An Economic Risk Analysis of Stocker Grazing on Conservation Tillage Small Grains Forage in Arkansas

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Abstract

This study evaluates both the profitability and risk efficiency of grazing stocker steers on conservation tillage winter wheat pasture using simulation and stochastic efficiency with respect to a function (SERF). Average daily gains are simulated for steers grazed on conventional tillage (CT), reduced tillage (RT) and no-till (NT) winter wheat pasture. Steer price distributions and prices for key production inputs such as diesel, fertilizer, and glyphosate are also simulated. Stocker steer net return distributions by tillage treatment are constructed and ranked for risk efficiency using SERF. The results indicate the NT system is the most profitable and most risk efficient of the three tillage systems, followed by the RT system. Both conservation tillage systems dominate the CT system under risk aversion based on SERF analysis and generate positive risk premiums for risk-averse cattle producers above the CT system.

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Grains Forage in Arkansas

Introduction

Winter wheat is one of the most common winter annuals grown in the United

States due to its high forage quality and adaptability to a wide range of climates. Soft red

winter wheat is the common wheat type grown in the southern United States and is the

primary wheat type produced in Arkansas. Grazing cattle on winter wheat is a common

practice in the Southern Great Plains (Decker et al.; Epplin, Krenzer, and Horn; Krenzer

et al.). However, winter wheat is almost exclusively harvested for grain in Arkansas with

the majority of total planted wheat area located in the eastern part of the state (Anders et

al.). Many areas of Arkansas are well suited for grazing stocker calves on winter wheat

or other small grains forage, but few cattle operations take advantage of this potential

value-adding opportunity. Most cattle operations in the state can be classified as cow-

calf operations, where calves are typically born in late winter or spring and sold at

weaning in the fall (Troxel et al.).

Production systems that integrate stocker cattle with soft red winter wheat may

have value both in Arkansas and the southern United States. Research conducted from

1996 to 2001 at the Livestock and Forestry Branch Station (LFBS) near Batesville,

Arkansas demonstrated that stocker calves can be productively grazed on soft red winter

wheat during the winter (Daniels et. al.). However, conventional tillage planting methods

were used exclusively in this research. Much of the land area that could potentially be

used for production of winter wheat forage in Arkansas is highly erodible, and

conservation tillage practices that maintain surface residue may be more appropriate in

areas susceptible to soil erosion. Intensive tillage also releases soil organic carbon in gaseous form into the atmosphere when the soil is turned and thus contributes to the accumulation of greenhouse gases. Conservation tillage practices such as no-till have been promoted as ways to sequester carbon in agricultural production (Hartell; West and Post).

Profit generation is also a major consideration when evaluating alternative winter wheat forage production methods. Conventional tillage requires the use of large and expensive pieces of equipment and is very fuel and labor intensive. In contrast, conservation tillage systems require less machinery and equipment and are less fuel and labor intensive. However, conservation tillage systems control weeds by substituting herbicides for tillage either partially or exclusively, and the additional cost of herbicide applications can be substantial (Epplin et al.).

Two recent studies have evaluated the economics of stocker grazing on conservation tillage winter forage using partial budget analysis. Anders et al. used partial budget analysis to evaluate the average profitability of grazing stocker steers on soft red winter wheat and rye forage planted with conservation tillage methods in Arkansas. Three years of steer weight gain and forage production data from the LFBS were used to calculate stocker grazing returns to conventional tillage (CT), reduced tillage (RT), and no-till (NT) forage production. The NT system was the most profitable of the three systems on average followed by the RT system. The CT system had a negative average return over the three-year study period. Lower forage production costs and higher fall weight gains were cited as the primary reasons for greater profitability of the conservation tillage systems relative to the CT system. Biermacher et al. used partial

budget analysis to compare the relative profitability of stocker grazing on NT and CT winter rye/ryegrass forage based on 8 years of data from the Pasture Demonstration Farm of the Samuel Roberts Nobel Foundation in south-central Oklahoma. Their study found greater average profitability for NT relative to CT, but the authors noted the relative profitability of NT to CT was sensitive to both the price of herbicide and the price of fuel.

Both studies cited above demonstrate that conservation tillage systems can be profitable alternatives to conventional tillage systems in the production of winter small grains forage for stocker grazing. However, the findings of both studies are based on the assumption of risk neutrality in that they assume the decision maker will choose the strategy with the highest expected return regardless of return variability. Empirical investigations of risk in agriculture indicate that farmers express varying degrees of risk aversion and that their risk attitudes may strongly affect their economic behavior (Robison et al.). Therefore, a more complete investigation of the profitability of stocker grazing on conservation tillage winter wheat forage should account for risk in the form of return variability.

This study uses simulation and and stochastic efficiency with respect to a function (SERF) to evaluate the risk efficiency of stocker grazing on conservation tillage winter wheat pasture. Average Daily Gains (ADGs) and steer price distributions are simulated using seven years of stocker weight gain data from the Livestock and Forestry Branch Station (LFBS) near Batesville, Arkansas and steer price data from the Arkansas Weekly Livestock Summary (USDA, Agricultural Marketing Service) for the period 2002-2003 through 2007-2008. Prices for key production inputs such as diesel, fertilizer, and glyphosate are also simulated to account for the impacts of stochastic input prices on

stocker return variability. Stocker steer net return distributions by tillage treatment are constructed and ranked for risk efficiency using SERF.

