheat after Grain Sorghum
NTWG	No-till Wheat after Grain Sorghum
RTWC	Reduced-till Wheat after Corn
NTWC	No-till Wheat after Corn
M = May planting	J = June Planting

Table 1.2. Planted and Harvested Cropland Acres for South Central Kansas (2008).

County	Wheat	Sorghum	Soybean	Corn	Total Harvested Acres
Barber	127,700	6,700	3500		84,930
Comanche	64,400	20,600	500		100,800
Edwards	121,900	31,100	17,900	65,300	240,440
Harper	249,300	7,000	4,400	1,900	128,540
Harvey	133,700	47,500	49,000	35,200	256,100
Kingman	205,100	11,800	10,900	9,300	157,990
Kiowa	75,700	20,600	6,300	30,500	129,550
Pawnee	152,900	49,600	14,400	37,400	276,490
Pratt	178,100	31,300	14,400	63,700	271,830
Reno	254,600	55,400	43,400	36,500	375,380
Sedgwick	207,700	45,300	40,800	31,200	278,520
Stafford	154,900	26,700	22,500	65,400	283,440
Sumner	399,000	46,400	37,000	11,300	286,290
TOTAL	2,325,000	400,000	265,000	387,700	2,870,300

Kansas 2008 Farm Facts
Available online at:
http://nass.usda.gov/Statistics_by_State/Kansas/Publications/Annual_Statistical_Bulletin/ff2009.pdf

CHAPTER 2 - Review of Literature

2.1 Effects of Tillage and Crop Rotation on Grain Yields

Woody Allen once said, “80 percent of success is showing up” (Allen, 2009). I think this is especially true for farming. For a producer, showing up means developing and implementing the right management plan for his or her operation. While not the only options, tillage and crop rotation are two of the most important management decisions a producer has to make. Tillage and crop rotation both have direct effects on physical soil properties and in turn, an effect on the yield potential of each crop and overall net income achieved.

2.1a Effects of Tillage on Grain Yields

A number of studies have been conducted to evaluate the impact of alternative tillage methods on wheat grain yield. Unfortunately, the research has been unable to present a solid conclusion with respect to the correlation between the use of conservation tillage and wheat yield.

Zingg and Whitfield (1957) summarized results from several studies in which the conservation tillage practice of stubble mulching was compared with conventional tillage in western states. They concluded that mulch tillage resulted in either improved or equivalent wheat yields in the drier regions of the West; however, they also found an inverse relationship between the amount of residue left on the soil and wheat yield. Too much residue on the soil surface in humid regions was found to be a hindrance.

Multiple assumptions have been made regarding the reasons for decreased yields with mulch tillage in humid regions. Cook and Veseth (1991) argued that root diseases such as take-all, pythium root rot, and rhizoctonia root rot, primarily caused decreased yields. Still other researchers claimed that the extra surface residue provided the ideal environment for microbes to thrive, many of which were not beneficial and could harbor pathogens, such as tan spot, that would hamper yields (Williams and Gough, 1985). The review of the aforementioned studies support the hypothesis that as farmers adjust tillage systems to retain wheat plant residue on the soil surface, lower yields can be expected.

Conversely, a study in western Kansas (Norwood et al., 1990) found wheat yields to be greater in wheat-fallow and wheat-sorghum-fallow rotations, using a reduced-tillage system due to the increase in retained soil moisture. Norwood found the same to be true for grain sorghum yields at Tribune, Kan. but could find no significant differences in yield with either system at Garden City, Kan. Studies by Reed and Erickson (1984) also have found that conservation tillage can provide consistent yield advantages over conventional tillage for wheat in Kansas and northeast Colorado, and grain sorghum in Kansas and Nebraska. Wiese et al. (1994) reported greater yields for continuous wheat two of four years in the southern plains when no-till was used versus sweep plowing, as well.

On the other hand, studies by Daniel, Cox and Elwell (1956), Harper (1960), Davidson and Santelmann (1973), Heer and Krenzer (1989), and Claassen (1996) all found continuous wheat yields to be less under no-tillage operations when compared to conventional tillage methods. These studies were all conducted in areas of the Great Plains where typical rainfall received is between 710 to 820 mm (28 to 32 inches). Lastly, research exists finding no statistically significant differences between conventional and no-till wheat and grain sorghum yields (Morrison et al., 1990).

One additional method of conservation tillage that is used by some producers is the use of burning. Burning residue, primarily wheat straw, is done to alleviate the “problem” of excess residue. While ultimately an easy and cost-effective way to remove residue and help control weed growth, research has shown that burning might actually do more harm than good.

In 1969, an experiment by Hooker, Herron and Penas (1982) was conducted at Kansas State University’s Garden City Branch Experiment Station to determine the effects of various methods of managing irrigated winter wheat and grain sorghum residues on yield and several soil chemical properties. One of the four methods used to manage the residue was burning. At the conclusion of the 10-year study period, soil samples were taken to a depth of 180 cm to determine what chemical changes had occurred. No significant differences were observed in the quantities of Bray #1-P, DTPA-Zn, Na, Ca, or Mg in the top 15 centimeters of the surface. No significant change was found for total NO^{-}_{3} in the 180-cm profile. Results for the burn treatment indicated significantly less organic matter and potassium, and higher pH levels than the other treatments. Additionally, the burn treatment resulted in significantly greater NO_3 leaching than the other treatments. In the early years of the experiment, no consistent differences in yield were found due to the residue treatments; however, in the later years of the experiment, a trend toward lower yields on the burned plots started to emerge.

Another study done at Texas A&M University’s Agriculture Experiment Station by Unger, Allen and Parker (1973) compared roto-tilling, moldboard plowing, disking, burn-listing and listing (moldboard plow with a double moldboard designed to move dirt to either side of a central furrow) to see which tillage practice best managed residues from continuous irrigated winter wheat. The burn-list (burn then plow) treatment resulted in very poor water infiltration. Organic matter content in the soil was also found to be the least for burn-lister tillage and greatest for lister and disk tillage. Water-stable aggregation was greatest for roto-tilling and least for burn-lister tillage. Moldboard plowing resulted in the smallest and burn-lister tillage in the greatest percentage of fine aggregates. All treatments resulted in a relatively high percentage of wind-erodible aggregates; however, the finer the aggregate, the higher the erosion potential. Ultimately, moldboard plowing and roto-tilling produced greater yields than listing and disking, but the benefits from the increased yields were minimized because of the higher tillage cost involved with those systems. Unger, Allen and Parker (1973) concluded that no certain tillage treatment was superior or inferior for all the factors evaluated; therefore, any tillage system was deemed satisfactory for continuously irrigated wheat production.

Siemens and Oschwald (1978) compared seven tillage systems (conventional fall moldboard plowing, spring moldboard plowing, disk-chisel, coulter-chisel, chisel, disk and no-till) for producing corn and soybeans in terms of erosion control and crop production on the Creuse Farm near Champaign, Ill. All six of the conservation-tillage systems reduced soil erosion. Yields, however, tended to be lower with conservation tillage. On the other hand, a Michigan study conducted by Hesterman, Pierce and Rossman (1988) found no significant difference in corn yields between conventional-tillage and no-till systems. Their results also indicated that the performance of different corn hybrids was unaffected by the choice of tillage system.

2.1b Effects of Crop Rotation on Yields

The most common dry-land cropping system in the Great Plains has traditionally been a wheat-fallow rotation using conventional tillage. During the fallow period, the field can store moisture for future use. In this rotation, weeds are controlled with multiple tillage operations. Herbicides can also be used to control weeds, and in conservation-tillage systems, the use of herbicides has replaced tillage for weed control. A study by Farahani et al. (1998) concluded that across most areas of the Great Plains, conservation-tillage systems conserve more water early in the fallow period than conventional (CT) systems, often having as much water stored by May of the fallow year as CT systems have saved three to four more months later. This makes it possible to crop more frequently than would be possible in a conventional crop-fallow system (Shanahan et al., 1988; Halvorson, 1990; Peterson et al., 1993; Halvorson and Reule, 1994; Farahani et al., 1998). Therefore, producers must determine what crop rotation and tillage system will be the most efficient and profitable for their farming operations.

Singer, Chase and Karlen (2003) present a review of Copeland et al. (1993), Crookston et al. (1991), Lund, Carter and Oplinger (1993), Peterson and Varvel (1989; 1989b), Singer and Cox (1998a), and West et al. (1996). Throughout these studies, crop rotation was shown to increase corn yield five to 30 percent and soybean yield from eight to 16 percent compared to continuous production of either crop.

The study by Singer and Cox (1998a) reported greater yield for corn in rotation with reduced inputs compared to continuous corn with full inputs in New York; a similar study by Katsvairo and Cox (2000) reached the same conclusion. Katsvairo and Cox (2000) found that 5-year average corn yields for chisel-tilled continuous corn with applications of herbicide, insecticide, and the recommended sidedress N rate yielded the same as a corn-soybean (C-S) rotation with no insecticide, banded herbicide plus cultivation, and half the sidedress N rate at the Musgrave Research Farm near Aurora, N.Y. Lastly, in a 10-year study conducted at Hesston, Kansas, Claassen (1996) found grain sorghum planted after wheat over the 10 years of the study averaged 9.8 bushels per acre more than continuous grain sorghum.

2.2 Economic Analysis of Tillage and Crop Rotation

A number of studies have been conducted to compare production costs for different tillage systems. The primary difference between conventional and conservation tillage systems is how operating costs are distributed. Conservation tillage often requires more herbicides, but fewer tillage operations than conventional tillage methods. Conservation tillage lessens pre-harvest labor, uses less tractor fuel, and allows farmers to invest less in machinery; however, it is possible that the savings gained from no-tillage are offset by the increased amount spent on herbicides. Consequently, the evidence on the relative profitability of conservation tillage is mixed.

2.2a Economic Analysis of Tillage

Epplin et al. (1982 and 1983) examined tillage systems for wheat in a region of the Great Plains that receives adequate precipitation and concluded that savings in fuel, labor and repairs did not offset the additional cost of herbicides in the no-till system. When fixed costs were included, however, some of the conservation systems had net returns that were competitive with those of conventional tillage.

Duffy and Hanthorn (1984) found no significant difference in net returns from conservation tillage versus conventional strategies for United States corn or soybean producers in the mid-southern and southeastern U.S. in 1980; however, Midwest soybean farmers reported greater returns with conventional-tilled soybeans than with no-till, primarily because of greater yields. “Studies from across the Corn Belt area have shown that declines in production expenses because of lower fuel, repair and capital costs may be largely offset by increases in chemical costs for most crops, including corn, soybeans, grain sorghum and wheat,” (Klemme 1983; Duffy and Hanthorn 1984; Brady 1984; Johnson et al. 1986).

Klemme (1985) conducted a stochastic dominance comparison over four tillage systems for corn and soybean production in north-central Indiana. Average expected returns per acre were greatest for the conventional-tillage system and smaller for the no-till system; however, the stochastic dominance rankings changed when costs associated with annual soil loss were included. The greater dollar loss of soil associated with conventional tillage shifted farmers more towards conservation tillage practices.

A study conducted on northern Texas high plains by Harmen et al. (1985) found that the adoption of a no-till grain sorghum and corn production system in a crop rotation with irrigated wheat increased farm income, reduced underground water depletion, conserved energy, and reduced labor needs. Returns to land, management and risk for each of the tillage systems and two natural gas price scenarios were analyzed. For each well-pumping lift and gas price situation, the no-till system resulted in greater profits than the conventional-tillage system.

Fletcher and Lovejoy (1988) conducted a tillage demonstration study by using actual plot data from participating farmers around the Lake Erie Basin in 1985. A survey was also conducted from a sample of the project participants to examine the effects of no-till and ridge-till systems on net returns for corn and soybeans when compared to conventional-tillage systems. Yields and net returns for the no-till and ridge-till systems were greater than for the conventional system. The extent to which yields were greater depended on the previous crop. Fletcher and

Lovejoy (1988) found net returns of $14 to $18 per acre more for corn produced under no-till versus conventional tillage.

Results from a study by Williams, Mikesell and Long (1988) for a 640-acre hypothetical grain farm raising sorghum and soybeans in northeast Kansas show that no-till systems for grain sorghum and soybeans both had slightly higher net returns when compared to conventional tillage practices. Their results also found no-till to be more risky, and a stochastic dominance analysis indicated that risk-averse farmers would still prefer a continuous grain sorghum rotation using conventional tillage methods.

Williams et al. (1989) examined dry-land tillage systems with wheat and grain sorghum in the Great Plains. They found that grain sorghum grown under a reduced tillage system had both higher expected net revenues and lower risk than conventional tillage. Reduced tillage wheat-sorghum-fallow rotation had the highest net returns. Greater yields in conjunction with reduced labor, fuel and repair costs were found to more-than-compensate for the increase in chemical costs from the reduced-till operations. Additionally, their study found that managers classified as risk-averse would prefer conservation tillage systems for wheat and grain sorghum instead of the traditional, conventional, wheat-fallow cropping system.

Williams, Llewelyn and Mikesell (1989) found that conventional tillage had lower expected returns than no-till for grain sorghum production in northeastern Kansas but conventional tillage had a lower coefficient of variation. Stochastic dominance analysis indicated that risk-averse farmers would select conventional tillage.

Brown, Cruse, and Colvin (1989) evaluated production costs and yields for three tillage systems growing corn and soybeans in southeastern Iowa. They found that the breakeven price for corn was significantly less under a reduced-tillage system due to reduced production cost;

however, yields were still higher with the conventional tillage system. High pesticide costs made no-till the system with the highest production costs.

Morrison et al. (1990) studied multiple tillage systems for grain sorghum, wheat, corn and cotton on the Vertisol clay soils of the Texas Blackland Prairie. They found that net returns for no-tillage grain sorghum were higher than for chisel-tilled grain sorghum. They attributed the higher net returns to improved grain yield and slightly reduced costs in the no-till system. Their results also indicated that returns for no-till wheat were higher than conventional-tilled wheat because of reduced machinery and labor costs. Returns to land and management for no-till corn also were higher than chisel-tilled corn. The income gained from the higher grain yields was enough to offset high herbicide costs.

A study evaluating the economic returns for dry-land soybeans at several Arkansas locations found that conventional- and fallow-production systems generally outperformed no-till systems in terms of the magnitude of their economic returns (Popp et al., 2002). Results suggested that total specified costs increase as the production system is changed from conventional to fallow to no-till.

A study by Al-Kaisi and Yin (2004) conducted at five locations across Iowa from 1978 through 2001 evaluated corn production under seven different tillage systems in terms of corn yield and economic return. Their studies found very little change in either corn yield or economic return between no-till and other tillage systems over time. This is important to note, as many farmers have concerns about the profitability of their corn crops in the first years after switching to no-till.

Results over time show that the use of conservation tillage practices, such as mulch till, ridge-till and no-till can provide a number of benefits. These benefits include, but are not limited to, the ability to conserve soil moisture, reduce soil erosion, improve water quality, benefit wildlife, increase labor use efficiency, limit machinery investments, sequester atmospheric carbon dioxide, etc (Beck, Miller, Hagny, 1998). All the same, claims are less consistent when it comes to identifying the impact no-till or other reduced tillage operations can have on making individual producers more profitable.

As shown, a multitude of studies exist that would indicate the indefiniteness of whether no-till and reduced-till applications are more profitable, less profitable, or the same as a conventional system. It appears that the "devil is in the detail," meaning that factors such as trial location and duration, experimental methods, and the economic assumptions employed play a major role in determining the calculated relative profitability of the tillage practices tested (Beck, Miller, Hagny). This unpredictability makes it difficult to choose with certainty which tillage system is best for individual producers exhibiting different management styles, risk preferences, locations and economic circumstances.

2.2b Economic Analysis of Crop Rotation

"The use of crop rotations has generally been thought to reduce risk, compared with monoculture cropping." (Helmers et al., 1986). Crop rotation reduces risk in several ways. Rotations provide diversity. This diversity helps offset risk because when one crop has low returns there is still another crop in season that has the potential to do better and balance out the final returns. Practicing proper crop rotations can reduce yield variability compared with monoculture practices. Additionally, rotations have been shown to result in not only greater yields, but also lower production costs compared to monoculture cropping (Helmers et al., 1986).

Dhuyvetter et al. (1996) conducted a review of economic analyses of dry-land cropping systems in the Great Plains. In the review, it was found that seven of eight studies reported greater net returns for a more intensive crop rotation than the traditional wheat-fallow rotation, when reduced-tillage or no-till was used following wheat harvest and prior to summer crop planting.

Norwood and Dhuyvetter (1993) compared a wheat-sorghum-fallow rotation (WSF) with a traditional wheat-fallow rotation (WF) in southwestern Kansas for conventional, reduced and no-till. Their results indicated that WSF was more profitable than WF for each tillage system.

Dhuyvetter and Norwood (1994) again found that more intensive cropping systems increased the profit potential for farmers in southwest Kansas who were practicing a wheat-fallow rotation. Returns were compared for a wheat-fallow rotation (WF), wheat-sorghum-fallow (WSF) and no-till continuous sorghum (SS). WF and WSF were grown under conventional-tillage, reduced-tillage and no-till practices; however, tillage system was found not to affect the relative profitability of the cropping system used. WSF was again more profitable than the WF rotation under each tillage system.

A study by Jones and Johnson (1993) in Bushland, Texas, found that cropping systems with sorghum had higher returns than continuous wheat. Their study also concluded that WSF was more profitable than WF, but WF was still more profitable than continuous wheat for both conventional tillage and no-till. Returns were higher under conventional tillage for both continuous wheat and grain sorghum. Conversely, WF and WSF both experienced higher returns with no-tillage.

A study in south-central Kansas (Williams, Roth, and Claassen, 2000) found that moderately risk-averse producers preferred a rotation of reduced-till grain sorghum and no-till wheat, while more strongly risk-averse producers preferred a rotation of reduced-till grain sorghum and reduced-till wheat. Rotations of the two crops were also found to be economically advantageous to continuous cropping.

A 14-year study in Nebraska evaluated the impact of crop rotation of corn and soybeans on risk. Results indicate that a corn-soybean rotation was significantly less risky than monoculture practices. Diversification was found to increase the reduction in risk, while higher yields and reduced cost also contributed to lower risk (Helmers, Yamoah and Varvel, 2001).

A study by Rutgers University on their Research and Extension Farm near Pittstown, N.J. compared continuous corn (C-C-C) and continuous soybean (S-S-S) with 2-, 3- and 5-year rotations, the latter two including wheat (W) and alfalfa (A) using either chisel plow or no-tillage practices. Crop yield and returns to land and management were evaluated. Results indicate there was no economic advantage for either type of tillage system. They did find that differences in returns to land and management were more closely related to crop rotation. Incorporating alfalfa into the rotation generated the highest returns to land and management for all cropping systems except no-till continuous soybean (S-S-S). Specifically, the no-till and chisel plow C-S-A-A-A rotations attained the two highest returns (Singer, Chase and Karlen, 2003).

2.3 Risk Analysis using Stochastic Efficiency with Respect to a Function

Stochastic Efficiency with Respect to a Function (SERF), developed by Hardaker et al. (2004), has been used to rank tillage and cropping systems for varying degrees of risk preference or aversion. A study by Pendell et al. (2007) examined continuous corn systems grown in northeastern Kansas using no-tillage or conventional tillage with either commercial nitrogen or cattle manure for sequestering carbon in the soil. Their research used SERF to determine the preferred production systems under various risk preferences and utility-weighted certainty equivalent risk premiums to determine the carbon credit values needed to motivate adoption of cropping systems that sequester higher levels of carbon. The systems receiving cattle manure have lower net returns than the systems receiving commercial nitrogen, but were found to sequester greater amounts of carbon (C). Their results also indicated that no-till systems had higher net returns and greater sequestration rates than conventional till. Carbon credits or government program incentives were not required to entice risk-averse managers to use no-tillage, but were required to encourage producers to use manure even though commercial nitrogen prices were high.

The SERF results reveal that the no-till system that received 150 lbs of commercial nitrogen (NT150N) sequestered more C and had a higher net return than the no-till system that received 75 lbs of commercial nitrogen (NT75N). Less risk-averse managers preferred NT150N, while managers with greater levels of risk aversion prefer NT75N. The NT75M (M=manure) and NT150M systems are the third and fourth most preferred systems, respectively, over the entire range of risk aversion. Carbon credit prices on the Chicago Climate Exchange since May 2005, ranged from $4.37 to $10.89/ton. These price levels were not enough incentive for risk-averse managers to substitute manure for commercial nitrogen at the 150 lb rate to increase C sequestration.

A study by Ribera, Hons and Richardson (2004) compared the economics of conventional tillage (CT) and no-tillage (NT) systems for grain sorghum, wheat, and soybeans grown in southern Texas. Empirical distributions of net income for different tillage systems under risk were estimated using a Monte Carlo simulation model of net income per hectare. Certainty equivalents were used to rank the tillage systems. Risk-neutral decision makers prefer continuous sorghum to all other rotations under the CT system; however, under NT, risk-neutral decision makers prefer the sorghum–wheat–soybean rotation to all other rotations. The results also suggest that under risk-neutral rankings, NT is preferred to CT in three out of the five crop rotations tested. Risk-averse decision makers preferred NT to CT in all five rotations.

A study by Williams et al. (2010) examined the economic potential of producing a wheat-grain sorghum-fallow rotation (WSF) under three tillage strategies – conventional (CT), reduced (RT) and no-till (NT) – compared to Conservation Reserve Program (CRP) rental rates in western Kansas. Their research used enterprise budgeting and SERF to determine the preferred management strategies under various risk preferences. Production costs were based on actual field operations and input rates used. The cost information was combined with yield and price data to calculate net returns for each enterprise budget and to simulate a distribution of net returns for the SERF risk analysis.

Results indicated that net returns calculated using average commodity prices from January 2006 - December 2008 with 2008 costs were greatest for the RT system, followed by NT. However, both of the net returns were less than the CRP payment typically received by participants in the area. In this period, SERF analysis found that CRP was consistently preferred to crop production under any of the tillage systems for producers, regardless of risk preference. Results for the January 2007 through December 2008 period found that RT and NT had a higher net return than even the largest CRP payment. The SERF analysis indicated that only a risk-neutral or slightly risk-averse producer would prefer the RT system to CRP. Moderately to strongly risk-averse producers were found to prefer CRP to any of the tillage systems. Based on the results of their analysis, Williams et al. (2010) concluded that only producers who are risk-neutral or slightly risk-averse would prefer crop production to continued CRP enrollment in this region, unless commodity prices reach the historically high levels of late 2007 and early 2008 and remain there.

CHAPTER 3 - Data and Methods

3.1 Overview of Procedures

Enterprise budgets were developed for thirteen cropping systems consisting of wheat, grain sorghum, corn and soybeans using 2009 input costs, 2009 crop prices, and the average of crop yields from 1997 to 2006. Yield and input data for the budgets were collected from the Harvey County Experiment Station in south-central Kansas. Systems included no-till and reduced-till continuous wheat as well as no-till and reduced-till continuous grain sorghum. Continuous grain sorghum was analyzed for two different planting dates, May and June. Corn, soybeans and grain sorghum also were grown in annual rotation with winter wheat under no-till and reduced-till. Distributions of net returns were developed several ways. First, the 10-year (1997-2006) average yield for each crop was multiplied by 2009 average commodity prices from the National Agricultural Statistics Service, and 2009 input costs were subtracted to calculate the distribution of net returns to land and management. A distribution of net returns was also calculated using the actual historical yields and crop prices from 1997 to 2006 and 2009 input prices. This process was repeated, except average crop prices from 2006, 2007, 2008 and 2009 were used. Finally, net returns were calculated using simulated yield and price distributions based on actual historical yields, four historical monthly price series, and 2009 input costs. Stochastic efficiency techniques were used to compare the variation in net returns from these cropping systems.

3.2 Descriptions of Cropping Systems

Actual field operations and inputs used were obtained from historical experiments at the Harvey County Experiment Station in Hesston, Kansas. Although 10 years of historical input data from this experiment exists, only the last four years of input data (2003 to 2006) were used for calculating 2009 costs. These inputs were used because the last four years of the study most accurately reflect the input technology farmers are currently using. These inputs included the newest chemical formulations in herbicides and genetic improvements in seed.

Each row crop was planted at a 30-inch row spacing using the same planter. Winter wheat was drilled with eight-inch row spacing. For the reduced tillage systems, weeds were controlled by using either one or a combination of the following implements: field cultivator, V-blade, chisel, disk, roller harrow and two customized implements (sweep and mulch treader) designed by the staff at the experiment station. Due to the small size of the experiment plots (30 by 50 feet), tillage implements could only be used across the field in one direction. This would result in residue being dragged across the field and deposited at the end of the rows. To ensure residue was left evenly across the field, a field cultivator frame was retrofitted with different sweeps and the frame was elevated for better ground clearance. The sweep treader is similar in many aspects to a fallow-master. The mulch treader is a separate implement that can be used on its own or behind the sweep treader. The mulch treader rolls on a set of wheels and has gangs like a tandem disk. This implement, when used behind the sweep treader, uproots any remaining weeds missed by the sweep treader. Table 3.1 summarizes the number of field operations, excluding planting and harvest for each system. All field operation costs were based on 2008 custom rates for Kansas (Twete et al., 2009).

Nitrogen and phosphorus sources were the same for all crops. Fertilizer rates were kept constant across rotations. Ammonium nitrate (34-0-0) was the actual nitrogen source used throughout the experiment, but it is no longer available to the public. Instead, actual pounds of nitrogen used were converted into a more readily available formulation, in this case urea

(46-0-0). Wheat always received 107.44 lbs of urea in the fall. The other fertilizer used in this study is Di-ammonium phosphate, commonly referred to as DAP (18-46-0). Wheat always received 73.75 lbs of DAP at planting. In this study, urea (46-0-0) was broadcasted in dry granules before planting and DAP (18-46-0) was applied in the furrow at planting. Soybeans are a nitrogen-fixing crop, so urea was not needed. The soybeans received a 20-lb application of DAP at planting. Grain sorghum required 101.66 lbs of urea and 80 lbs of DAP. Corn also received 107.44 lbs of urea and 80 lbs of DAP at planting. The following is an explanation of the field operations that occurred for the 13 cropping systems.

Reduced Till Wheat/Soybean (RTWS) Wheat stubble was tilled in July with a V-blade. Urea (46-0-0) was custom-applied in the granular form in late fall before planting. Wheat was planted using a no-till drill, and DAP (18-46-0) was applied in the furrow at planting. If weed control was needed after planting herbicides labeled for wheat, such as Olympus or Maverick, were applied according to the labeled rates and timing. Wheat was typically harvested in late June. Then, typically, the sweep treader was used once or twice during the fall and then again in the spring. If weed pressure was still high, herbicides were used as well. Soybeans were planted mid-May with DAP (18-46-0) fertilizer banded during the planting operation. Weed control throughout the growing season was achieved with one or two herbicide applications. Pre-plant weed control was usually achieved by using a glyphosate-based herbicide; however, if there was an overabundance of grass or broadleaves, another herbicide (2, 4-D, Atrazine, Banvel, Dual, Select, etc.) was added to control the problem weeds. Soybean harvest usually occurred in late September. Following harvest, any remaining weeds were sprayed again. Nitrogen fertilizer was broadcast prior to planting. Wheat was planted in late October with an application of DAP (18-46-0) fertilizer banded during the planting. Wheat was harvested in late June.

No-Till Wheat/Soybean (NTWS) As the names suggest, herbicide applications were used instead of tillage in the NTWS system. If necessary, multiple herbicide applications were applied in the fall and throughout the spring. Soybeans were planted in mid-May; DAP (18-46-0) fertilizer was banded at this time as well. Weed control during the growing season was achieved with one or two herbicide applications. Soybeans were harvested in late September. Any remaining weeds were sprayed after soybean harvest. Urea (46-0-0) fertilizer was broadcast before wheat planting. Wheat was planted in late October and was harvested in late June.

Reduced Till Continuous Sorghum May planted (RTGG-M) In this system, the field was chiseled in November following the fall harvest. The field was left idle until spring, at which point either the mulch or sweep treader were used to break up the soil and knock down weeds. An herbicide application was often necessary as well to achieve complete weed control. Urea fertilizer was broadcast before planting. Grain sorghum was planted in mid-May and DAP (18-46-0) was banded during the planting operation. Harvest occurred in September.

No-Till Continuous Sorghum May planted (NTGG-M) In this system, weed control was accomplished solely with herbicides. Herbicide was applied in the fall if needed, followed by multiple applications in late spring and early summer. Urea (46-0-0) fertilizer was broadcasted prior to planting. Grain sorghum seed, pre-treated with insecticide, was planted in mid-May, and DAP (18-46-0) was banded during the planting process. Harvest occurred in mid-to-late September.

Reduced Till Continuous Sorghum June planted (RTGG-J) In this system, the field was chiseled after fall harvest in late November or early December. The field was left idle until late spring, at which time the mulch or sweep treader was used to knock down weeds and prepare the seedbed for planting. Again, a herbicide application was often necessary to achieve full weed control. Urea (46-0-0) fertilizer was broadcasted prior to planting. Grain sorghum was planted in mid-to-late June; DAP (18-46-0) fertilizer was banded during planting. Harvest typically occurred in late October.

