

Use of a Producer Survey to Reconcile Differences in Experiment Station Yield Estimates

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Abstract

Average producer practice reveals that the expected returns are greater from dual-purpose wheat grown for both forage and grain than for grain-only wheat. Variety trials report an 11 bushel per acre yield advantage and hence economic advantage for grain-only. Research was conducted to reconcile the inconsistency.

Keywords:

direct elicitation method, dual-purpose, simulation, stocker steers, survey, triangular distribution, wheat

Introduction

Winter wheat may be grown in the Southern Plains either to produce grain-only (GO), or as a dual-purpose (DP) crop to produce both fall-winter forage and grain (Redmon et al. 1995). The decision to produce DP wheat is not straightforward since (a) the expected grain yield from DP wheat is less than the expected grain yield from GO wheat; (b) DP wheat is more expensive to produce since it requires more fertilizer and seed; and (c) prices of wheat and the value of the fall-winter forage are not known precisely a priori. For DP wheat to be more economical than GO wheat, the value of the fall-winter forage must be sufficient to offset both the additional production costs and the value of the reduced grain yield. Surveys conducted by True et al. (2001) and Hossain et al. (2004) found that between 49-66 percent of the wheat acres planted in Oklahoma are intended for DP, 25-31 percent are intended for GO with the remaining acres intended for forage only. This

suggests that producers interpret the expected returns from DP to be at least as great as the expected returns from GO.

The USDA provides annual estimates of wheat acres planted and harvested for grain. However, the USDA does not differentiate among uses and historical estimates of acres used to produce DP wheat (fall-winter grazing plus grain) are not available. For the time period from 1998 through 2006, the USDA reported that the average acre of wheat in the region returned from \$2.08 to \$8.56 per acre for the production of a secondary product, either wheat straw harvested after grain, or forage harvested by livestock prior to grain harvest (USDA 2006). The USDA did not report estimates of the proportion of acres on which straw was harvested or the proportion that were grazed. The estimates as reported fail to adequately capture either the returns from GO wheat or the returns from DP wheat. Similarly, the USDA does not report average daily gain or stocking density of livestock grazing on wheat pastures.

Ideally, in years when realized wheat grain prices are high relative to the realized value of livestock weight gain, the decision would have been made to produce GO wheat. Alternatively, when the value of the fall-winter forage is high relative to the value of wheat grain, the decision would have been made to produce DP wheat. Of course, the value of fall-winter forage and price of wheat grain are not known prior to the end of the season. And, the optimal planting date, fertilizer strategy, and seeding rate is different for the two systems. Farmers must make the decision to produce either GO or DP wheat based on expected forage and grain yields, expected livestock weight gain, expected prices of wheat, and expected value of livestock weight gain.

Figure 1 includes a bar chart of an estimate of the historical gross value (\$/acre) of the fall-winter forage component of DP wheat. The estimated values are based on production parameters obtained from surveys of producers reported by True et al. (2001) and Hossain et al. (2004) and budgets prepared by Taylor et al. (2007). The key assumptions are that the fall-winter forage would be grazed by steers with an initial weight of 450 pounds, average daily gain of one pound for a 21 day receiving period, a stocking density of 196 pounds per acre (2.3 acres per steer) and an average daily gain of 2.1 pounds for 112 days of grazing on wheat for a steer sale weight of 719 pounds. Historical Oklahoma City (1992-2008) prices for 450 and 719 pound steers for the budgeted purchase and sale dates of October 21 and March 3 were obtained from the data base maintained by the Livestock Marketing Information Center (LMIC). By these measures, during the 16 year period (1993-2008), gross returns from steers grazing DP wheat during the fall-winter season averaged \$64 per acre. This added value from the grazing component of DP must be sufficient to compensate for the lower expected grain yield and the higher expected production cost of DP.

Expected grain yield is lower for DP as a result of a planting date effect (Epplin et al. 2000; Hossain et al. 2003) and a grazing effect. Planting date trials conducted on plots that were not grazed find a planting date effect, but do not provide information regarding the grazing effect. For the past five years wheat variety trials have been conducted under both a DP and GO management system producing an estimate of the grain yield difference between early planted and grazed DP plots (capturing the combined planting date and grazing effect) and later planted but ungrazed GO plots (Edwards et al. 2005-2009). The average yield obtained from the DP variety trial plots that were planted on average on

September 9 and grazed, was 23.4 bushels per acre (Edwards et al. 2005-2009). This is 11 bushels less than the average yield of 34.4 bushels per acre produced during the same five years with the same varieties on the adjacent GO plots that were on average planted on October 20 and not grazed. By this measure the DP system reduced grain yield by 11 bushels per acre (32 percent).