Materials and Methods

Description of Tillage Systems. A research study was initiated in the fall of 2002 at the University of Arkansas LFBS near Batesville, Arkansas to evaluate forage production, animal performance, changes in soil characteristics, and economic returns associated with stocker grazing on soft red winter wheat forage established under conservation tillage. The study is ongoing and was in its eighth year at the time of this analysis. Details of the first four years of the study may be found in Anders et al. and Bowman et al.

Three tillage systems are evaluated in this study: 1) CT, 2) RT, and 3) NT. The CT system consists of chisel plowing to a depth of 8 to 10 in followed by disking two times with a cutting disk to incorporate any plant material and fertilizer or lime into the soil. A finishing disk is used two times prior to planting with seeds planted into a prepared seedbed using a conventional grain drill. The RT strategy consists of applying 4 pt ac^{-1} of glyphosate one week prior to planting. Tillage is limited to one pass of a finishing disk to disturb the soil surface with a target of 50% soil residue cover remaining at the time of seeding. A conventional fertilizer spreader is used to plant seed, and a harrow is used to drag the field to cover the seed. The NT strategy controls weeds exclusively by applying 4 pt ac^{-1} of glyphosate one week prior to planting. Seed is planted directly into the stubble using a no-till grain drill.

Pastures are planted during the first week of September for all three tillage systems. 60 lb ac^{-1} of soft red winter wheat seed and 60 lb ac^{-1} of cereal rye seed were

planted during the first four years of the study (Bowman et al.) while 110 lb ac^{-1} of soft red winter wheat seed was planted exclusively during the last three years of the study. Fertilizer and lime were applied each year based on soil testing and soil test recommendations. Nitrogen fertilizer was applied twice in the form of urea to each tillage system with the first application occurring in the fall prior to planting and the second application occurring during the last two weeks of February. Both nitrogen applications consisted of 135 lb ac^{-1} urea each (60 lb ac^{-1} N). Average soil surface residue was 82, 65, and 4% for NT, RT, and CT, respectively, during the first four years of the study (Bowman et al.).

Simulated Average Daily Gains, Death Loss, Steer Prices, and Production Costs. Steer average daily gains (ADGs) were simulated using seven years of average daily gain data obtained from a conservation tillage winter wheat forage production study conducted at the University of Arkansas LFBS for the period 2002-2003 to 2008-2009. Average daily gain data were collected for both a fall and a spring grazing period by tillage system (CT, RT, and RT). During the fall period, steers were generally placed on winter wheat pasture in mid to late November and removed sometime during the last week of January to the middle of February. During the spring grazing period, steers were typically placed on winter wheat pasture at the beginning of March and removed either at the end of April or during the beginning week of May. Pastures were stocked when forage height reached 8 in and were removed when forage mass (end of winter grazing period) or forage quality (end of spring grazing period) limited steer performance. A transition period of approximately 15 days occurred between fall and spring grazing periods in most study years to allow for a second application of nitrogen fertilizer and to

allow for sufficient forage mass accumulation for initiation of spring grazing. Details of fall and spring ADG values and grazing initiation and termination dates for the first four years of this study may be found in Anders et al. and Bowman et al.

Fall and spring ADGs were simulated using Simulation and Econometrics To Analyze Risk (SIMETAR), developed by Richardson, Schumann, and Feldman. Multivariate empirical distributions (MVEs) were used to simulate 500 iterations of fall and spring ADGs by tillage system. A MVE distribution simulates random values from a frequency distribution made up of actual historical data and has been shown to appropriately correlate random variables based on their historical correlation (Richardson, Klose, and Gray). Parameters for the MVE include the means, deviations from the mean or trend expressed as a fraction of each variable, and the correlation among variables. The MVE distribution is used in instances where data observations are too few to estimate parameters for another distribution (Pendell et al.).

Deviations from the 7-year means and their associated correlations were used to estimate the parameters for the MVE ADG distributions. Summary statistics for the simulated ADGs are presented by tillage system in Table 1. Stochastic fall ADG values for late-November through April were calculated by weighting the simulated fall and spring ADG values by the average number of grazing days for each period during the 7-year study (88 fall days; 53 spring days; 141 total grazing days). A 15 day transition period was assumed to occur in February between the fall and spring periods in which fall steers are briefly removed from winter pasture to allow a second nitrogen application to winter pasture.

Death losses have averaged around 2% for the Batesville study period and have ranged from 1 to 3.5%. A stochastic series of death loss percents was generated for the study using a truncated gamma distribution, with a mean of 2, a standard deviation of 0.75 [$\Gamma(\alpha=5.33; \beta=0.375)$], an absolute minimum value of 1, and an absolute maximum value of 3.5. The parameter values used for α and β parameters in the truncated gamma distribution were obtained from Anderson et al. Summary statistics for the generated stochastic death loss series are presented in Table 1.

