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Energy Supplementation Strategies for Wheat Pasture Stocker Cattle Under Uncertain Forage Availability

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ABSTRACT

Energy supplementation provides a means of reducing production risk of growing stocker cattle on winter wheat pasture. This study addresses the issue of risk aversion and energy supplement input use. Differences in supplementation practices induced by risk aversion and the effects of cattle and feed market conditions are examined. Results show that supplementation practices are likely to be similar across producers, irrespective of their risk attitudes. Cattle and feed market conditions, however, markedly affect supplementation practices. These findings provide information for assisting stockmen in identifying efficient supplementation strategies.

Key Words: energy supplementation, numerical integration, risk, wheat pasture grazing.

Grazing stocker cattle on winter wheat pasture is an important activity for farmers in much of the Southern Plains of the United States. During the vegetative growth stage of winter wheat (typically early November through mid-March), stocker cattle can be grazed on wheat pasture until the initiation of jointing, when they must be removed to avoid reduction in grain yield. Over the past two decades, grazing stocker cattle on wheat pasture has been one of the most profitable cattle enterprises available to Oklahoma stockmen (Bernardo and Wang). However, returns from grazing stocker cattle on winter wheat pasture are also very volatile due to cattle and feed market conditions and production uncertainty.

Production risk occurs because rates of weight gain are uncertain due to volatile weather and forage supply conditions. Since wheat pasture stocker production occurs in the fall-winter period (November–March), considerable variability in forage supplies can occur. Inadequate soil moisture in the fall, prolonged winter dormancy, or extended periods of snow cover can greatly reduce forage availability. Fall-winter forage production observed in the last five years has ranged from less than 100 pounds per acre to over 4,000 pounds per acre (Krenzer, Austin, and Jones).

Recently, the use of energy supplements has been proposed as a means of reducing production risk of growing cattle on winter-wheat pasture (Horn et al. 1992).[1] Supplemental energy provides

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[1] Energy supplement refers to a supplemental food source with high levels of energy content (Mcal/head). In

a means of improving the balance between nitrogen and energy supply from wheat forage, and hence, improves weight gain performance of wheat pasture stocker cattle. Previous analyses have indicated that the introduction of an energy supplementation program can result in an increase in the profitability of the wheat pasture stocker cattle enterprise (Horn et al. 1991).

Producers' risk attitudes, however, may have important implications on the use of energy supplements. For example, alternative risk preferences may induce large differences in supplementation practices across stockmen. In this case, failing to incorporate the influence of risk into winter wheat-pasture stocker cattle production decision analysis may be misleading. Previous studies have not addressed the issue of producers' risk attitudes and their effect on energy supplement input use. This study investigates the influence of risk attitudes on the supplementation practices of wheat pasture stocker producers in central Oklahoma. The effects of cattle and feed market conditions on energy supplement input decisions are also examined. The findings reported here should prove useful in assisting stockmen to identify efficient supplementation strategies.

Theoretical Model

Several approaches have been applied to determine optimal input levels under alternative risk preferences. One approach employs stochastic production functions, such as the specification proposed by Just and Pope, to represent the relationship between input levels and production risk. Certainty equivalent models have also been proposed; however, these models assume normally distributed returns, and thus ignore the effects of higher order moments. Alternatives to the above approaches are methods that explicitly include probability density functions for stochastic variables in the decision model. Dai, Fletcher, and Lee used this approach to determine the effect of soil moisture on optimal nitrogen use. Their specification of the decision problem assumed risk neutrality, and thus did not evaluate the effects of risk preferences on optimal input levels.

The decision model developed in this analysis is similar to the one proposed by Dai, Fletcher, and Lee. The decision model explicitly incorporates the random variability of forage production, and the stochastic variable's effect on input use is examined. The stochastic decision model is formulated and applied under assumptions of risk neutrality and risk aversion. Through comparison of these solutions, differences in supplementation levels induced by risk can be determined.

