A Risk Analysis of Converting CRP Acres to a Wheat-Sorghum-Fallow Rotation

Jeffery R. Williams, Professor
Department of Agricultural Economics
Kansas State University
215 Waters Hall
Manhattan, KS 66506-4011
785-532-4491 jwilliam@agecon.ksu.edu

Richard V. Llewelyn, Extension Assistant
Department of Agricultural Economics
Kansas State University
303 Waters Hall
Manhattan, KS 66502-4011
785-532-1504 rvl@ksu.edu

Dustin L. Pendell, Assistant Professor
Department of Agricultural & Resource Economics
Colorado State University
Fort Collins, CO 80523-1172
970-491-2233 Dustin.Pendell@ColoState.edu

Alan Schlegel, Professor
Agronomist-in-Charge
Southwest Research-Extension Center
Rt. 1 Box 148
Tribune, Kansas 67679
316-376-4761 schlegel@ksu.edu

Troy Dumler, Southwest Area Agricultural Economist
Kansas State University
4500 East Mary Street
Garden City, KS 67846-0132
620-275-9164 tdumler@oznet.ksu.edu

Selected Paper prepared for presentation at the
Southern Agricultural Economics Association Annual Meeting,
Atlanta, Georgia, January 31 – February 3, 2009

A Risk Analysis of Converting CRP Acres to a Wheat-Sorghum-Fallow Rotation

Abstract

This study examines the economic potential of producing a wheat (*Triticum aesitivum*) and grain sorghum (*Sorghum bicolor (L.) Moench*) rotation with three different tillage strategies compared to the Conservation Reserve Program (CRP) in a semi-arid region. This research uses stochastic efficiency with respect to a function (SERF) to determine the preferred management strategies under various risk preferences and utility-weighted certainty equivalent risk premiums. Yields, input rates, and field operations from an experimental field in western Kansas are used to calculate net returns for each tillage strategy. Although current net returns to crop production using reduced tillage and no-tillage strategies are higher than CRP, risk analysis indicates CRP would be the preferred strategy for some risk-averse managers.

Keywords: CRP, grain sorghum, no-tillage, reduced tillage, risk, rotation, wheat

Introduction

Between 2009-2012, 18.31 million acres of Conservation Reserve Program (CRP) contracts across the United States will expire (Linsenbigler, 2008). Because of higher commodity prices recently, farm managers have increased interest in converting CRP acres to crop production. Some, in fact, are taking CRP land out early by returning rental payments and paying a penalty. Secretary of Agriculture Ed Schafer, in announcing there would be no early opt-out without penalties in July, 2008 also noted that farmers across the nation have pulled out nearly 300,000 acres early since the beginning of 2007, with a peak of this activity occurring in April and May of 2008 (Looker and Caldwell, 2008).

In addition to historically high grain prices, another factor driving the conversion of CRP acres to cropland is the 2008 Farm Bill, which lowered the cap on CRP acres from 39.2 million total acres through 2009 to 32.0 million acres for 2010-2012 (Linsenbigler, 2008). Current enrolled acres in 2008 were 34.7 million acres (USDA-FSA, 2008a), so the current cap has little actual effect, but the new cap beginning in 2010 will be lower than current acres, meaning that there will be at least 2.7 million fewer acres enrolled in CRP than is currently the case.

Kansas is third in total CRP acreage nationally with 3.1 million acres currently under contract (USDA-FSA, 2008a). Over the next four years, 74,407 acres of CRP contracts will expire in Greeley County, Kansas, and a total of 430,919 acres of contracts will expire in the four counties surrounding Greeley County in western Kansas and eastern Colorado (USDA-FSA, 2008b).

Little research is available which directly compares the economics of cropping rotations with the returns from CRP and there is an even smaller amount of research which analyzes the economic risk involved in taking land out of CRP and returning it to cropping practices. Further, the recent experience of high grain prices for wheat and grain sorghum, in addition to corn and soybeans, is unprecedented, further requiring evaluation of alternatives.

The objective of this study is to use field experiment data from Greeley County Kansas, a semi-arid region of the Great Plains, to determine if CRP or a wheat-sorghum-fallow cropping strategy is preferred. Net returns from three tillage strategies; conventional, reduced and no-tillage are compared to current CRP rental rates for the area using both static and risk analyses.

Recent Literature

When considering the use of post-expiration CRP land, most studies evaluate alternatives to which the land could be converted, but generally do not include leaving the land in CRP as one of the alternatives. Much of the research related to the return of CRP acres to cropping practices was conducted in the 1990's, when the first CRP contracts were set to expire beginning in 1996. Heimlich and Kula (1990) were one of the first to analyze this and based on their results, anticipated that no more than 20% of the land in CRP would remain in grass following the expiration of the first wave of contracts, a result clearly contradicted by the reality six years later. This was in an era of relatively low grain prices, in contrast to current market conditions.

Kalaitzandonakes and Monson (1994) surveyed a sample of CRP contract holders in Missouri to determine factors which would influence their decision after the contract had expired, finding that economic factors such as grain prices and rental payments dominated the decision, not attitudes toward conservation. Another survey, by Johnson, Misra and Ervin (1997), of Texas High Plains contract holders, found that the presence of a livestock enterprise in the contract holder's operation significantly increased the probability of the CRP acres remaining in grass. Participation in government commodity programs also influenced the probability of returning the CRP acres to crop production.

Yield analysis of the conversion of CRP land to wheat or grain sorghum in a semi-arid region was conducted by Unger (1999). Seven tillage treatments, some of which involved burning to remove vegetation, were evaluated. Low moisture conditions over the three-year analysis period led to low crop yields. The study concluded that disk-tillage, followed by reduced or no-tillage was best for converting the CRP grassland to crops and suggested waiting a season following the killing of vegetation on the CRP land to allow time for storing soil water and increasing the potential for favorable yields.

Tillage and residue management alternatives on smooth-brome CRP land were evaluated for corn, soybeans and grain sorghum in Nebraska by Shapiro et al. (2001). No-till soybeans were found to perform best in the first year of grain crop production following CRP and they recommended shredding the residue, rather than removing it or leaving it undisturbed. No consideration was given to leaving the land in CRP.

The agronomic aspects of post-contract grassland management, winter wheat, and cotton production in the southern Great Plains region were evaluated by Dao et al. (2000). They found that in the semi-arid environment where their analysis took place, grass production had the best agronomic result, followed by no-till wheat, then tilled wheat and finally dryland cotton, on former CRP fields. Unfortunately, no economic analysis was included.