Multivariate empirical distributions were used to simulate steer purchase and sale prices and key production input prices. Summary statistics for each simulated price are presented in Table 2. All price simulations were based on historical prices observed for the 2002-2003 through 2008-2009 period. Deviations from 7-year means and their associated correlations were used to simulate the MVE price distributions for each price series. Historical steer prices for medium and large number 1 steers were used to simulate the MVE distributions and were obtained from archival publications of the Arkansas Weekly Livestock Summary (USDA, Agricultural Marketing Service). The fall 400-500 lb steer purchase price was simulated based on average prices for October and November. October and November prices were used to reflect the fact that a set of stocker calves for grazing is often put together from purchases made over several weeks (Anderson et al.). The January 500-600 lb steer purchase price was simulated to account for the purchase of additional steers to fully utilize spring grazeout capacity. A May 700-800 lb steer sell price was simulated to account for the sale of fall and spring steers after removal from spring pasture at the end of April. Historical prices for urea, DAP, potash, diesel, and glyphosate were obtained from the USDA, National Agricultural

Statistics Service (2006, 2009a) to simulate fuel, fertilizer and herbicide prices for winter wheat forage production. Historical input prices represent April U.S. prices for the period 2002-2008.

A price slide similar to that used by Anderson et al. was used to adjust simulated May steer prices upward or downward in instances where stochastic steer ending weights were below 700 lb or above 800 lb hd^{-1}. Simulated May steer prices were adjusted upward by $0.0438 lb^{-1} when stochastic steer ending weights fell below 700 lb hd^{-1} and were adjusted downward by $0.0104 lb^{-1} when stochastic steer ending weights exceeded 800 lb hd^{-1}. These adjustments represent historical differences between average 650-700 lb and 700-800 lb May steer prices (+$0.0438 lb^{-1}) and between average 800-850 lb and the 700-800 lb May steer prices (-$0.0104 lb^{-1}) obtained for the period 2004-2009 from the Arkansas Weekly Livestock Summary (USDA, Agricultural Marketing Service).

Simulated Stocker Steer Net Returns. Stocker steer net returns were simulated by iteration and tillage system using the following equation:

$$SNR_{ij} = \sum_{k=1}^{2} [SR_k (MAYP_{ijk} \cdot SWHT_{ijk} - (1 + C_k) \cdot BUYP_{ik} \cdot PWHT_k - DL_{ijk}$$

$$- SHRINK_{ijk} - STEER_k)] - FORAGE_{ij} \tag{1}$$

where i = 1 to 500 iterations; j = 1 to 3 tillage systems (CT, RT, or NT); k = 1 to 2 grazing seasons (fall, spring); SNR_{ij} = the simulated stocker steer net return for iteration i and tillage system j ($ ac^{-1}); SR_k = stocking rate for grazing season k (hd ac^{-1}); $MAYP_{ijk}$ = simulated May steer selling price for iteration i, tillage system j, and grazing season k ($ lb^{-1}); $SWHT_{ijk}$ = the simulated steer selling weight for iteration i, tillage system j, and grazing season k (lb hd^{-1}); C_k = the cost of borrowed capital required to purchase steers

10

for grazing season k (%); $BUYP_{ik}$ = simulated steer purchase price for iteration i and

grazing season k ($ lb^{-1}); $PWHT_k$ = the fall steer purchase weight for grazing season k (lb

hd^{-1}); DL_{ijk} = simulated death loss for iteration i, tillage system j and grazing season k ($

hd^{-1}); $SHRINK_{ijk}$ = shrinkage cost for iteration i, tillage system j, and grazing season k ($

hd^{-1}); $STEER_k$ = steer receiving and hauling expense for grazing season k ($ hd^{-1}); and

$FORAGE_{ij}$ = the simulated forage production expense for iteration i, and tillage system j

($ ac^{-1}). The variable C_k is equal to the interest rate for borrowed capital weighted by the

number of months steers are held after purchase (7 months for the fall grazing period; 4

months for the spring grazing period). An interest rate of 8.25% was charged for

borrowed capital in this study. The DL_{ijk} variable is calculated as steer sell value

multiplied by the simulated death loss percent. The $SHRINK_{ijk}$ variable is calculated as

the steer sell value adjusted for death loss multiplied by the shrink percent associated

with the stress of transport during the sale process. A shrinkage percent of 2% was used

for this study. The forage and livestock production input data used to calculate stocker

net returns in equation 1 are presented in Table 3.

The simulated May steer selling weight variable was calculated as follows:

$$SWHT_{ijk} = PWHT_k + ADGR_k \cdot RD_k + ADGG_{ijk} \cdot GD_k \tag{2}$$

where $ADGR_k$ = the receiving period average daily gain for grazing period k (lb d^{-1}); RD_k

= the number of receiving days for grazing period k; $ADGG_{ijk}$ = the simulated grazing

average daily gain for iteration i, tillage system j, and grazing season k (lb d^{-1}); GD_k = the

number of grazing days on winter wheat forage for grazing season k; and $PWHT_k$ is as

defined above. The values used for $PWHT_k$, $ADGR_k$, RD_k , and GD_k are presented in Table 3.

Per steer receiving and hauling expenses for fall and winter grazing were calculated as follows:

$$STEER_k = FEED \cdot (RD_k + TD_k) + LABOR_k + MINERALS \cdot (RD_k + TD_k + GD_k)$$
$$+ VET_k + CHKOFF + HAULIN + HAULOUT \qquad (3)$$

where $FEED$ = the cost of feed and hay associated with receiving and transition days ($ hd^{-1} d^{-1}); TD_k = transition days for grazing season k when steers are pulled off winter wheat pasture for pasture fertilization; $LABOR_k$ = the labor expense associated with receiving and hauling for grazing season k ($ hd^{-1}); $MINERALS$ = the cost of minerals ($ hd^{-1} d^{-1}); VET_k = the steer veterinary and medicine cost for grazing season k ($ hd^{-1}); $CHKOFF$ = the Checkoff cost per steer ($ hd^{-1}); $HAULIN$ = the haul in cost per steer ($ hd^{-1}); $HAULOUT$ = the haul out cost per steer ($ hd^{-1}); and RD_k and GD_k are as defined above. The TD_k variable equals 15 for the fall grazing period and 0 for the spring grazing period (Table 3). Inputs used to calculate receiving and hauling expenses are found in Table 4 and are based on actual costs incurred in the Batesville study during the 2008-2009 study period.