No-Till Continuous Sorghum June planted (NTGG-J) Weed control was accomplished by herbicides only. Herbicide was applied in the fall as needed, followed by several applications in late spring and early summer. Urea (46-0-0) fertilizer was broadcasted prior to planting. Grain sorghum was planted mid to late June; DAP (18-46-0) fertilizer was banded during planting as well. Harvest occurred in mid-to-late October.

Burn Continuous Wheat (BWW) In this system, wheat stubble was burned after harvest to remove much of the excess straw. Remaining residue was then disked and chiseled. During late summer and fall, arrived weed control was accomplished using a field cultivator and the sweep-mulch treaders. Urea (46-0-0) was custom-applied late fall, before planting. In mid-October, wheat was drilled and DAP (18-46-0) was applied in the furrow during planting. An additional herbicide application after planting was commonly used and often necessary in the fall and again in spring as the wheat continued to grow. Again, Olympus and Maverick were the two post-emergence herbicides used. Wheat was harvested in late June.

Reduced Till Continuous Wheat (RTWW) In the RTWW system, wheat stubble was disked after wheat harvest, usually around mid-July. A week or two later, the field was chiseled. For the rest of the summer and into the fall, weeds were controlled using a field cultivator and the sweep and mulch treader. Urea was applied in the fall before planting. Wheat was planted using a no-till drill, and DAP (18-46-0) was applied in the furrow at planting. If additional weed control was needed after planting, Olympus herbicide was applied according to labeled rates and timing. Wheat was typically harvested in late June.

<u>No-Till Continuous Wheat (NTWW)</u> In this system, weed control was again accomplished entirely by use of herbicides. Less than a month after wheat harvest, the stubble was sprayed to control weeds and volunteer wheat. In September, another herbicide application, similar to the one in July, was applied. Urea (46-0-0) was broadcasted as dry granules before planting, and DAP (18-46-0) was applied in the furrow during planting, which typically occured in mid-October. If weed control was still a problem after planting, Olympus or Maverick herbicides were used.

<u>Reduced Till Wheat/Sorghum (RTWG)</u> In the RTWG system, the sweep treader was used once or twice in the fall to control weeds. The field is left idle over the winter. The sweep treader was typically used twice again in the spring to prepare the soil for planting and to control new weeds. If necessary, a herbicide application was applied to combat heavier weed densities before planting. Urea (46-0-0) fertilizer was broadcasted before the grain sorghum was planted in May. Grain sorghum was harvested mid September. Weeds were sprayed after the grain sorghum harvest to prepare for the next crop or wheat. Urea fertilizer was broadcasted before planting. Wheat was planted in mid-October; DAP (18-46-0) fertilizer was banded during planting. Wheat was harvested in late June.

<u>No-Till Wheat after Sorghum (NTWG)</u> Multiple herbicide applications were often required in both the fall and spring to control weeds as a substitute to tillage. Otherwise, the fertilizer and planting operations were the same as the RTWG system.

<u>Reduced Till Wheat/Corn (RTWC)</u> Tillage operations for this system were very similar to the RTWS system. The field was tilled with a V-blade in July, and then re-worked again in the

fall and spring with the sweep and mulch treaders. Weed control was also accomplished with an herbicide application in the spring before planting. Urea (46-0-0) fertilizer was broadcast prior to planting. The corn seed was planted in mid-April with DAP (18-46-0) fertilizer banded at this time as well. Corn was harvested in early September. If necessary, an herbicide was applied for weed control before planting wheat in mid-October. Urea (46-0-0) fertilizer was broadcast prior to planting. DAP (18-46-0) fertilizer was banded during planting. Wheat was harvested in late June.

No-till Wheat/Corn (NTWC) In this system, weed control was accomplished through multiple herbicide applications throughout the fall and spring months. Urea (46-0-0) was broadcasted before planting, and DAP (18-46-0) was banded during wheat planting in October. Wheat was harvested in late June.

3.3 Enterprise Budgets

An example budget is included in Table 3.2. The enterprise budget example lists each field operation sequentially for the season by crop in the first column. The second column lists the frequency of field operations for each production cycle. This is followed by the numerical amount of input (seed, herbicide, fertilizer) used. The second column also includes the crop yield and interest rate. The third column lists the units. The fourth column contains the costs per acre for each operation. A cost per acre for each operation is calculated by multiplying the input data in the middle column by the price of the inputs and number of applications. Budget costs are totaled, and gross and net returns are calculated for each rotation. The cost information is also used to calculate simulated distributions of net returns for each system for risk analysis.

3.4 Costs

The enterprise budgets contain complete detail on the frequency of field operations, input levels and their costs per acre. The budget for each system can be found in Tables A.1-A.13 in Appendix A. All of the field operation costs were obtained from the 2008 Kansas Custom Rates publication (Twete et al., 2009) with the exception of one. The prescribed burning cost of $7/acre is an estimate from the NRCS Field Office Technical Guide (USDA - NRCS, 2008). A list of the Kansas custom rates used in this study can be found in Table 3.3.

Actual input costs came from several sources. The 2009 seed prices for corn and grain sorghum were obtained from a Pioneer seed salesman in Sedgwick, Kansas, which is near the experiment field. Soybean seed price was also obtained from the Farmer's Cooperative in the neighboring town of Sedgwick. Wheat seed price was obtained from KSU Agronomist Vernon Schaffer with Kansas Foundation Seed in Manhattan, Kan. Table 3.4 lists the seed, fertilizer and herbicide prices used. Fertilizer and herbicides prices used in the enterprise budgets are summer 2009 prices from the Andale's Farmers Cooperative, which is in the vicinity of the experiment field. The remaining herbicide prices used in this experiment were obtained from the 2009 Chemical Weed Control handbook for Field Crops, Pastures, Rangeland and Noncropland published by Kansas State University Research and Extension (Thompson et al., 2009). Prices for some of the name brand herbicides used were not available, so prices for generic brands were used in their place. The original nitrogen source used in the experiment was ammonium nitrate (34-0-0); however, this product is no longer sold commercially. The actual pounds of N needed were calculated, and urea (46-0-0) was used as the primary nitrogen source in the enterprise budgets. The other fertilizer used in this study was di-ammonium phosphate (18-46-0), or DAP.

Interest costs also were taken into consideration and are included in the budgets. An annual interest rate of 8 percent was applied to half of all variable costs to account for the opportunity costs on inputs for one half year. This is the suggested rate from the Prices for Crop and Livestock Cost-Return Budgets published by Kansas State University (Dhuyvetter et al., 2008).

3.5 Net Returns, Prices, and Yields

Net returns to land and management per acre for each production system were calculated several ways once the basic enterprise budgets were constructed to see how sensitive the net returns were to commodity price variability. The first procedure used the 10-year average yield for each crop, the average crop price from 2009, and 2009 input prices. Further analysis was performed by calculating the historical net return distribution for each production system by using the actual historical yields that were recorded at the research station for each year of the study (1997 to 2006), the south-central Kansas crop prices from 1997 to 2006, and 2009 input prices. Net returns also were calculated using the historical yields, and 2009 input costs, but commodity prices were held constant at the 2006, 2007, 2008 or 2009 price level, in the respective separate analyses.

Crop prices from the South Central Kansas Crop and Livestock Reporting District from the United States Department of Agriculture (USDA), for 1997 to 2009 are reported in Table 3.5. Prices were kept at or above the national average loan rate for each commodity. The 2009 loan rates are $2.75/bushel for wheat, $1.95/bushel for corn and grain sorghum, and $5.00/bushel for soybeans (USDA - FSA, 2009). Producers can receive a commodity specific loan rate for designated crops from the government if they pledge the production as loan collateral (USDA - ERS, 2009).

Due to a computer failure, a record of corn yields for the year 2000 was lost. To replace the year 2000 corn yields the following procedure was used. Two regression equations were estimated with corn yield as a function of the wheat yield from the same rotation. In the first equation the RT corn yield (the dependent variable) from years 1997-1999 and 2001- 2006 were regressed on the RT wheat yield (the independent variable) from years 1997-1999 and 2001-2006. In the second equation the NT corn yield from years 1997-1999 and 2001- 2006 were regressed on the RT wheat yield from years 1997-1999 and 2001- 2006. RT wheat yields were used in the second equation rather than NT wheat yield because the resulting equation was used to predict the missing year 2000 yield and this equation provided a better fit (R-squared) than using NT wheat yields as the independent variable. The RT wheat yield from the year 2000 was entered in the first and second regression equation to predict the RT corn and NT corn yield for the year 2000.

No trends were found in the yield results over the ten-year period. Furthermore, yields for each crop were not found to be statistically significant. The yields from the experiment station are reported in Table 3.6. As a further comparison, the historical yields from the south central district for 1997-2009 for each commodity are located in Table B.1 in Appendix B.

3.6 Simulated Net Returns

Stochastic Efficiency with Respect to a Function (SERF) was used to rank the various systems using utility-weighted certainty equivalents for various degrees of risk aversion. The certainty equivalents are used to calculate risk premiums at each risk aversion level. Simulation and Econometrics to Analyze Risk (SIMETAR©) developed by Richardson, Schumann and Feldman (2004) is used to simulate yield and price distributions and calculate distributions of net returns to land and management with 2009 costs. Net return distributions were constructed using equation 3.1.

(3.1) $$NR_{ijk} = \sum_{j=1}^{2}(Y_{ijk} * EP_{ij} - C_{jk} - HC_{ijk})/2$$

where

NR_{ijk} = net return to land & management ($/acre) for observation i for crop production system k, i = observation, i = 1 to 1000,

j = crop, j = 1-2,

k = crop production system k, k = 1-13,

$Y_{i\,jk}$ = simulated yield (bu/acre) for observation i of crop j for crop production system k,

EP_{ij} = simulated price ($/bu) for observation i for crop j,

C_{jk} = preharvest production costs ($/acre) for crop j in production system k,

HC_{ijk} = harvest cost ($/acre) for yield observation i for crop j in production system k.

Crop yields and prices in the model are stochastic, while all costs are pre-determined. A simulated correlated multivariable empirical yield distribution derived from actual historical yields is multiplied by a simulated multivariate empirical price distribution derived from actual historical prices to calculate gross returns for each cropping system. Current year production and harvest costs are then subtracted from gross returns to obtain the net return. It is assumed that each crop in rotation is grown on one acre, so the net return is divided by two and reported as $/acre of a rotation.

The price and yield distributions are generated in the following manner: a cumulative probability distribution function (CDF) using the 10 years of yield and price data with the probability ranging from 0.0 to 1.0 is formed by ordering the data and assigning a cumulative probability for each observation. The same process is repeated using monthly prices from January 2006 through December 2009. This 48-month empirical data set was used to capture the variability in the large increase of crop prices seen in 2007 and the first half of 2008, and the moderate decline in prices since. This analysis is also re-conducted using the 36 months of January 2007 to December 2009, the 24 months of January 2008 to December 2009, and the 12-month period of January 2009 to December 2009. A summary of the price distribution characteristics is reported in Table 3.7. These alternative price distributions demonstrate how sensitive the results are to price variability.

Each yield or price observation is assumed to have an equal probability of occurring. A simulated distribution of 1000 observations is generated by drawing 1000 values from a uniform standard deviate ranging in value from zero to 1.0. The corresponding price or yield assigned to the distribution is from the cumulative probability represented by the uniform standard deviate value. The price is found by interpolation if the value from the uniform standard deviate falls between the cumulative probabilities assigned the original data values (Pendell et al., 2007). A multivariate distribution has been shown to correlate random yields appropriately, based on their historical correlation (Richardson, Klose and Gray, 2000). The multivariate distribution is a closed-form distribution, which eliminates the possibility of simulated values exceeding values observed in history (Ribera, Hons and Richardson, 2004).

Yield and price distributions are correlated in the simulation. Yield correlations for 1997-2006 (Table C.1) in Appendix C range from -0.01 to 0.99. The correlation between district crop price series for 1997-2006 (Table C.2) ranges from .89 to .99 for the 10 years of historical crop prices. All of the price correlations are statistically significant at the 95 percent level. Correlation between yields and correlation between prices are included in the simulated net returns. Correlation between prices and yields are not used in the simulation because the two are not typically highly correlated at the farm level.

The monthly price data from 2006 to 2009 that was used in the simulations is also correlated. Tables C.3-C.6 in Appendix C shows the correlations for each period. Price correlations range from 0.77 to 0.94 for 2006 to 2009, with all values statistically significant at the 95 percent level. Price correlations range from 0.69 to 0.91 for the 2007 to 2009, with all values again being significant at the 95 percent level. Price correlations range from 0.78 to 0.95 for 2008 to 2009. These values too, were found to be statistically significant. Price correlations range from 0.39 to 0.71 for the four crops in 2009. Only corn price was found to be significantly correlated with wheat and sorghum prices.

3.7 Stochastic Efficiency with Respect to a Function

According to Hardaker et al. (2004), stochastic efficiency with respect to a function (SERF) orders a set of risky alternatives in terms of certainty equivalents for a specified risk preference. The SERF procedure can be applied to any utility function with risk attitudes classified by matching ranges of absolute, relative, or partial risk aversion coefficients. SERF works by identifying utility-efficient alternatives for a risk preference, not by finding dominated alternatives such as stochastic dominance. SERF orders preferences in terms of certainty equivalents (CEs). The CE of a risk strategy is the amount of money at which the decision maker is indifferent between the certain dollar value and the risky strategy. Strategies with higher CEs are preferred to those with lower CEs. For a risk-averse decision maker (someone who avoids risk), the estimated CE is typically less than the expected value of the risky strategy. Hardaker et al. (2004) also demonstrates how SERF can potentially find a smaller set of preferred strategies compared to stochastic dominance.

The calculation of the CE depends on the utility function specified. For this analysis, a negative exponential utility function is used. Therefore a specific absolute risk aversion coefficient (RAC) defined by Pratt (1964) as, ra(w) = -u"(w)/u'(w), which represents the ratio of derivatives of the decision maker's utility function, u(w), is used to derive CEs.

The negative exponential utility function used in the SERF analysis conforms to the hypothesis that managers prefer less risk to more, given the same expected return. Under this functional form, managers are assumed to have constant, absolute risk aversion. This means that a manager would view a risky strategy for a specified level of risk aversion the same, no matter their level of wealth. Babcock, Choi and Feinerman (1993) note that this functional form is often used to analyze farmers' decisions under risk.

The simulated net return data outcomes from each crop production system are sorted into cumulative distribution functions (CDFs) which are used in the SERF analysis. Once the strategies are ranked using the CE results, a utility-weighted risk premium (RP) can be calculated using equation 3.2. This is accomplished by subtracting the CE of a less preferred strategy (L) from the preferred strategy (P).

(3.2) $$RP_{L,P,ra} = CE_P, ra\ (w) - CE_L, ra(w).$$

The risk premium for a risk-averse decision maker reflects the minimum amount ($/acre) that a decision maker would have to be paid to justify a switch from the preferred strategy (P) to (L) a less-preferred strategy under a specific risk-aversion coefficient (RAC). These risk premiums and the resulting rankings are reported in graphical form for a range of RACs from risk-neutral to very risk-averse. An RAC equal to zero means the decision maker is risk-neutral. As the RAC increases from zero, so does the decision maker's risk aversion, or desire to avoid risk. The actual RACs used in the final analysis range from 0.00 to 0.12; above 0.12 the rankings do not change.

Table 3.1. Annual Frequency of Field Operations.[1]

System[2]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
Burn							1.00						
Chisel			1.00		1.00		0.25	1.00					
Disk							1.00	1.00					
Roller Harrow							0.25	0.25					
Field Cultivate							0.25	0.25					
V-Blade	0.75									0.75		0.75	
Sweep Treader	3.75		1.25		2.50		1.75	1.50		3.75		3.00	
Mulch Treader			0.75		0.75		0.25	0.25				0.50	
Total Tillage Operations	0.00	0.00	3.00	0.00	4.25	0.00	4.75	4.25	0.00	4.50	0.00	4.25	0.00
Fertilizer Application (Dry)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Herbicide Application (Ground Rig)	2.25	5.75	1.00	2.25	1.00	2.50	0.25	0.50	3.25	1.75	5.75	2.00	5.50
Total Operations by System	7.75	6.75	8.00	3.25	10.50	3.50	10.75	10.00	4.25	11.75	6.75	11.50	6.50

[1]Numbers indicate the frequency of field operations or inputs used per year for the four year period of 2003-2006.

[2] RT = Reduced-till, NT = No-till, B = Burn, WS = Wheat-Soybean, GG-M = Continuous Grain Sorghum May planted,
GG-J = Continuous Grain Sorghum June planted, WW = Continuous Wheat, WG = Wheat-Grain Sorghum, WC = Wheat-Corn

Table 3.2. Example Enterprise Budget (NTWC).

Wheat			
Sept. Herbicide application	0.75	application	$3.76
Glyphosate	16.33	oz/ac.	$7.57
AMS	1.20	lbs/ac.	$0.42
2,4-D LVE	6.50	oz/ac.	$1.13
Preplant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs material/ac.	$16.41
April Herbicide application	0.25	application	$1.25
Everest	0.15	oz/ac.	$4.73
Surfactant	1.60	oz/ac.	$0.29
Late June Wheat Harvest	57.89	bu./ac.	29.43
Corn			
July Herbicide Application	1.00	application	$5.01
Glyphosate	23.21	oz/ac.	$10.76
ProPak	9.50	oz/ac.	$1.59
AMS	0.75	lbs/ac	$0.26
2,4-D Amine	4.75	oz/ac.	$0.63
Banvel	3.25	oz/ac.	$2.03
Select	2.00	oz/ac.	$2.38
Superb HC Crop Oil Conc.	4.00	oz/ac.	$0.71
Sept. Herbicide Application	1.00	application	$5.01
Glyphosate	18.94	oz/ac.	$8.78
ProPak	4.75	oz/ac.	$0.79
AMS	1.20	lbs/ac	$0.42
2,4-D Amine	5.00	oz/ac.	$0.66
Nov. Herbicide Application	0.75	application	$3.76
COC	16.00	oz/ac.	$1.31
2,4-D LVE	8.00	oz/ac.	$1.39
Atrazine 90 DF	0.42	lbs/ac.	$1.83
Atrazine 4L	0.75	pt/ac.	$1.88
Glyphosate	4.00	oz/ac.	$1.85
AMS	0.13	lbs/ac.	$0.04
April Herbicide Application	0.75	application	$3.76
Glyphosate	16.34	oz/ac.	$7.58
AMS	1.30	lbs./ac.	$0.46
Banvel	1.38	oz/ac.	$0.86

Table 3.2. Example Enterprise Budget (NTWC) Continued

April Herbicide Application	1.00	application			$5.01
Atrazine 90 DF	0.28	lbs/ac			$1.22
Atrazine 4L	0.38	pts/ac			$0.94
Dual 2 Mag	1.57	pts/ac			$25.66
COC	8.00	oz/ac			$0.66
Preplant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	107.44	lbs/N ac.			$46.71
Mid-April Planted Corn	1.00	application			$15.41
Pioneer 35P - series	18.70	1000 seeds/ac.			$34.24
DAP (18-46-0) banded	80.00	lb/ac			$17.80
Early Sept. Corn Harvest	66.06	bu./ac.			$26.51
Interest	0.08	%			$15.57
Total Cost					$404.79
Total/acre of rotation					$202.39
Gross Return					
Wheat	57.89	bu.	5.13	$/ac.	$296.96
Corn	66.06	bu.	3.56	$/ac.	$235.17
Total/acre of rotation					$266.07
Net Return					**$63.67**

Table 3.3. Field Operation Costs (Kansas Custom Rates).

Field Operation	Price[1]	Units
Field cultivation without fertilizer (Mulch/Sweep Treader)	$8.95	acre
Sweep/undercut without fertilizer (V-Blade)	$7.73	acre
Disk	$9.02	acre
Chisel, less than 12 inches deep	$11.19	acre
Spiketooth Harrow	$6.71	acre
Broadcast dry fertilizer	$4.96	acre
Spray chemical (ground rig)	$5.01	acre
No-till plant with fertilizer	$15.41	acre
No-till drill and/or air-seed with fertilizer	$15.43	acre
Regular-till plant with fertilizer	$14.12	acre
Harvest wheat	$21.65	acre
Wheat yield above base rate of 21 bu./ac.	$0.21	bushel
Harvest corn	$26.51	acre
Corn yield above base rate of 68 bu./ac.	$0.20	bushel
Harvest grain sorghum	$22.99	acre
Grain sorghum yield above base rate of 36 bu./ac.	$0.22	bushel
Harvest soybeans	$26.47	acre
Soybean yield above base rate of 26 bu./ac.	$0.21	bushel
Prescribed Burning[2]	$7.00	acre

[1] 2008 Custom application rates. Twete et al. (2009).

[2] Rate obtained from NRCS Field Office Technical Guide.

Table 3.4. Input Costs.

Input[1]	Price	Units	
Overly Wheat Seed	$9.50	60 lb bag	
Asgrow 3302 RR/STS Soybean Seed	$47.00	50 lb bag	155,000 seeds/bag
Pioneer 8500 Poncho treated Grain Sorghum Seed	$135.50	50 lb bag	650,000 seeds/bag
Pioneer 35P80RR Poncho treated Corn Seed	$146.50	50 lb bag	80,000 seeds/bag
46-0-0 Urea[2]	$400.00	ton	
18-46-0 DAP[2]	$445.00	ton	
2,4-D Amine 4 L	$17.00	gallon	
2,4-D LVE 4 EC	$22.25	gallon	
AMSU Adjuvant	$0.35	lbs	
Atrazine 4 L	$20.00	gallon	
Atrazine 90 DF[2]	$4.38	lbs	
Banvel or Clarity	$80.00	gallon	
COC	$10.50	gallon	
Dual II Mag	$130.94	gallon	
Everest[2]	$31.56	oz	
Maverick	$18.20	oz	
Non-ionic Surfactant	$23.00	gallon	
Olympus 70 WG	$14.18	oz	
Placement ProPak Adjuvant	$21.40	gallon	
Roundup Orginal Max 4.5 A.I.[2]	$59.35	gallon	
Sceptor 70 DG	$4.00	oz	
Select	$152.00	gallon	
Superb HC COC[2]	$22.77	gallon	
Interest rate on half of variable costs	8.00%		

[1] The use of trade names does not imply endorsement of these products

[2] Price obtained from Andale Farmer's Cooperative

Remaining herbicide prices were obtained from 2009 KSU herbicide handbook

Table 3.5. South Central Kansas Crop & Livestock Reporting District Crop Prices ($/bu.).

Year	Soybeans	Grain Sorghum	Wheat	Corn
1997	$7.30	$2.25	$3.70	$2.62
1998	$5.75	$1.95	$2.78	$2.19
1999	$5.00	$1.95	$2.75	$1.95
2000	$5.00	$1.95	$2.75	$1.96
2001	$5.00	$1.95	$2.77	$2.00
2002	$5.00	$2.03	$3.38	$2.21
2003	$6.18	$2.12	$3.28	$2.38
2004	$7.45	$2.19	$3.49	$2.59
2005	$5.76	$1.95	$3.26	$2.01
2006	$5.52	$2.38	$4.43	$2.44
2007	$7.88	$3.57	$5.95	$3.67
2008	$11.72	$4.66	$7.77	$5.21
2009	$9.82	$3.00	$5.13	$3.56
Mean	$6.72	$2.46	$3.96	$2.68
Std Dev	$2.09	$0.82	$1.51	$0.95
CV	0.31	0.33	0.38	0.35
Min	$5.00	$1.95	$2.75	$1.95
Max	$11.72	$4.66	$7.77	$5.21

Prices reflect 2009 national average loan rates (USDA-FSA, 2009).

Table 3.6. Crop Yields by System (bu./acre).

System[1]	RTWS		NTWS		RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG		NTWG		RTWC		NTWC	
Crop	Wheat	Soybean	Wheat	Soybean	Sorghum	Sorghum	Sorghum	Sorghum	Wheat	Wheat	Wheat	Wheat	Sorghum	Wheat	Sorghum	Wheat	Corn	Wheat	Corn
1997	78.81	49.52	83.86	51.15	90.33	85.55	88.42	100.21	74.20	76.88	59.18	52.79	115.98	36.43	121.08	83.57	121.72	89.07	102.28
1998	48.77	22.16	50.71	21.71	97.50	94.48	47.32	49.23	42.23	42.23	44.01	42.53	105.47	41.63	108.02	51.30	47.80	44.76	51.94
1999	45.35	35.54	55.02	33.61	72.01	70.58	83.64	80.61	32.27	14.27	29.29	30.63	85.87	42.08	97.50	43.27	74.88	49.37	69.30
2000	54.42	25.28	64.68	20.37	83.80	86.67	43.97	50.82	46.99	41.19	43.57	33.31	115.19	37.03	109.13	47.88	52.32	42.23	49.78
2001	45.35	12.49	47.58	13.53	47.00	47.16	56.40	61.34	38.36	39.55	36.73	40.89	55.12	37.03	60.38	48.47	44.45	48.92	31.07
2002	55.02	18.88	49.52	20.52	50.50	50.98	73.92	74.08	58.14	53.23	45.95	55.61	58.15	48.03	56.56	49.07	44.93	50.56	47.48
2003	59.33	7.73	59.18	7.88	42.38	44.77	45.56	45.41	37.32	44.46	56.50	58.88	43.33	68.70	51.46	59.63	37.28	70.33	37.76
2004	52.94	51.60	57.10	50.41	115.66	125.54	81.25	86.67	66.62	67.21	71.82	64.83	156.93	65.72	145.78	68.55	137.65	67.36	135.10
2005	73.75	30.63	69.44	27.66	66.91	65.96	49.39	49.71	29.74	26.17	44.01	51.15	81.25	51.30	81.41	57.99	85.08	54.87	73.76
2006	63.05	32.42	64.09	38.96	64.68	59.43	75.99	84.12	62.01	59.63	65.57	62.90	66.75	53.68	73.92	65.43	70.10	61.41	62.13
Mean	57.68	28.62	60.12	28.58	73.08	73.11	64.59	68.22	48.79	46.48	49.66	49.35	88.41	48.16	90.52	57.52	71.62	57.89	66.06
Std Dev.	11.35	14.43	10.96	14.74	23.72	25.29	17.67	19.37	15.45	18.62	13.24	11.99	35.03	11.72	30.97	12.27	34.37	14.39	31.62
CV	0.20	0.50	0.18	0.52	0.32	0.35	0.27	0.28	0.32	0.40	0.27	0.24	0.40	0.24	0.34	0.21	0.48	0.25	0.48
Min	45.35	7.73	47.58	7.88	42.38	44.77	43.97	45.41	29.74	14.27	29.29	30.63	43.33	36.43	51.46	43.27	37.28	42.23	31.07
Max	78.81	51.60	83.86	51.15	115.66	125.54	88.42	100.21	74.20	76.88	71.82	64.83	156.93	68.70	145.78	83.57	137.65	89.07	135.10

[1] RT = Reduced-till, NT = No-till, B = Burn, WS = Wheat-Soybean, GG-M = Continuous Grain Sorghum May planted, GG-J = Continuous Grain Sorghum June planted, WW = Continuous Wheat, WG = Wheat-Grain Sorghum, WC = Wheat-Corn

Table 3.7. Simulated Commodity Price Distribution Characteristics ($/bu.).

		Corn	Wheat	Soybean	Sorghum
	Mean	$3.72	$5.82	$8.73	$3.41
January 2006	Std Dev	$1.10	$1.68	$2.62	$1.01
to	CV	0.29	0.29	0.30	0.29
December 2009	Min	$1.97	$3.53	$5.18	$1.95
	Max	$6.63	$10.60	$14.70	$5.82
	Mean	$4.15	$6.28	$9.80	$3.74
January 2007	Std Dev	$0.89	$1.69	$2.12	$0.89
to	CV	0.21	0.27	0.22	0.24
December 2009	Min	$3.05	$3.90	$6.27	$2.61
	Max	$6.63	$10.60	$14.70	$5.82
	Mean	$4.39	$6.45	$10.77	$3.83
January 2008	Std Dev	$1.00	$1.83	$3.33	$1.79
to	CV	0.23	0.28	0.31	0.47
December 2009	Min	$3.05	$3.90	$0.22	$0.24
	Max	$6.63	$10.60	$14.70	$5.82
	Mean	$3.56	$5.13	$9.82	$3.00
January 2009	Std Dev	$0.31	$0.70	$0.80	$0.29
to	CV	0.09	0.14	0.08	0.10
December 2009	Min	$3.05	$3.90	$8.82	$2.61
	Max	$4.12	$6.08	$11.50	$3.47

CHAPTER 4 - Analysis and Results

4.1 Overview

Net returns to land and management per acre for each production system were calculated several ways once the basic enterprise budgets were constructed. The first procedure used the 10-year average yield for each crop, the average crop price from 2009, and 2009 input prices. The cost and return information from the enterprise budgets were used to compare the production systems. These results are explained in further detail in section 4.4.