The economics of tillage systems for post-CRP land in Illinois was evaluated by Phillips, et al. (1997). Three tillage systems (no-till, chisel plow, and moldboard plow) were evaluated for a six year rotation of corn and soybeans using a simulation model to select equipment and estimate costs. Net return analysis found that the no-till system had the highest net income overall as well as having the highest crop yields, and also reduced soil erosion compared to the other systems. However, this study did not compare these systems with leaving the land in CRP.

Tillage studies of cropping systems are more numerous, but again, these studies do not compare cropping and tillage systems directly with CRP. Continuous wheat, continuous grain sorghum, and wheat-grain sorghum rotation yields were evaluated to determine the effects of tillage in the Texas Rolling Plains area by Bordovsky, Choudhary and Gerard (1998). Reduced-tillage grain sorghum had higher yields than conventional tillage and the wheat-grain sorghum rotation had lower yields than continuous cropping systems.

In Kansas, tillage systems and crop rotations have been evaluated, but not directly compared with CRP. Williams (1988) analyzed dryland tillage systems for wheat and grain sorghum in western Kansas, concluding that risk-averse managers would prefer reduced tillage systems, given the reduced costs and increased yields for both crops.

Williams, Johnson, and Gwin (1987) evaluated returns for conservation tillage systems in western Kansas for wheat and grain sorghum rotations, finding that reduced-tillage wheat-grain sorghum-fallow had the highest net returns. In a separate study, Williams, Llewelyn, and Mikesell (1989) found that conventional tillage wheat-sorghum-fallow had the highest net return, but that was followed closely by no-till wheat-sorghum-fallow. The second study was in an area with 30% more rainfall than the first.

A yield study at two locations in western Kansas, Garden City and Tribune (the site of this study) by Norwood, et. al., (1990) compared wheat-fallow and wheat-grain sorghum-fallow rotations with continuous wheat and continuous grain sorghum using conventional till, reduced till, minimum till, and no-till systems. They found the wheat-grain sorghum-fallow rotation to be the preferred rotation in terms of yield and soil water storage and that reduced tillage resulted in increased yields for both wheat and grain sorghum, particularly at Tribune.

The wheat-grain sorghum-fallow rotation was specifically analyzed in this region for effects of tillage and nitrogen fertilizer management on yields by Thompson and Whitney

(1998). They found that the reduced tillage system resulted in higher yields than no-till or conventional tillage systems with optimum nitrogen rates of 60 lb. N/acre for each crop.

Risk analysis of crop rotations and tillage systems by Williams, Roth and Claasen (2000) found that a rotation of reduced-tillage grain sorghum and no-till wheat was preferred by moderately risk-averse producers, while more strongly risk-averse producers preferred a rotation of reduced-tillage grain sorghum and reduced-tillage wheat. Rotations of the two crops were economically advantageous to continuous cropping.

These past studies occurred in an era of relatively low and stable grain prices, as well during a period of relatively high rainfall in the 1990's, which has now been followed by dry weather since the turn of the decade. Most of these studies did not include the possibility of the land remaining in the CRP program, but rather sought to determine what crop rotation and/or tillage system would be best suited for land which was coming out of CRP. Currently, several factors are at work which encourage the conversion of land from CRP into crop production, including the relatively high amounts of expiring CRP contract acres, the recent push for renewable energy from biofuels, rising (and volatile) market prices for wheat, grain sorghum, soybeans and corn, and advances in biotechnology (Stubbs, 2008). Thus the need for research to compare existing cropping and tillage systems with CRP, including analysis of risk.

Methodology and Data

Yields, input types and rates, and field operations are from eleven years (1991-2001) of data from an experiment station in Tribune, Kansas. Production costs are based upon actual field operations and input rates. The cost information is used with yield and price data to calculate current net returns and also to simulate a distribution of net returns for each strategy. Stochastic Efficiency with Respect to a Function (SERF) is used to rank the alternative production strategies 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.

Study Region and Production Methods

The yield data are from an experiment field located in the western Kansas (30^{o} 30'N, 101^{o} 41'W). The climate is characterized by annual mean temperature of 51.3 degrees and precipitation of 17.44 inches. The soil is classified as Richfield silt loam (fine smectitic, mesic Aridic, Argiustolls). The natural vegetation type is C_3 and C_4 grasses with the dominant species being buffalograss (*Buchloe dactyloides*). The study began in 1988 but yields were not collected for analysis purposes until 1991 when the first complete cycle of the cropping rotation occurred.

The production strategies for the wheat-sorghum-fallow rotation include the use of conventional tillage (CT), reduced tillage (RT), and no-tillage (NT). A complete cycle of the rotation takes three years. Two crops are produced during each three year period. After wheat harvest in June of Year-1, the land is in fallow until grain sorghum planting occurs 11 months later in May of Year-2. After sorghum harvest in October of Year-2, the land is in fallow until wheat planting occurs 11 months later in September of Year-3. These strategies are compared to land enrolled in CRP.

The CT system field operations consist of two sweep tillage operations during mid-summer of the fallow period after wheat harvest and two sweep tillage operations the following spring before sorghum planting. One application of herbicide also occurs at sorghum planting. After sorghum harvest in the fall, the land is idle until the following spring. Five sweep tillage operations occur between the months of May and August. Wheat is planted in September, sprayed with an herbicide once the following March, and then harvested in June.

The RT system field operations consist of two herbicide applications during mid-summer of the fallow period after wheat harvest and two sweep tillage operations the following spring before sorghum planting. One application of herbicide also occurs at sorghum planting. After sorghum harvest in the fall, the land is idle until the following spring. One herbicide application is used in May. Three sweep tillage operations occur during the months of June, July and August. Wheat is planted in September, sprayed with a herbicide once the following March, and then harvested in June.

The NT systems do not have any tillage operations. Field operations consist of two herbicide applications during mid-summer of the fallow period after wheat harvest and another, the following spring before sorghum planting. One application of herbicide also occurs at sorghum planting. After sorghum harvest in the fall, the land is idle until the following spring. Four herbicide applications occur during the months of May, June, July and August. Wheat is planted in September, sprayed with a herbicide the following March and harvested in June.