The simulated forage production expense variable was calculated as follows:

$$FORAGE_{ij} = FVE_j + FFE_j + FUELP_i \cdot FUELQ_j + UREAP_i \cdot UREAQ + DAPP_i$$
$$\cdot DAPQ + POTASHP_i \cdot POTASHQ + HERBP_i \cdot HERBQ_j \qquad (4)$$

where FVE_j = forage production variable expenses excluding fuel, fertilizer, and herbicide for tillage system j ($ ac^{-1}); FFEj = forage production fixed expenses for tillage system j ($ ac^{-1}); $FUELP_i$ = the simulated diesel fuel price for iteration i ($ gal^{-1}); $FUELQ_j$ = the quantity of diesel fuel used for tillage system j (gal ha^{-1}); $UREAP_i$ = the simulated urea price for iteration i ($ lb^{-1}); $UREAQ$ = the quantity of urea applied in each tillage system (lb ha^{-1}); DAP_i = the simulated diammonium phosphate price for iteration i ($ lb^{-1}); $DAPQ$ = the quantity of diammonium phosphate applied in each tillage system; $POTASHP_i$ = the simulated potash price for iteration i ($ lb^{-1}); $POTASHQ$ = the quantity of potash applied in each tillage system; $HERB_i$ = the simulated glyphosate price for iteration i ($ pt^{-1}); and $HERBQ_j$ is the quantity of glyphosate used for each tillage system j (pt ac^{-1}). $HERBQ_j$ = 0 for the CT system. The inputs used to calculate forage production expenses are presented in Table 5.

Risk Analysis. Stocker net return distributions under CT, RT, and NT were ranked according to risk attitudes using stochastic efficiency with respect to a function (SERF). The SERF method orders a set of risky alternatives in terms of certainty equivalents (CE) calculated for specified ranges of risk attitudes (Hardaker et al.). A certainty equivalent (CE) is equal to the amount of certain payoff an individual would require to be indifferent between that payoff and a risky investment. The CE is typically less than the expected (mean) monetary value and greater than or equal to the minimum monetary value of a stream of monetary outcomes (Hardaker et al.). The SERF method allows for simultaneous rather than pairwise comparison of risky alternatives (Hardaker et al.). Graphical presentation of SERF results facilitates the presentation of ordinal rankings for decision makers with different risk attitudes and provides a cardinal measure

of a decision maker's conviction for preferences among risky alternatives at each risk aversion level by interpreting differences in CE values for a given risk aversion level as risk premiums (Hardaker et al.).

The SERF method calls for calculating CE values over a range of absolute risk aversion coefficients (ARACs). The ARAC represents a decision maker's degree of risk aversion. Decision makers are risk averse if ARAC > 0; risk neutral if ARAC = 0, and risk preferring if ARAC < 0. The range of ARAC values used in this analysis was from 0 (risk neutral) to 0.005 (strongly risk averse). The latter value was calculated using the formula proposed by Hardaker et al. of $r_a(w) = r_r(w)/w$, where $r_a(w)$ = absolute risk aversion with respect to wealth (w), and $r_r(w)$ = relative risk aversion with respect to wealth. In this analysis, $r_r(w)$ was set to 4 (very risk averse) as proposed by Anderson and Dillon. The value for w was estimated as the average stocker steer return across the three tillage treatments ($35.15 ac^{-1}) divided by an estimated rate of return on wealth of 4.46 percent. The 4.46 percent was approximated as the ratio of the 2009 cash rent to cropland value reported for Arkansas in Land Values and Cash Rents 2009 Summary (USDA, National Agricultural Statistics Service, 2009b).

The SERF procedure in SIMETAR was used to calculate CE values by stocker steer grazing strategy over the ARAC ranges specified above. A negative exponential utility function was used to calculate CE values for each ARAC range (Hardaker et al.). Risk premiums associated with steers grazed on conservation tillage winter wheat were also calculated by subtracting conventional tillage CE values from reduced tillage and no-till CE values and were mapped across ARAC values.

Results and Discussion

Summary statistics of stocker steer returns and forage production expenses are presented by tillage system in Table 6. Summary statistics are presented for fall and spring steer returns above receiving and hauling expenses, winter wheat forage production expenses, and steer net returns above both receiving and hauling expenses and forage production expenses.

Steer returns above receiving and hauling expenses are larger and less variable for the fall grazing season than for the spring grazing season across all three tillage systems. Minimum steer returns above receiving and hauling expenses are also larger in magnitude for spring steers than for fall steers across all three tillage systems. These results occur because spring steers are purchased at heavier weights and are on wheat pasture for a shorter time frame than fall steers. Thus, returns net of purchase cost, shrinkage, and death loss for spring steers are smaller and cover receiving and hauling expenses less often than those for fall steers.