Net returns were also calculated using the actual historical yields and 2009 input costs, but commodity prices were held constant at the 2006, 2007, 2008 or 2009 price level, respectively in separate analyses. Table 4.5 contains a summary of the net return characteristics for each year and a full explanation of these results is presented in section 4.5a.

Further analysis was performed by calculating the historical net return distribution for each production system by using the actual historical yields that were recorded at the research station for each year of the study (1997-2006), the south-central Kansas crop prices from 1997 to 2006, and 2009 input prices. Further explanation of these gross (Table 4.3) and net returns (Table 4.4) and comparisons across the production systems are presented in section 4.5. These historical net returns were also sorted into cumulative distribution functions (CDFs) which were used in the SERF analysis. Figure 4.1 provides a graph of all the CDFs for the historical net returns. Figure 4.2 summarizes the SERF analysis results. The CDFs and risk premiums from this SERF analysis are also discussed in further detail in sections 4.5b and 4.5c.

Finally, net return distributions were developed by simulating net returns for each production system, using yield and price distributions based on actual historical yields, prices and 2009 input costs. Four different historical monthly price series ranging from January 2006 to December 2009, January 2007 to December 2009, January 2008 to December 2009, and January 2009 to December 2009 were used to develop empirical simulated price distributions. Explanations of these net returns and comparisons across production systems start in section 4.6.

4.2a Yields by Cropping System

In order to understand fully the results of any of the net return distributions discussed later, it is important to examine and understand the yields and costs associated with each crop rotation and tillage system. Wheat yields after soybeans and corn were found to be greater than those produced in rotation with grain sorghum or in continuous wheat. On average, wheat yields after corn or soybeans were eight to 13 bushels greater than those from continuous wheat or the wheat-grain sorghum rotation for both the reduced-till and no-till systems (Table 4.1). Wheat after soybean yielded approximately 57 bushels per acre for the reduced-till system and 60 bushels per acre with the no-till system. Wheat after corn also yielded on average 57 bushels per acre for both systems. The 10-year averages (Table 4.1) show that the yields for reduced-till and no-till wheat rotated with grain sorghum were 49 and 48 bushels/acre respectively, are comparable to the yields from the continuous wheat system which were 46, 48 and 49 bushels/acre for the RTWW, BWW and NTWW, respectively. The experiment station data also show that grain sorghum yields were greater when rotated with wheat for both reduced-till and no-till than from continuous grain sorghum cropping.

4.2b Yields by Tillage System

Tillage system selection also had no statistically different impact on yield. Tillage system had very little effect on continuous wheat yield. As seen in Table 4.1, there is only a three bushel per acre difference between the three monoculture wheat systems: 46, 48 and 49 bushels/acre for RTWW, BWW and NTWW, respectively. NTWW had slightly higher yields than BWW, and BWW only had slightly higher yields than the RTWW system. The average wheat yields for the NTWS and RTWS system were only three bushels per acre different. Average wheat yields in the RTWC and NTWC systems were both 57 bushels/acre (Table 4.1).

Tillage system selection was also found to have minimal effect on soybean, corn and grain sorghum yields when averaged over the 10-year period. As Table 4.1 indicates, average soybean yield was 28 bushels/acre for both RTWS and the NTWS rotations. Average corn yields were 71 bushels/acre for the RTWC system and 66 bushels/acre for the NTWC. Average yields for the May-planted continuous grain sorghum were 73 bushels/acre for both the reduced-till and no-till systems. Average yields for the June-planted continuous grain sorghum were 64 bushels/acre for the reduced-till and 68 bushels/acre for the no-till.

4.2c Overall Yield Comparison

Table 4.1 reports NTWS and NTWC as the systems with the two highest wheat yields, while RTWC and RTWW had the lowest wheat yields across all the systems. The highest grain sorghum yield occurred with the NTWG system, while the lowest grain sorghum yield was RTGG-J. The highest corn yield was from the RTWC system as opposed to NTWC. Lastly, 10-year average soybean yields for RTWS and NTWS were separated by less than 0.10 bushels.

4.2d Residue Cover after Planting

Residue cover after planting was also measured at the experiment station. As expected residue cover was always greatest for the no-till systems. Annual percentage residue cover after row crop planning for the no-till systems were more than double the percent residue cover left from the reduced-till operations. Annual percent crop residue after winter wheat planting was on average 8-10% greater for the no-till rotations that reduced-till. Residue cover for wheat planted after soybean was less than in wheat planted after corn or grain sorghum. Residue cover after grain sorghum planting averaged 11% more in no-till grain sorghum after wheat than in no-till sorghum after wheat than in no-till continuous grain sorghum. In continuous wheat, the chisel and burn systems left significantly less residue cover than no-till. Overall, the researchers at the experiment field found that maintenance of more than 30% crop residue cover between winter wheat harvest and row crop planting the next spring is difficult if tillage is the only method of weed control (Claassen and Roozeboom, 2007). Table D.1 and D.2 in Appendix D contains a complete listing of the measured percent residue cover for each system (Claassen and Roozeboom, 2007).

4.3a Costs by Cropping System

The RTWS and NTWS systems have substantially lower total costs than any of the other systems. As indicated by Table 4.2, which shows the total costs for each system by category, RTWS and NTWS require less nitrogen fertilizer that the other systems. Fertilizer costs for RTWS and NTWS are approximately \$33.00/acre. All of the other systems have fertilizer costs between \$62.00 and \$64.00/acre. Aside from the BWW and RTWW systems, RTWS also has lower herbicide costs compared to the other systems. NTGG-J, NTWG and NTGG-M have the highest herbicide costs. Tillage costs are highest for the BWW, RTGG-J and RTWW systems: approximately \$40.00/acre. Ignoring the no-till systems, RTWS, RTWG and RTWC all have tillage costs of approximately \$20.00/acre.

Total costs for both May-planted sorghum systems are less than both June-planted grain sorghum systems. Table 4.2 shows that tillage costs for RTGG-M are \$10.00/acre less than the

RTGG-J system. Additionally, Table 4.2 shows that total herbicide costs (chemicals and application) for NTGG-M are approximately $4.00/acre less than NTGG-J.

4.3b Costs by Tillage System

A comparison of total costs by tillage system shows that for all of the systems, except the two continuous grain sorghum systems, no-tillage results in higher total costs than reduced tillage (Table 4.2). This is due to the additional herbicide applications used in the no-tillage system. The cost difference between reduced-till and no-tillage herbicide applications is double in many cases. For example, the total herbicide cost (chemicals and application) for NTWS are $53.26/acre. This is approximately $33.00/acre more than the total herbicide costs for RTWS. No-till planting is also about $1.00/acre more than reduced-till. Fertilizer, harvest and seed costs are nearly the same for each system, so herbicide costs should be compared against tillage costs. Tillage costs for RTWS are $19.68/acre and NTWS is $0.00 (Table 4.2); however, until gross returns are calculated, we cannot say for sure which of these tillage systems will be the most profitable.

RTGG-M and NTGG-M have a total cost difference of $1.50/acre. The difference in tillage costs between RTGG-M and NTGG-M is $29.00/acre. The difference in herbicide costs between the two systems is $26.00/acre; including the small increase in planting cost for the NTGG-M, these two systems are almost even. Total costs for RTGG-J are approximately $8.00/acre more than NTGG-J. The difference in herbicide cost is $30.50/acre, while the difference in tillage cost is $40.00/acre. Again, include the increase in planting cost for NTGG-J, and the difference comes to $8.00/acre (Table 4.2).

BWW has the lowest cost of the three continuous wheat rotations at $176.67/acre; RTWW is next with $180.36/acre in total costs; and NTWW has the highest total cost of the three at $191.32/acre. NTWW is the most expensive because herbicide costs are $58.50/acre, while tillage costs for the other two systems are approximately $40.00/acre. The tillage operations for the BWW system cost about $1.00/acre more than the RTWW, but herbicide costs were almost $5.00/acre less for the BWW system (Table 4.2). As was the case with RTWS and NTWS, herbicide costs for NTWG and NTWC are more than the costs of tillage saved by not using the RTWG and RTWC systems, and therefore have higher total costs than the reduced-till systems.

4.3c Overall Costs Comparison

RTWS and NTWS have the lowest total cost of all the systems at $149.66/acre and $165.13/acre respectively (Table 4.2). The RTWG system has the next-lowest total cost of $172.37/acre followed closely by the BWW system with total cost of $176.67/acre. The rest of the cropping systems have total costs that range from $180.00 to $202.39/acre. The systems with the highest total cost are the NTWG, RTGG-J and NTWC systems at $193.11, $199.25 and $202.39/acre, respectively (Table 4.2).

4.4 Average Net Returns calculated using 10-Year Average Yields

Average net returns are calculated by subtracting costs from gross returns. Annual average net returns to land and management for the 13 crop rotations from the enterprise budgets are also listed in Table 4.2. The following is a comparison of rotation, tillage, and overall net returns.

4.4a Average Net Returns compared by System

Overall, RTWS and NTWS have the highest net returns to land and management of $138.83 and $129.40/acre, respectively. RTWS has the second-highest gross return of

$288.49/acre, and NTWS the highest gross return of $294.53/acre. Total costs for the RTWS and the NTWS systems are $149.66 and $165.13/acre, making them the lowest cost rotations of the 13. This makes sense because fertilizer costs for these systems were almost half of the cost of all the other systems ($36.00 versus $66.00/acre). The substantial difference in cost can be explained by the fact that soybeans are a legume. Legumes produce nodules on their roots that contain nitrogen-fixing bacteria. Since soybeans can produce their own nitrogen, an application of nitrogen fertilizer was not needed. All the other crops in the study did require an application of urea fertilizer.

The system with the next-highest net return is RTWC, with a net return of $89.88/acre. Gross returns for the RTWC system are third highest at $275.01/acre. Very close to the RTWC, system is the RTWG system with a net return of $86.82/acre. Gross returns for RTWG are actually $16.00/acre lower than the RTWC gross returns, but total costs for the RTWG system are $13.00/acre less than total cost for the RTWC system.

BWW has the next-highest net return of $73.61/acre. With gross returns of $250.28/acre and total costs of $176.67/acre, this is the most profitable of the monoculture wheat systems.

NTWG has the next-highest net return of $66.21/acre. NTWG has gross returns of $259.32/acre and total costs of $193.11/acre. NTWC has the next-highest net return of $63.67/acre. Gross returns for this system are $266.07/acre. Total costs for NTWC are $202.39/acre, making it the highest-cost system.

The remaining monoculture wheat and grain sorghum systems round out the bottom half of the net returns for the 13 cropping systems. While total costs for the monoculture wheat systems are very similar to the total costs for the continuous grain sorghum system, net returns for both RTWW ($58.10/acre) and NTWW ($63.46/acre) are higher than both the May (NT,

$31.26 and RT, $29.67/acre) and June monoculture grain sorghum systems (NT, $13.35 and RT, $-5.49/acre). The gross returns for the May-planted and the June-planted grain sorghum are the lowest of the 13 systems.

In the monoculture grain sorghum systems, the May planting date has higher net returns for both no-till and reduced-till compared to the later June planting. There are two reasons for this. First, average yields for June-planted grain sorghum are lower than May-planted grain sorghum. June-planted grain sorghum yields were 65 and 68 bushels/acre for RT and NT, respectively, while May-planted grain sorghum yields averaged 73 bushels/acre for both RT and NT, respectively. Later-planted grain sorghum is more likely to face heat stress and receive less moisture than earlier-planted grain sorghum. The second reason May-planted grain sorghum is more profitable is cost. May-planted grain sorghum is better able to compete with weeds by establishing itself before many weeds are in full force. June-planted grain sorghum does not have this advantage; because of this, more tillage is needed to prepare the seedbed for planting and to control weeds with the reduced-tillage system, and more herbicide applications are necessary to control weeds with the no-till system.

4.4b Average Net Returns compared by Tillage System

Comparisons across tillage systems show mixed results between reduced-tillage and no-tillage systems. Monoculture grain sorghum and monoculture wheat (excluding BWW) have higher net returns under no-till rather than reduced-tillage, while the rest of the systems have higher net returns under reduced tillage. NTGG-M has a higher net return ($31.26/acre) than RTGG-M ($29.67/acre) because of lower combined tillage and herbicide costs. Tillage costs for RTGG-M are approximately $29.00/acre versus $0.00/acre for the NTGG-M; however, the difference in additional herbicide costs for the NTGG-M system is only $26.00/acre. NTGG-J also has a higher net return than RTGG-J. Tillage costs for RTGG-J are approximately $40.00/acre, compared to $0.00/acre for NTGG-J; however, the difference in additional herbicide costs for the NTGG-J system compared to RTGG-J is only $30.00/acre.

In the monoculture wheat systems, BWW has the highest net return ($73.61/acre), followed by NTWW ($63.46/acre), and then RTWW ($58.10/acre). Gross returns are $4.50/acre higher for the NTWW rotation than the BWW gross returns, but that is not enough to offset the higher total cost of the NTWW system ($191.32/acre) with the total costs of the BWW system ($176.67/acre). Total costs for BWW ($176.67/acre) are only slightly less than the RTWW system ($180.36/acre). NTWW has a higher net return than RTWW because average yields for NTWW are three bushels higher than the yields in the RTWW system. Finally, it is important to note that, while the burn system increased continuous wheat yields in some years, in high rainfall seasons burning can actually result in lower production because of poor water infiltration (Claassen, 2009).

For all remaining systems, the reduced-tillage systems have higher net returns than their no-till counterparts do do. RTWS ($138.83/acre) has a higher net return than NTWS ($129.40/acre). This is because the total costs for RTWS are nearly $15.50/acre less than the NTWS. Tillage costs are approximately $20.00/acre with the reduced-tillage system; however, herbicide costs associated with the no-till system are nearly $33.00/acre more than the reduced-tillage system. RTWC is also more profitable than NTWC for the same reasons: $89.88/acre versus $63.67/acre, respectively. Total costs are separated by $17.00/acre, with reduced-tillage operations costing roughly $19.00/acre and increased herbicide costs of nearly $35.00/acre with the no-till system. The last system RTWG also has higher net returns ($86.82) with the reduced-tillage system than the no-till system ($66.21). RTWG has gross returns of $259.20/acre and total costs of $172.37/acre, while NTWG has gross returns of $259.32/acre and total costs of $193.11/acre. The gross returns for NTWG are $0.12/acre more than RTWG, but net returns fall short of RTWG because of the $20.00/acre difference in total costs. RTWC and RTWS also experience higher net returns than their no-till counterparts do because of the difference in total costs.

4.4c Average Net Returns Overall Comparison

The RTWS and NTWS systems are the two most profitable cropping systems because they have both the highest gross returns and lowest total costs of the 13 systems. Alternatively, the continuous or monoculture grain sorghum systems are the least profitable of the 13 systems because they have some of the highest total costs and lowest gross returns. As for the remaining systems, those with the lowest total costs are the most profitable

4.5 Historical Net Return Distributions

Historical net returns per acre (Table 4.4) for each production system were calculated using the actual historical yields that were recorded at the research station from 1997 to 2006, south-central Kansas crop prices from 1997 to 2006, and 2009 input prices. Table 4.3 provides the gross returns, and Table 4.4 reports the net returns.

The RTWS and NTWS show the highest net returns, followed by the RTWG and the RTWC systems. Table 4.4 indicates that some systems experience negative net returns because the 2009 input costs made total costs higher than the gross returns for many systems. Ultimately, the systems that were the most profitable when the 10-year average yields and 2009 crop prices were used are still the most profitable when historic crop yields and prices are used.

The RTWS, NTWS and RTWG systems have positive net returns when averaged over the 10 years of the study. RTWC and BWW are the next most profitable systems in this analysis, followed by NTWG, RTWW, NTWW and NTWC. In the previous analysis, NTWG was fifth and BWW was sixth, followed by NTWC, NTWW and RTWW. As before, the monoculture grain sorghum systems have the lowest net returns of the 13 systems, with June-planted grain sorghum systems being the worst. Net returns for each of the grain sorghum system were negative at least eight out of the 10 years, with RTGG-J experiencing negative net returns all 10 years.

4.5a Net Return Distributions using Historic Yield and Constant Crop Prices

Net return distributions are also calculated using the actual historical yields and the 2009 input costs as before; however, four separate sets of distributions are calculated by using the average crop price for 2006, 2007, 2008 and 2009 price levels, respectively. In other words, net return variability within each set of distributions is due only to yield variability. Table 4.5 contains a summary of the average net returns for each system for each year.

For the 2006 commodity price scenario, RTWS, NTWS, RTWG, BWW and NTWW have the highest net returns to land and management. Net returns range from $56.66/acre for RTWS to $28.70/acre for the NTWW system. RTWC, RTWW, NTWG and NTWC also have positive net returns that range from $28.33/acre for RTWC to $5.16/acre for NTWC. The four lowest net returns are the continuous grain sorghum systems. NTGG-M has a negative net return of $14.07/acre, followed by RTGG-M, NTGG-J and finally RTGG-J, which has a negative net return of $45.53/acre. Compared to the net returns calculated using historic yields and historic prices, the ranking of system profitability changes very little. RTWS, NTWS and RTWG are still the most profitable systems in each analysis, and the four grain sorghum systems are consistently least profitable.

The increase in average crop prices from 2006 to 2007 makes all of the net returns positive when calculated at the 2007 commodity prices. RTWS is the most profitable system with net returns of $134.20/acre. RTWG has the second-highest net return and the NTWS system the third highest. RTWC, BWW and NTWG are the next-highest net returns, as they also are in the net return distribution calculated using historic yields and historic prices. NTWW, RTWW and NTWC are the next three highest net returns, ranging from $104.14/acre for NTWW to $89.87/acre for NTWC. The four continuous grain sorghum systems again have the lowest net returns. NTGG-M has a net return of $72.86/acre, followed by RTGG-M, NTGG-J and finally RTGG-J, with a net return of $31.26/acre.

Under the 2008 commodity price scenario RTWS, NTWS, RTWG and RTWC are again the highest net returns. Net returns range from $241.52/acre for RTWS to $223.58/acre for the RTWC system. Using 2008 prices, NTWG is more profitable than BWW. Also because of the 2008 prices, NTWW and NTWC are more profitable than the RTWW system. NTWW has a net return of $194.37/acre, while RTWW has a net return of $180.47/acre. The four continuous grain sorghum systems are still the least profitable. NTGG-M has a net return of $152.86/acre, followed by RTGG-M, NTGG-J, and RTGG-J, with a net return of $101.43/acre.

Finally, net returns to land and management are calculated using 2009 commodity prices. RTWS, NTWS and RTWC have the highest net returns. RTWC surpasses RTWG as the third-most profitable system in 2009. Net returns range from $138.37/acre for RTWS to $88.68/ acre for RTWC. RTWG, BWW and NTWG are the systems with the next-highest net returns. NTWW and NTWC are more profitable than the RTWW system, with net returns ranging from

$63.46/acre for NTWW and $57.95/acre for RTWW. The four continuous grain sorghum systems are again the least profitable. NTGG-M has a net return of $57.95/acre, followed by RTGG-M, NTGG-J, and finally RTGG-J, which has a negative net return of $5.49/acre.

4.5b Cumulative Distribution Functions (CDF) and Stochastic Dominance

While examining net returns is useful, it is also beneficial to examine variation in net returns to determine if risk affects a manager's decision to use one strategy or cropping system over another. "Stochastic dominance is a risk analysis technique that chooses among a set of alternatives by comparing the entire distribution of possible returns for each strategy (cropping system) and selecting preferred strategies based on risk preferences and not just the mean and standard deviations" (Williams, Roth, and Claassen, 2000).

Many Kansas farmers are risk-averse and are often willing to accept fewer dollars of profit for fewer dollars of variability or a smaller chance of loss. No two producers have the same risk tolerance, making it difficult to prescribe a specific strategy that suits all producers.

Cumulative probability distribution functions (Figure 4.1) are created using SIMETAR© for the net return distributions calculated with the historic crop yields and prices (Table 4.4). Several different decision criteria can be used to compare the risk of alternative production systems. Risk-averse managers normally prefer strategies that have the largest mean net return and the smallest standard deviation; however, none of the systems (strategies) meets these criteria (Table 4.4). Another method is comparing the minimum net return across strategies. This method is useful because very risk-averse producers select the strategies with the highest minimum net return. Table 4.4 and Figure 4.1 indicate that RTWS has the highest minimum net return followed closely by NTWS and RTWG.

The strategy or system that has a CDF falling to the right of all the other CDFs would be the preferred strategy. This criterion indicates the strategy is first-degree stochastic dominant over all the other strategies or systems. It is not always possible to find one dominant strategy this way. RTWS is first-degree stochastic dominant over all other systems, with the exception of NTWS. NTWS is first-degree dominant over all strategies except RTWS and RTWG. Therefore, testing for second-degree stochastic dominance must be performed. A Strategy (system) A, dominates Strategy (system) B by second-degree stochastic dominance for all risk-averse individuals if the cumulative area under System A's CDF, summing from left to right, is always less than the area under System B's CDF. The RTWS rotation is second-degree stochastic dominant over NTWS and first-degree stochastic dominant over all remaining systems. RTWS has higher net returns approximately 78 percent of the time, compared to NTWS, and 100 percent of the time when compared to the other rotations. Therefore, RTWS is likely to be preferred by most risk-averse producers.

4.5c Historical Net Return Distribution SERF Results

SERF works by identifying utility-efficient alternatives for ranges of risk attitudes. SERF orders alternatives in terms of certainty equivalents (CE) as a selected measure of risk aversion is varied over a defined range. The primary advantage SERF analysis has over stochastic dominance is the potential to identify a smaller efficient set. SERF picks only the utility-efficient alternatives and simultaneously compares each with all the other alternatives, whereas stochastic dominance can only compare alternatives in pairs.

This SERF analysis examines which cropping systems a producer would choose at varying levels of risk aversion by comparing their net returns to land and management, calculated using the historic crop price and yield data (Table 4.4). Figure 4.2 provides the SERF results in graphical form. The risk premiums for each system relative to RTWS are graphed as a function of risk aversion. The risk premium is the amount of additional net return ($/acre) that a producer would require to make each respective system equally preferred to the RTWS system. These risk premiums are also reported in Table 4.6. With an RAC of zero, or risk-neutral, NTWS needs an additional return of $11.97/acre to be equally preferred to RTWS. The risk premiums for NTWS remain relatively constant across all levels of risk aversion. At an RAC of zero, RTWG requires an additional return of $30.07/acre to be equally preferred to the RTWS rotation; however, as risk aversion grows, this risk premium decreases. At an RAC of 0.02, RTWG crosses the NTWS line (Figure 4.2) and only requires an additional $13.68/acre to be equally preferred to RTWS. With very high risk aversion (0.12), the producer needs to make an additional $4.66/acre to equally prefer RTWS. This means that only a producer who is inclined to take more risk will choose NTWS over RTWG.

4.6 Simulated Net Return Distributions

The previous analysis examines the net returns and the producer risk preferences that were calculated using the yearly historic prices for each crop (1997-2006). Additional analyses using the simulated 4-year (January 2006-December 2009), 3-year (January 2007-December 2009), 2-year (January 2008-December 2009), and 1-year (January 2009-December 2009) monthly crop prices also were conducted. Table 3.7 reports the monthly price distribution characteristics for each period. The average simulated crop prices for corn, wheat and grain sorghum for 2009 are the lowest of the four price distribution scenarios. The average soybean price for the 2009 distribution is higher than both the 2006 to 2009 and 2007 to 2009 distributions. The average simulated crop prices for the 4-year period (2006-2009) are lower for each crop than either the 3- or 2-year simulated monthly price series. The average simulated crop prices for the 3-year series are lower than the 2-year series. The average simulated crop prices for the 2008-2009 monthly price series are the highest of all the simulated crop prices.

With the exception of corn for the 2006 to 2009 price series, the standard deviations are largest for the 2008 to 2009 crop price distributions, which would indicate that this 24-month period experienced volatile changes in crop prices, resulting in the wide distribution. The standard deviation for the 4-year simulated crop prices are the next largest, again indicative of a wide distribution of prices across the four years. Two of the four standard deviations are less than 1.0 for the 2007 to 2009 crop price distribution. The simulated 2009 crop prices all have standard deviations below 1.0, again indicating lower variability in the range of crop prices.

With the exception of grain sorghum for the 24-month price series, the coefficients of variation (CVs) for the 48-, 36- and 24-month price series are relatively close, ranging from 0.21 to 0.31. Coefficients of variation for the 48-month price series were 0.29 for corn, wheat and grain sorghum and 0.30 for soybeans. Coefficients of variation for the 24-month price series range from 0.23 for corn, 0.28 for wheat, 0.31 for soybeans and 0.47 for grain sorghum. The CVs in each of these periods are higher than the CVs for the 36-month price series, which are 0.21 for wheat, 0.27 for wheat, 0.22 for soybeans and 0.24 for grain sorghum. The CVs for 2009 are the smallest and range from 0.08 for soybeans, 0.09 for corn, 0.10 for grain sorghum and 0.14 for wheat. This means that there is less relative variability in the soybean price for 2009 than the corn, wheat and grain sorghum prices.

Table 4.7 contains a summary of the average simulated net returns for each monthly price series. RTWS has the highest net returns for each price series, followed closely by NTWS. For the 2006 to 2009 monthly price series and the 2007 to 2009 monthly price series, RTWG has the next highest net returns, followed by the RTWC system. For the 2008 to 2009 monthly price series and the 2009 monthly price series, RTWC has the third highest net returns, followed by RTWG. Overall, the 2008 to 2009 monthly price series has the highest average simulated net returns. The simulated net return for RTWS is $188.90/acre, followed by NTWS with a net return of $181.03/acre, RTWC with a net return of $154.88/acre, and RTWG with a net return of $153.73/acre. The average simulated net returns for the 2007 to 2009 monthly price series are the next highest. RTWS has a net return of $169.51/acre. NTWS has a net return of $160.97/acre. RTWG has a net return of $146.52/acre and RTWC has a net return of $140.49/acre. The average simulated net returns are slightly higher for the 2006 to 2009 monthly price series than the 2009 price series: RTWS has a net return of $139.53/acre; NTWS has a net return of $130.61/acre; RTWG has a net return of $119.42/acre; RTWC has a net return of $111.43/acre. The average simulated net returns for 2009 are $138.60/acre for RTWS, $129.16/acre for NTWS, $90.13/acre for RTWC and $87.98/acre for RTWG.

4.6a CDF Results for Simulated Price Distributions

Cumulative probability distribution functions were created for the simulated net returns using SIMETAR©. The first noticeable difference between the historic return CDFs (Figure 4.1) and the CDFs for the simulated returns (Figures 4.3-4.6) is the difference in the level of net returns. The historic yields and prices, coupled with the present day input cost, made the first set of net returns substantially lower. All of the CDFs for the historic prices have a minimum net return of at least negative $50.00/acre and maximum net returns that do not exceed $200.00/acre. While the CDFs for the simulated price distributions still have negative minimum net returns, the minimums are higher and maximum net returns now reach above $500.00/acre.

Figure 4.3 shows the CDFs of net returns for the 2006 to 2009 crop price distribution. RTWS once again has the highest net returns approximately 89 percent of the time compared to

NTWS. Figure 4.4 shows the CDFs for the 2007 to 2009 crop price distribution. Only one system has a minimum net return less than negative $60.00/acre. RTWS experiences higher net returns 78 percent of the time compared to NTWS. RTGG-M has one of the highest minimum net returns, so an extremely risk-averse producer might consider this system, but as Figure 4.4 shows, it ends up having one of the lowest maximum net returns. The CDFs for the 2008 to 2009 simulated net returns are found in Figure 4.5. Again, the higher average crop prices result in higher minimum net returns, with only one system having a minimum net return below negative $50.00/acre. RTWS and NTWS CDFs cross at the 0.78 probability line, meaning RTWS experiences higher returns than the NTWS rotation approximately 78 percent of the time. For the 2009 simulated net returns, (Figure 4.6) the CDFs experience minimum net returns lower than previous simulations. RTWS still has the highest net return, but only 72 percent of the time, compared to the previous 78 percent or better in the simulations.

4.6b Simulated Price Distributions SERF Results

Risk premiums at the lower end of the RAC range vary for the simulated 2006 to 2009 net returns (Figure 4.7). A complete listing of risk premiums for the 2006 to 2009 monthly price series can be found in Table 4.8. RTWS is the preferred system, followed by NTWS and RTWG. At an RAC of zero, or risk neutrality, NTWS requires an additional $8.92/acre to be equally preferred to RTWS. Risk premiums for NTWS remain mostly constant, near $10.50/acre as risk aversion increases. At an RAC of zero, RTWG requires an additional $20.10/acre to be equally preferred to RTWS. At an RAC of 0.03, RTWG crosses NTWS, and risk premiums decrease as risk aversion increases. At the very high risk aversion level of 0.12, RTWG risk premium is $8.51/acre. This means that any producer that is at least moderately risk-averse will prefer RTWG to NTWS.

At an RAC of zero, RTWC requires an additional $28.10/acre to be equally preferred to RTWS and an additional $42.41/acre for NTWG. As risk aversion increases, the risk premiums decline, and NTWG crosses RTWC. Extremely risk-averse producers (0.12) now will choose NTWG, as it slightly preferred to the RTWC system.