Fertilizer applications are similar for CT and RT tillage and based on experiment station practices. The CT system receives 80 lbs. of N/acre from anhydrous ammonia with the first sweep tillage operation during the spring before sorghum planting. The RT system receives 100 lbs. of N/acre. Ammonium polyphosphate (10-34-0) is also applied at a rate of 80 lbs./acre during the sorghum planting operation in both the CT and RT systems. The following summer anhydrous ammonia is applied with the July sweep operation at a rate of rate of 80 lbs. of N/acre in both systems. During wheat planting in September both systems receive 80 lbs./acres of monoammonium phosphate (11-52-0). The NT system receives 110 lbs. of N/acre from UAN instead of anhydrous ammonia during the spring before sorghum planting. Ammonium polyphosphate is also applied at a rate of 80 lbs./acre during the sorghum planting operation. During wheat planting in September 80 lbs./acre of monoammonium phosphate is applied. The wheat is also top dressed with 80 lbs. of N/acre from UAN the following spring.

The native grass CRP system does not have any field operations so consequently there are no direct costs associated with this system and land costs are assumed to be equivalent across all systems. To convert the native grass to cropland two disking operations are used beginning before the field operations discussed previously. Each disking operation costs $8.25/acre (Ranek, 2008). The total cost of $16.50/acre amortized at 8.5% annual interest over the 10 year life of a CRP contract results in an annualized cost of $2.51/acre.

Yields, Prices, Costs, and Net Returns used in Static Analysis

Table 1 provides a summary of the experimental yields from 1991-2001. Western Kansas average wheat and grain sorghum prices for the period of June 2007 to May 2008, are used for the static analysis. The price for wheat is $7.56/bu and the price for grain sorghum is $4.02/bu. These prices are multiplied by average yields to calculate gross returns. Net returns to land, management, and risk are calculated by subtracting 2008 costs. Costs for each field operation are obtained from Ranek et al. (2008). Input costs are based on actual experiment application rates. Spring 2008 prices for seed, fertilizers, and herbicides obtained from input dealers are used.

Simulated Net Returns

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. The net return distributions are constructed using equation (1). A simulated correlated multivariate empirical yield distribution derived from actual yields is multiplied by a simulated multivariate empirical price distribution derived from actual prices to calculate gross returns. Current year production and harvest costs are then subtracted from gross returns to obtain the net return.

CRP acres that are returned to crop production at the expiration of their contracts may qualify for commodity program payments. Therefore, returns to crop production are calculated with and without commodity program payments. These payments are calculated based on the provisions of the program described in Pendell et al. (2003) and equations (2) and (3). Direct payment and counter-cyclical payment yields are from the CT system. Counter-cyclical program yields are based on 1998 to 2001 as specified in the commodity program provisions. Direct payment yields are simply the average historical yields from the CT system because 1981-1985 yields are not available. The market price used in the analysis is high enough that counter-cyclical payments are $0.00. Direct payments are $0.52/bu. for wheat and $0.35/bu. for grain sorghum. Program yields of 36.1 bu./acre for wheat and 41.6 bu./acre for grain sorghum are used. Direct payments are received on 85% of the base acres. The resulting direct payments are $15.96/acre for wheat and $12.38/acre for grain sorghum.

This analysis assumes that CRP acres returning to crop production would be eligible for commodity program payments.

(1) $$NR_{ik} = 0.33 \times \sum_{j=1}^{2} \left[(Y_{ijk} \times MP_{ij} - C_{jk} - HC_{ijk}) + DP_j + CCP_{ij} \right]$$

(2) $$DP_j = .85 \times DPY_j \times DPR_j$$

(3) $$CCP_{ij} = .85 \times CCPY_j \times \max\left\{ \left[TP_j - \max\left\{ MP_{ij}, LR_j \right\} - DPR_j \right], 0 \right\}$$

where:

NR_{ik}	=	net return to land and management ($/acre) for observation i for crop production system k,
i	=	observation, i = 1 to 1000,
j	=	crop j, j=1 to 2 for wheat and grain sorghum,
k	=	crop production system k, k = 1 to 3 for CT, RT, NT,

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

MP_{ij} = simulated market price ($/bu.) for observation i of crop j,

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

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

DP_j = direct payment ($/acre) for crop j,

DPY_j = direct payment yield (bu./acre) for crop j,

DPR_j = direct payment rate ($/bu.) for crop j,

CCP_{ij} = counter cyclical payment ($/acre) for observation i of crop j,

$CCPY_j$ = counter cyclical payment yield (bu./acre) for crop j,

TP_j = target price ($/bu.) for crop j, and

LR_j = loan rate ($/bu.) for crop j.

The empirical distribution shape is specified by the data used because too few observations exist to estimate parameters for another distribution (e.g., normal distribution). The following explains the SIMETAR© procedure used to generate the price and yield distributions. A cumulative probability distribution function (CDF) using the eleven years of yield data with probability ranging from 0.0 to 1.0 is constructed by ordering the data and assigning a cumulative probability for each observation (data point). The same thing is done for prices using monthly prices from June of 2006 through June of 2008. This 24 month empirical data set is used to capture the variability in prices before and after 2007. Each yield or price observation is assumed to have an equal probability of occurring, so the additional probability for each sequential observation is equivalent. A simulated distribution of 1,000 observations is generated by drawing 1,000 values from a uniform standard deviate ranging in value from 0 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).

The multivariate distribution procedure used in this study has been shown to appropriately correlate random observations of data 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 distributions are correlated in the simulation. Price distributions are also correlated. The yield correlations range from -0.01 to 0.95. Statistically significant correlation (95% level) is found among the historical wheat yields series and the sorghum series, but not between any wheat and sorghum series. The correlation between the price series is 0.75 and is also statistically significant. Because prices are not typically correlated with farm level yields and are from a different time period, correlations between prices and yields are not included in the simulation. T-tests and F-tests are used to test for significant differences between the simulated data and the actual data. The statistical tests indicate the differences between the mean and variances of the experimental data and simulated data are not statistically different.

Stochastic Efficiency with Respect to a Function

Stochastic efficiency with respect to a function (SERF) orders a set of risky alternatives in terms of certainty equivalents (CEs) for a specified risk preference (Hardaker, et. al.). SERF orders preferred alternatives in terms of CEs as the degree of risk aversion increases. Strategies with higher CEs are preferred to those with lower CEs. The CE of a risky strategy is the amount of money at which the decision maker is indifferent between the certain (generally lower) dollar value and the expected value of the risky strategy. For a risk-averse decision maker, the estimated CE is typically less than the expected value of the risky strategy.