Average total (fall plus spring) steer returns above receiving and hauling are larger for the NT system than for the RT or CT systems ($219 ac^{-1} for NT; $198 ac^{-1} and $190 ac^{-1} for RT and CT, respectively). The return variability of total steer returns above receiving and hauling expenses is nearly equal for the RT and CT systems but is slightly smaller for the NT system as measured by the CV (CV = 57 and 58 for CT and RT, respectively; CV = 51 for NT). Thus the NT system is more profitable and slightly less risky than either the RT or CT systems when forage production expenses are excluded from consideration.

The average cost of producing winter wheat forage is largest for the CT system

($177 ac^{-1}) but is nearly equal for both the NT and RT systems ($162 ac^{-1} and $161 ac^{-1}

for NT and RT, respectively). The relative variability of forage production expenses is

comparatively equal across the three tillage systems (CV = 16 for CT and RT; CV = 15

for NT). These results imply that stochastic fuel, fertilizer, and herbicide prices impact

the cost variability of forage production uniformly across tillage systems, but the relative

expense of forage production is larger for conventional tillage than for conservation

tillage, implying a cost savings for conservation tillage.

Average steer net returns above total specified expenses are largest for the NT

system ($56 ac^{-1}), followed by the RT system ($37 ac^{-1}) and the CT system ($12 ac^{-1}).

Thus a risk-neutral cattle producer would prefer the NT system to either the RT or the CT

system. These results are similar to those found using partial budget analysis by Anders

et al. (2007) and Biermacher et al. (2009). The NT system also has the smallest relative

return variability (CV = 204) while the CT system has the largest relative return

variability (CV = 910) of the three tillage systems. The NT system is therefore the most

profitable and least risky of the three systems, while the CT system is the least profitable

and most risky of the three systems.

The steer net return statistics presented in Table 6 demonstrate the relative

profitability and return variability of the three tillage systems, but also reveal potential for

receiving either large negative returns or large positive returns among the three systems.

Minimum net returns for all three systems are large and negative, ranging from -$341 ac^{-1}

for the CT system to -$313 ac^{-1} for the RT system. Alternatively, maximum net returns

for each tillage system are well above mean returns and range from $355 ac^{-1} for the CT

system to $390 ac^{-1} for the NT system. Probabilities of receiving a return below $0 ac^{-1}

and the probabilities of receiving a return above $150 ac^{-1} are presented in Figure 1. The

$150 ac^{-1} value represents the average of the mean steer net return plus one standard

deviation across the three tillage systems. Thus, probabilities of receiving returns greater

than $150 ac^{-1} represent probabilities of receiving favorable or exceptional returns.

Consequently, probabilities of receiving returns below $0 ac^{-1} represent the probabilities

of receiving negative returns. The NT system has the smallest probability of receiving a

negative return (32%), and the largest probability of receiving a favorable return (22%),

while the CT system has the largest probability of receiving a negative return (45%) and

the smallest probability of receiving a favorable return (10%).

Steer net return SERF results are plotted across ARAC values by forage tillage

treatment in Figure 2. Strategies that are risk preferred in Figure 2 have the locus of

points of highest CE values. Thus the NT system would be the most preferred of the

three systems by risk-averse cattle produces, followed by the RT system. Consequently,

the CT system would be the least preferred system by risk-averse cattle producers. In

fact, CE values for the CT system become negative at ARAC values greater than 0.002,

implying that this system would be too risky for cattle producers with ARAC values

greater than 0.002. Risk premiums associated with the NT and the RT systems over the

CT system are mapped across ARAC values in Figure 3. Risk premiums are largest for

the NT system and average $43 ac^{-1} over the CT system across ARAC values. Risk

premiums for the RT system average $23 ac^{-1} over the CT system across ARAC values.

Thus both conservation tillage systems exhibit positive monetary benefits over the CT

system under risk aversion.

Summary and Conclusions

This study evaluated both the profitability and risk efficiency of grazing stocker steers on conservation tillage winter wheat pasture using simulation and SERF analysis. Average daily gains were simulated for steers grazed on CT, RT and NT winter wheat pasture. Steer price distributions and prices for key production inputs such as diesel, fertilizer, and glyphosate were also simulated to account for the impacts of stochastic steer and input prices on stocker return variability. Summary statistics of steer net returns and forage production expenses were presented to evaluate the relative profitability and cost of each tillage system, and SERF analysis was used to rank each tillage system according to risk efficiency.

The NT system is the most profitable and most risk efficient of the three tillage systems, followed by the RT system. The CT system is the least profitable and least risk efficient of the three tillage systems. Both conservation tillage systems dominate the CT system under risk aversion using SERF analysis and generate positive risk premiums for risk-averse cattle producers above the CT system. The risk premium for NT averages $43 ac^{-1}, while the risk premium for RT averages $23 ac^{-1} above the CT system. The SERF results also indicate that certainty equivalents for the CT system become negative as risk aversion increases, implying that this system may be too risky a gamble for cattle producers exhibiting strong risk aversion.