Consider the following stocker cattle weight gain response function:

$$(1) \quad G = f(EN, PF),$$

where G is daily rate of weight gain (lbs./head), EN is daily quantity of energy supplement (Mcal/head), and PF is the amount of forage available per day (lbs./head). The amount of forage available per steer day (PF) is a function of stocking density (SD) and forage production (F), and is calculated as

$$(2) \quad PF = F \times \frac{SD}{GDAYS},$$

where F is total forage production (lbs./acre), SD is stocking density (acres/head), and $GDAYS$ is grazing days. Stocking densities are assumed constant during the grazing season. Calves are purchased at the beginning of the grazing season, based on information available at that time, and stocked at constant densities until take-off date. Throughout the grazing period, stockmen focus on supplemental feeding decisions as a response to uncertain forage production. This assumption is consistent with management practices employed by producers. In a survey of Oklahoma wheat pasture stocker producers, the majority of producers indicated that they normally feed cattle in response to poor forage production conditions. Only 18% of the producers reported that they remove some or all of their stockers in periods of poor forage production (Walker et al.).

Given that stocking densities are assumed constant, the amounts of forage available per steer day, PF, are random (because of the random fluctuations in forage production levels, F), and thus are outside

this situation, an energy supplement is either a corn-based or a high-fiber ration fed to stocker cattle in order to provide them with an additional source of energy. More details on supplemental feeds are provided in the data section.

the stockman's control. Let the distribution of PF be characterized by the probability density function, $\varphi(PF)$, with $\varphi(PF)$ being conditional on stocking density.

The Decision Problem Under Risk Aversion

The risk-averse stockman's decision problem is to choose the amount of energy supplement, EN, that maximizes expected utility of profit. The optimization problem can be expressed as

$$(3)\quad \underset{EN}{\text{Max}}\ E[U(\pi)] = \underset{EN}{\text{Max}}\ E[U(p \times G(EN, PF) - r_e \times EN - OC)] = \underset{EN}{\text{Max}} \int_{\Omega} U(p \times G(EN, PF) - r_e \times EN - OC)\varphi(PF)\, dPF,$$

where U is a von Neumann-Morgenstern utility function, with $U' > 0$ and $U'' \leq 0$. E is the expectation operator, OC denotes other costs, r_e is the unit cost of energy supplement (\$/Mcal), p is the expected cattle price (\$/lb.), and Ω is the support of PF.

The Decision Problem Under Risk Neutrality

Under risk neutrality, the stockman's decision problem is to choose the quantity of energy supplement that maximizes expected profit:

$$(4)\quad \text{Max}\ E(\pi) = \underset{EN}{\text{Max}}\ E[(p \times G(EN, PF) - r_e \times EN - OC)] = \underset{EN}{\text{Max}} \int_{\Omega} (p \times G(EN, PF) - r_e \times EN - OC)\varphi(PF)\, dPF,$$

where the variables are as defined above.

Procedures

The stocker cattle weight gain response function is estimated using experimental data from a three-year project designed to evaluate alternative supplementation programs for wheat pasture stocker cattle. Time effects are considered by using dummy variables representing different time periods. The following quadratic production function is used:

$$(5)\quad G_{it} = \beta_0 + \beta_1 INWT_{it} + \beta_2 EN_{it} + \beta_3 PF_{it} + \beta_4 EN_{it}^2 + \beta_5 PF_{it}^2 + \beta_6 EN_{it} \times PF_{it} + \sum_{t=1}^{2} a_t D_t + \varepsilon_{it},$$

where G_{it} is daily rate of weight gain (lbs./grazing day), $INWT_{it}$ is the calf weight (lbs.), EN_{it} is daily quantity of energy supplement fed (Mcal/head), PF_{it} denotes the pounds of forage available per steer day on the ith cross-sectional unit at period t. The D_t notations represent year dummy variables, $INWT$ is a covariate, and ε_{it} is the error term.

Ordinary least squares (OLS) regression is used to estimate the production function. The Glejser statistic indicates the presence of heteroskedasticity at the 5% level; thus, the production function is reestimated using maximum likelihood procedures.

The beta density function is chosen to represent the conditional probability distribution of PF. For estimation, the forage production data are scaled from zero to one ($0 < PF < 1$). The beta density function (Mood, Graybill, and Boes) is expressed as

$$(6)\quad \varphi(PF) = \frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} PF^{\alpha-1}(1 - PF)^{\beta-1}, \quad 0 < PF < 1,$$

where $\Gamma(\cdot)$ is the gamma function and is defined as

$$(7)\quad \Gamma(x) = \int_0^{\infty} x^{t-1}e^{-t}\, dt.$$

The two parameters, α and β, are estimated by maximizing the log of the likelihood function:

$$(8)\quad \underset{\alpha,\beta}{\text{Max}}\ \text{Log}L = (\alpha - 1)\sum_t \log(PF_t) + (\beta - 1)\sum_t \log(1 - PF_t) + N\log\Gamma(\alpha + \beta) - N\log\Gamma(\alpha) - N\log\Gamma(\beta),$$

$$\text{s.t.:}\quad \alpha > 0,\quad \beta > 0.$$

Consider the risk-averse stockman's decision model. The optimization problem expressed in equation (3) requires choosing the energy supplement level which maximizes expected utility of average daily net returns. Assuming a negative expo-

nential utility function, the maximization problem can be written as

$$(9)\quad \max_{EN} E[U(\pi_a(EN, PF))] = \max \int_{\Omega} [1 - e^{-\lambda\pi_a(EN,PF)}]\varphi(PF)\, dPF,$$

where λ is the Pratt-Arrow risk aversion coefficient, and $\pi_a(EN, PF)$ denotes average daily net returns per head. Average per head net returns are estimated as

$$(10)\quad \pi_a = p \times G(EN, PF) - 5.64 \times r_s \times EN - OC,$$

where $G(EN, PF)$ represents the estimated production function. The value 5.64 is a conversion factor used to convert the daily quantity of energy supplement (Mcal/head) to a supplemental feed quantity (lbs./head), and r_s (\$/lb.) is the unit cost of supplemental feed.[2]

The integral in equation (9) is approximated using the Gaussian quadrature method of numerical integration (Preckel and DeVuyst). Let utility of average daily net returns be represented by $\Phi(EN, PF)$. Then expected utility of π_a can be expressed as

$$(11)\quad E[U(\pi_a(EN, PF))] = \int_0^1 \Phi(EN, PF)\varphi(PF)\, dPF = \sum_{i=1}^{n} \omega_i \Phi(EN, PF_i),$$

where the PF_i notations are the Gaussian quadrature points and the ω_i expressions are the associated weights. Nine Gaussian quadrature points and associated weights are determined using the procedure of Preckel and DeVuyst. To determine if the nine points are sufficient to give a good approximation of the integral, the solutions obtained with the Gaussian quadrature approximation (in terms of the values of the maximized expected utility) were compared to the solutions obtained using a more accurate numerical integration routine in Maple V (Bruce et al.). The percentage error between the two solutions was approximately zero.

The objective function to be maximized is

$$(12)\quad \max_{EN} E[U(\pi_a(EN, PF))] = \max_{EN} \sum_{1}^{9} \omega_i[1 - e^{-\lambda\pi_a(EN,PF_i)}].$$

Equation (12) is solved using nonlinear optimization subroutines in GAMS/MINOS (Brooke, Kendrick, and Meeraus). Given that PF was scaled from zero to one for the estimation of the beta distribution, the Gaussian quadrature points are scaled to match the original PF data.

Under risk neutrality, the objective is to maximize expected average daily net returns:

$$(13)\quad \max_{EN} E[\pi_a(EN, PF)] = \max_{EN} \sum_{1}^{9} \omega_i[\pi_a(EN, PF_i)].$$

Data and Variable Transformations

Data were obtained at the Oklahoma State University Wheat Pasture Research Facility in Marshall, Oklahoma, from a project designed to evaluate a grain-based, high-starch energy supplement versus a high-fiber energy supplement for growing cattle on wheat pasture. The experiment was conducted over three grazing seasons (1989–90, 1990–91, and 1991–92). Control cattle received no supplement other than free-choice access to a commercial mineral mixture. The other cattle were hand-fed either a corn-based energy supplement (i.e., high-starch supplement) or a high-fiber energy supplement that contained about 47% soybean hulls and 42% wheat middlings (as-fed basis). In 1989–90 and 1991–92, stocking densities were two acres/head for control cattle and 1.5 acres/head for supplemented cattle; in 1990–91, control and supplemented cattle were each allocated to three stocking densities (2.0, 1.64, and 1.38 acres/head). Fall-weaned crossbred steer calves grazed clean-tilled wheat pasture for 115, 107, and 84 days during 1989–90, 1990–91, and 1991–92, respectively. For additional details of the experimental procedures, see Horn et al. (1992).