For the 2007 to 2009 monthly price series (Figure 4.8), RTWS is the preferred system. NTWS requires an additional $8.54/acre to be equally preferred to RTWS at an RAC of zero. Risk premiums for NTWS remain mostly constant across all levels of risk aversion. RTWG is the next-preferred system with an additional $22.99/acre needed to be equally preferred to RTWS at an RAC of zero. RTWG passes NTWS as the next-preferred system at an RAC of 0.03. RTWC is the next-preferred system at risk neutrality, but it too passes RTWG and NTWS at an RAC of 0.1. A moderately risk-averse producer will choose RTWG over NTWS. Likewise, a moderately risk-averse producer will still choose NTWS over RTWC, but, at an incredibly high level of risk aversion (0.1), that same producer will choose RTWC over RTWG and NTWS.

SERF analysis for the 2008 to 2009 monthly price series (Figure 4.9) also has NTWS as the next-preferred rotation to RTWS. An additional $7.87/acre is needed for NTWS to be equally preferred to RTWS at an RAC of zero. No other system becomes more preferred than the NTWS. RTWC and RTWG require additional returns of $34.02 and $35.17/acre, respectively, to be equally preferred with RTWS at risk neutrality. A cross right after risk neutrality allows RTWG to become the more preferred system by moderately risk-averse producers. It is not until very high levels of risk aversion are reached that RTWC again becomes more preferred by producers.

For the January 2009 to December 2009 price series, NTWS is again the next-preferred system after RTWS by all producers regardless of risk aversion level (Figure 4.10). At an RAC of zero, NTWS requires an additional $9.43/acre to be equally preferred to RTWS. Risk premiums for NTWS stay mostly constant for all levels of risk aversion. RTWG is the next system that most moderately risk-averse producers will choose.

The primary difference between the 2006 to 2009 simulated SERF results and the other price series results is the range of risk premiums. Risk premiums across all levels of risk aversion are smallest for the 2006 to 2009 period. Risk premiums at an RAC of zero for NTWS vary some, but are mostly constant across simulations. RTWG and RTWC risk premiums increase over each period from $22.99 and $29.01/acre for the 2006 to 2009 period to $50.61 and $48.45/acre for 2009. The range or difference in risk premiums increases as the monthly price series gets shorter.

4.7 Herbicide Cost Sensitivity Analysis

Over the last three or four years, herbicide prices, especially glyphosate-based products, have been quite variable. Therefore, a sensitivity analysis was conducted to examine the impact of changes in herbicide prices on the net returns for each system. Several scenarios were analyzed; these include a 10 and 20 percent reduction in the price of all herbicides used for the systems and two different changes in the price of glyphosate. The base analysis uses the spring 2009 price for Roundup Original MAX, which was $59.35/gallon at the Andale Farmer's Cooperative. The sensitivity analysis compared this with the 2010 price of Roundup PowerMAX, which lists for $37.00/gallon in the 2010 Chemical Weed Control handbook published by Kansas State University Research and Extension (Thompson et al., 2010). The sensitivity analysis also compared the Original MAX price to the 2010 price for the generic glyphosate product, Cornerstone Plus, which sells for $16.25/gallon at the Andale Farmer's Cooperative. The results for each price scenario listing the chemical cost, total cost and net return for each system are reported in Table 4.9. For additional comparison historical glyphosate prices from 1997-2009 are located in Table E.1 and Figure E.1 in Appendix E. These historic glyphosate prices are from the USDA's Agriculture Prices Summary reports (USDA-NASS, 2009).

The 10 percent price reduction of the herbicides is not enough to change the order of net returns in terms of profitability by system. RTWS, NTWS, RTWC, RTWG and BWW are still the most profitable systems and the monoculture grain sorghum systems still experience the lowest net returns. Overall, the 10 percent price reduction of the herbicides results in a $2.83/acre increase in net returns from the base scenario across all the systems on average.

RTWS, NTWS, RTWC and RTWG still have the highest net returns even with the 20 percent price decrease. NTWG becomes the fifth highest net return instead of BWW. Overall, a 20 percent price reduction on herbicides results in a $5.66/acre increase in net returns from the base scenario across all the systems on average. Figure 4.11 compares the net returns in a bar chart for the base scenario, 10 percent price reduction, and 20 percent price reduction by cropping system.

The next part of the herbicide sensitivity analysis looks specifically at the price of Roundup or glyphosate-based herbicides. In 2008 and early 2009, the price of Roundup and other generic glyphosate herbicides were twice as expensive as they are now. Roundup Original MAX is the glyphosate herbicide used in the budgets and sold for $59.35/gallon in 2009. Monsanto's replacement for Original MAX is Monsanto's Roundup PowerMAX, which sells for $37.00/gallon. The lower PowerMAX price continues to narrow the difference between RTWS and NTWS net returns; however, RTWS remains the most profitable system by $2.33/acre. RTWS, NTWS, RTWC and RTWG still have the highest net returns. NTWG becomes the fifth highest net return instead of BWW. Overall, the lower price of the PowerMAX results in a $4.10/acre increase in net returns from the base scenario across all the systems on average.

The final scenario of the herbicide sensitivity analysis compares the base model that uses the Roundup Original MAX versus a cheaper generic glyphosate product (Cornerstone Plus) that many farmers might choose. At $16.25/acre, the generic glyphosate is three and a half times less expensive than the Roundup Original MAX ($59.35). In spite of that, the largest difference in net returns for a system between the two price levels is approximately $15.00/acre. The lower price of the generic glyphosate allows NTWS to surpass RTWS as the most profitable rotation by an additional $4.26/acre. RTWC and RTWC remain the systems with the next highest net returns. The lower glyphosate price allows NTWW to move from the being the seventh highest net return in the base scenario to fifth. NTWG and NTWC are the sixth and seventh most profitable systems at both the Roundup Original MAX price ($59.35/gallon) and the generic glyphosate price ($16.25/gallon). BWW falls from the fifth highest net return under the Original MAX price to the eighth highest return under then generic glyphosate price. Overall, the lower price of the generic glyphosate results in a $7.91/acre increase in net returns from the base scenario across all the systems on average. Figure 4.12 compares the net returns in a bar chart for the base scenario (Roundup Original MAX) with Roundup PowerMAX, and the generic glyphosate product (Cornerstone Plus) by cropping system.

A break-even analysis was also conducted to find the exact glyphosate price where NTWS becomes more profitable than RTWS by using the solver add-in on Microsoft Excel. The calculation results indicate that when glyphosate herbicide reaches a price of $29.66/gallon the NTWS and RTWS returns are equal. NTWS becomes the more profitable system for any glyphosate price below the $29.66/gallon.

An important trend emerges when the 20 percent price reduction scenario for all herbicides is compared with the generic glyphosate scenario. Seven of the 13 systems experience higher net returns under the 20 percent price reduction than under the generic glyphosate returns. Six of those seven systems are reduced-till. Conversely, the remaining six no-till systems experience higher net returns under the generic glyphosate scenario than the 20 percent price reduction. This trend is logical, as the no-till systems have more Roundup applications throughout the season. Additionally, the RTGG, BWW and RTWW systems do not receive any Roundup applications throughout the season.

4.7a Herbicide Cost Sensitivity Analysis SERF Results

A SERF analysis was conducted using the simulated 2006-2009 monthly crop price series, the historic crop yields, and the 2009 inputs cost with one change: the glyphosate price used was changed from the brand name Roundup Original MAX ($59.35/acre) previously used to the generic glyphosate product, Cornerstone Plus ($16.25/acre). Glyphosate is the primary herbicide used amongst the systems, and it is reasonable to assume that many producers are or would be willing to use the cheaper glyphosate product. The SERF analysis now determines what effect, if any, using the cheaper glyphosate product has on a producers' cropping system selection across various levels of risk aversion.

The risk premiums found in Table 4.10 and illustrated in Figure 4.13 indicate that NTWS now becomes the most preferred system across all levels of risk aversion. RTWS follows closely as the next-preferred system across all levels of risk aversion. At an RAC of zero, RTWS would require an additional \$4.67/acre in net returns to be equally preferred to NTWS. At extremely high levels of risk aversion, RTWS would still require \$2.20/acre to be equally preferred to NTWS. The RTWG system is the third preferred system by producers. However, this system would require a significant increase in net returns (\$25.71-\$28.80/acre) to be equally preferred to NTWS. As the sensitivity analysis indicated, reducing the price of glyphosate allows NTWS to surpass RTWS as the system with the highest net returns. The SERF analysis results found the same to be true, and the producers' level of risk aversion did not change the outcome of preferred systems.

4.8 Fertilizer Costs Sensitivity Analysis

In the past few years' fertilizer, an input traditionally not known for price volatility has experienced wild price swings. To evaluate the effect of these large price fluctuations on a producer's net returns sensitivity analysis was conducted. Three scenarios were analyzed. The first analysis compared the enterprise budget net returns that were calculated using the 2009 fertilizer prices and the 2009 glyphosate price (\$59.35/gallon) with the net returns calculated using the 1997 price for urea and DAP and the 2009 glyphosate price. The second analysis compared the net returns that were calculated using the 2009 fertilizer prices and the 2010 generic glyphosate price (\$16.25/gallon) with the net returns calculated using the 1997 price for urea and DAP and the generic glyphosate price. The analysis was also conducted using the generic glyphosate price relying on the assumption that given the choice many producers would choose to use the lower priced generic glyphosate herbicides to the more expensive name-brand glyphosate herbicides. The third and final analysis compared the net returns calculated with the 2009 fertilizer price and 2010 generic glyphosate with the net returns calculated for 2008 fertilizer price and the 2010 generic glyphosate price. The 2009 prices for urea and DAP was obtained from the Andale Farmer's Cooperative, which is near Hesston (Youk, 2009). The historic fertilizer prices for urea and DAP from 1997-2008 were attained from the USDA's Agricultural Prices Summary reports (USDA-NASS, 2009). Table E.2 and Figure E.2 in Appendix E illustrate these fertilizer prices over time.

In the first analysis, the price of urea and DAP were changed from the 2009 price levels of $400.00/ton and $445.00/ton to the lower prices from 1997. The experiment began in 1997 and these fertilizers happened to be near the lowest price/ton at this time as well. On average, urea was $247.00/ton and DAP was $257.00/ton (USDA-NASS, 2009). All other inputs were kept at their respective 2009 costs.

The results indicate that the order of systems in terms of relative profitability by net return do not change from the enterprise budget net return rankings. RTWS, NTWS, RTWC, and RTWG are again the systems with the highest net returns. The lower priced urea and DAP from 1997 result in a $13.87/acre increase in net returns for the RTWS and NTWS systems above the enterprise budget net returns calculated with the 2009 fertilizer costs. The RTWC and RTWG systems experience a $26.80/acre and $25.60/acre increase in net returns above the enterprise budget net returns.

For the second analysis, the price of urea and DAP were kept at the lower 1997 prices, but the 2010 generic glyphosate price was used in place of the 2009 name brand glyphosate. Using the generic glyphosate price changes the order of systems in terms of relative profitability by net return very little. NTWS surpasses RTWS and becomes the system with the highest net return. RTWC and RTWG remain the systems with the next highest net returns. The lower priced urea and DAP from 1997 result in a $13.88/acre and $13.87/acre increase in net returns for NTWS and RTWS above the net returns calculated with the 2009 fertilizer costs and generic glyphosate price. The RTWC and RTWG systems experience a $26.10/acre and $25.59/acre increase in net returns above the net returns calculated with the 2009 fertilizer costs and the generic glyphosate price.

In the third analysis, the price of urea and DAP were changed from the 2009 price levels to a higher price from 2008. The fertilizer price levels reached their highest price per ton in 2008. On average, urea was $537.00/ton and DAP was $876.00/ton (USDA-NASS, 2009). This analysis also used the generic glyphosate price. Even though the fertilizer prices were higher for this analysis, the results did not change. NTWS, RTWS, RTWC, and RTWG are again the systems with the highest net returns, only now the net returns decrease instead of increase as they do in the other sensitivity analysis. The higher priced urea and DAP results in an $18.82/acre and $18.83/acre decrease in net returns for NTWS and RTWS from the net returns calculated using the 2009 fertilizer costs and generic glyphosate price. The RTWC and RTWG systems experience a decrease of $33.87/acre and $33.43/acre in net returns from the net returns calculated using the 2009 fertilizer costs and generic glyphosate price.

As the results indicate, the changes in fertilizer cost, in either direction, are still not enough to change the order of systems by highest net return. The differences in net returns are larger for the corn and grain sorghum systems because both of these systems receive urea applications that the soybean rotations do not.

Table 4.1. Summary Statistics of Ten Year Yield Averages (1997-2006).

System[1]	RTWS		NTWS		RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG		NTWG		RTWC		NTWC	
Crop	Wheat	Soybean	Wheat	Soybean	Sorghum	Sorghum	Sorghum	Sorghum	Wheat	Wheat	Wheat	Wheat	Sorghum	Wheat	Sorghum	Wheat	Corn	Wheat	Corn
Mean (bu./acre)	57.68	28.62	60.12	28.58	73.08	73.11	64.59	68.22	48.79	46.48	49.66	49.35	88.41	48.16	90.52	57.52	71.62	57.89	66.06
Std Dev.	11.35	14.43	10.96	14.74	23.72	25.29	17.67	19.37	15.45	18.62	13.24	11.99	35.03	11.72	30.97	12.27	34.37	14.39	31.62
CV	0.20	0.50	0.18	0.52	0.32	0.35	0.27	0.28	0.32	0.40	0.27	0.24	0.40	0.24	0.34	0.21	0.48	0.25	0.48
Min	45.35	7.73	47.58	7.88	42.38	44.77	43.97	45.41	29.74	14.27	29.29	30.63	43.33	36.43	51.46	43.27	37.28	42.23	31.07
Max	78.81	51.60	83.86	51.15	115.66	125.54	88.42	100.21	74.20	76.88	71.82	64.83	156.93	68.70	145.78	83.57	137.65	89.07	135.10

[1] RT = Reduced-till, NT = No-till, B = Burn, WS = Wheat-Soybean, GG-M = Continuous Grain Sorghum May planted, GG-J = Continuous Grain Sorghum June planted, WW = Continuous Wheat, WG = Wheat-Grain Sorghum, WC = Wheat-Corn

Table 4.2. Summary Statistics in $/acre (Average of 1997-2006 Yields, 2009 Crop Prices, & 2009 Input Costs).

Systems[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
Costs													
Tillage	$19.68	$0.00	$29.09	$0.00	$40.28	$0.00	$40.63	$39.79	$0.00	$19.68	$0.00	$18.56	$0.00
Planting	$14.77	$15.42	$14.12	$15.41	$14.12	$15.41	$15.43	$15.43	$15.43	$14.77	$15.42	$14.77	$15.42
Seeds	$25.38	$25.38	$8.76	$8.76	$8.76	$8.76	$14.25	$14.25	$14.25	$11.50	$11.50	$24.25	$24.25
Chemicals application	$5.64	$14.40	$5.01	$11.27	$5.01	$12.53	$1.25	$2.51	$16.28	$4.38	$14.40	$5.01	$13.78
Chemicals	$13.96	$38.86	$27.35	$47.44	$27.30	$50.35	$2.71	$6.33	$42.21	$16.91	$45.76	$18.34	$44.41
Chemicals (applic.+ inputs)	$19.60	$53.26	$32.36	$58.71	$32.31	$62.87	$3.96	$8.84	$58.50	$21.29	$60.17	$23.35	$58.19
Fertilizer Application	$2.48	$2.48	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96	$4.96
Fertilizer	$33.79	$33.79	$62.00	$62.00	$62.00	$62.00	$63.12	$63.12	$63.12	$62.56	$62.56	$63.82	$63.82
Fertilizer (applic.+ inputs)	$36.27	$36.27	$66.96	$66.96	$66.96	$66.96	$68.08	$68.08	$68.08	$67.52	$67.52	$68.78	$68.78
Harvest[2]	$28.20	$28.45	$31.00	$31.01	$29.16	$29.95	$27.51	$27.03	$27.70	$30.97	$31.07	$28.30	$27.97
Interest	$5.76	$6.35	$7.29	$7.23	$7.66	$7.36	$6.79	$6.94	$7.36	$6.63	$7.43	$7.12	$7.78
Total cost	$149.66	$165.13	$189.57	$188.07	$199.25	$191.31	$176.67	$180.36	$191.32	$172.37	$193.11	$185.13	$202.39
Gross return	$288.49	$294.53	$219.24	$219.33	$193.76	$204.66	$250.28	$238.45	$254.78	$259.20	$259.32	$275.01	$266.07
Net Return	$138.83	$129.40	$29.67	$31.26	-$5.49	$13.35	$73.61	$58.10	$63.46	$86.82	$66.21	$89.88	$63.67

[1] RT = Reduced-till, NT = No-till, B = Burn, WS = Wheat-Soybean, GG-M = Continuous Grain Sorghum May planted, GG-J = Continous Grain Sorghum June planted, WW = Continous Wheat, WG = Wheat-Grain Sorghum, WC = Wheat-Corn

[2] Based on 10 year average crop yield

Table 4.3. Gross Returns ($/acre) Calculated using 1997-2006 Yields, 1997-2006 Prices, & 2009 Input Costs.

System[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
1997	$326.53	$341.85	$203.40	$192.64	$199.09	$225.64	$274.35	$284.25	$218.82	$228.17	$203.67	$313.90	$298.61
1998	$131.47	$132.87	$190.13	$184.23	$92.27	$96.00	$117.43	$117.43	$122.40	$161.96	$163.21	$123.60	$119.04
1999	$151.21	$159.66	$140.42	$137.63	$163.10	$157.20	$88.73	$39.26	$80.56	$125.84	$152.93	$132.50	$135.45
2000	$138.03	$139.87	$163.41	$169.00	$85.74	$99.10	$129.22	$113.27	$119.81	$158.11	$157.31	$117.00	$106.74
2001	$94.06	$99.75	$91.65	$91.96	$109.98	$119.61	$106.30	$109.60	$101.77	$110.40	$110.17	$111.50	$98.77
2002	$140.10	$134.90	$102.57	$103.54	$150.13	$150.46	$196.32	$179.75	$155.15	$152.94	$138.52	$132.47	$137.80
2003	$121.31	$121.53	$89.88	$94.95	$96.64	$96.30	$122.57	$146.01	$185.57	$142.65	$167.38	$142.34	$160.49
2004	$284.33	$287.16	$253.53	$275.18	$178.10	$189.97	$232.21	$234.29	$250.35	$284.98	$274.32	$297.62	$292.24
2005	$208.39	$192.80	$130.48	$128.62	$96.31	$96.93	$96.93	$85.29	$143.45	$162.58	$162.97	$180.00	$163.55
2006	$229.14	$249.51	$153.95	$141.43	$180.87	$200.20	$274.69	$264.15	$290.50	$218.76	$206.87	$230.32	$211.73
Mean	$182.46	$185.99	$151.94	$151.92	$135.22	$143.14	$163.88	$157.33	$166.84	$174.64	$173.73	$178.13	$172.44
Std Dev.	$76.66	$80.59	$52.79	$56.00	$43.38	$48.93	$73.57	$80.98	$68.21	$53.30	$45.17	$76.04	$72.42
CV	0.42	0.43	0.35	0.37	0.32	0.34	0.45	0.51	0.41	0.31	0.26	0.43	0.42
Min	$94.06	$99.75	$89.88	$91.96	$85.74	$96.00	$88.73	$39.26	$80.56	$110.40	$110.17	$111.50	$98.77
Max	$326.53	$341.85	$253.53	$275.18	$199.09	$225.64	$274.69	$284.25	$290.50	$284.98	$274.32	$313.90	$298.61

[1] For system descriptions see Table 4.1.

Table 4.4. Net Returns ($/acre) Calculated using 1997-2006 Yields, 1997-2006 Prices, & 2009 Input Costs.

System[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
1997	$172.32	$171.70	$9.95	$1.77	-$5.51	$27.15	$92.11	$97.22	$25.42	$52.32	$8.41	$120.62	$89.18
1998	-$16.93	-$30.95	-$4.93	-$8.65	-$103.10	-$91.04	-$57.80	-$61.99	-$67.68	-$11.58	-$31.15	-$60.46	-$81.92
1999	$2.16	-$5.45	-$48.91	-$49.88	-$40.43	-$36.89	-$84.31	-$135.51	-$106.29	-$44.19	-$40.30	-$51.40	-$66.15
2000	-$10.99	-$25.49	-$28.57	-$22.12	-$108.88	-$88.30	-$47.06	-$65.92	-$70.17	-$15.51	-$36.67	-$66.69	-$93.93
2001	-$53.96	-$63.73	-$92.07	-$90.29	-$87.44	-$70.15	-$68.08	-$69.24	-$86.71	-$57.31	-$78.34	-$72.26	-$102.65
2002	-$8.98	-$28.79	-$81.93	-$79.56	-$51.22	-$42.17	$17.60	-$2.09	-$35.35	-$16.72	-$50.76	-$51.35	-$63.79
2003	-$28.25	-$43.23	-$92.79	-$86.75	-$98.34	-$89.88	-$51.58	-$33.90	-$7.25	-$25.71	-$23.60	-$42.64	-$43.27
2004	$132.74	$120.02	$54.39	$75.33	-$24.90	-$5.48	$51.63	$49.38	$54.17	$103.22	$73.07	$104.31	$81.73
2005	$56.76	$26.75	-$57.71	-$57.85	-$99.53	-$90.22	-$75.56	-$90.60	-$46.63	-$9.19	-$29.46	-$6.60	-$39.13
2006	$78.49	$82.83	-$33.74	-$43.57	-$20.95	$5.33	$95.12	$80.91	$95.69	$47.33	$15.02	$44.49	$8.94
Mean	$32.33	$20.37	-$37.63	-$36.16	-$64.03	-$48.17	-$12.79	-$23.17	-$24.48	$2.27	-$19.38	-$8.20	-$31.10
Std Dev.	$74.87	$78.68	$47.61	$50.45	$39.52	$44.67	$70.35	$77.30	$65.44	$49.68	$42.11	$72.42	$69.09
CV	0.95	3.86	--	--	--	--	--	--	--	21.92	--	--	--
Min	-$53.96	-$63.73	-$92.79	-$90.29	-$108.88	-$91.04	-$84.31	-$135.51	-$106.29	-$57.31	-$78.34	-$72.26	-$102.65
Max	$172.32	$171.70	$54.39	$75.33	-$5.51	$27.15	$95.12	$97.22	$95.69	$103.22	$73.07	$120.62	$89.18

[1] For system descriptions see Table 4.1.

Table 4.5. Net Return ($/acre) Characteristics for 1997-2006 Yields, 2006-2009 Commodity Prices, & 2009 Input Costs.

	System[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
	Mean	$56.66	$46.44	-$15.64	-$14.07	-$45.53	-$28.94	$39.46	$25.41	$28.70	$42.15	$21.29	$28.33	$5.16
2006	Std Dev.	$52.78	$55.75	$51.13	$54.51	$38.08	$41.76	$65.05	$78.68	$55.76	$45.49	$39.42	$60.47	$58.66
Commodity	CV	0.93	1.20	--	--	--	--	1.65	3.10	1.94	1.08	1.85	2.13	11.36
Price	Min	-$13.08	-$20.73	-$81.81	-$75.16	-$89.97	-$78.12	-$40.74	-$111.53	-$57.08	-$11.53	-$34.64	-$22.23	-$55.20
	Max	$157.05	$156.83	$76.14	$98.94	$5.84	$40.01	$146.46	$153.54	$121.98	$148.58	$117.81	$140.12	$112.47
	Mean	$134.20	$125.78	$71.25	$72.86	$31.26	$52.17	$113.57	$96.03	$104.14	$132.19	$111.69	$116.18	$89.87
2007	Std Dev.	$74.55	$78.74	$79.34	$84.58	$59.09	$64.80	$88.52	$106.96	$75.88	$68.01	$58.77	$89.03	$85.67
Commodity	CV	0.56	0.63	1.11	1.16	1.89	1.24	0.78	1.11	0.73	0.51	0.53	0.77	0.95
Price	Min	$36.08	$31.36	-$31.42	-$21.93	-$37.68	-$24.13	$4.43	-$89.84	-$12.58	$52.30	$29.38	$42.00	$1.12
	Max	$275.26	$280.80	$213.68	$248.22	$110.98	$159.16	$259.18	$270.32	$231.09	$291.12	$254.40	$278.66	$243.20
	Mean	$241.52	$235.22	$150.64	$152.29	$101.43	$126.29	$50.46	$35.89	$39.89	$225.04	$204.62	$223.58	$193.32
2008	Std Dev.	$107.39	$113.38	$105.11	$112.05	$78.28	$85.85	$68.53	$82.88	$58.75	$89.97	$77.73	$124.30	$118.98
Commodity	CV	0.44	0.48	0.70	0.74	0.77	0.68	1.36	2.31	1.47	0.40	0.38	0.56	0.62
Price	Min	$101.24	$100.55	$14.62	$26.71	$10.09	$25.20	-$34.04	-$108.31	-$50.47	$119.39	$95.81	$120.26	$69.47
	Max	$441.86	$455.12	$339.33	$384.60	$207.04	$268.03	$163.19	$170.87	$138.18	$435.25	$393.28	$448.29	$402.97
	Mean	$138.37	$128.90	$29.67	$31.26	-$5.49	$13.35	$73.61	$57.95	$63.46	$86.82	$66.21	$88.69	$62.53
2009	Std Dev.	$84.49	$88.98	$65.84	$70.18	$49.03	$53.77	$75.86	$91.71	$65.03	$56.92	$49.21	$82.82	$79.18
Commodity	CV	0.61	0.69	2.22	2.25	--	4.03	1.03	1.58	1.02	0.66	0.74	0.93	1.27
Price	Min	$29.63	$25.01	-$55.54	-$47.40	-$62.71	-$49.97	-$19.93	-$101.53	-$36.57	$19.87	-$2.96	$19.71	-$20.63
	Max	$291.05	$296.11	$147.86	$176.77	$60.66	$102.14	$198.40	$207.35	$172.26	$219.92	$186.00	$237.73	$202.74

[1] For system descriptions see Table 4.1.

Figure 4.1. Cumulative Probability Distributions of Historical Net Returns for 1997-2006 using 2009 costs.

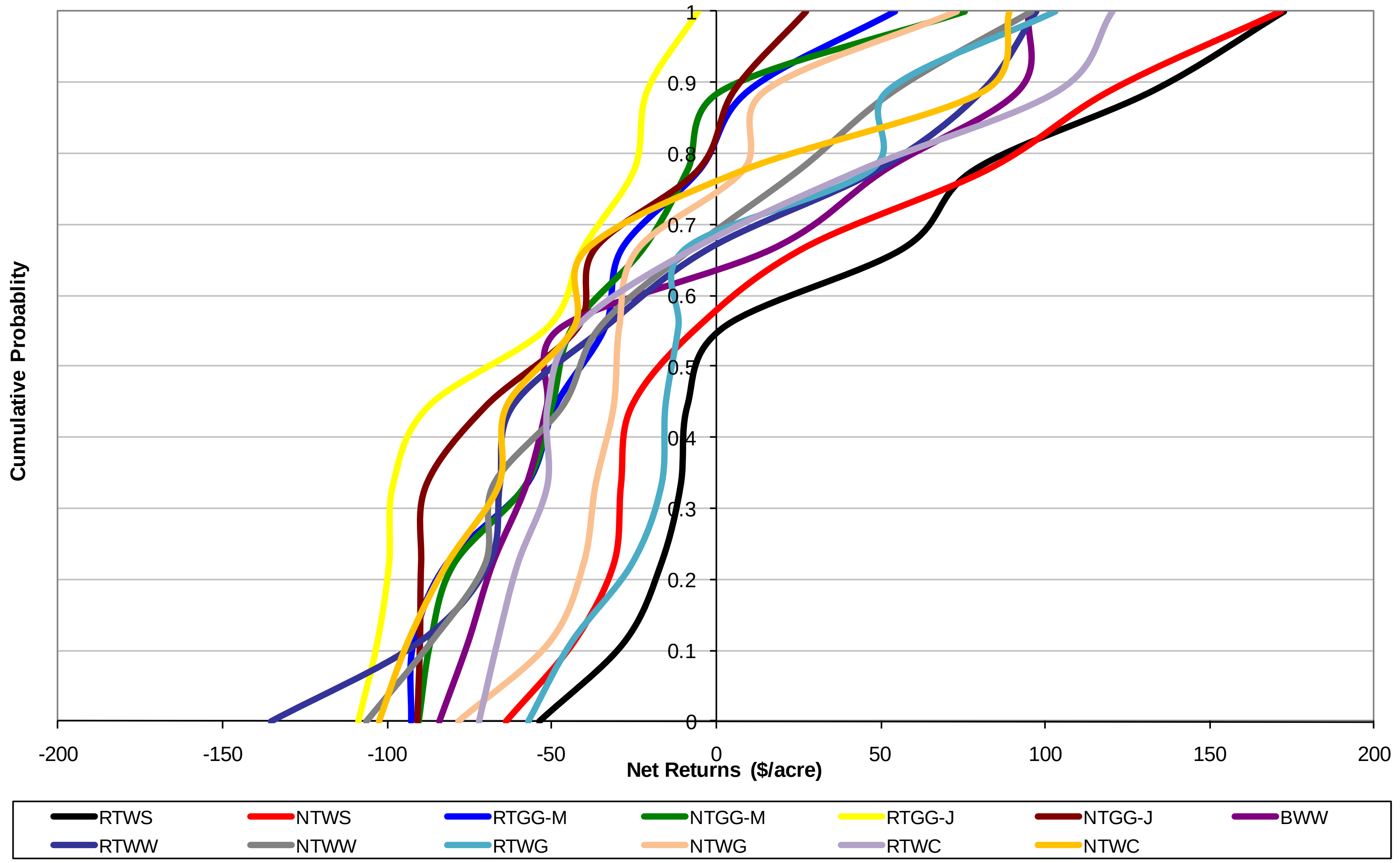


Figure 4.2. Risk Premiums Relative to RTWS for Historical 1997-2006 Net Returns.