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

A 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. This functional form assumes managers have constant absolute risk aversion. Under this assumption, managers view a risky strategy for a specific level of risk aversion the same without regard for their level of wealth. Babcock, Choi, and Feinerman (1993) note that this functional form is often used to analyze farmers' decisions under risk. For additional justification for this functional form refer to Schumann et al. (2004) Their work demonstrates the negative exponential function can be used as a reasonable approximation of risk averting behavior.

The simulated net return data for each strategy is sorted into cumulative probability distribution functions (CDFs) which are used in the SERF analysis. Decision makers with RACs greater than zero exhibit risk-averse behavior. The actual RACs used in the final analysis range from 0.00 to 0.01 because the rankings do not change for RACs above 0.01 for the strategies examined.

A utility weighted risk premium (RP), when risk aversion is considered, can be calculated using equation (4) once the strategies are ranked using the CE results. This is accomplished by subtracting the CE of a less preferred strategy (L) from the preferred strategy (P).

(4) $$RP_{L,P,r_a} = CE_{P,r_a(w)} - CE_{L,r_a(w)}$$

The RP, a utility weighted risk premium for a risk-averse decision-maker, reflects the minimum amount ($/acre) that will have to be paid to a decision maker to justify a switch from alternative P to L (Hardaker et al. 2004). As the degree of risk aversion increases, the risk premium generally increases.

Results and Analysis

Static Analysis Net Returns and Costs

The net return is highest for the RT strategy (Table 1). The NT strategy is the second most profitable. This result occurs because NT has higher costs than RT (Table 2). Although NT has higher yields, the additional gross income does not offset the higher costs. Herbicide costs are higher for NT systems, and although field operation costs are less than those in the CT and RT systems (Table 2), the lower field operation costs do not outweigh the impact of higher chemical costs.

Average annual CRP rental payments for Greeley County are $32.73/acre (Agapoff, et al., 2006). They range from $26.00 to $41.00/acre with the majority of the payments at $38.00/acre. These payments are less than the returns from the wheat-sorghum-fallow rotation using the RT and NT strategies with and without commodity program payments (Table 3). Therefore, increased net returns due to increased commodity payments currently provide a substantial incentive to convert land from CRP to crop production.

Sensitivity Analysis

The 2007-2008 prices of $7.56/bu. for wheat and $4.02/bu. for grain sorghum are higher than their target prices of $3.92/bu. and $2.57/bu., respectively, and higher than the average annual cash prices for west central Kansas the last 10 years (1998-2007). During that period, annual average wheat prices ranged from $2.29 to $5.80/bu. Grain sorghum prices ranged from $1.58/bu. to $3.49/bu. Because of the significant increase in the 2008 price, a sensitivity analysis is performed on the prices. The price pairs of wheat and grain sorghum that are required to generate net returns from crop production that are equivalent to the CRP returns are calculated. The initial difference between the wheat and grain sorghum prices of $3.54/bu. is maintained in the analysis. None of the resulting wheat or grain sorghum breakeven prices fall below their current target price (Table 4). Further, none of the breakeven wheat prices fall below the highest annual average price from 1998 to 2007. However, several of the sorghum prices do fall below sorghum's previous high price of $3.49/bu. that occurred in 2007. None fall below the second highest sorghum price of $2.31/bu. that occurred in 2006.

This sensitivity analysis shows that prices would not need to fall below price levels that occurred prior to 2008 for crop production to have smaller returns than CRP. For the RT system, the wheat price would need to fall 13.6% and the grain sorghum price would need to decrease 25.6% for the RT system to be equivalent to the typical $38.00 per acre CRP payment, holding yields constant. Wheat prices would only need to decrease 11.5% and grain sorghum prices by 21.6% for the NT system to be equivalent in net returns to the CRP payment of $38.00. These results point to the need for further analysis that takes price and yield risk into account. Although farm managers may delay re-enrolling CRP acres in the short-run to earn higher returns, this may not be the best long-term strategy when price and yield risk is accounted for.

Risk Analysis

Although examining average net returns is useful, it is also important to examine variation in net returns to determine if risk affects the decision to use one strategy or another. Many farm managers are risk averse and will accept less dollars of return for less dollars of variability or loss. Each decision maker trades off risk and return at their own rate, thus it is difficult to prescribe a specific strategy for any one manager, but some general conclusions can be made with the use of decision criteria.

Cumulative probability distribution functions are created for yields and prices using the simulation procedure previously described. Decision criteria are then used to evaluate and compare the net return variability (risk) of alternative production systems or management strategies. One commonly used decision criterion is the mean-standard deviation. Risk-averse managers generally prefer strategies that have both the largest mean net return and smallest the standard deviation. The 'maximin' criterion, which compares the minimum net return across strategies to determine the largest minimum value, can also be used. This comparison is useful because extremely risk-averse managers select the strategies with the largest minimum net return or smallest negative loss. In addition, the probability of having a loss can be compared across strategies with data from the CDFs. Managers can weigh the probability of losses and gains to make a decision. Stochastic efficiency with respect to a function as described previously can also be used.

Beginning with the mean-standard deviation criterion, there is no crop production strategy that has the largest mean net return and smallest standard deviation (Table 5). The NT strategy can be eliminated with the mean standard deviation criteria, because it has a lower average net return and higher standard deviation than the RT strategy. The crop production strategy with the least amount of net return risk, as measured by standard deviation, is CT, but on average, this strategy loses money.

When the minimum net returns of the crop production strategies are compared, and the maximin decision criterion is employed, the RT strategy is preferred (Table 5) to the other tillage systems, though CRP, with a constant per acre return of $38.00, would be preferred to RT. The probability of having a negative net return is also derived from the CDFs of the net returns. The

CDFs of net returns from the three tillage strategies and the constant $38.00/acre CRP payment are illustrated in Figure 1. A strategy that has a distribution lying totally to the right of all others would be preferred by risk-neutral and risk-averse managers. Using this criterion the RT is preferred to CT, but it is not singularly preferred to all others.

The CDF is used to determine the probability of a net return above or below a specific level of net return. The CRP payment strategy of $38.00/acre/year has no probability of a loss. Of the crop production strategies, RT has the smallest probability of loss, at 30%, with NT second at 33%, and CT is at 53%. These strategies have a 70%, 67%, and 47% chance of having positive net returns in any given year, respectively. CRP has a 100% chance of a positive return. The probabilities of the cropping strategies having net returns larger than $38/acre, the typical return from CRP acres, are 25%, 49%, and 45% respectively, for CT, RT, and NT. Of the crop production strategies, RT would likely be preferred by managers who are more risk averse or by those placing more emphasis on potential losses. However, the RT strategy has considerably more risk than receiving a CRP payment.