Time-series and cross-sectional data on pounds of forage available per steer day, quantities of feed supplements, initial calf weights, and final weights are used to estimate the steer weight gain produc-

[2] $EN = (SCONS \times SDAYS \times 0.39)/(2.2 \times GDAYS)$, where *SCONS* is feed supplement (lbs./day), *SDAYS* is supplementation days, and *GDAYS* is grazing days. Letting *SDAYS* equal *GDAYS*, then $SCONS = 5.64 \times EN$. Thus, daily supplementation costs are calculated as $r_s \times 5.64 \times EN$; r_s is now the supplemental feed cost (\$/lb.) rather than the energy supplement cost (\$/Mcal), r_e, as defined in equation (3).

Table 1. Mean and Standard Deviation of Weight Gains (lbs./head) for Control, High-Fiber, and High-Starch Supplemented Wheat Pasture Stocker Cattle (1989–90, 1990–91, and 1991–92)

Feed Type	Mean	Standard Deviation
Control (no supplement)	236.92	39.42
High-Fiber	274.92	36.03
High-Starch	264.45	33.83

Note: Number of observations = 45.

tion function. Weight gains are calculated as final weights minus initial calf weights. The summary statistics for seasonal weight gains in the three-year study are presented in table 1. To account for differences in the quality of the alternative supplements, the quantity of each supplement fed is expressed in net energy terms (Mcal/grazing day).

Twenty years of simulated seasonal forage production data are used. The simulated biomass levels (combined weight of leaves and stems) are estimated using the CERES-wheat process growth model (Godwin et al.). Historical weather data (1971–90) and soil data from Kingfisher, Oklahoma, are used. The seasonal forage production data are converted to daily quantities of forage supplied (*PF*) assuming a grazing season of 125 days. The forage availability per steer day (*PF*) is then calculated for the stocking density of 1.5 acres/head. This assumption is consistent with previous studies which have assumed a stocking density of 1.5 acres/head for evaluating wheat pasture programs (e.g., Horn et al. 1992).

Production costs and receipts are calculated for a representative stocker enterprise in central Oklahoma. Calves are purchased in November at a weight of 450 pounds and grazed through the fall-winter season (November–March) for 125 days. Operating costs (excluding the cost of the calf and supplemental feed) total $49.75 over the grazing season, or $.40 per grazing day. Optimal supplementation levels are derived for the high-fiber energy supplement.

Feed costs include the ingredient cost, a milling, and a delivery charge. Mineral expenses for the supplemented calves were included in supplement costs. Feed costs were estimated as $.07/lb. An additional $.01/lb. was added to this cost to account for the cost of labor required to feed energy supplements (Tarrant). Optimal supplementation levels are determined for two other supplemental feed prices: $.04 and $.06/lb.

The cattle prices represent average prices received over the past 15 years at the Oklahoma City Livestock Auction for No. 1 medium-framed steers. The purchase price of the calf is known with certainty by the producer at the beginning of the grazing season; therefore, price uncertainty results from volatility in the spread between the purchase and the selling prices. The calf price is set at $.91/lb., the average November price received (in real terms) for 400–500 pound calves over the 15-year period. Cattle price spreads are then calculated as the difference between March and November cattle prices. The average calf price is added to each of the price spreads to obtain the distribution of cattle sale prices. These prices are used to obtain the three cattle price scenarios used in the analysis (low, average, and high). The low and high price scenarios are calculated as the average of the four lowest and four highest cattle price spreads, respectively. The average price scenario is calculated as the mean of the cattle price spreads. Low, average, and high steer sale prices are $.65, $.79, and $.94/lb., respectively.

The risk aversion coefficients employed are based upon the empirical work of Raskin and Cochran. The risk aversion coefficients range from zero to 0.00125 for the class of almost risk-neutral farmers, and from 0.02 to 0.03 for the class of strongly risk-averse farmers. Since in the original study these coefficients were applied to annual returns, they are scaled to reflect the unit of the outcome space used in this study ($/day).

Empirical Results

Maximum likelihood parameter estimates of the production function are presented in table 2. The estimated coefficients are significant at the 5% level, except the coefficient of the interaction term. The estimated parameters of the beta density function indicate that the distribution of forage production is asymmetric. The parameter estimates of the beta distribution function are $\alpha = 1.15$ and $\beta = 1.26$; their standard errors are 0.341 and 0.375, respectively.