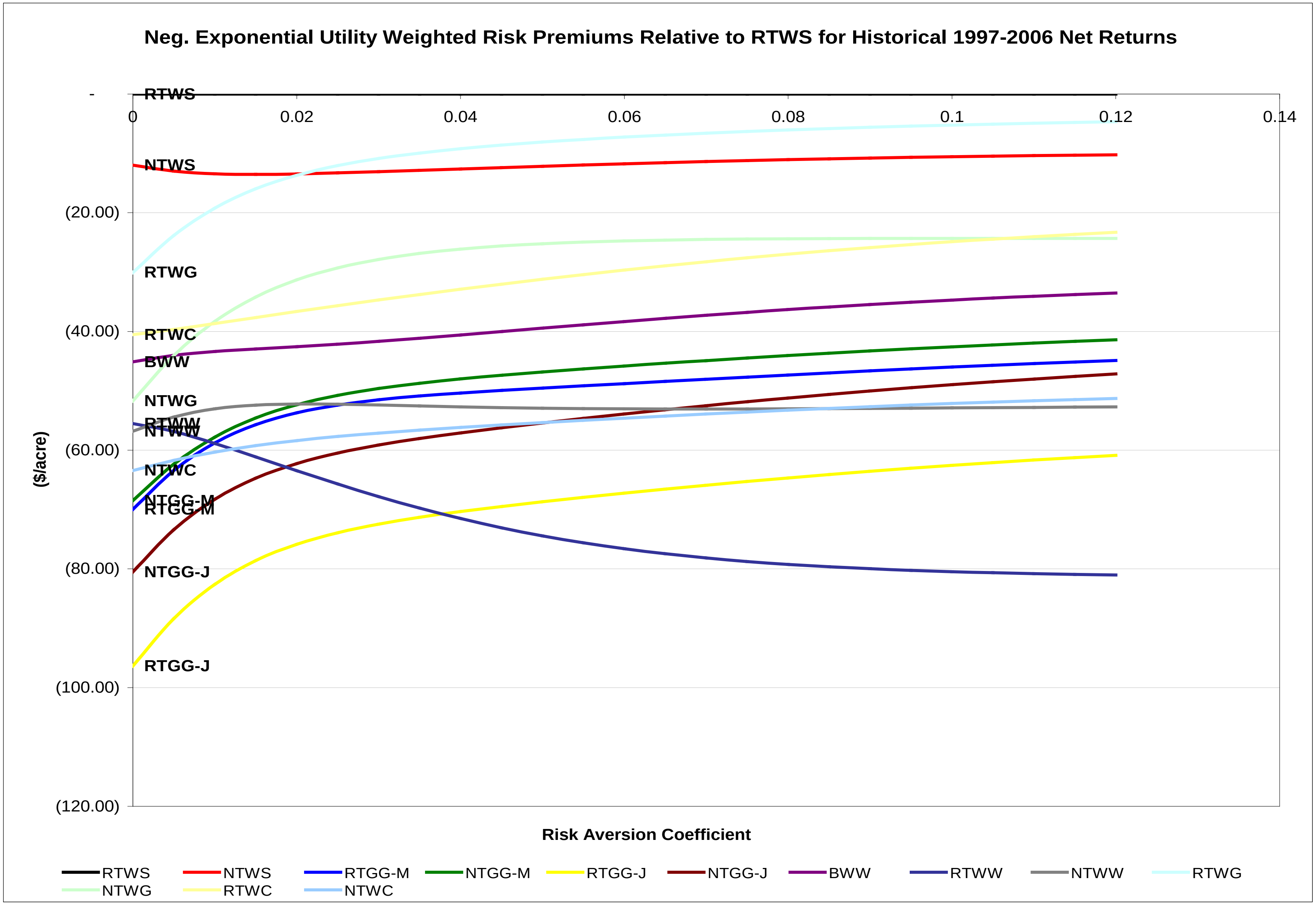


Table 4.6. Risk Premiums Relative to RTWS for 1997-2006.

ARAC	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
0	-	(11.97)	(69.96)	(68.49)	(96.36)	(80.50)	(45.13)	(55.51)	(56.82)	(30.07)	(51.71)	(40.53)	(63.43)
0.0050	-	(12.97)	(63.42)	(62.36)	(88.39)	(73.40)	(44.01)	(56.85)	(54.41)	(23.82)	(44.04)	(39.65)	(61.71)
0.0100	-	(13.42)	(58.79)	(57.79)	(82.61)	(68.27)	(43.38)	(58.86)	(53.03)	(19.21)	(38.29)	(38.66)	(60.31)
0.0150	-	(13.53)	(55.71)	(54.58)	(78.61)	(64.72)	(42.96)	(61.14)	(52.40)	(15.96)	(34.18)	(37.64)	(59.23)
0.0200	-	(13.45)	(53.71)	(52.34)	(75.85)	(62.26)	(42.56)	(63.46)	(52.20)	(13.68)	(31.31)	(36.63)	(58.38)
0.0250	-	(13.28)	(52.40)	(50.77)	(73.91)	(60.49)	(42.13)	(65.70)	(52.24)	(12.06)	(29.29)	(35.64)	(57.69)
0.0300	-	(13.07)	(51.51)	(49.61)	(72.46)	(59.14)	(41.65)	(67.81)	(52.37)	(10.86)	(27.86)	(34.69)	(57.12)
0.0350	-	(12.85)	(50.87)	(48.72)	(71.31)	(58.04)	(41.13)	(69.75)	(52.53)	(9.93)	(26.85)	(33.77)	(56.62)
0.0400	-	(12.62)	(50.37)	(48.00)	(70.35)	(57.09)	(40.58)	(71.50)	(52.69)	(9.20)	(26.12)	(32.88)	(56.17)
0.0450	-	(12.39)	(49.94)	(47.38)	(69.49)	(56.22)	(40.02)	(73.06)	(52.82)	(8.60)	(25.59)	(32.03)	(55.75)
0.0500	-	(12.17)	(49.54)	(46.82)	(68.70)	(55.41)	(39.44)	(74.43)	(52.92)	(8.08)	(25.21)	(31.21)	(55.35)
0.0550	-	(11.95)	(49.16)	(46.31)	(67.96)	(54.64)	(38.88)	(75.60)	(53.00)	(7.64)	(24.93)	(30.42)	(54.97)
0.0600	-	(11.74)	(48.79)	(45.82)	(67.25)	(53.90)	(38.32)	(76.61)	(53.04)	(7.25)	(24.73)	(29.66)	(54.60)
0.0650	-	(11.55)	(48.42)	(45.35)	(66.56)	(53.19)	(37.78)	(77.45)	(53.06)	(6.90)	(24.59)	(28.93)	(54.25)
0.0700	-	(11.37)	(48.05)	(44.90)	(65.91)	(52.50)	(37.26)	(78.16)	(53.06)	(6.58)	(24.49)	(28.24)	(53.90)
0.0750	-	(11.20)	(47.69)	(44.47)	(65.28)	(51.84)	(36.77)	(78.75)	(53.05)	(6.30)	(24.42)	(27.59)	(53.57)
0.0800	-	(11.04)	(47.33)	(44.06)	(64.67)	(51.21)	(36.30)	(79.23)	(53.03)	(6.04)	(24.37)	(26.98)	(53.25)
0.0850	-	(10.90)	(46.98)	(43.66)	(64.10)	(50.61)	(35.86)	(79.64)	(52.99)	(5.81)	(24.34)	(26.40)	(52.95)
0.0900	-	(10.77)	(46.64)	(43.28)	(63.55)	(50.03)	(35.45)	(79.97)	(52.95)	(5.59)	(24.32)	(25.85)	(52.66)
0.0950	-	(10.65)	(46.32)	(42.92)	(63.04)	(49.48)	(35.06)	(80.24)	(52.91)	(5.40)	(24.31)	(25.35)	(52.39)
0.1000	-	(10.55)	(46.00)	(42.58)	(62.55)	(48.96)	(34.71)	(80.47)	(52.87)	(5.22)	(24.31)	(24.87)	(52.13)
0.1050	-	(10.46)	(45.70)	(42.26)	(62.09)	(48.47)	(34.37)	(80.65)	(52.83)	(5.06)	(24.31)	(24.43)	(51.89)
0.1100	-	(10.37)	(45.41)	(41.95)	(61.66)	(48.01)	(34.07)	(80.80)	(52.79)	(4.91)	(24.31)	(24.02)	(51.67)
0.1150	-	(10.30)	(45.14)	(41.66)	(61.25)	(47.57)	(33.79)	(80.93)	(52.75)	(4.78)	(24.31)	(23.64)	(51.46)
0.1200	-	(10.24)	(44.88)	(41.39)	(60.87)	(47.15)	(33.52)	(81.03)	(52.71)	(4.66)	(24.31)	(23.29)	(51.27)

Table 4.7. Simulated Net Return ($/acre) Characteristics for Simulated Monthly Price Series.

	System[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
	Mean	$139.53	$130.61	$58.33	$58.19	$19.77	$40.22	$105.47	$87.02	$94.11	$119.42	$97.12	$111.43	$84.89
January 2006	Std. Dev	$102.39	$105.74	$68.36	$100.52	$60.38	$88.29	$110.93	$122.03	$99.15	$94.08	$88.34	$109.57	$103.95
to	CV	73.38	80.96	117.21	172.74	305.49	219.54	105.18	140.24	105.35	78.78	90.95	98.33	122.45
December 2009	Min	-$46.71	-$57.81	-$56.64	-$94.41	-$78.66	-$97.65	-$65.16	-$120.85	-$73.26	-$45.72	-$59.60	-$67.03	-$92.23
	Max	$564.45	$577.02	$241.91	$528.35	$180.99	$380.97	$540.78	$573.45	$499.99	$483.18	$430.40	$544.42	$517.02
	Mean	$169.51	$160.97	$82.18	$84.80	$40.93	$62.40	$128.91	$110.67	$119.50	$146.52	$125.08	$140.49	$112.62
January 2007	Std. Dev	$107.22	$109.68	$59.69	$105.80	$53.04	$84.04	$121.01	$134.24	$112.45	$98.53	$91.62	$112.86	$108.30
to	CV	63.26	68.14	72.64	124.77	129.58	134.68	93.87	121.30	94.10	67.25	73.25	80.33	96.16
December 2009	Min	-$21.01	-$31.03	-$5.41	-$63.72	-$34.62	-$63.84	-$44.01	-$111.59	-$60.46	-$32.40	-$32.32	-$20.86	-$51.77
	Max	$583.60	$533.93	$241.38	$527.78	$180.67	$385.05	$560.25	$544.05	$556.72	$516.20	$503.98	$632.73	$609.17
	Mean	$188.90	$181.03	$88.20	$87.74	$46.17	$69.30	$137.57	$117.71	$127.67	$153.73	$131.72	$154.88	$127.01
January 2008	Std. Dev	$114.93	$119.96	$72.43	$111.19	$63.71	$100.23	$125.00	$137.14	$113.03	$107.66	$101.11	$126.11	$120.96
to	CV	60.84	66.26	82.12	126.73	137.99	144.63	90.86	116.50	88.53	70.03	76.76	81.42	95.23
December 2009	Min	-$23.27	-$30.08	-$6.74	-$64.22	-$34.70	-$67.49	-$55.80	-$118.75	-$70.57	-$45.51	-$46.08	-$40.35	-$65.58
	Max	$591.19	$600.47	$242.78	$531.20	$180.62	$382.30	$579.92	$578.59	$517.81	$568.02	$569.90	$649.09	$598.48
	Mean	$138.60	$129.16	$29.91	$30.45	-$5.35	$13.52	$75.82	$59.46	$65.54	$87.98	$66.28	$90.13	$64.28
January 2009	Std. Dev	$81.47	$84.97	$18.30	$69.03	$16.13	$53.59	$77.72	$92.29	$69.24	$59.35	$52.45	$81.50	$78.48
to	CV	58.78	65.78	61.20	226.71	-301.48	396.41	102.52	155.23	105.65	67.46	79.14	90.43	122.10
December 2009	Min	-$17.96	-$23.61	-$8.21	-$64.09	-$35.49	-$66.82	-$53.09	-$117.45	-$71.90	-$36.48	-$36.92	-$38.63	-$67.75
	Max	$357.70	$357.31	$70.83	$235.79	$29.30	$149.24	$267.22	$278.66	$240.23	$273.87	$248.65	$331.66	$319.73

[1] For system descriptions see Table 4.1.

Figure 4.3. Cumulative Probability Distributions of Simulated Net Returns using 2006-2009 Commodity Prices.

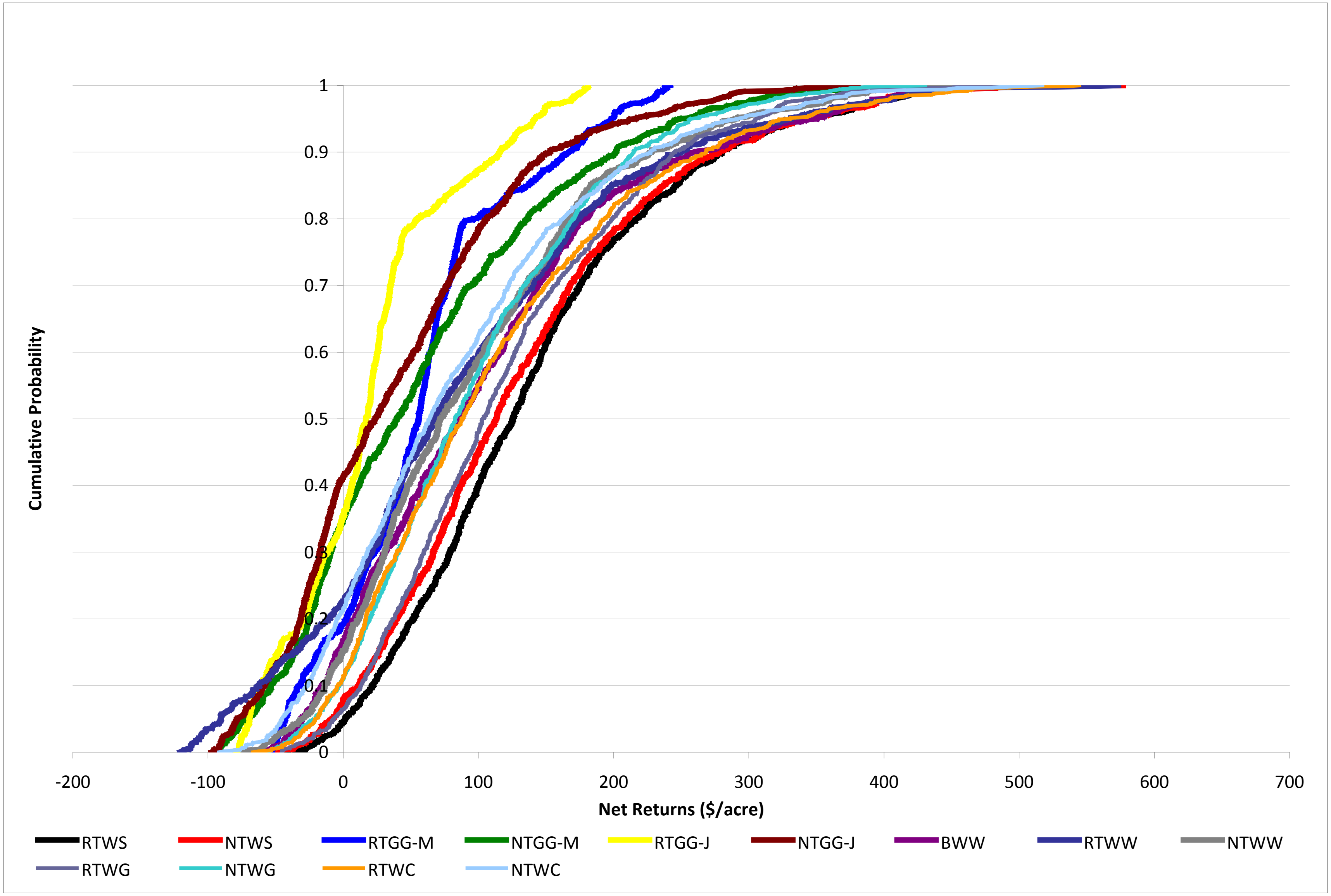


Figure 4.4. Cumulative Probability Distributions of Simulated Net Returns using 2007-2009 Commodity Prices.

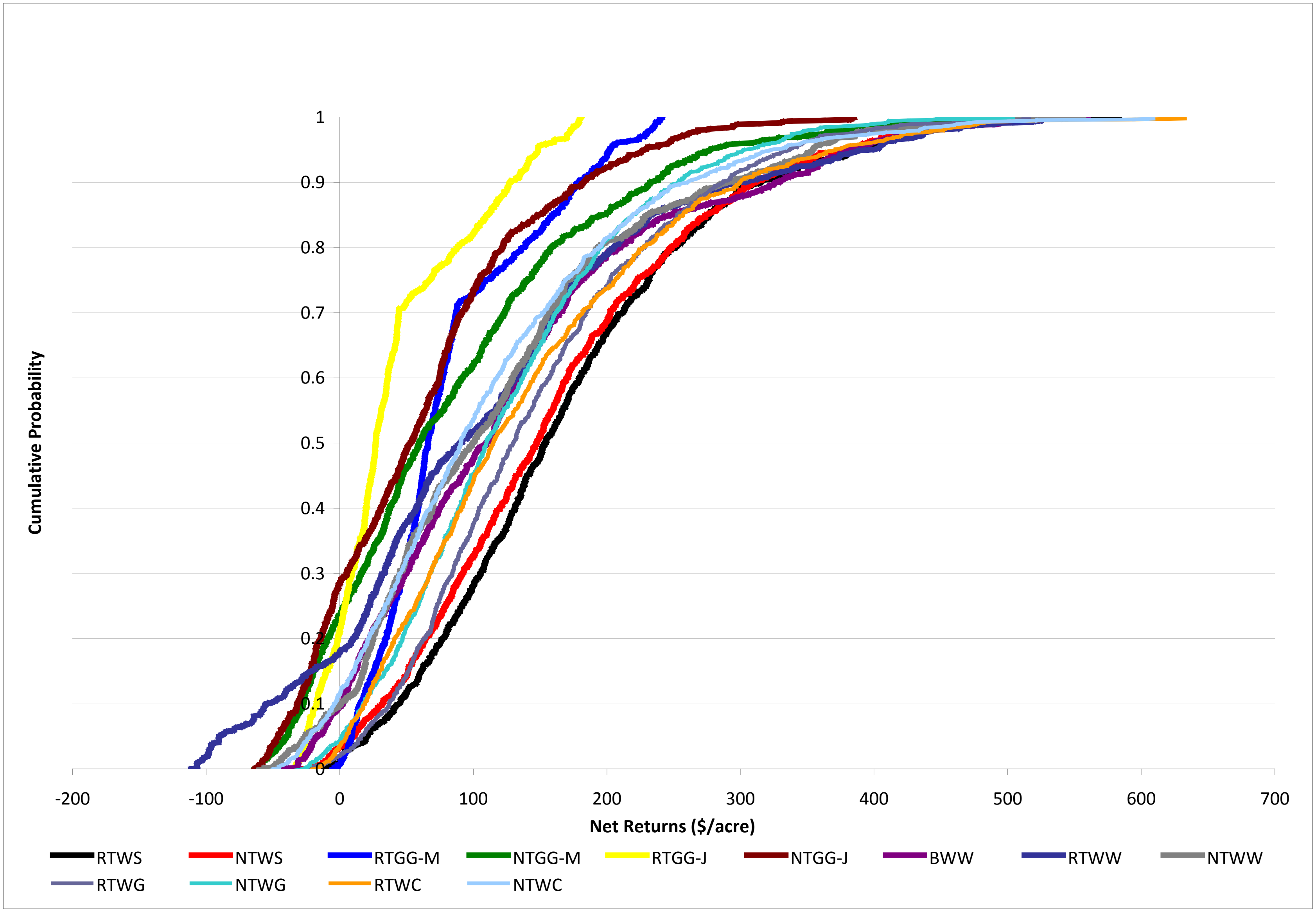


Figure 4.5. Cumulative Probability Distributions of Simulated Net Returns using 2008-2009 Commodity Prices.

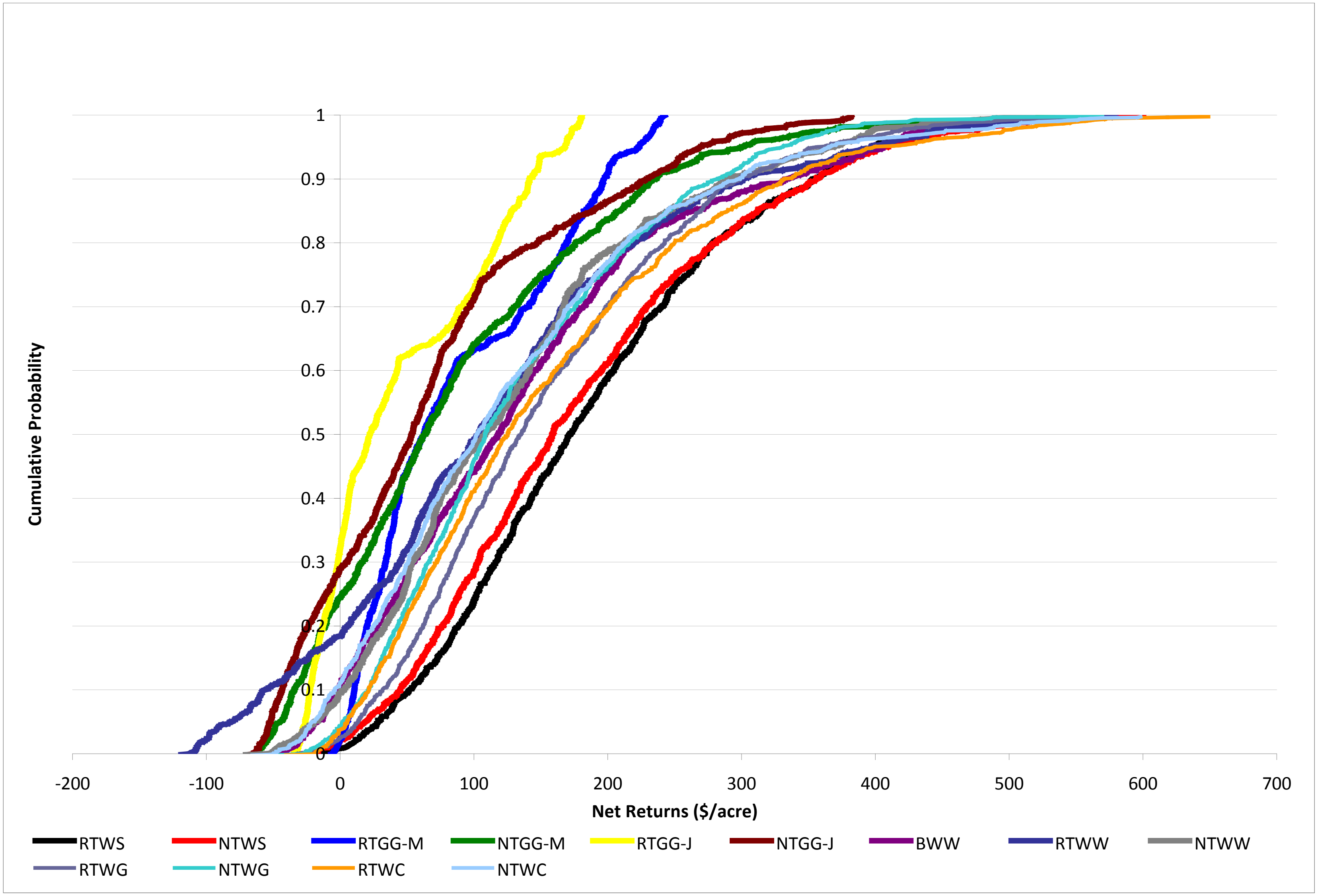


Figure 4.6. Cumulative Probability Distributions of Simulated Net Returns using 2009 Commodity Prices.

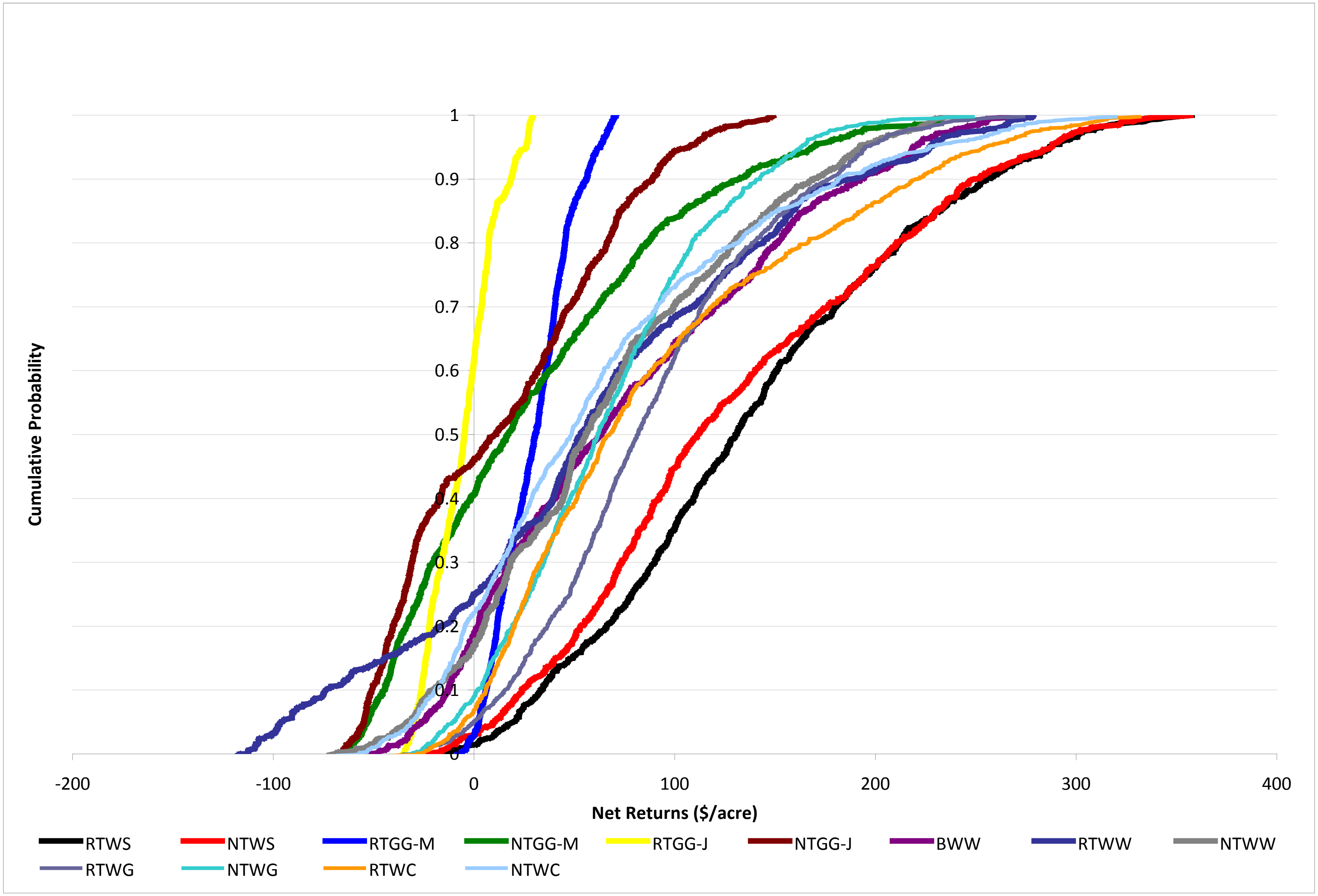


Figure 4.7. Risk Premiums Relative to RTWS for Simulated Net Returns using 2006-2009 Commodity Prices.