For ease of interpreting the CE results, the CEs of the alternatives can be graphed on the vertical axis against risk aversion on the horizontal axis over the range of risk aversion coefficients. Figure 2 reports the CE results for each RAC for each of the crop production strategies and the CRP strategy that receives a $38.00/acre rental payment. The ranking of the crop production strategies do not change as risk aversion increases. The CE lines for CT, RT, and NT never cross, so the strategies are never equivalent to each other in terms of preferences. RT is always preferred by risk neutral and risk averse decision makers. However, the preferences do change when CRP is considered. The RT strategy is preferred by risk neutral and risk averse managers up to an RAC of 0.0033. After this point, CRP becomes preferred. CRP becomes even more preferred as the level of risk aversion increases because the distance between the CRP and each cropping strategy CE line gets larger. NT is preferred to CRP at an RAC of up to 0.0008, representing decision-makers who are only very slightly risk averse or nearly risk-neutral.

The procedure used to derive risk premiums compares the absolute differences in the CEs for a base strategy (CRP) to the three cropping strategies for each RAC (Figure 3). For a risk-neutral decision maker, RT is preferred to the other strategies. The difference between the mean net returns of CRP and RT on the vertical axis is $6.73/acre at a RAC of 0.00 which indicates the risk-neutral manager will need to receive $6.73/acre more for CRP to be equivalently preferred to RT. Alternatively, the manager will pay up to $6.73/acre to use RT rather than CRP. The RP is calculated using equation (4) for RACs greater than 0.0. As shown in Figure 3, CRP is the preferred strategy at RACs greater than 0.0033. The manager needs to be paid $6.14/acre to use RT and $12.36/acre to use NT at an RAC of 0.006 rather than CRP.

Summary and Implications

The purpose of this study was to examine the net returns and economic risk of a wheat-grain sorghum-fallow rotation in western Kansas using conventional (CT), reduced tillage (RT) and no-tillage (NT) in comparison to CRP rental payments. Commodity program payments were included in the analysis.

Static profitability analysis, using 2007-2008 output prices and 2008 costs, found that net returns were highest for the RT system, followed by NT system, both with net returns higher than the CRP payment of $38.00 per acre typically received by program participants in this area. Historically, high current commodity prices are part of the reason for this level of profitability. Sensitivity analysis on output prices shows that if prices return to pre-2007 levels, CRP is more profitable.

Analysis using various decision criteria to include risk shows somewhat inconclusive results, though the RT system is generally preferred to the NT and CT systems by risk averse decision-makers. The mean-standard deviation criterion eliminates the NT system and though the CT system has less variation, it has generally negative yields. When comparing minimum net returns (maximin), RT is preferred to other tillage systems, but CRP would be preferred to the RT system, with a constant annual payment of $38.00 per acre.

Using CDFs of the distribution of returns, it is found that RT has a 49% probability of having net returns larger than the typical CRP payment, while NT has a 45% probability of this, and the CT system has only a 25% probability of being higher than $38.00 per acre. Among tillage systems, RT has the lowest probability of a negative return (30%), followed by NT at 33% and CT with 53%, though again, CRP would be preferred to RT, since it has no probability of a loss.

Stochastic efficiency with respect to a function (SERF) analysis finds that the RT system is consistently preferred to the other tillage systems by risk neutral and risk averse decision-makers. However, only risk-neutral or slightly risk-averse producers prefer the RT system to CRP. Moderately and strongly risk-averse individuals prefer CRP to any of the tillage systems.

Using certainty equivalents (CE) shows that a risk-neutral individual would need to receive additional CRP payments of $6.73 per acre for CRP to be equivalent with the RT system. This amount decreases as risk aversion increases and becomes zero when the risk-aversion coefficient (RAC) is 0.0033. A more strongly risk-averse individual, with an RAC value of 0.006, would need to receive an additional net return of $6.14 per acre for RT to become equivalent to CRP and an additional $12.36 per acre for NT to be equally preferred to CRP.

Recent high grain prices may lead producers to consider converting CRP land to crop production when CRP contracts expire. However, these results suggest that care should be given when making this decision. Though net returns may be higher due to the higher prices, the inclusion of risk due to price and yield variability in the analysis suggests that risk averse producers would still prefer the lower but constant payments with no probability of loss which the CRP program provides. Based on this analysis, only those individuals who are risk neutral or very slightly risk averse would prefer crop production to continued CRP enrollment in this region.

Current market volatility make it difficult to determine the future direction of grain prices, but this analysis finds that if current (January to June 2008 average) high grain prices decline by only 25%, that even risk-neutral individuals would prefer to continue with the CRP program. Even if high grain prices remain, economic theory suggests that producers will bid up the price of inputs, including land. This has already occurred in 2007 and 2008, with land rental rates (Dhuyvetter and Kastens, 2008) and land values (Kastens and Dhuyvetter, 2008) increasing. Thus, even if grain prices remain high, net returns may decline as input prices rise, making CRP more preferable. However, because commodity prices may be positively correlated with energy prices a decline in commodity prices may be caused by a decline in energy prices which may lead to a decline in the cost of energy intensive inputs, particularly fertilizer. In the current economic environment, the volatility of input costs may play nearly as big a role in cropping decisions as commodity prices.

One further note is that the yield distribution was generated using data from what is generally considered a relatively wet time period (1991-2001). Dry weather has plagued this area periodically, particularly since 2002. A check of the drought indicator maintained by the University of Nebraska shows that portions of southwest Kansas, including Greeley County, are currently experiencing drought conditions in August, 2008 and that at least 20% of the state experienced at least moderate drought conditions during 44% of the weekly reporting periods since January, 2000 (University of Nebraska, 2008). This means that yields during the study period may have been higher than producers could achieve currently, given the relatively dry conditions which have occurred since the end of the study period. Recent years in this study have also shown an increased yield benefit to no-till rotations which could mitigate the impact of lower precipitation on no-till yields.

References

Agapoff, J., A. Barbarika, J. Connelly, P. Harte, S. Hyberg, C. Kasak, M. Linsenbigler, T. Lloyd, L. Nesbit, B. Preston, and R. Stephenson. 2006. "The Conservation Reserve Program: 33rd Signup County by County Summary." United States Department of Agriculture. June. http://www.fsa.usda.gov/dafp/cepd/crp.htm

Babcock, B.A., E.K. Choi, and E. Feinerman. "Risk and Probability Premiums for CARA Utility Functions." *J. Agr. Res. Econ.* 18(July 1993): 17-24.