Optimal daily supplementation levels are reported in table 3 for various degrees of risk aversion

Table 2. Parameter Estimates of the Production Function, Time-Series, and Cross-Section Data Over Three Grazing Seasons (1989–90, 1990–91, and 1991–92)

Variables	Parameter Estimates	Standard Errors
Intercept	−6.297*	(0.672)
Initial Weight	0.016*	(0.001)
Energy	0.688*	(0.323)
Forage	0.104*	(0.028)
Energy^2	−0.446*	(0.217)
Forage^2	−0.002*	(0.001)
Energy × *Forage*	−0.002	(0.011)
*D*1	−0.377	
*D*2	−0.472	
R^2 adjusted	0.940	

Notes: Asterisks denote significance at the 5% level. *D*1 and *D*2 represent dummy variables for periods 1989–90 and 1990–91, respectively; dependent variable = daily weight gain (lbs./head); and number of observations = 45.

and alternative feed and cattle price scenarios. Optimal daily supplementation levels increase as risk aversion increases, indicating that risk-averse producers would supplement more than risk-neutral producers. However, increases in supplementation levels due to increased risk aversion are small, suggesting that supplementation practices are likely to be similar across producers.

The magnitude of increase in supplementation levels averages 0.47 lb./head/day as one moves from risk neutrality to strong risk aversion. Although a risk-averse producer would use more supplemental energy than a risk-neutral producer, differences in supplementation levels induced by production risk are small. Intuitively, risk-neutral stockmen may find it optimal to supplement more in order to increase the likelihood of adjusting to the randomness of forage production, and thus add a certain flexibility to the management of their wheat pasture enterprise.

Findings also show that, at any risk aversion level, optimal daily supplementation levels are highly affected by feed and cattle prices. Under average cattle price conditions, optimal supplementation levels increase approximately two lbs./head/day as a result of a $.02/lb. decrease in feed prices. Reductions in supplementation levels were of a similar magnitude when feed prices were increased by $.02/lb.

Under average feed prices, daily supplementation levels decrease approximately 1.3 lbs./head/day when cattle price expectations are changed from average to low levels, and increase one lb./head/day when cattle prices increase to high levels. When average and high cattle prices are combined with low feed prices, optimal supplementation levels approach yield-maximizing levels (5.1 to 6.2 lbs./head/day). Under the low cattle and low feed price scenario, optimal supplementation levels decrease to between 4.2 and 4.7 lbs./head/day. Supplementation levels are zero when high feed prices are combined with low cattle prices. At this price ratio, the marginal value product of energy supplement does not cover the marginal cost associated with energy supplement. These results show that cattle and feed market conditions would markedly affect supplementation practices.

Summary and Conclusions

This study has addressed the issue of risk aversion and energy supplement input decisions under various cattle and feed price scenarios. Optimal daily supplementation levels were determined for various degrees of risk aversion (from risk neutrality to strong risk aversion) and alternative cattle and feed price scenarios. Results show that daily supplementation levels increase as risk aversion increases. However, increases in daily supplementation levels resulting from increased risk aversion are small, implying that supplementation practices are likely to be similar across stockmen, irrespective of their risk attitudes.

Daily supplementation levels are markedly affected by cattle and feed price conditions, ranging from zero to six lbs./head. This result suggests that, while supplementation reduces production risk, stockmen must closely monitor supplement costs and cattle prices in order to efficiently incorporate supplementation programs into their stocker cattle enterprises.

The empirical decision model was developed to combine experimental results from livestock grazing trails with information on forage production variability to provide supplementation recommendations. The specific results depend, of course, upon the experimental data and functional form selected, as well as the economic conditions assumed in the analysis. This limits the broad interpretation

Table 3. Optimal Energy (Mcal/head/day) and Feed Supplementation Levels (lbs./head/day), with Stocking Density of 1.5 Acres/Head

	Energy Feed			
	Risk Neutral	Slightly Risk Averse	Strongly Risk Averse	
Feed Price ($/lb.)	(λ = 0)	(λ = 0.5)	(λ = 7.3)	(λ = 11)
Low Cattle Price:				
0.04	0.341	0.343	0.375	0.379
	(4.23)	(4.26)	(4.65)	(4.70)
0.06	0.146	0.148	0.180	0.183
	(1.81)	(1.84)	(2.23)	(2.27)
0.08	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Average Cattle Price:				
0.04	0.411	0.414	0.447	0.449
	(5.10)	(5.14)	(5.55)	(5.57)
0.06	0.251	0.253	0.287	0.289
	(3.11)	(3.14)	(3.56)	(3.59)
0.08	0.090	0.093	0.126	0.128
	(1.11)	(1.15)	(1.56)	(1.59)
High Cattle Price:				
0.04	0.461	0.464	0.499	0.500
	(5.72)	(5.76)	(6.19)	(6.20)
0.06	0.326	0.329	0.363	0.365
	(4.05)	(4.08)	(4.50)	(4.53)
0.08	0.191	0.194	0.228	0.229
	(2.37)	(2.41)	(2.83)	(2.84)