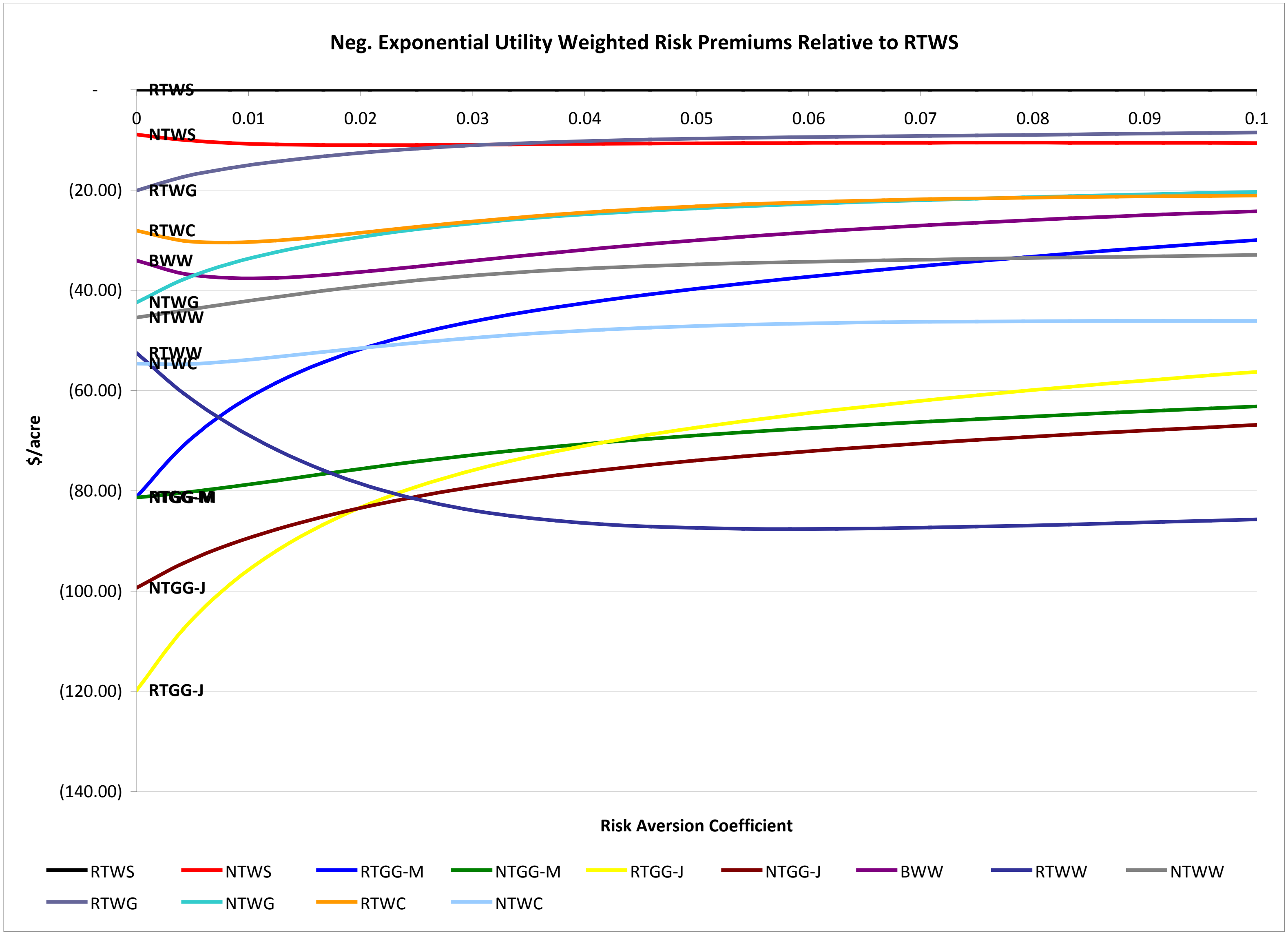


Figure 4.8. Risk Premiums Relative to RTWS for Simulated Net Returns using 2007-2009 Commodity Prices.

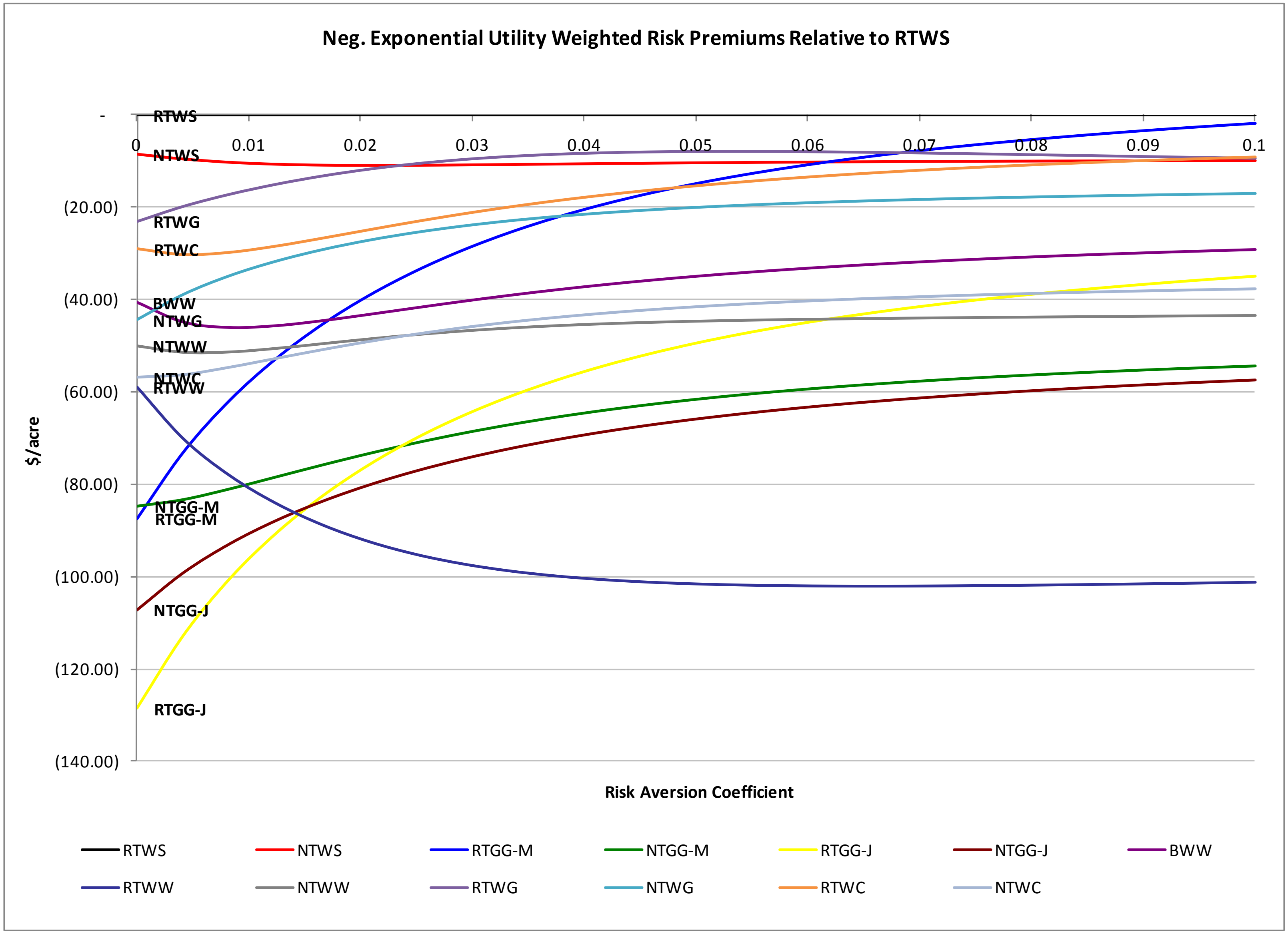


Figure 4.9. Risk Premiums Relative to RTWS for Simulated Net Returns using 2008-2009 Commodity Prices.

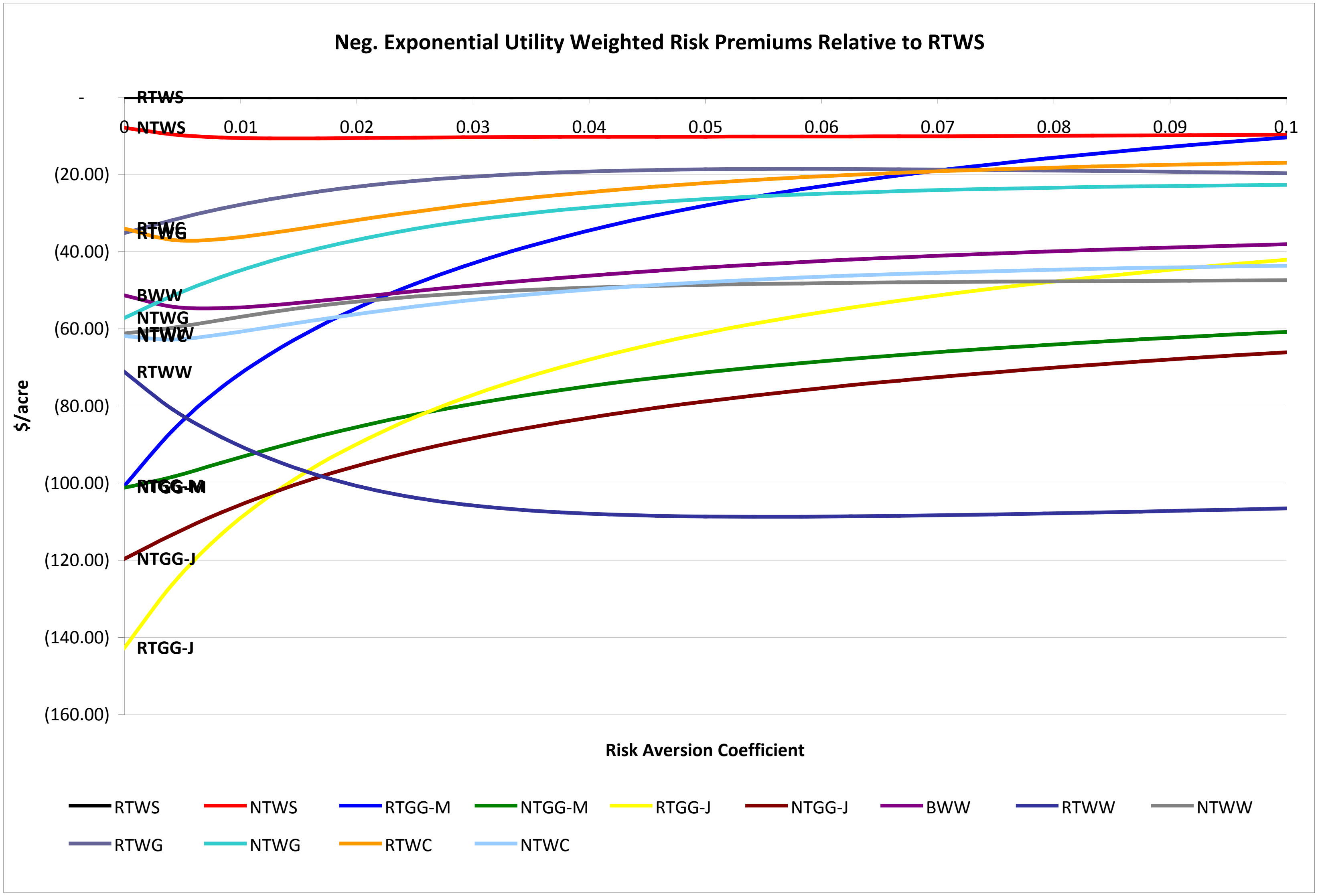


Figure 4.10. Risk Premiums Relative to RTWS for Simulated Net Returns using 2009 Commodity Prices.

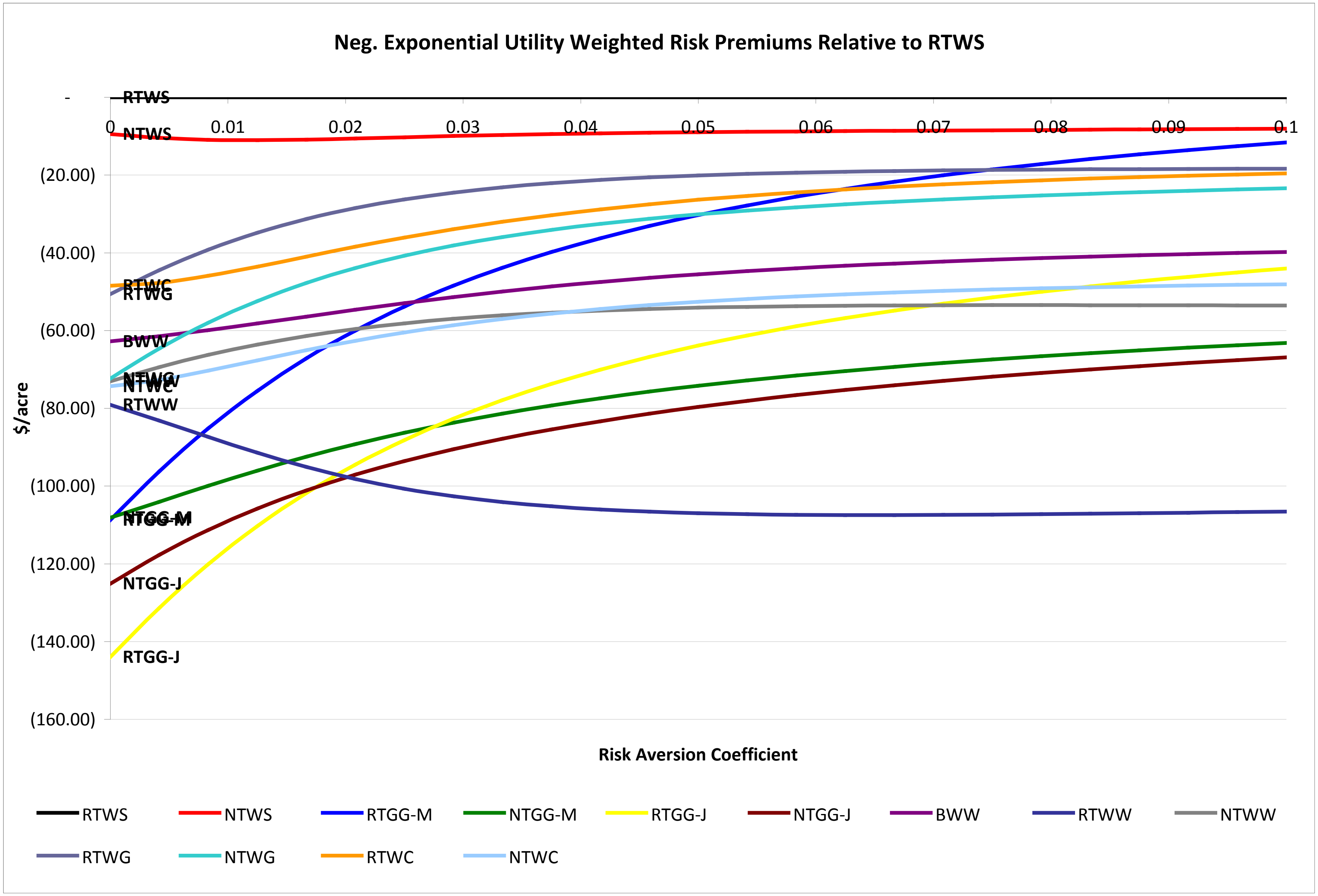


Table 4.8. Risk Premiums Relative to RTWS for Simulated Net Returns using 2006-2009 Commodity Prices.

ARAC	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
0.00	-	(8.92)	(81.21)	(81.34)	(119.77)	(99.31)	(34.06)	(52.51)	(45.42)	(20.11)	(42.41)	(28.10)	(54.64)
0.00	-	(10.03)	(71.00)	(80.38)	(107.59)	(94.44)	(36.65)	(60.49)	(44.03)	(17.39)	(37.82)	(30.10)	(54.74)
0.01	-	(10.62)	(63.73)	(79.22)	(98.68)	(90.69)	(37.54)	(66.74)	(42.65)	(15.60)	(34.68)	(30.49)	(54.16)
0.01	-	(10.92)	(58.39)	(77.95)	(91.95)	(87.68)	(37.51)	(71.81)	(41.33)	(14.30)	(32.36)	(30.07)	(53.28)
0.02	-	(11.03)	(54.34)	(76.64)	(86.72)	(85.16)	(36.98)	(75.91)	(40.10)	(13.27)	(30.55)	(29.27)	(52.31)
0.02	-	(11.05)	(51.19)	(75.36)	(82.56)	(83.01)	(36.19)	(79.16)	(38.99)	(12.43)	(29.07)	(28.32)	(51.34)
0.03	-	(11.02)	(48.67)	(74.16)	(79.19)	(81.15)	(35.27)	(81.67)	(38.03)	(11.75)	(27.84)	(27.35)	(50.44)
0.03	-	(10.96)	(46.60)	(73.06)	(76.41)	(79.54)	(34.31)	(83.56)	(37.20)	(11.19)	(26.82)	(26.44)	(49.64)
0.03	-	(10.90)	(44.86)	(72.06)	(74.07)	(78.13)	(33.36)	(84.95)	(36.52)	(10.75)	(25.96)	(25.61)	(48.94)
0.04	-	(10.83)	(43.35)	(71.16)	(72.07)	(76.89)	(32.44)	(85.96)	(35.96)	(10.41)	(25.24)	(24.88)	(48.35)
0.04	-	(10.77)	(42.02)	(70.35)	(70.32)	(75.79)	(31.57)	(86.66)	(35.50)	(10.14)	(24.63)	(24.25)	(47.86)
0.05	-	(10.72)	(40.80)	(69.62)	(68.77)	(74.81)	(30.76)	(87.12)	(35.13)	(9.92)	(24.10)	(23.70)	(47.46)
0.05	-	(10.68)	(39.69)	(68.94)	(67.38)	(73.93)	(30.01)	(87.41)	(34.83)	(9.75)	(23.65)	(23.24)	(47.13)
0.05	-	(10.64)	(38.65)	(68.32)	(66.11)	(73.12)	(29.31)	(87.56)	(34.58)	(9.61)	(23.25)	(22.86)	(46.87)
0.06	-	(10.62)	(37.67)	(67.74)	(64.94)	(72.38)	(28.66)	(87.60)	(34.37)	(9.49)	(22.89)	(22.53)	(46.67)
0.06	-	(10.60)	(36.74)	(67.20)	(63.85)	(71.69)	(28.06)	(87.57)	(34.18)	(9.38)	(22.56)	(22.25)	(46.51)
0.07	-	(10.58)	(35.86)	(66.68)	(62.82)	(71.05)	(27.51)	(87.47)	(34.02)	(9.29)	(22.26)	(22.02)	(46.38)
0.07	-	(10.57)	(35.02)	(66.18)	(61.86)	(70.44)	(26.99)	(87.32)	(33.87)	(9.19)	(21.99)	(21.83)	(46.29)
0.08	-	(10.57)	(34.21)	(65.71)	(60.95)	(69.86)	(26.51)	(87.14)	(33.73)	(9.10)	(21.72)	(21.67)	(46.22)
0.08	-	(10.57)	(33.43)	(65.25)	(60.08)	(69.31)	(26.06)	(86.93)	(33.59)	(9.01)	(21.47)	(21.53)	(46.17)
0.08	-	(10.58)	(32.69)	(64.81)	(59.25)	(68.78)	(25.64)	(86.70)	(33.46)	(8.92)	(21.24)	(21.42)	(46.13)
0.09	-	(10.58)	(31.98)	(64.38)	(58.46)	(68.27)	(25.25)	(86.46)	(33.33)	(8.82)	(21.01)	(21.32)	(46.11)
0.09	-	(10.60)	(31.29)	(63.96)	(57.70)	(67.78)	(24.88)	(86.20)	(33.21)	(8.72)	(20.79)	(21.24)	(46.10)
0.10	-	(10.61)	(30.63)	(63.56)	(56.98)	(67.31)	(24.54)	(85.94)	(33.08)	(8.61)	(20.57)	(21.17)	(46.09)
0.10	-	(10.63)	(29.99)	(63.17)	(56.29)	(66.86)	(24.22)	(85.67)	(32.95)	(8.51)	(20.36)	(21.11)	(46.09)

Table 4.9. Summary of Herbicide Price Sensitivity Analysis ($/acre).

	Systems[1]	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
BASE SCENARIO	Chemicals	$13.96	$38.86	$27.35	$47.44	$27.30	$50.35	$2.71	$6.33	$42.21	$16.91	$45.76	$18.34	$44.41
Roundup Original MAX	Total cost	$149.66	$165.13	$189.57	$188.07	$199.25	$191.31	$176.67	$180.36	$191.32	$172.37	$193.11	$185.13	$202.39
($59.35/gal.)[2]	Net Return	$138.83	$129.40	$29.67	$31.26	-$5.49	$13.35	$73.61	$58.10	$63.46	$86.82	$66.21	$89.88	$63.67
10% Price Reduction	Chemicals	$12.71	$35.11	$24.73	$43.06	$24.81	$45.50	$2.65	$6.22	$38.51	$15.26	$41.32	$16.55	$40.13
of all Herbicides	Total cost	$148.35	$161.24	$186.85	$183.52	$196.66	$186.26	$176.61	$180.23	$187.47	$170.66	$188.50	$183.27	$197.93
	Net Return	$140.14	$133.29	$32.38	$35.81	-$2.90	$18.40	$73.67	$58.22	$67.31	$88.54	$70.83	$91.74	$68.13
20% Price Reduction	Chemicals	$11.45	$31.37	$22.12	$38.68	$22.32	$40.65	$2.59	$6.10	$34.81	$13.62	$36.88	$14.76	$35.84
of all Herbicides	Total cost	$147.04	$157.34	$184.13	$178.97	$194.07	$181.21	$176.55	$180.11	$183.61	$168.95	$183.88	$181.41	$193.47
	Net Return	$141.45	$137.19	$35.10	$40.36	-$0.31	$23.44	$73.73	$58.34	$71.16	$90.25	$75.44	$93.60	$72.60
Roundup PowerMAX	Chemicals	$10.49	$28.55	$27.35	$43.24	$27.30	$44.13	$2.71	$6.33	$32.54	$15.59	$38.35	$16.54	$37.53
($37.00/gal.)[3]	Total cost	$146.04	$154.41	$189.57	$183.71	$199.25	$184.84	$176.67	$180.36	$181.26	$171.00	$185.41	$183.26	$195.24
	Net Return	$142.45	$140.12	$29.67	$35.62	-$5.49	$19.82	$73.61	$58.10	$73.52	$88.19	$73.92	$91.75	$70.83
Cornerstone Plus	Chemicals	$7.26	$18.98	$27.35	$39.34	$27.30	$38.36	$2.71	$6.33	$23.56	$14.37	$31.47	$14.87	$31.14
($16.25/gal.)[4]	Total cost	$142.68	$144.46	$189.57	$179.66	$199.25	$178.84	$176.67	$180.36	$171.92	$169.73	$178.25	$181.52	$188.59
	Net Return	$145.81	$150.07	$29.67	$39.68	-$5.49	$25.82	$73.61	$58.10	$82.86	$89.47	$81.07	$93.49	$77.48

[1] For a description of the systems, see Table 4.1.
[2] Roundup Original MAX is base scenario, price in $ 2009.
[3] Roundup PowerMAX, price in $ 2010.
[4] Cornerstone Plus is a generic glyphosate, price in $ 2010

Figure 4.11. Net Returns ($/acre) of Cropping Systems by Herbicide Price.

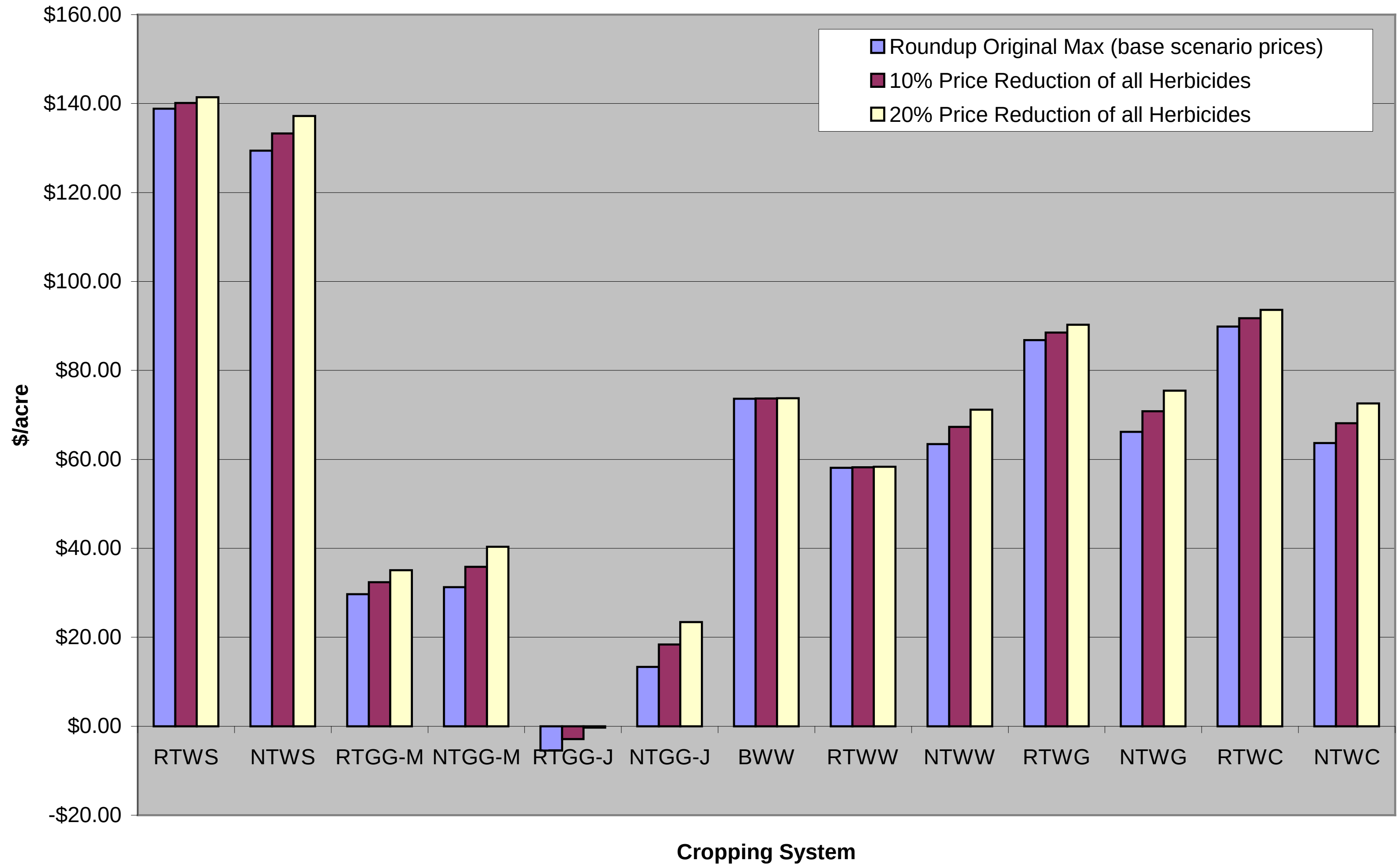


Figure 4.12. Net Returns ($/acre) by Cropping System at Various Glyphosate Prices.