Bordovsky, D.G., M. Choudhary, and C.J. Gerard. "Tillage Effects on Grain Sorghum and Wheat Yields in the Texas Rolling Plains". *Agronomy Journal*. 90(Sept/Oct 1998): 638-643.

Dao, T.H., J.H. Stiegler, J.C. Banks, L. Bogle-Boerngen, and B. Adams. "Post-Contract Grassland Management and Winter Wheat Production on Former CRP Fields in the Southern Great Plains". *Agronomy Journal*. 92(Nov/Dec 2000): 1109-1117.

Dhuyvetter, K. and T. Kastens. *Kansas Land Values and Cash Rents at the County Level.* White paper posted on AgManager.info website. http://www.agmanager.info/farmmgt/land/county/CountyValues&Rents(Aug2008).pdf Accessed August 27, 2008.

Good, D. and S. Irwin. "The New Era of Corn, Soybean, and Wheat Prices." Marketing and Outlook Briefs. MOBR 08-04. September 2, 2008. http://www.farmdoc.uiuc.edu/marketing/mobr/mobr_08-04/mobr_08-04.html. Accessed September 12, 2008.

Hardaker, J.B., J.W. Richardson, G. Lien, and K.D. Schumann. "Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach." *Austral. J. Agr. Res. Econ.* 48(June 2004): 253-70.

Heimlich, R.E. and O.E. Kula. "Grasslands: The Future of CRP Land After Contracts Expire". *Journal of Production Agriculture.* 3(Jan/Mar 1990): 7-12.

Johnson, P.N., S.K. Misra, and R.T. Ervin. "A Qualitative Choice Analysis of Factors Influencing Post-CRP Land Use Decisions". *Journal of Agriculture and Applied Economics.* 29(July 1997): 163-173.

Kalaitzandonakes, N.G. and M. Monson. "An Analysis of Potential Conservation Effort of CRP Participants in the State of Missouri: A Latent Variable Approach". *Journal of Agriculture and Applied Economics.* 26(July 1994): 200-208.

Kastens, T.L. and K.C. Dhuyvetter. *Valuing and Buying U.S. Farmland with a Consideration of Non-Ag Features.* White paper posted on AgManager.info website. http://www.agmanager.info/farmmgt/land/land_buy/LandValuePaper(Aug2008).pdf Accessed August 27, 2008.

Linsenbigler, M. “What is the Future of The Conservation Reserve Program (CRP)?” Presentation for 2008 NACD Legislative Conference. http://www.nacdnet.org/events/legconference/Linsenbigler.pdf. Accessed: August 26, 2008.

Looker, D. and J. Caldwell. “Schafer: No Early CRP Opt-Outs”. *Agriculture Online.* http://www.agriculture.com/ag/story.jhtml?storyid=/templatedata/ag/story/data/1217359199273.xml. Accessed August 26, 2008.

Norwood, C.A., A.J. Schlegel, D.W. Morishita, and R.E. Gwin. “Cropping System and Tillage Effects on Available Soil Water and Yield of Grain Sorghum and Winter Wheat”. *Journal of Production Agriculture.* 3(July/Sept 1990): 356-362.

Pendell, D.L., W.R. Perry, J.R. Williams, G.A. Barnaby, and B.D. Lubben. 2003. “Mathematical Formulas for Calculating Net Returns from Participation in Government Programs, CRP, and Crop Insurance.” Kansas State University, Department of Agricultural Economics. Staff Paper 04-02. August. http://www.agmanager.info/crops/insurance/workshops/filespdf/fp_math.pdf

Pendell, D.L., J.R. Williams, S.B. Boyles, C.W. Rice, and R.G. Nelson. "Soil Carbon Sequestration Strategies with Alternative Tillage and Nitrogen Sources under Risk." *Review of Agricultural Economics*. 29(2007): 247-268.

Phillips, S.R., K.R. Olson, J.C. Siemens, and S.A. Ebelhar. “Economics of Conservation Tillage Systems for CRP Land in Southern Illinois.” *Journal of Production Agriculture.* 10(July/Sept 1997): 483-489.

Pratt, J.W. "Risk Aversion in the Small and in the Large." *Econometrica* 32(January – April 1964): 122-36.

Ranek, D., E.J. Thiessen, S. Habbets, and E. Wells. 2008. "2007 Rates Paid by Kansas Farmers for Custom Work." Topeka, KS: Kansas Agricultural Statistics Service.

Ribera, L.A., F.M. Hons, and J.W. Richardson. "An Economic Comparison between Conventional and No-tillage Farming Systems in Burleson County, Texas." *Agronomy Journal* 96(March-April 2004): 415-24.

Richardson, J.W., S.L. Klose, and A.W. Gray. "An Applied Procedure for Estimating and Simulating Multivariate Empirical Probability Distributions in Farm Level Risk Assessment and Policy Analysis." *Journal of Agriculture and Applied Economics* 32(August 2000): 299-315.

Richardson, J.W., K. Schumann, and P. Feldman. "SIMETAR©. Simulation for Excel to Analyze Risk." Agricultural and Food Policy Center, Dept. of Agric. Econ., Texas A&M University, January 2004.

Schumann, K.D., J.W. Richardson, G. Lien, and J.B. Hardaker. "Stochastic Efficiency Analysis Using Multiple Utility Functions." Paper presented at the AAEA Annual Meeting, Denver, CO, 1-4 August, 2004.

Shapiro, C.A., D.L. Holshouser, W.L. Kranz, D.P. Shelton, J.F. Witkowski, K.J. Jarvi, G.W. Echtenkamp, L.A. Lunz, R.D. Frerichs, and R.L. Brentlinger. "Tillage and Management Alternatives for Returning Conservation Reserve Program Land to Crops". *Agronomy Journal*. 94(July/Aug 2001): 850-862.

Stubbs, M. *Land Conversion in the Northern Plains*. Congressional Research Service, Library of Congress. CRS Report for Congress. 2007

Thompson, C.A. and D.A. Whitney. "Long-term Tillage and Nitrogen Fertilization in a West Central Great Plains Wheat-Sorghum-Fallow Rotation". *Journal of Production Agriculture.* 11(July/Sept 1998): 355-359.

Unger, P.W. "Conversion of Conservation Reserve Program (CRP) Grassland for Dryland Crops in a Semi-Arid Region". *Agronomy Journal*. 91(Sept/Oct 1999): 753-760.