This analysis also highlights the riskiness associated with stocker grazing on winter wheat forage. Based on the findings of this study, stocker grazing on winter wheat forage has the potential to be both highly lucrative and highly unprofitable regardless of the tillage system used. Maximum returns were well above average returns for each

tillage system, but all three systems also had high probabilities of receiving negative returns ranging from 32% for the NT system to 45% for the CT system. Much of the risk associated with stocker grazing on winter wheat pasture may be attributed to the large level of capital required to purchase calves (Anderson et al.) and the highly volatile nature of cattle prices (Harrison et al.). Contract grazing may be one way to reduce the financial risk associated with stocker grazing on winter wheat forage. Contract grazing occurs when a cattle owner contracts with a caretaker to turn out cattle on pasture owned or leased by the caretaker. The caretaker receives a fee (either a fee per unit of gain or a flat charge fee for each day the animal is on the caretaker's pasture or both) from the cattle owner. Contract grazing provides limited capital landowners with a means of utilizing winter forage without having to buy the animals (Anderson et al.) and removes all risks associated with the market (Harrison et al.). However, tradeoffs may exist between the reduced return variability associated with contract grazing and the higher expected returns associated with full ownership. Thus an extension of this study would be to compare the tradeoffs of full ownership as modeled in this analysis with contract grazing.

This analysis also did not consider the possibility of harvesting a wheat crop in addition to grazing cattle on winter wheat. Dual purpose wheat systems for which the wheat crop is both grazed in the fall and winter prior to the first hollow stem and then latter harvested as a crop are common in the Southern Great Plains (Decker et al.; Epplin, Krenzer, and Horn; Krenzer et al.). Such a system would likely have great appeal to Arkansas wheat producers located in river valleys or areas where major row crop production merges with rolling, hilly terrain. Thus another extension of this study would

be to evaluate the profitability and risk efficiency of dual purpose conservation tillage winter wheat systems compared with wheat grazeout systems as modeled in the present study.

Acknowledgements

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Table 1. Simulated Average Daily Gain (ADG) and Death Loss Summary Statistics.

Variable	Mean[*]	sd	CV[†]	Minimum	Maximum
CT Fall ADG (lb d^{-1})	2.28	0.52	22.8	1.04	2.67
RT Fall ADG (lb d^{-1})	2.12	0.68	32.3	1.04	2.79
NT Fall ADG (lb d^{-1})	2.34	0.48	20.3	1.44	2.73
CT Spring ADG (lb d^{-1})	2.05	0.38	18.4	1.32	2.64
RT Spring ADG (lb d^{-1})	2.27	0.30	13.4	1.68	2.71
NT Spring ADG (lb d^{-1})	2.27	0.39	17.1	1.38	2.83
CT Fall (November-April) ADG (lb d^{-1})[‡]	2.19	0.33	14.9	1.15	2.65
RT Fall (November-April) ADG (lb d^{-1})[‡]	2.17	0.41	18.9	1.29	2.76
NT Fall (November-April) ADG (lb d^{-1})[‡]	2.32	0.30	13.2	1.42	2.77
Death Loss (%)[§]	2.00	0.62	31.0	1.02	3.50

Notes: CT = conventional tillage; RT = reduced tillage; NT = no-till.

[*]Summary statistics calculated from 500 simulated iterations.

[†]Coefficient of variation (CV) is a unitless measure of relative risk and is equal to the standard deviation (sd) divided by the mean.

[‡]Sum of fall and spring ADG values weighted by the average number of fall (88) and spring (53) grazing days on winter wheat pasture over the 7 year study period (141 total grazing days). Assumes fall steers are placed on winter wheat pasture in late November, removed briefly for 15 days in February for pasture fertilization, and placed back on pasture at the beginning of March.

[§]Generated using a truncated gamma distribution with a mean of 2, a standard deviation of 0.75 [$\Gamma(\alpha=5.33; \beta=0.375)$], an absolute minimum value of 1, and an absolute maximum value of 3.5.

Table 2. Simulated Steer and Forage Production Input Price Summary Statistics.

Variable	Mean[*]	sd	CV[†]	Minimum	Maximum
Fall, 400-500 lb Steer Price ($ lb^{-1})	1.15	0.12	10.5	0.91	1.32
January, 500-600 lb Steer Price ($ lb^{-1})	1.05	0.11	10.1	0.89	1.26
May, 700-800 lb Steer Price ($ lb^{-1})	0.99	0.08	8.5	0.81	1.10
Potash ($ lb^{-1})	0.13	0.06	44.1	0.08	0.28
Diammonium phosphate (DAP) ($ lb^{-1})	0.19	0.09	49.0	0.11	0.43
Urea ($ lb^{-1})	0.17	0.05	31.5	0.10	0.28
Diesel ($ gal^{-1})	1.97	0.82	41.7	0.96	3.62
Glyphosate ($ pt^{-1})	4.63	0.72	15.5	3.61	5.44

[*]Summary statistics calculated from 500 simulated iterations.
[†]Coefficient of Variation (CV) is a unitless measure of relative risk and is equal to the standard deviation (sd) divided by the mean.

Table 3. Inputs Used to Calculate Stocker Net Returns

Input	Value
Fall Steer Purchase Weight (lb hd^{-1})	431
Fall In Weight (lb hd^{-1})*	489
Fall Receiving Days	45
Fall Grazing Days	141
Fall to Spring Pasture Transition Days	15
Fall Stocking Rate (hd ac^{-1})	1
Spring Steer Purchase Weight (lb hd^{-1})	562
Spring In Weight (lb hd^{-1})*	620
Spring Receiving Days	45
Spring Grazing Days	53
Spring Stocking Rate (hd ac^{-1})	1.5
Interest on Borrowed Capital (%)	8.25
Months Holding Fall Stockers Purchased with Capital	7
Months Holding Spring Stockers Purchased with Capital	4
Shrinkage (%)	2.00
ADG During Receiving (lb d^{-1})	1.29[†]

[*]Weight per steer when placed on winter wheat pasture (equal to the steer purchase weight plus the weight gained during receiving).