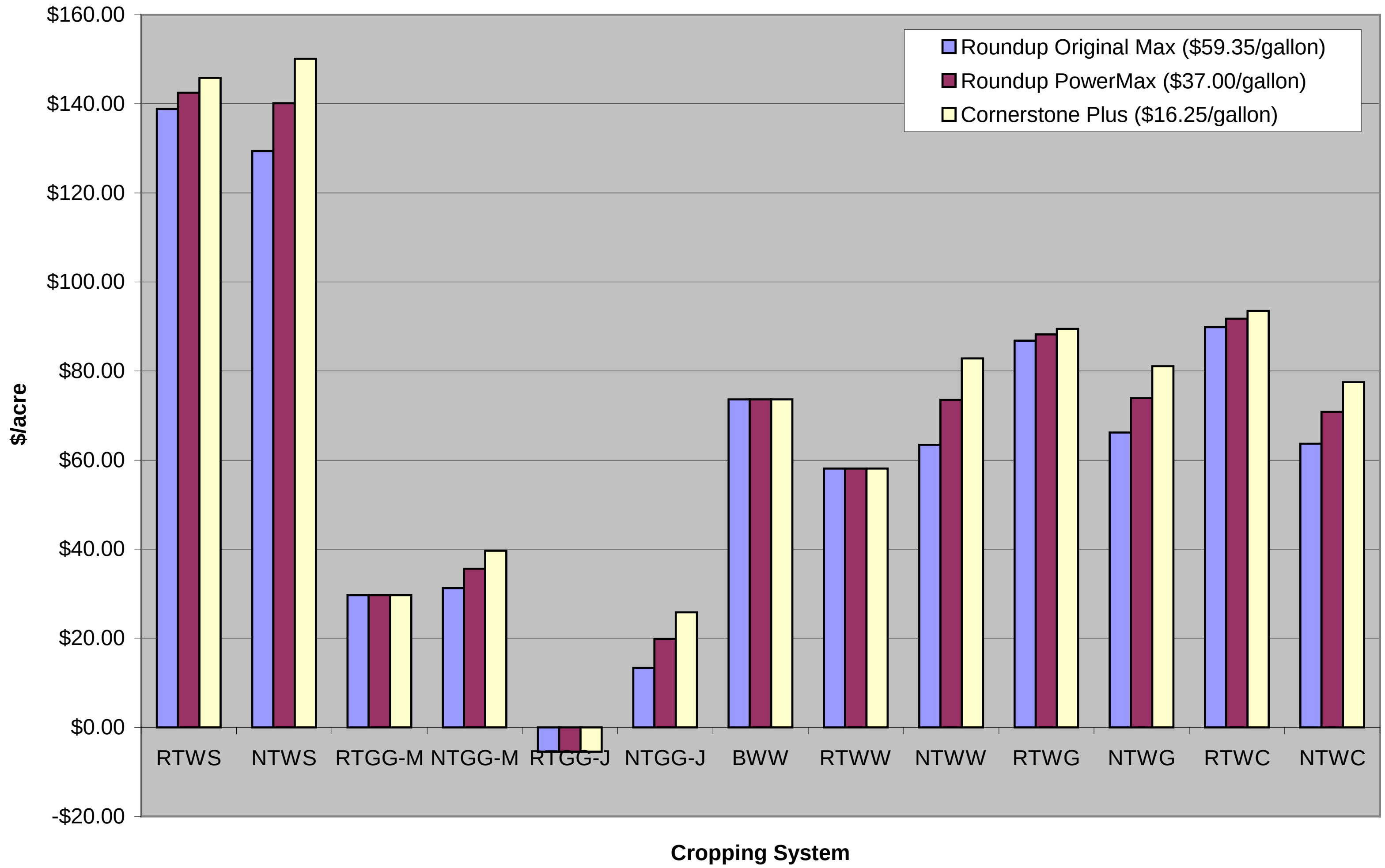


Figure 4.13. Risk Premiums Relative to NTWS for Simulated Net Returns using 2006-2009 Commodity Prices.

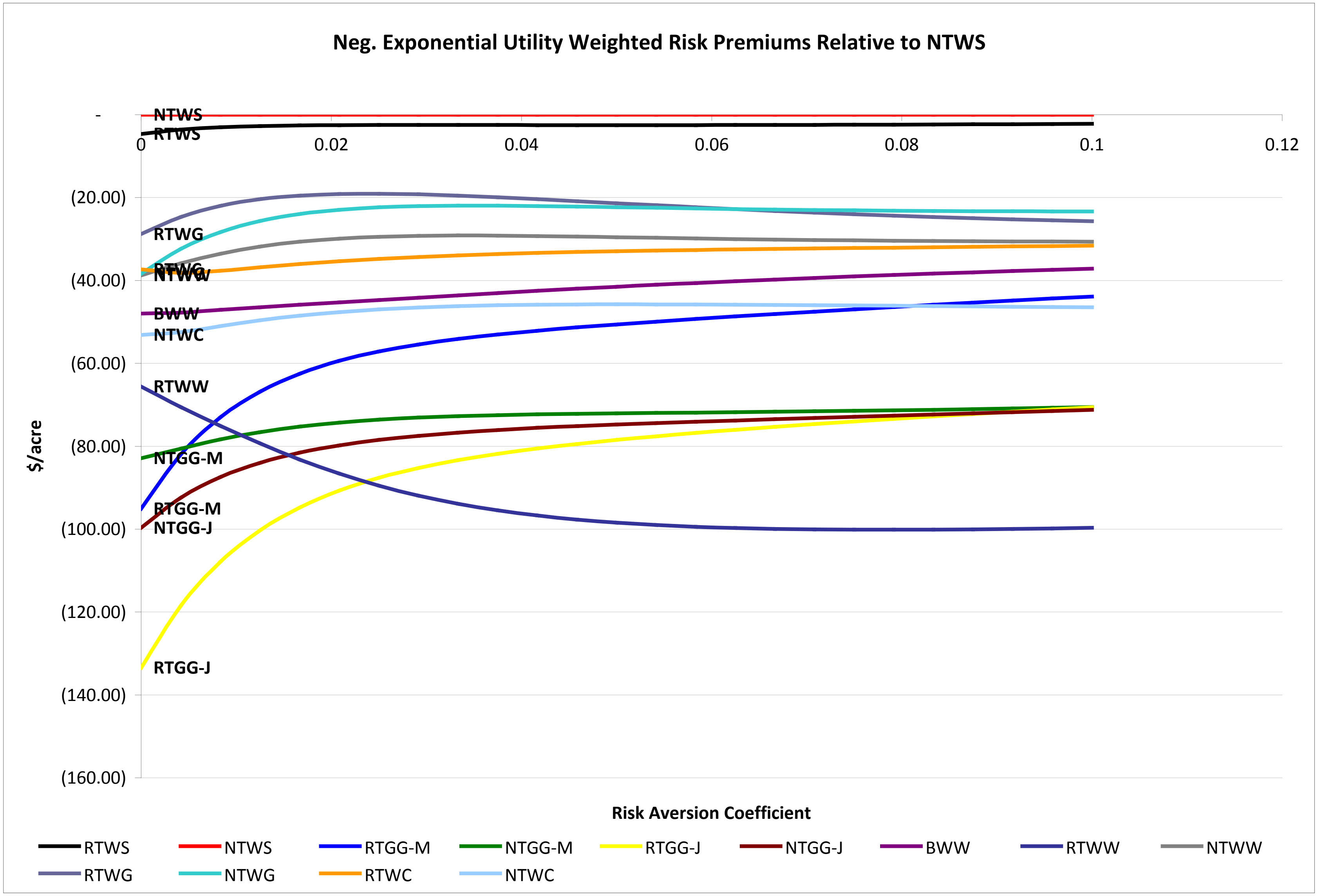


Table 4.10. Risk Premiums Relative to NTWS for Simulated Net Returns using 2006-2009 Commodity Prices.

ARAC	RTWS	NTWS	RTGG-M	NTGG-M	RTGG-J	NTGG-J	BWW	RTWW	NTWW	RTWG	NTWG	RTWC	NTWC
0	(4.67)	-	(95.05)	(82.90)	(133.46)	(99.69)	(47.99)	(65.61)	(38.78)	(28.80)	(38.41)	(37.33)	(53.17)
0.0042	(3.60)	-	(81.99)	(80.56)	(118.45)	(92.41)	(47.73)	(70.56)	(35.88)	(24.68)	(32.37)	(38.14)	(52.49)
0.0083	(3.03)	-	(73.04)	(78.35)	(107.86)	(87.45)	(47.10)	(75.06)	(33.54)	(22.01)	(28.32)	(37.64)	(51.03)
0.0125	(2.74)	-	(66.85)	(76.59)	(100.30)	(84.01)	(46.45)	(79.31)	(31.83)	(20.39)	(25.67)	(36.84)	(49.63)
0.0167	(2.59)	-	(62.50)	(75.27)	(94.80)	(81.57)	(45.85)	(83.20)	(30.65)	(19.51)	(23.98)	(36.06)	(48.49)
0.0208	(2.52)	-	(59.40)	(74.29)	(90.71)	(79.80)	(45.28)	(86.62)	(29.90)	(19.12)	(22.95)	(35.37)	(47.62)
0.0250	(2.49)	-	(57.13)	(73.59)	(87.62)	(78.48)	(44.71)	(89.52)	(29.45)	(19.05)	(22.35)	(34.79)	(46.98)
0.0292	(2.48)	-	(55.42)	(73.09)	(85.24)	(77.48)	(44.14)	(91.93)	(29.22)	(19.21)	(22.05)	(34.32)	(46.52)
0.0333	(2.49)	-	(54.10)	(72.73)	(83.35)	(76.70)	(43.58)	(93.89)	(29.15)	(19.52)	(21.93)	(33.93)	(46.20)
0.0375	(2.50)	-	(53.02)	(72.48)	(81.82)	(76.07)	(43.04)	(95.46)	(29.18)	(19.92)	(21.94)	(33.61)	(45.99)
0.0417	(2.51)	-	(52.11)	(72.30)	(80.54)	(75.56)	(42.51)	(96.70)	(29.27)	(20.37)	(22.03)	(33.35)	(45.86)
0.0458	(2.51)	-	(51.32)	(72.17)	(79.44)	(75.13)	(42.00)	(97.68)	(29.40)	(20.86)	(22.16)	(33.13)	(45.79)
0.0500	(2.51)	-	(50.59)	(72.06)	(78.47)	(74.75)	(41.51)	(98.43)	(29.55)	(21.36)	(22.31)	(32.95)	(45.76)
0.0542	(2.51)	-	(49.92)	(71.97)	(77.60)	(74.40)	(41.05)	(99.00)	(29.71)	(21.85)	(22.47)	(32.79)	(45.77)
0.0583	(2.50)	-	(49.28)	(71.88)	(76.79)	(74.08)	(40.61)	(99.43)	(29.86)	(22.33)	(22.62)	(32.65)	(45.80)
0.0625	(2.49)	-	(48.67)	(71.79)	(76.04)	(73.77)	(40.18)	(99.73)	(30.00)	(22.78)	(22.76)	(32.52)	(45.84)
0.0667	(2.47)	-	(48.08)	(71.69)	(75.33)	(73.48)	(39.78)	(99.94)	(30.12)	(23.22)	(22.89)	(32.40)	(45.90)
0.0708	(2.44)	-	(47.51)	(71.58)	(74.66)	(73.18)	(39.39)	(100.07)	(30.23)	(23.62)	(23.00)	(32.29)	(45.96)
0.0750	(2.42)	-	(46.95)	(71.46)	(74.01)	(72.90)	(39.03)	(100.13)	(30.33)	(24.00)	(23.09)	(32.18)	(46.03)
0.0792	(2.39)	-	(46.40)	(71.33)	(73.39)	(72.61)	(38.68)	(100.14)	(30.41)	(24.35)	(23.17)	(32.07)	(46.10)
0.0833	(2.35)	-	(45.87)	(71.19)	(72.79)	(72.32)	(38.34)	(100.11)	(30.48)	(24.68)	(23.23)	(31.97)	(46.18)
0.0875	(2.32)	-	(45.35)	(71.05)	(72.22)	(72.04)	(38.02)	(100.04)	(30.53)	(24.97)	(23.28)	(31.87)	(46.25)
0.0917	(2.28)	-	(44.85)	(70.89)	(71.66)	(71.75)	(37.72)	(99.95)	(30.58)	(25.24)	(23.32)	(31.78)	(46.33)
0.0958	(2.24)	-	(44.36)	(70.73)	(71.12)	(71.47)	(37.43)	(99.83)	(30.61)	(25.49)	(23.34)	(31.68)	(46.40)
0.1000	(2.20)	-	(43.89)	(70.56)	(70.60)	(71.19)	(37.15)	(99.70)	(30.64)	(25.71)	(23.35)	(31.59)	(46.48)

CHAPTER 5 - Summary and Conclusions

5.1 Summary

Net returns to land and management per acre for each of the 13 production systems were calculated using several different methods. The first procedure used the 10-year average yield for each crop, the average crop price from 2009, and 2009 input prices. The next analysis calculated the historical net return distribution for each production system by using the actual historical yields, crop prices from 1997 to 2006, and 2009 input prices. Net returns to land and management were also calculated using the historical yields and 2009 input costs, but four sets of net return distributions were calculated using the average commodity prices for the 2006, 2007, 2008 and 2009 price levels. Finally, net returns were calculated for each production system using yield and price distributions based on actual historical yields, 2009 input costs, and four simulated historical monthly price series: 2006 to 2009, 2007 to 2009, 2008 to 2009, and 2009.

After developing the different net return distributions, risk analysis was conducted on the historical net returns and simulated net returns by using basic stochastic dominance comparisons as well as stochastic efficiency with respect to a function (SERF). The SERF analysis evaluates which system producers with different risk aversion preferences would select. Finally, sensitivity analysis was conducted on herbicide and fertilizer prices to see how the relative profitability of each system would change.

5.2 Conclusions

Farming has come a long way since the late 1800s, when the Mennonites arrived in Kansas and first broke sod on their farms. Much has changed. Producers now know so much more because of the research and development that has occurred since. While technology continues to advance at seemingly exponential rates, two things consistently remain out of the producers' control: nature and the inability to predict or know the actions of others. It is for these reasons that it is crucial for producers to control what they can – their costs.

RTWS is the most profitable system for each set of the net return distributions examined. NTWS is the second-most profitable system for each set of the distributions, except for the distribution using 2007 commodity prices. RTWS and NTWS were the most profitable systems because they always had the lowest total costs by system. RTWG or RTWC took turns sharing the next-highest net return for each distribution. Total costs were also consistently very low for RTWG, while gross returns were always very high for RTWC.

The monoculture grain sorghum systems consistently had the lowest net returns for each distribution. Interestingly, only the continuous grain sorghum and continuous wheat, excluding BWW, had higher net returns under no-till. The other systems all experienced higher net returns under reduced-tillage.

According to the SERF analysis, RTWS is the system most preferred by all producers, regardless of their level or risk aversion. Recall that producers with no aversion to risk have a risk aversion coefficient (RAC) of zero. Producers with a risk aversion coefficient of 0.1 are considered extremely risk-averse. Producers who are risk neutral or have an RAC of zero would choose NTWS as their next-preferred system to RTWS across each of the net return distributions. The risk premiums at an RAC of zero, or amount of additional returns needed per acre for the NTWS system to be equally preferred to RTWS, range from $7.87 to $11.97/acre for the distributions.

Examination of the risk premium graph for the historic net returns distributions shows that NTWS and RTWG cross at an RAC of 0.02. This means that a slightly to moderately risk-averse producer would choose RTWG over NTWS. A closer examination of the SERF results for the simulated net returns shows a similar pattern. Simulated net returns for 2006 to 2009 and 2007 to 2009 price series also have RTWG crossing NTWS at an RAC of 0.03. Again, this means that a moderately risk-averse producer would choose RTWG over NTWS. Interestingly, RTGG-M becomes the next-preferred system after RTWS after an RAC of 0.07 in the 2007 to 2009 price series. This means that in spite of RTGG-M's low net returns, it is still a preferred system by extremely risk-averse producers. For the 2008 to 2009 and 2009 price series, NTWS is the next-preferred system to RTWS for all levels of risk aversion. At an RAC of 0.10, RTGG-M is only slightly less preferred to NTWS for the 2008 to 2009 price series as well as the 2009 price series.

Sensitivity analysis shows that as the price of glyphosate decreases the no-till systems becomes relatively more profitable to other crop rotation systems. Switching from Roundup Original MAX to the generic glyphosate herbicide (Cornerstone Plus) resulted in the largest increase in net returns/acre ($7.91) above the base scenario returns. The 20 percent herbicide price reduction is next with net returns that are $5.66/acre above the base scenario. The change from Roundup Original MAX to PowerMAX result in a $4.10/acre increase in net returns. Lastly is the 10 percent reduction in herbicide prices, which results in a $2.83/acre increase in net returns from the base scenario.

RTWS remains the most profitable system at both the 10 and 20 percent herbicide price reduction levels as well as at the PowerMAX price level; however, as the glyphosate price is lowered from the Original Max price to the PowerMAX price, the gap in net returns between RTWS and NTWS narrows from $9.44 to $2.33/acre. As the glyphosate price is lowered further by switching to Cornerstone Plus, NTWS now becomes the most profitable system with net returns exceeding the RTWS system by $4.26/acre. Additionally, switching to a lower-priced glyphosate allowed NTWW to become more profitable than BWW.

The changes in fertilizer cost in either direction were not enough to change the order of systems by highest net return. The differences in net returns were larger for the corn and grain sorghum systems because both of these systems received urea applications that the soybean rotations did not need.

5.3 Limitations of the Study

This study is based on an agronomic study that was conducted at the Kansas State University Hesston Experiment field. It should be noted that the agronomic study was carried out to examine the effects of tillage and crop rotations on yield, specifically wheat yield after a row crop, and was not designed specifically with economic analysis in mind. The tillage practices and input levels used were assumed optimal for their research plots; however, a practice that is considered optimal by one producer might not be by another. In this study the use of herbicides on the plots was not constrained, which may explain why more no-till systems were not preferred. This study also did not consider the effects of soil erosion or the effects that increased chemical use can have on the environment, either of which could make the no-till systems more economical.

This study used custom rates for determining machinery cost. An alternative method would have been to use standardized costs for machinery and to calculate a separate labor expense. By isolating labor, one could determine the total number of hours required for each rotation by tillage treatment. This information could be of value for producers of different sizes, as some producers know the fixed number of labor hours they have available per month or year.

This study does not consider any of the risk management strategies that producers can use to safeguard their bottom line. One risk management strategy that many producers use is crop insurance. Crop insurance has the potential to change producers risk aversion preferences; this of course would then change the risk analysis results. Other risk management options that producers might use include hedging, forward contracting, or loan-deficiency payments if they are available.

5.4 Future Research Needs

The sensitivity analysis shows that a closer examination of the herbicides used in this study could lead to a more cost-effective herbicide program. Additionally, the soil needs to have an economic value placed on it. Changes in organic matter, soil structure and most certainly erosion need to be quantified and have given value, because each of these qualities has a direct effect on the relative profitability of the crop grown in that season, as well as seasons to come.

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Appendix A - Enterprise Budgets

A.1Explanation of Enterprise Budgets

The following 13 enterprise budgets reflect the input use of each system averaged for the last four years of the study (2003-2006), as well as the current 2009 cost of those inputs. Only the last four years of inputs were used because they most accurately reflect the input technology producers are using now, from the latest herbicides to the newest seed genetics. All inputs and their rates were recorded at the experiment station. For the budgets, all inputs were assumed to be custom-applied. Current costs of the inputs (seed, fertilizer, herbicides) were multiplied by the average rate at which they were used in each system, and a cost per acre was determined for each operation. These costs were tallied and a complete total cost per acre for the system was determined. Gross returns were calculated by multiplying the 2009 commodity price for each crop by the 10-year average of the reported yields. Net returns were then calculated by subtracting the total cost from the gross returns.

Table A.1. RTWS

RTWS			
Wheat			
Sept/Oct. Herbicide Application	0.50	application	$2.51
Glyphosate	10.83	oz/ac	$5.02
AMS	1.08	lbs/ac	$0.38
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid to late June Planted Wheat	1.00	application	$15.43
Wheat seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs material/ac.	$16.41
Late June Wheat Harvest	57.68	bu./ac.	$29.39
Soybean			
July V-blade	0.75	application	$5.80
Fall and spring Sweep Tread	3.75	application	$33.56
March Herbicide Application	0.25	application	$1.25
Glyphosate	4.25	oz/ac	$1.97
AMS	0.25	lb/ac	$0.09
May Herbicide Application	0.25	application	$1.25
Dual 2 Mag	0.33	pt/ac	$5.44
Sceptor 70 DG	0.70	oz/ac	$2.80
Mid May Planted Soybeans	1.00	application	$14.12
RR Soybean Seed	120.40	1000s seeds/ac.	$36.51
DAP (18-46-0) banded	20.00	lbs material/ac.	$4.45
May/June Herbicide application	0.75	application	$3.76
Glyphosate	13.75	oz/ac	$6.38
AMS	1.20	lbs/ac	$0.42

RTWS Continued

June Herbicide application	0.50	application			$2.51
Glyphosate	11.00	oz/ac			$5.10
AMS	0.95	lbs/ac			$0.33
Late Sept. Soybean Harvest	28.62	bu./ac.			$27.01
Interest	0.08	%			$11.75
Total Cost					299.31
Total/acre of rotation					149.66
Gross Return					
Soybeans	28.62	bu.	9.82	$/ac.	281.09
Wheat	57.68	bu.	5.13	$/ac.	295.89
Total/acre of rotation					$288.49
Net Return					**$138.83**

Table A.2. NTWS

NTWS			
Wheat			
Sept/Oct. Herbicide Application	0.50	application	$2.51
Glyphosate	10.83	oz/ac	$5.02
AMS	1.08	lbs/ac	$0.38
Preplant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid to late June Planted Wheat	1.00	application	$15.43
Wheat seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs material/ac.	$16.41
Late June Wheat Harvest	60.12	bu./ac.	$29.90
Soybean			
July Herbicide Application	1.00	application	$5.01
Glyphosate	23.21	oz/ac	$10.76
ProPak	9.50	oz/ac	$1.59
AMS	0.75	lbs/ac	$0.26
2,4-D Amine	4.75	oz/ac	$0.63
Banvel	3.25	oz/ac	$2.03
Select	2.00	oz/ac	$2.38
Superb COC	3.25	oz/ac	$0.58
Sept. Herbicide Application	1.00	application	$5.01
Glyphosate	18.94	oz/ac	$8.78
ProPak	4.75	oz/ac	$0.79
AMS	1.20	lbs/ac	$0.42
2,4-D Amine	5.00	oz/ac	$0.66
Nov. Herbicide Application	0.75	application	$3.76
Glyphosate	14.82	oz/ac	$6.87
ProPak	4.75	oz/ac	$0.79
AMS	0.55	lbs/ac	$0.19
2,4-D Amine	5.00	oz/ac	$0.66
Banvel	0.50	oz/ac	$0.31

NTWS Continued

March Herbicide Application	0.50	application			$2.51
Glyphosate	15.25	oz/ac			$7.07
AMS	0.90	oz/ac			$0.32
Banvel	1.38	oz/ac			$0.86
May Herbicide Application	0.75	application			$3.76
Glyphosate	14.29	oz/ac			$6.63
ProPak	4.75	oz/ac			$0.79
AMS	1.08	lbs/ac			$0.38
2,4-D LVE	0.50	oz/ac			$0.09
May Herbicide Application	0.25	application			$1.25
Dual 2 Mag	0.33	pt/ac			$5.44
Sceptor 70 DG	0.70	oz/ac			$2.80
Mid May Planted Soybeans	1.00	application			$15.41
RR Soybean Seed	120.40	1000s seeds/ac.			$36.51
DAP (18-46-0) banded	20.00	lbs material/ac.			$4.45
June Herbicide application	0.75	application			$3.76
Glyphosate	15.25	oz/ac			$7.07
AMS	1.08	lbs/ac			$0.38
June Herbicide application	0.25	application			$1.25
Glyphosate	5.50	oz/ac			$2.55
AMS	0.65	lbs/ac			$0.23
Late Sept. Soybean Harvest	28.58	bu./ac.			$27.00
Interest	0.08	%			$12.70
Total Cost					$330.26
Total/acre of rotation					$165.13
Gross Return					
Soybeans	28.58	bu.	9.82	$/ac.	$280.65
Wheat	60.12	bu.	5.13	$/ac.	$308.40
Total/acre of rotation					$294.53
Net Return					**$129.40**

Table A.3. RTGG-M

RTGG-M					
Grain Sorghum					
Nov or Dec. Chisel	1.00	Application			$11.19
April Mulch Tread	0.75	Application			$6.71
May Sweep Tread	1.25	Application			$11.19
May Herbicide application	1.00	Application			$5.01
Dual 2 Mag	1.33	pt/ac			$21.77
Atrazine 4L	1.75	pt/ac			$4.38
Atrazine 90 DF	0.28	lb/ac			$1.20
Pre-plant Nitrogen application	1.00	Application			$4.96
Urea (46-0-0)	101.66	lbs N/ac.			$44.20
Mid May Planted G. Sorghum	1.00	Application			$14.12
Concept & Poncho treated GS seed	42.00	1000s seeds/ac.			$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0			$17.80
Mid Sept. G. Sorghum Harvest	73.08	bu./ac.			$31.00
Interest	0.08	%			$7.29
Total Cost					$189.57
Gross Return					
Grain Sorghum	73.08	bu.	3.00	$/ac.	$219.24
Total					$219.24
Net Return					**$29.67**

Table A.4. NTGG-M

NTGG-M					
Grain Sorghum					
Nov. Herbicide application	0.50	application			$2.51
2,4-D LVE	8.00	oz/ac			$1.39
COC	16.00	oz/ac			$1.31
Atrazine 90 DF	0.42	lbs/ac			$1.83
Atrazine 4L	0.75	pt/ac			$1.88
April/May Herbicide application	1.00	application			$5.01
Glyphosate	24.04	oz/ac			$11.15
ProPak	4.75	oz/ac			$0.79
AMS	1.73	lbs/ac			$0.60
Dual 2 Mag	0.67	pts/ac			$10.88
Atrazine 90 DF	0.42	lbs/ac			$1.83
2,4-D LVE	4.75	oz/ac			$0.83
May Herbicide application	0.75	application			$3.76
Dual 2 Mag	0.67	pts/ac			$10.88
Atrazine 4 L	1.63	pts/ac			$4.06
Pre-plant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	101.66	lbs N/ac.			$44.20
Mid May Planted G. Sorghum	1.00	application			$15.41
Concep & Poncho treated GS seed	42.00	1000s seeds/ac.			$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0			$17.80
Mid Sept. G. Sorghum Harvest	73.11	bu./ac.			$31.01
Interest	0.08	%			$7.23
Total Cost					$188.07
Gross Return					
Grain Sorghum	73.11	bu.	3.00	$/ac.	$219.33
Total					$219.33
Net Return					**$31.26**

Table A.5. RTGG-J

RTGG-J					
Grain Sorghum					
Nov. or Dec. Chisel	1.00	application			$11.19
May Mulch Tread	0.75	application			$6.71
June Sweep Tread	2.50	application			$22.38
June Herbicide Application	1.00	application			$5.01
Dual 2 Mag	1.33	pts/ac			$21.77
Atrazine 4L	1.25	pts/ac			$3.13
Atrazine 90 DF	0.55	lbs/ac			$2.41
Pre-plant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	101.66	lbs N/ac.			$44.20
Mid June Planted G. Sorghum	1.00	application			$14.12
Concep & Poncho treated GS seed	42.00	1000s seeds/ac.			$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0			$17.80
Late Oct. G. Sorghum Harvest	64.59	bu./ac.			$29.16
Interest	0.08	%			$7.66
Total Cost					$199.25
Gross Return					
Grain Sorghum	64.59	bu.	3.00	$/ac.	$193.76
Total					$193.76
Net Return					**$-5.49**

Table A.6. NTGG-J

NTGG-J					
Grain Sorghum					
Nov. Herbicide application	0.25	application			$1.25
2,4-D LVE	4.00	oz/ac			$0.70
Atrazine 4L	0.75	pts/ac			$1.88
COC	8.00	oz/ac			$0.66
April/May Herbicide application	0.75	application			$3.76
Glyphosate	15.25	oz/ac			$7.07
AMS	1.30	lbs/ac			$0.46
Dual 2 Mag	0.33	pts/ac			$5.44
Atrazine 4L	0.75	pts/ac			$1.88
Atrazine 90 DF	0.42	lbs/ac			$1.83
2,4-D LVE	8.75	oz/ac			$1.52
COC	8.00	oz/ac			$0.66
May/June Herbicide application	1.00	application			$5.01
Dual 2 Mag	0.67	pts/ac			$10.88
Atrazine 4L	0.75	pts/ac			$1.88
Glyphosate	16.34	oz/ac			$7.58
AMS	1.50	lbs/ac			$0.53
June Herbicide application	0.50	application			$2.51
Glyphosate	4.00	oz/ac			$1.85
AMS	0.33	lbs/ac			$0.11
Dual 2 Mag	0.33	pts/ac			$5.44
Pre-plant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	101.66	lbs N/ac.			$44.20
Mid June Planted G. Sorghum	1.00	application			$15.41
Concep & Poncho treated GS seed	42.00	1000s seeds/ac.			$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0			$17.80
Late Oct. G. Sorghum Harvest	68.22	bu./ac.			$29.95
Interest	0.08	%			$7.36
Total Cost					$191.31
Gross Return					
Grain Sorghum	68.22	bu.	3.00	$/ac.	$204.66
Total					$204.66
Net Return					**$13.35**

Table A.7. BWW

BWW					
Wheat					
July Burn	1.00	application			$7.00
July Disk	1.00	application			$9.02
July Chisel	0.25	application			$2.80
July Roller harrow	0.25	application			$1.68
Sept. Field Cultivate	0.25	application			$2.24
Sept. Mulch Treader	0.25	application			$2.24
Sept. Sweep Tread	1.75	application			$15.66
Pre-plant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	107.44	lbs N/ac.			$46.71
Mid Oct. Planted Wheat	1.00	application			$12.47
Wheat Seed	90.00	lbs./ac.			$15.43
DAP (18-46-0) in furrow	73.75	lbs 18-46-0			$16.41
November Herbicide application	0.25	application			$1.25
Olympus	0.15	oz/ac.			$2.13
Surfactant	3.25	oz/ac.			$0.58
Late June Wheat Harvest	48.79	bu./ac.			$27.51
Interest	0.08	%			$6.68
Total Cost					$176.67
Gross Return					
Wheat	48.79	bu.	5.13	$/ac.	$250.28
Total					$250.28
Net Return					**$73.61**