USDA-FSA. 2008a. *Conservation Reserve Program Monthly Summary – July, 2008*. http://www.fsa.usda.gov/Internet/FSA_File/july2008.pdf . Accessed August 27, 2008.

USDA-FSA. 2008b. *CRP Enrollment By Year of Contract Expiration*, http://www.fsa.usda.gov/Internet/FSA_File/expiringfips.xls.Accessed August 27, 2008.

University of Nebraska-Lincoln. 2008. *U.S. Drought Monitor*. http://drought.unl.edu/dm/dmtabs_archive.htm. Access August 27, 2008.

Williams, J.R. "A Stochastic Dominance Analysis of Tillage and Crop Insurance Practices in a Semiarid Region." *American Journal of Agricultural Economics*. 70(Feb. 1988):112-120.

Williams, J.R., O.S. Johnson, and R.E. Gwin. Tillage Systems For Wheat and Sorghum: An Economic and Risk Analysis. *Journal of Soil and Water Conservation.* 42(1987):120-123.

Williams, J.R., R.V. Llewelyn, and C.L. Mikesell. "An Economic Analysis of Conservation Tillage Systems for Wheat, Grain Sorghum, and Soybeans in the Great Plains". *Journal of Soil and Water Conservation.* 22(May/June 1989): 234-239.

Williams, J.R., T.W. Roth, and M.M. Claassen. "Profitability of Alternative Production and Tillage Strategies for Dryland Wheat and Grain Sorghum in the Central Great Plains". *Journal of Soil and Water Conservation.* 22(Jan-Mar 2000): 49-56.

Table 1. Yields, gross returns, costs, and net returns for each wheat-sorghum-fallow strategies.

	Strategies[1]		
	CT	RT	NT
Mean Yield[1]			
Wheat	36.1	42.4	45.1
Sorghum	41.6	67.2	75.4
Std. Dev Yield[2]			
Wheat	19.3	20.4	20.4
Sorghum	30.8	30.5	34.9
C.V.			
Wheat	0.54	0.48	0.45
Sorghum	0.74	0.45	0.46
Gross Return[3]	$220.11	$295.17	$321.92
Total Costs[3]	$182.46	$192.27	$222.96
Net Return			
per harvested acre ($/acre)[4]	$37.65	$102.90	$98.97
per crop acre ($/acre) in rotation[5]	$25.10	$68.60	$65.98

[1] CT – Conventional tillage wheat-sorghum-fallow
RT – Reduced tillage wheat-sorghum-fallow
NT – No-tillage wheat-sorghum-fallow
[2] Bu./acre
[3] $/acre
[4] 2 acres harvested for every 3 in rotation
[5] 3 acres in rotation including fallow

Table 2. Selected costs ($/harvested acre).

	Strategies[1]		
	CT	RT	NT
Field Operations			
Tillage and Fertilizer	$30.80	$17.48	$4.37
Planting	$10.72	$10.72	$13.13
Herbicide	$4.50	$11.25	$20.25
Subtotal	$46.02	$39.45	$37.75
Inputs			
Seed	$8.96	$8.96	$8.96
Fertilizer	$83.17	$88.26	$106.78
Herbicides	$17.70	$26.84	$38.64
Subtotal	$109.83	$124.05	$154.37
Total[2]	$182.46	$192.27	$222.96

[1] Refer to Table 1 or text for a description of the strategies.
[2] Includes harvest costs that are a function of yield and interest on variable costs.

Table 3. Crop rotation net returns, and difference from CRP returns ($/acre).

	Strategies[1]		
	CT	RT	NT
Without commodity payments			
Net return	25.10	68.60	65.98
less CRP conversion cost[2]	22.59	66.08	63.46
Crop rotation return difference from			
CRP payment of $26.00	-3.41	40.08	37.46
CRP payment of $38.00	-15.41	28.08	25.46
CRP payment of $41.00	-18.41	25.08	22.46
With commodity payments			
Net return	34.55	78.05	75.43
less CRP conversion cost	32.03	75.53	72.91
Crop rotation return difference from			
CRP payment of $26.00	3.03	49.53	46.91
CRP payment of $38.00	-5.97	37.53	35.91
CRP payment of $41.00	-8.97	34.53	31.91

[1] Refer to Table 1 or text for a description of the strategies.
[2] Cost of preparing CRP for planting.

Table 4. Breakeven crop price pairs to equate crop returns to CRP rental rates ($/bu.)[1]

	Strategies[2]					
	CT		RT		NT	
	Wheat	Sorghum	Wheat	Sorghum	Wheat	Sorghum
<u>Without commodity payments</u>						
Crop rotation return difference from						
CRP payment of $26.00	7.69	4.15	6.46	2.92	6.63	3.09
CRP payment of $38.00	8.15	4.61	6.79	3.25	6.93	3.39
CRP payment of $41.00	8.27	4.73	6.87	3.54	7.00	3.46
<u>With commodity payments</u>						
Crop rotation return difference from						
CRP payment of $26.00	7.33	3.79	6.20	2.66	6.39	2.85
CRP payment of $38.00	7.79	4.25	6.53	2.99	6.69	3.15
CRP payment of $41.00	7.91	4.37	6.61	3.07	6.77	3.23

[1] A difference of $3.54/bu. between wheat and sorghum prices is maintained in these price pairs.
[2] Refer to Table 1 or text for a description of the strategies.

Table 5. Simulated net return characteristics for each wheat-sorghum-fallow production strategies ($/acre).

	Strategies[1]		
	CT	RT	NT
Mean	-$3.71	$36.20	$31.75
Std. Dev.	$51.71	$67.09	$71.73
C.V.[2]	NA	$1.85	$2.26
Minimum	-$95.50	-$77.09	-$100.00
Maximum	$237.12	$306.33	$347.02

[1] Refer to the text for a description of strategies.
[2] Coefficient of Variation (C.V.) is a unitless measure of relative risk; the standard deviation divided by the mean. An NA is reported if its value is negative.

Figure 1. Cumulative probability distributions of simulated net returns for each strategy ($/acre).