Notes: Quantities of feed supplement (lbs./head/day) are in parentheses and are obtained by multiplying the quantities of energy supplement (Mcal/head/day), *EN*, by 12.41; λ is the Arrow-Pratt absolute risk aversion coefficient (scaled to $/day outcome space).

of the specific supplementation recommendations; however, the general findings concerning the responsiveness of supplementation levels to risk attitudes, livestock prices, and feed prices should prove useful to wheat pasture stocker producers in the study area.

References

Bernardo, D. J., and G. Wang. "Real Returns from Beef Production Enterprises in Oklahoma." *Current Farm Econ.* 64(1991):3–17.

Brooke, A., D. Kendrick, and A. Meeraus. *GAMS: A User's Guide.* Redwood City CA: The Scientific Press, 1992.

Bruce, W. C., K. O. Geddes, G. H. Gonnet, B. L. Leong, M. B. Monogan, and S. M. Watt. *First Leaves: A Tutorial Introduction to Maple V.* Waterloo, Ontario, Canada: Waterloo Maple Publishing, 1992.

Dai, Q., J. J. Fletcher, and J. G. Lee. "Incorporating Stochastic Variables in Crop Response Models: Implications for Fertilizer Decisions." *Amer. J. Agr. Econ.* 75(1993):377–86.

Godwin, D., J. Ritchie, V. Singh, and L. Hunt. *A User's Guide to CERES-Wheat.* Muscle Shoals AL: International Fertilizer Development Center, 1989.

Horn, G. W., D. J. Bernardo, W. E. McMurphy, and M. D. Cravey. "High Starch Versus High Fiber Energy Supplements for Wheat Pasture Cattle: Cattle Performance and Economics." In *Animal Science Research Report, 1990,* pp. 129–43. Res. Rep. No. MP-13, Oklahoma Agr. Exp. Sta., Oklahoma State University, 1991.

Horn, G. W., M. D. Cravey, P. A. Beck, D. J. Bernardo, and K. B. Pooling. "A Self-Fed Monensin-Containing Energy Supplement for Stocker Cattle Grazing Wheat Pasture." In *Animal Science Research Report, 1991,* pp. 301–06. Res. Rep. No. MP-136, Oklahoma Agr. Exp. Sta., Oklahoma State University, 1992.

Just R. E., and R. D. Pope. "Production Function Estima-

tion and Related Risk Considerations." *Amer. J. Agr. Econ.* 61(1979):276–84.

Krenzer, G., D. Austin, and R. Jones. "Wheat Forage Yields in Fall and Winter." *Current Report* Nos. CR-2114, CR-2115, and CR-2116, Dept. of Agr. Econ., Oklahoma State University, 1988–92.

Mood, A.M, F. A. Graybill, and D.C. Boes. *Introduction to the Theory of Statistics.* New York: McGraw-Hill, Inc., 1974.

Preckel, P. V., and E. DeVuyst. "Efficient Handling of Probability Information for Decision Analysis Under Risk." *Amer. J. Agr. Econ.* 73(1991):655–62.

Raskin, R., and M. J. Cochran. "Interpretations and Transformations of Scale for the Pratt-Arrow Absolute Risk Aversion Coefficient: Implications for Generalized Stochastic Dominance." *West. J. Agr. Econ.* 11(1986):204–10.

Tarrant, A. R. "The Profitability of Various Wheat Pasture Management Practices." Unpublished master's thesis, Dept. of Agr. Econ., Oklahoma State University, 1993.

Walker, O. L., D. J. Bernardo, J. N. Trapp, and A. L. Rodriguez. "A Survey of Wheat Pasture Utilization Systems in Western Oklahoma." Res. Rep. No. P-903, Dept. of Agr. Econ., Oklahoma State University, 1988.