Table A.8. RTWW

RTWW					
Wheat					
July Disk	1.00	application			$9.02
July Chisel	1.00	application			$11.19
July Roller harrow	0.25	application			$1.68
Sept. Field Cultivate	0.25	application			$2.24
Sept. Mulch Treader	0.25	application			$2.24
Sept. Sweep Tread	1.50	application			$13.43
Preplant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	107.44	lbs N/ac.			$46.71
Mid Oct. Planted Wheat	1.00	application			$12.47
Wheat Seed	90.00	lbs./ac.			$15.43
DAP (18-46-0) in furrow	73.75	lbs 18-46-0			$16.41
November Herbicide application	0.25	application			$1.25
Olympus	0.15	oz/ac			$2.13
Surfactant	3.25	oz/ac			$0.58
April Herbicide application	0.25	application			$1.25
Surfactant	3.20	oz/ac			$0.58
Maverick	0.17	oz/ac			$3.05
Late June Wheat Harvest	46.48	bu./ac.			$27.03
Interest	0.08	%			$6.82
Total Cost					$180.36
Gross Return					
Wheat	46.48	bu.	5.13	$/ac.	$238.45
Total					$238.45
Net Return					**$58.10**

Table A.9. NTWW

NTWW			
Wheat			
July Herbicide Application	1.00	application	$5.01
Glyphosate	23.00	oz/ac	$10.66
ProPak	9.50	oz/ac	$1.59
2,4-D Amine	4.75	oz/ac	$0.63
Banvel	3.25	oz/ac	$2.03
AMS	0.75	lbs/ac	$0.26
Select	2.00	oz/ac	$2.38
Superb COC	2.50	oz/ac	$0.44
September Herbicide Application	1.00	application	$5.01
Glyphosate	18.94	oz/ac	$8.78
ProPak	4.75	oz/ac	$0.79
2,4-D Amine	5.00	oz/ac	$0.66
AMS	1.20	lbs/ac	$0.42
October Herbicide Application	0.75	application	$3.76
Glyphosate	13.44	oz/ac	$6.23
ProPak	4.75	oz/ac	$0.79
AMS	0.55	lbs/ac	$0.19
Preplant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs 18-46-0	$16.41
November Herbicide application	0.25	application	$1.25
Olympus	0.15	oz/ac	$2.13
Surfactant	3.25	oz/ac	$0.58
April Herbicide application	0.25	application	$1.25
Surfactant	3.20	oz/ac	$0.58
Maverick	0.17	oz/ac	$3.05
Late June Wheat Harvest	49.66	bu./ac.	$27.70

NTWW Continued

Interest	0.08	%			$7.36
Total Cost					$191.32
Gross Return					
Wheat	49.66	bu.	5.13	$/ac.	$254.78
Total					$254.78
Net Return					**$63.46**

Table A.10. RTWG

RTWG			
Wheat			
Sept. Herbicide Application	0.50	application	$2.51
Glyphosate	10.83	oz/ac	$5.02
AMS	1.08	lbs/ac	$0.38
2,4-D LVE	5.00	oz/ac	$0.87
Preplant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs 18-46-0	$16.41
Late June Wheat Harvest	49.35	bu	$27.63
Grain Sorghum			
July V-Blade	0.75	application	$5.80
Fall and spring Sweep	3.75	application	$33.56
March Herbicide Application	0.25	application	$1.25
Glyphosate	4.25	oz/ac	$1.97
AMS	0.25	lbs/ac	$0.09
May Herbicide Application	1.00	application	$5.01
Atrazine 4L	1.13	pts/ac	$2.81
Dual 2 Mag	1.33	pts/ac	$21.77
Atrazine 90 DF	0.21	lbs/ac	$0.91
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	101.66	lbs of N needed	$44.20
Mid-May Planted G. Sorghum	1.00	application	$14.12
Concep & Poncho treated GS seed	42.00	1000s seeds/ac.	$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0	$17.80
Mid Sept. G. Sorghum Harvest	88.41	bu./ac.	$34.31
Interest	0.08	%	$13.26
Total Cost			$344.74
Total/acre of rotation			$172.37

RTWG Continued

Gross Return					
Wheat	49.35	bu.	5.13	$/ac	$253.18
Grain Sorghum	88.41	bu.	3.00	$/ac	$265.22
Total/acre of rotation					$259.20
Net Return					**$86.82**

Table A.11. NTWG

NTWG			
Wheat			
Sept. Herbicide Application	0.50	application	$2.51
Glyphosate	10.83	oz/ac	$5.02
AMS	1.08	lbs/ac	$0.38
2,4-D LVE	5.00	oz/ac	$0.87
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs 18-46-0	$16.41
April Herbicide Application	0.25	application	$1.25
Surfactant	1.60	oz/ac	$0.29
Everest	0.15	oz/ac	$4.73
Late June Wheat Harvest	48.16	bu	$27.38
Grain Sorghum			
July Herbicide Application	1.00	application	$5.01
Glyphosate	23.21	oz/ac	$10.76
ProPak	9.50	oz/ac	$1.59
2,4-D Amine	4.75	oz/ac	$0.63
Banvel	3.25	oz/ac	$2.03
AMS	0.75	lbs/ac	$0.26
Select	2.00	oz/ac	$2.38
Superb COC	3.25	oz/ac	$0.58
Sept. Herbicide application	1.00	application	$5.01
Glyphosate	18.94	oz/ac	$8.78
ProPak	4.75	oz/ac	$0.79
2,4-D Amine	5.00	oz/ac	$0.66
AMS	1.20	lbs/ac	$0.42
Nov. Herbicide application	0.75	application	$3.76
Glyphosate	4.00	oz/ac	$1.85
AMS	0.13	lbs/ac	$0.04
COC	16.00	oz/ac	$1.31
2,4-D LVE	8.00	oz/ac	$1.39
Atrazine 90 DF	0.42	lbs/ac	$1.83
Atrazine 4L	0.75	pts/ac	$1.88

NTWG Continued

Spring Herbicide Application	1.00	application			$5.01
Glyphosate	19.63	oz/ac			$9.10
ProPak	4.75	oz/ac			$0.79
AMS	1.30	lbs/ac			$0.46
Banvel	1.38	oz/ac			$0.86
May Herbicide Application	1.00	application			$5.01
COC	8.00	oz/ac			$0.66
2,4-D LVE	1.50	oz/ac			$0.26
Banvel	0.50	oz/ac			$0.31
Dual 2 Mag	1.17	pts/ac			$19.11
Glyphosate	8.25	oz/ac			$3.83
AMS	1.08	lbs/ac			$0.38
Atrazine 90 DF	0.21	lbs/ac			$0.91
May Herbicide Application	0.25	application			$1.25
Atrazine 4L	0.38	pts/ac			$0.94
Dual 2 Mag	0.33	pts/ac			$5.44
Preplant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	101.66	lbs of N needed			$44.20
Mid-May Planted G. Sorghum	1.00	application			$15.41
Concep & Poncho treated GS seed	42.00	1000s seeds/ac.			$8.76
DAP (18-46-0) banded	80.00	lbs 18-46-0			$17.80
Mid Sept. G. Sorghum Harvest	90.52	bu./ac.			$34.77
Interest	0.08	%			$14.44
Total Cost					$386.22
Total/acre of rotation					$193.11
Gross Return					
Wheat	48.16	bu.	5.13	$/ac	$247.07
Grain Sorghum	90.52	bu.	3.00	$/ac	$271.57
Total/acre of rotation					$259.32
Net Return					**$66.21**

Table A.12. RTWC

RTWC			
Wheat			
Sept. Herbicide application	0.75	application	$3.76
Glyphosate	16.33	oz/ac.	$7.57
AMS	1.20	lb/acre	$0.42
2,4-D LVE	6.50	oz/ac.	$1.13
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs material/ac.	$16.41
Late June Wheat Harvest	57.52	bu./ac.	$29.35
Corn			
July V-blade	0.75	application	$5.80
Fall and spring Sweep Tread	3.00	applications	$26.85
March Mulch Tread	0.50	application	$4.48
March Herbicide Application	0.25	application	$1.25
Glyphosate	4.25	oz/ac.	$1.97
AMS	0.25	lb/ac.	$0.09
April Herbicide Application	1.00	application	$5.01
Atrazine 90 DF	0.21	lbs/ac	$0.91
Atrazine 4L	1.13	pt/ac.	$2.81
Dual 2 Magnum	1.33	pt/ac.	$21.77
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs/N ac.	$46.71
Mid-April Planted Corn	1.00	application	$14.12
Pioneer 35P - series	18.70	1000 seeds/ac.	$34.24
DAP (18-46-0) banded	80.00	lb/ac	$17.80
Early Sept. Corn Harvest	73.76	bu./ac.	$27.16
Interest	0.08	%	$14.24
Total Cost			$370.16
Total/acre of rotation			$185.08

RTWC Continued

Gross Return					
Wheat	57.52	bu.	5.13	$/ac.	$295.06
Corn	73.76	bu.	3.56	$/ac.	$253.46
Total/acre of rotation					$274.26
Net Return					**$89.18**

Table A.13. NTWC

NTWC			
Wheat			
Sept. Herbicide application	0.75	application	$3.76
Glyphosate	16.33	oz/ac.	$7.57
AMS	1.20	lbs/ac.	$0.42
2,4-D LVE	6.50	oz/ac.	$1.13
Pre-plant Nitrogen application	1.00	application	$4.96
Urea (46-0-0)	107.44	lbs N/ac.	$46.71
Mid Oct. Planted Wheat	1.00	application	$15.43
Wheat Seed	90.00	lbs./ac.	$14.25
DAP (18-46-0) in furrow	73.75	lbs material/ac.	$16.41
April Herbicide application	0.25	application	$1.25
Everest	0.15	oz/ac.	$4.73
Surfactant	1.60	oz/ac.	$0.29
Late June Wheat Harvest	57.89	bu./ac.	$29.43
Corn			
July Herbicide Application	1.00	application	$5.01
Glyphosate	23.21	oz/ac.	$10.76
ProPak	9.50	oz/ac.	$1.59
AMS	0.75	lbs/ac	$0.26
2,4-D Amine	4.75	oz/ac.	$0.63
Banvel	3.25	oz/ac.	$2.03
Select	2.00	oz/ac.	$2.38
Superb HC Crop Oil Conc.	4.00	oz/ac.	$0.71
Sept. Herbicide Application	1.00	application	$5.01
Glyphosate	18.94	oz/ac.	$8.78
ProPak	4.75	oz/ac.	$0.79
AMS	1.20	lbs/ac	$0.42
2,4-D Amine	5.00	oz/ac.	$0.66
Nov. Herbicide Application	0.75	application	$3.76
COC	16.00	oz/ac.	$1.31
2,4-D LVE	8.00	oz/ac.	$1.39
Atrazine 90 DF	0.42	lbs/ac.	$1.83
Atrazine 4L	0.75	pt/ac.	$1.88
Glyphosate	4.00	oz/ac.	$1.85
AMS	0.13	lbs/ac.	$0.04

NTWC Continued

April Herbicide Application	0.75	application			$3.76
Glyphosate	16.34	oz/ac.			$7.58
AMS	1.30	lbs./ac.			$0.46
Banvel	1.38	oz/ac.			$0.86
April Herbicide Application	1.00	application			$5.01
Atrazine 90 DF	0.28	lbs/ac			$1.22
Atrazine 4L	0.38	pts/ac			$0.94
Dual 2 Mag	1.57	pts/ac			$25.66
COC	8.00	oz/ac			$0.66
Pre-plant Nitrogen application	1.00	application			$4.96
Urea (46-0-0)	107.44	lbs/N ac.			$46.71
Mid-April Planted Corn	1.00	application			$15.41
Pioneer 35P - series	18.70	1000 seeds/ac.			$34.24
DAP (18-46-0) banded	80.00	lb/ac			$17.80
Early Sept. Corn Harvest	67.87	bu./ac.			$26.51
Interest	0.08	%			$15.57
Total Cost					$404.79
Total/acre of rotation					$202.39
Gross Return					
Wheat	57.89	bu.	5.13	$/ac.	$296.96
Corn	67.87	bu.	3.56	$/ac.	$233.84
Total/acre of rotation					$265.40
Net Return					**$63.01**

Appendix B - South Central Kansas Crop Yields

Table B.1. South Central Kansas Crop Yields from 1997-2006.

Year	Soybeans	Grain Sorghum	Wheat	Corn
1997	35.00	75.00	49.00	82.00
1998	23.00	61.00	44.00	58.00
1999	24.00	63.00	45.00	80.00
2000	18.00	59.00	37.00	80.00
2001	15.00	38.00	39.00	34.00
2002	22.00	49.00	32.00	49.00
2003	17.00	41.00	49.00	45.00
2004	41.00	83.00	40.00	93.00
2005	25.00	64.00	40.00	77.00
2006	25.00	50.00	31.00	52.00
2007	23.00	65.00	20.00	90.00
2008	28.00	77.00[1]	39.50	86.00
2009	36.00	76.00	34.50	89.00
Mean	25.54	60.33	38.46	70.38
Std Dev	7.71	13.90	7.95	19.93
CV	0.30	0.23	0.21	0.28
Min	15.00	38.00	20.00	34.00
Max	41.00	83.00	49.00	93.00

Yields are from the USDA National Agricultural Statistics Service. Available online at: http://www.nass.usda.gov/QuickStats/PullData_US_CNTY.jsp

[1] 2008 Grain sorghum yield is for total crop acres, all other yields are non-irrigated acres. Not enough data was reported for a distribution of irrigated and non-irrigated for grain sorghum in 2008.

Appendix C - Correlation Matrices

Table C.1. Correlation Matrix for Crop Yields from 1997-2006.

	Wheat									Corn		Grain Sorghum						Soybean	
	RTWC	NTWC	RTWG	NTWG	RTWS	NTWS	BWW	RTWW	NTWW	RTWC	NTWC	RTWG	NTWG	RTGG-M	NTGG-M	RTGG-J	NTGG-J	RTWS	NTWS
RTWC	1.00	0.92	0.66	0.24	0.76	0.75	0.73	0.80	0.79	0.72	0.66	0.37	0.40	0.37	0.33	0.45	0.57	0.62	0.69
NTWC		1.00	0.61	0.32	0.69	0.68	0.60	0.69	0.67	0.62	0.55	0.17	0.22	0.15	0.13	0.50	0.57	0.49	0.56
RTWG			1.00	0.74	0.45	0.19	0.56	0.68	0.87	0.36	0.40	0.00	-0.05	0.02	0.06	0.27	0.30	0.21	0.33
NTWG				1.00	0.07	-0.10	0.04	0.17	0.62	0.15	0.26	-0.06	-0.10	-0.05	0.04	-0.02	-0.08	-0.02	0.01
RTWS					1.00	0.89	0.36	0.42	0.44	0.44	0.34	0.07	0.08	0.05	-0.02	0.15	0.24	0.38	0.41
NTWS						1.00	0.40	0.39	0.38	0.56	0.45	0.30	0.35	0.26	0.19	0.24	0.35	0.56	0.55
BWW							1.00	0.94	0.74	0.57	0.58	0.46	0.44	0.44	0.42	0.64	0.76	0.60	0.69
RTWW								1.00	0.83	0.48	0.48	0.36	0.33	0.35	0.34	0.42	0.57	0.43	0.52
NTWW									1.00	0.55	0.59	0.36	0.32	0.37	0.39	0.30	0.41	0.45	0.53
RTWC										1.00	0.98	0.75	0.77	0.71	0.70	0.65	0.70	0.95	0.93
NTWC											1.00	0.81	0.81	0.77	0.79	0.63	0.65	0.94	0.90
RTWG												1.00	0.99	0.97	0.98	0.29	0.36	0.79	0.69
NTWG													1.00	0.97	0.97	0.35	0.41	0.83	0.74
RTGG-M														1.00	0.99	0.28	0.34	0.77	0.69
NTGG-M															1.00	0.24	0.30	0.74	0.65
RTGG-J																1.00	0.97	0.72	0.79
NTGG-J																	1.00	0.76	0.84
RTWS																		1.00	0.98
NTWS																			1.00

Table C.2. Correlation Matrix for Commodity Prices from 1997-2006.

	Corn	Wheat	Beans	Sorghum
Corn	1.00	0.97	0.95	0.98
Wheat		1.00	0.88	0.98
Beans			1.00	0.89
Sorghum				1.00

Table C.3. Correlation Matrix for Commodity Prices from 2006-2009.

	Corn	Wheat	Beans	Sorghum
Corn	1.00	0.78	0.87	0.94
Wheat		1.00	0.77	0.82
Beans			1.00	0.80
Sorghum				1.00

Table C.4. Correlation Matrix for Commodity Prices from 2007-2009.

	Corn	Wheat	Beans	Sorghum
Corn	1.00	0.70	0.76	0.91
Wheat		1.00	0.69	0.77
Beans			1.00	0.69
Sorghum				1.00

Table C.5. Correlation Matrix for Commodity Prices from 2008-2009.

	Corn	Wheat	Beans	Sorghum
Corn	1.00	0.78	0.78	0.95
Wheat		1.00	0.78	0.87
Beans			1.00	0.88
Sorghum				1.00

Table C.6. Correlation Matrix for Commodity Prices for 2009.

	Corn	Wheat	Beans	Sorghum
Corn	1.00	0.71	0.05	0.71
Wheat		1.00	0.39	0.42
Beans			1.00	0.40
Sorghum				1.00

Appendix D - Percent Crop Residue Cover by System

Table D.1. Annual Crop Residue after Winter Wheat Planting, % Cover.

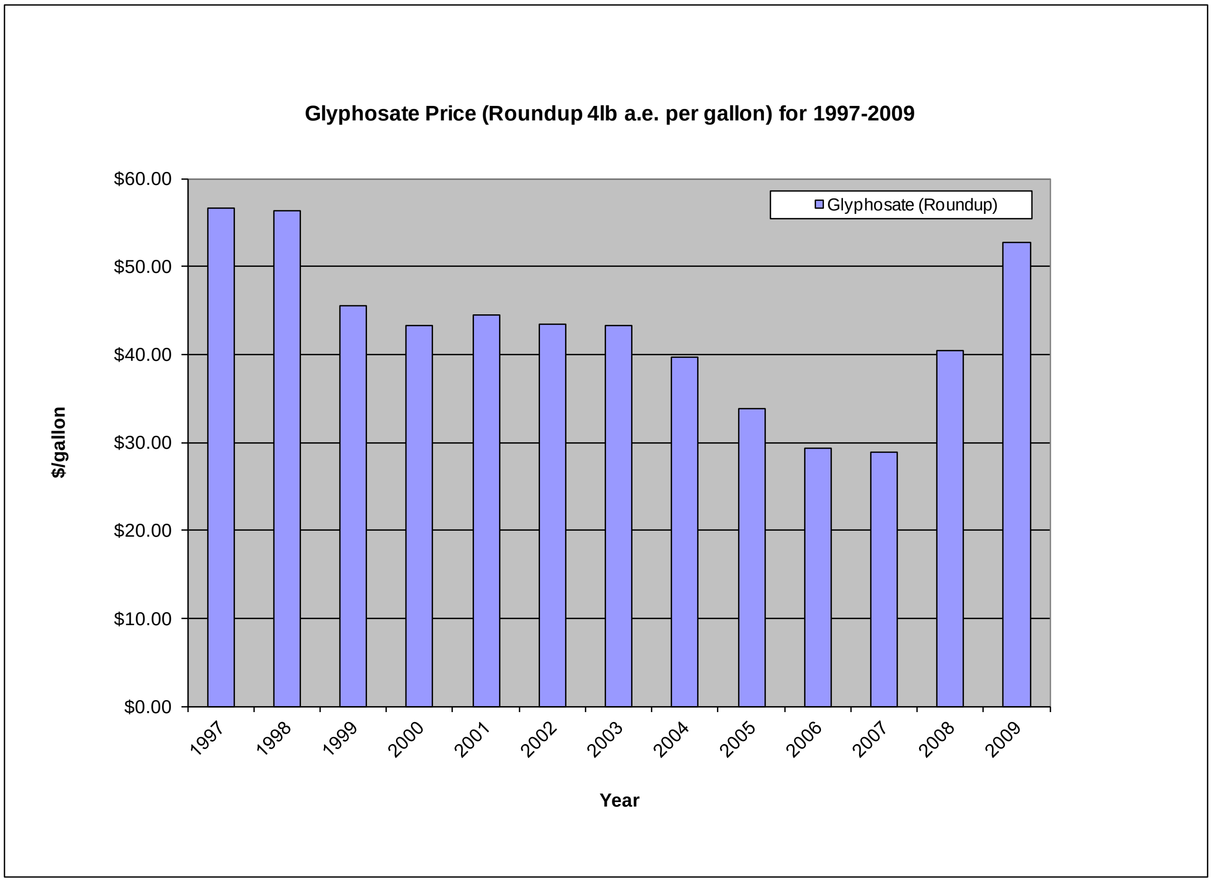
Rotation	Tillage	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
W-C	V-Blade	67.00	65.00	64.00	72.00	65.00	65.00	74.00	61.00	76.00	73.00	68.20
	No-Till	58.00	72.00	71.00	83.00	85.00	80.00	78.00	66.00	80.00	89.00	76.20
W-GS	V-Blade	48.00	76.00	67.00	66.00	63.00	65.00	73.00	54.00	72.00	81.00	66.50
	No-Till	80.00	74.00	66.00	75.00	84.00	80.00	84.00	63.00	82.00	89.00	77.70
W-S	V-Blade	34.00	46.00	43.00	51.00	48.00	21.00	39.00	20.00	58.00	49.00	40.90
	No-Till	32.00	49.00	54.00	67.00	61.00	52.00	57.00	34.00	59.00	67.00	53.20
W-W	Burn	5.00	2.00	4.00	1.00	6.00	8.00	9.00	4.00	8.00	4.00	5.10
	Chisel	17.00	22.00	63.00	17.00	40.00	35.00	57.00	22.00	27.00	19.00	31.90
	No-Till	80.00	68.00	89.00	91.00	86.00	71.00	85.00	73.00	75.00	92.00	81.00

Table D.2. Annual Crop Residue after Row Crop Planting, % Cover.

Rotation	Tillage	1997	1998	1999	2000	2001	2002	2003	2005	Average
C-W	V-Blade	41.00	36.00	36.00	34.00	29.00	45.00	49.00	34.00	38.00
	No-Till	70.00	73.00	86.00	96.00	83.00	76.00	89.00	92.00	83.13
GS-W	V-Blade	37.00	29.00	30.00	27.00	29.00	40.00	59.00	28.00	34.88
	No-Till	75.00	68.00	86.00	89.00	83.00	78.00	90.00	81.00	81.25
GS-GS	Chisel	37.00	38.00	22.00	44.00	38.00	37.00	38.00	39.00	36.63
(May)	No-Till	60.00	78.00	68.00	73.00	73.00	67.00	74.00	70.00	70.38
GS-GS	Chisel	31.00	23.00	19.00	27.00	-	35.00	24.00	15.00	24.86
(June)	No-Till	61.00	57.00	71.00	58.00	-	61.00	53.00	49.00	58.57
S-W	V-Blade	36.00	31.00	28.00	26.00	25.00	33.00	36.00	24.00	29.88
	No-Till	68.00	70.00	86.00	80.00	78.00	80.00	84.00	84.00	78.75

Appendix E - Glyphosate and Fertilizer Prices

Table E.1. Historic Glyphosate Prices for 1997-2009.



1997-2008 glyphosate prices are from USDA's National Agricultural Statistics Service Annual Agriculture Price Summaries. Available online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003.

2009 glyphosate price is from Andale Farmer's Cooperative (Andale, KS). The list price was $59.35/gallon; however, this price was for 4.5 lbs per gallon of active ingredient (a.e.). The price of $52.75 reflects the costs of 4 lbs per gallon of a.e.

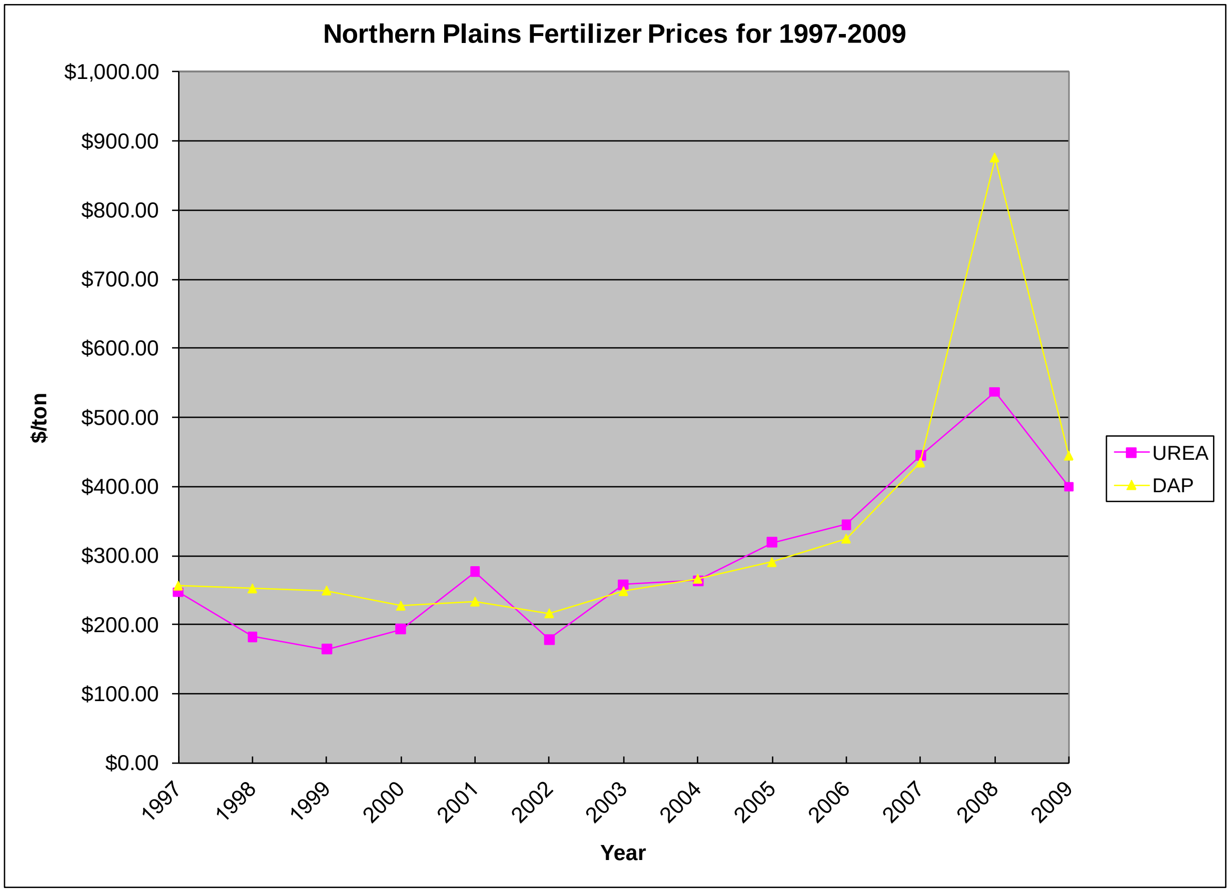
Table E.2. Historic Glyphosate Prices for 1997-2009.

Glyphosate Price (Roundup - 4 lb a.e. per gallon)	
Year	Price/Gallon
1997	$56.70
1998	$56.30
1999	$45.50
2000	$43.30
2001	$44.50
2002	$43.50
2003	$43.30
2004	$39.70
2005	$33.80
2006	$29.30
2007	$28.90
2008	$40.50
2009	$52.75

1997-2008 glyphosate prices are from USDA's National Agricultural Statistics Service Annual Agriculture Price Summaries. Available online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003.

2009 glyphosate price is from Andale Farmer's Cooperative (Andale, KS). The list price was $59.35/gallon; however, this price was for 4.5 lbs per gallon of active ingredient (a.e.). The price of $52.75 reflects the costs of 4 lbs per gallon of a.e.

Table E.3. Historic Fertilizer Prices for 1997-2009.



1997-2008 fertilizer prices are from USDA's National Agricultural Statistics Service Annual Agriculture Price Summaries. Available online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003.

Fertilizer prices for 2009 are from Andale Farmer's Cooperative (Andale, KS).

Table E.4. Historic Fertilizer Prices for 1997-2009.

Fertilizer Prices Northern Plains ($/ton)		
	UREA	DAP
Year	(46-0-0)	(18-46-0)
1997	$247.00	$257.00
1998	$183.00	$253.00
1999	$165.00	$250.00
2000	$194.00	$228.00
2001	$277.00	$234.00
2002	$179.00	$217.00
2003	$258.00	$249.00
2004	$264.00	$267.00
2005	$319.00	$291.00
2006	$345.00	$325.00
2007	$445.00	$435.00
2008	$537.00	$876.00
2009	$400.00	$445.00
Average	$293.31	$332.85

1997-2008 fertilizer prices are from USDA's National Agricultural Statistics Service Annual Agriculture Price Summaries. Available online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003.

Fertilizer prices for 2009 are from Andale Farmer's Cooperative (Andale, KS).