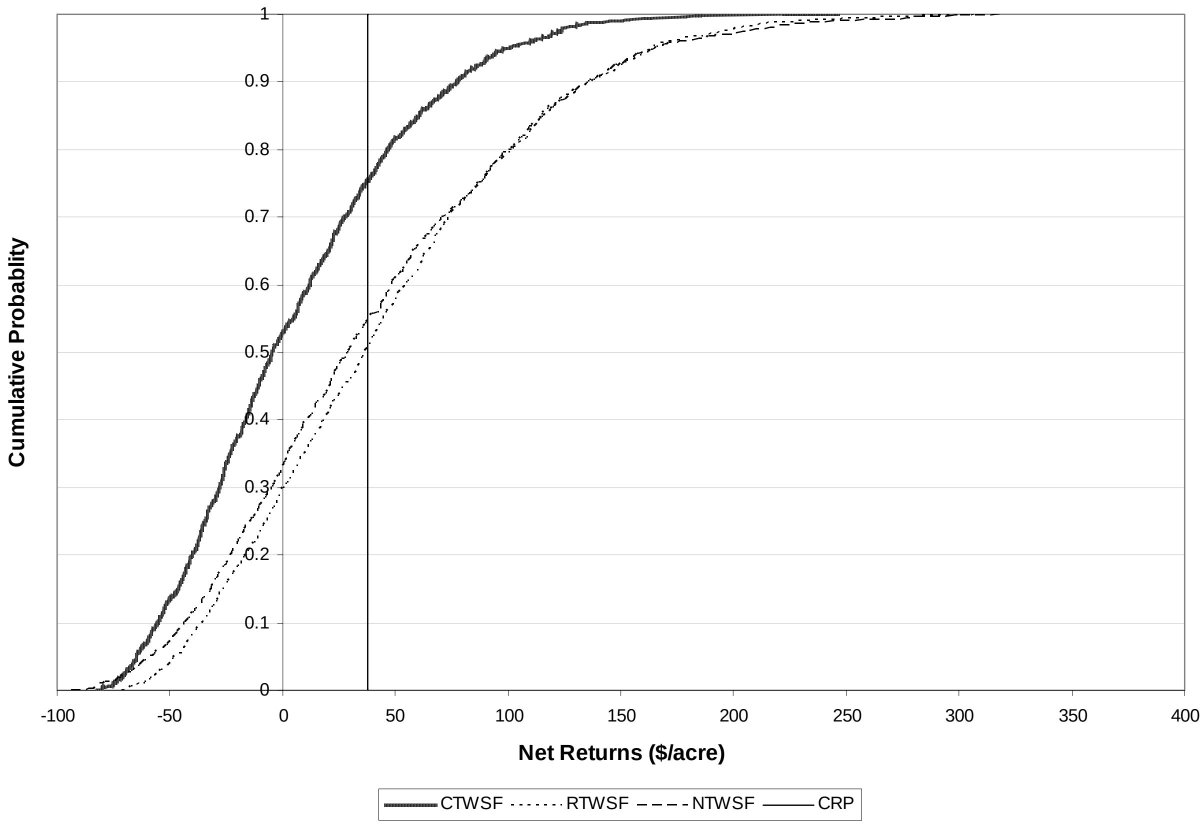

Figure 2. Stochastic Efficiency with Respect to A Function (SERF) Under a Negative Exponential Utility Function.

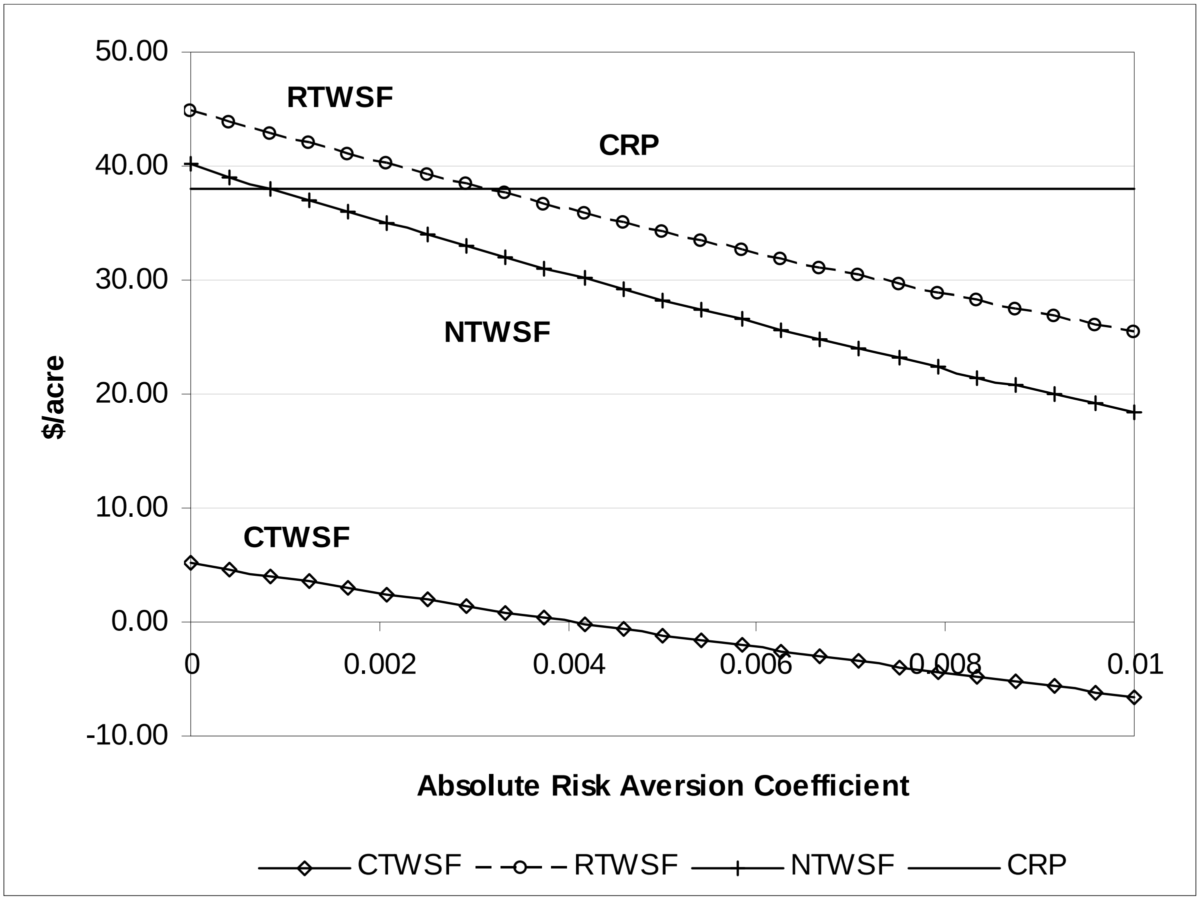

Figure 3. Negative Exponential Utility Weighted Risk Premiums Relative to CRP.