[†]Mid-range of ADG values reported for receiving in Rossi et al. (1.25 lb d^{-1}) and Dhuyvetter, (1.33 lb d^{-1})

Table 4. Inputs Used to Calculate Steer Receiving and Hauling Expenses.

Input	Value
Feed and Hay ($ hd^{-1} d^{-1})	1.17
Labor, Fall ($ hd^{-1})	9.13
Labor, Spring ($ hd^{-1})	3.04
Minerals ($ hd^{-1} d^{-1})	0.21
Vet and Medical, Fall ($ hd^{-1})	15.40
Vet and Medical, Spring ($ hd^{-1})	10.27
Checkoff ($ hd^{-1})	1.00
Hauling In ($ hd^{-1})	5.00
Hauling Out ($ hd^{-1})	5.00

Table 5. Inputs Used to Calculate Winter Wheat Forage Production Expenses by Tillage System.

	CT ($ ac^{-1})	RT ($ ac^{-1})	NT ($ ac^{-1})
Non-Stochastic Forage Production Expense Items			
Seed[*]	35.70	35.70	35.70
Custom lime	8.28	8.28	8.28
Hand labor	4.58	1.56	3.90
Operator Labor	11.92	6.12	4.21
Repairs & Maintenance	7.54	2.32	3.68
Interest on Operating Capital	4.86	4.97	4.96
Total Variable Expenses	72.89	58.95	60.73
Total Fixed Expenses	23.24	8.52	10.19
Total Expenses	96.13	67.47	70.92
Fuel, Fertilizer, and Herbicide Input Quantities			
Diesel (l ha^{-1})	6.50	3.33	2.30
Fall Urea (kg ha^{-1})	135	135	135
Spring Urea (kg ha^{-1})	135	135	135
DAP (kg ha^{-1})	60	60	60
Potash (kg ha^{-1})	77	77	77
Glyphosate (l ha^{-1})	0	4	4

Notes: CT = conventional tillage; RT = reduced tillage; NT = no-till
[*]Both winter wheat and rye were planted in first four years of study; only winter wheat was planted in the latter three study years. Seed costs are a weighted average of wheat and rye seed costs ($40.20 ac^{-1}) and winter wheat seed costs ($29.70 ac^{-1}).

Table 6. Simulated Steer Returns and Winter Wheat Forage Production Expenses Summary Statistics by Tillage System.

Tillage System	Mean*	sd	CV[†]	Minimum	Maximum
Fall Steer Returns Above Receiving and Hauling Expenses ($ ac^{-1})					
CT	148	49	33	13	274
RT	146	59	41	-33	290
NT	163	50	31	5	287
Spring Steer Returns Above Receiving and Hauling Expenses ($ ac^{-1})					
CT	41	75	180	-202	258
RT	52	76	146	-168	271
NT	56	76	135	-177	280
Total Steer Returns Above Receiving and Hauling Expenses ($ ac^{-1})					
CT	190	109	57	-149	515
RT	198	114	58	-138	513
NT	219	112	51	-161	553
Winter Wheat Forage Production Expenses ($ ac^{-1})					
CT	177	29	16	141	241
RT	161	26	16	124	223
NT	162	25	15	126	223
Steer Net Returns ($ ac^{-1})					
CT	12	112	910	-341	355
RT	37	117	317	-313	362
NT	56	115	204	-339	390

Notes: CT = conventional tillage; RT = reduced tillage; NT = no-till.

*Summary statistics calculated from 500 simulated iterations.

[†]Coefficient of Variation (CV) is a unitless measure of relative risk and is equal to the standard deviation (sd) divided by the mean.

Figure 1. Steer Net Return Probabilities by Return Interval and Winter Wheat Forage Tillage Method Based on 500 Iterations.
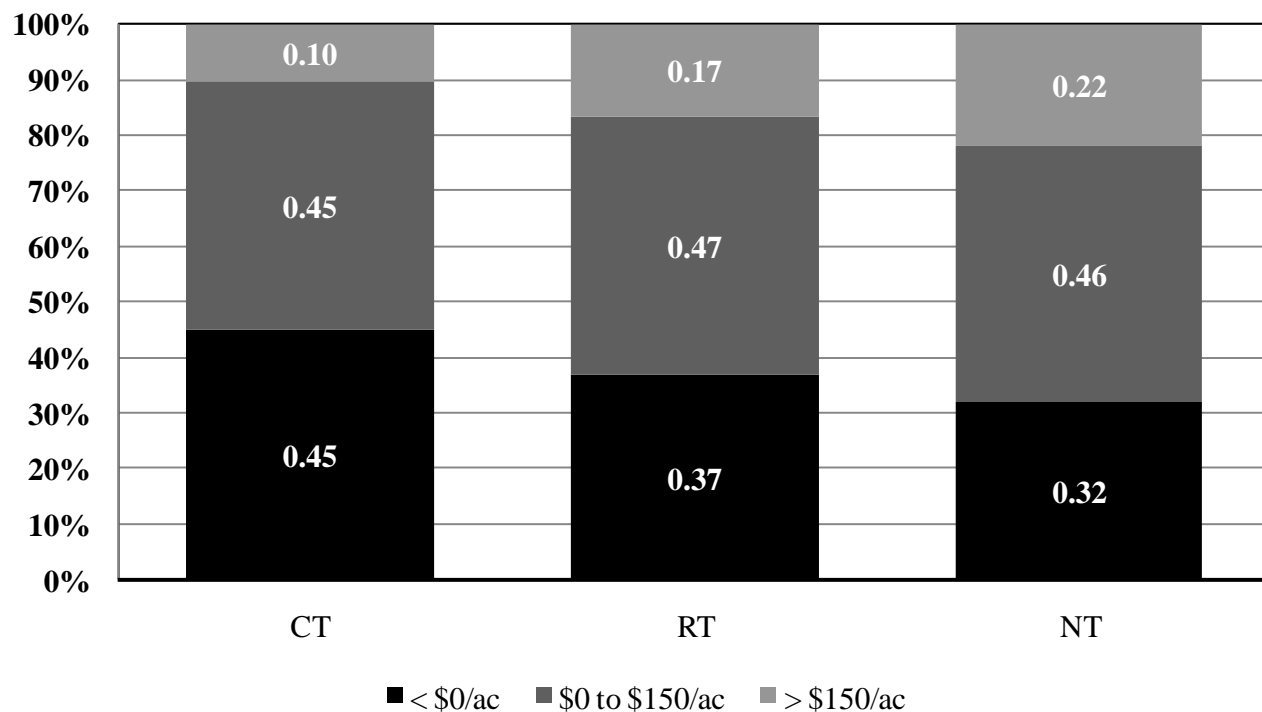
Figure 2. Steer Net Return SERF Results by Winter Wheat Forage Tillage Method Over Absolute Risk Aversion Range of 0.000-0.005 Assuming a Negative Exponential Utility Function.
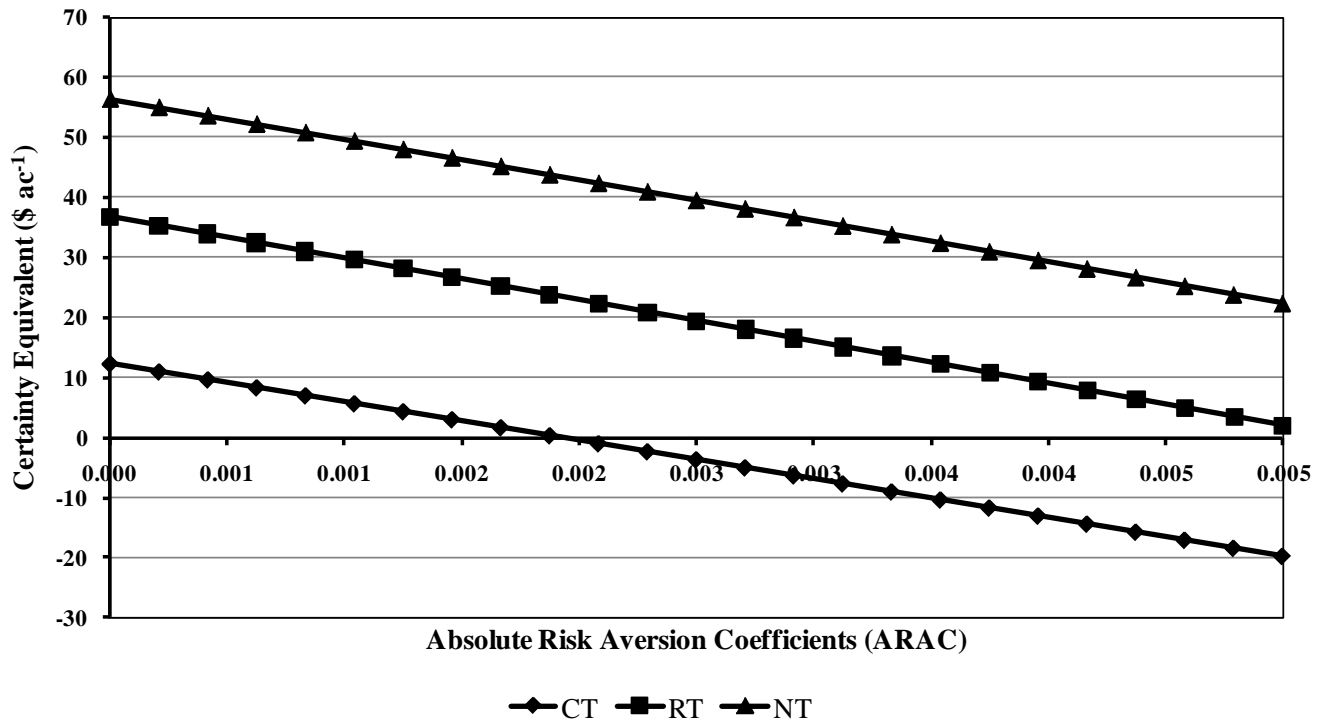
Figure 3. Risk Premiums Associated with Steers Grazed on Conservation Tillage Winter Wheat Forage Over Absolute Risk Aversion Range of 0.000-0.005 Assuming a Negative Exponential Utility Function.