Given the low and high wheat prices from 1992 to 2008 of \$2.31 and \$7.93 per bushel, a difference of 11 bushels would amount to \$25 to \$87 per acre in lost potential revenue from grain that must be overcome by the DP system. Given the estimated average grazing value of \$64 per acre and the additional costs required for growing DP rather than GO, it would be difficult for a DP system that produced 11 bushels per acre less grain to compete economically with a GO system. However, as noted, based on the revealed production patterns, producers interpret the expected returns from DP to be at least as great as the expected returns from GO. This suggests that either the management system used in the variety trials is not consistent with the management system used by farmers, or one or more of the parameter values (e.g. initial weight of steers; average daily gain; stocking density) used to estimate the value of grazing is incorrect. The objective of the research reported in this paper is to reconcile these inconsistencies and to determine expected net returns distributions for both production systems. Distributions of key production parameters, grain yield, stocking density, and average daily gain, are constructed from survey responses provided by producers. Historical price data are used to construct steer purchase price, steer sale price, and wheat sale price distributions.

Methods and Procedures

A phone survey of thirty-one producers that have experience in growing both GO and DP wheat was conducted. The direct elicitation method was used (Anderson, Dillon, and Hardaker 1977). Subjective distributions were elicited for targeted planting dates for both DP and GO; GO wheat yield; DP wheat yield; initial weight of steers purchased to stock on DP wheat; stocking density of steers on DP wheat; and average daily gain of steers on DP wheat. This was done by asking the producers to consider a six year time horizon. They were then asked what their expected average, high, and low values would be over the next six years (Hull 1976; Sonka and Patrick 1984; Shapiro, Brorsen, and Doester 1992). Covariance among yields was also elicited by asking for each level of wheat yield (low, average, and high), expectations regarding average daily gain levels (low, average, or high).

The questions were designed to enable the construction of triangular distributions for yield and average daily gain (Anderson, Dillon and Hardaker 1977; de Finetti 1964; Hogarth 1975; Norris and Kramer 1990; Raiffa 1968; von Holstein and Carl-axel 1970). Cumulative distribution functions (CDF) were formulated from the information provided (Schlaifer 1969). Since the producers were specifically asked to provide expected low, average, and high yields over a six year time horizon, the distribution values were adjusted so that the average low value occurred at the probability level of 0.16 on the CDF (84 percent of the time the average producer would expect higher yields). Similarly, the distributions were adjusted so that the average high value occurred at approximately the 0.84 probability level on the triangular distribution.

Wheat Prices

During the 1992 to 2008 time period the average June cash wheat price was \$3.61 per bushel with a standard deviation of 1.43 (NASS 2008). The USDA loan rate provides an effective floor price for wheat. Therefore, the nominal wheat prices were assumed to be normally distributed but truncated at the 2008 loan rate of \$2.75 per bushel (NASS 2008).

$$(1) \quad W_p = X_{Wp} + (\sigma_{Wp} * N(0,1))$$

Where: W_p is the distributed wheat price (\$/bu) greater than or equal to \$2.75; X_{Wp} is the average historical nominal wheat price, \$3.61; and σ_{Wp} is the standard deviation of the historical nominal wheat prices, 1.43. Wheat prices were assumed to be uncorrelated with yield since the grain yield on a specific field in Oklahoma is assumed to not influence the global price of wheat.

Value of Fall-Winter Grazing of DP Wheat

It was assumed that the fall-winter wheat pasture would be grazed by young steers. Two steer budgets were prepared, one with an initial steer weight of 450 and the other with an initial steer weight of 550 pounds. A 21-day receiving program and 112 days on wheat were assumed. The steers were assumed to have an average daily gain of one pound during the receiving program (Taylor et al. 2007), a mean gain of 2.11 pounds per day during the 112 days on wheat, and a 1.5 percent death loss (Taylor et al. 2007). The ending weight was calculated for each of the two buy weights of 450 and 550 pounds by adding the 21 pounds of assumed gain during the receiving period and the weight gain during the 112 days of grazing. Gain during grazing is assumed to be stochastic.

Steer price data were obtained from data bases maintained by the LMIC (2008). Weekly cattle prices were available from 1992 to 2007. Observations for the appropriate

week and weight were used to compute the nominal mean and standard deviation. For the price simulations it was assumed that the steer purchase price is normally distributed.

$$(2) \quad B_p = X_{Bp} + (\sigma_{Bp} * N(0,1))$$

Where: B_p is the October buy price; X_{Bp} is the average historical buy price; and σ_{Bp} is the standard deviation of the historical buy prices.

Since the March sale price for steers is correlated with the previous October buy price, it was assumed that the sell price is normally distributed with respect to the interpolated average price slide and standard deviation from 1992 to 2008. The price margin is the difference between the October 21 price of 450 (or 550) pound steers and the March 3 price for the heavier steers. The weight of the steers on March 3 depends not only on the initial weight but also on the stochastic average daily gain. Stochastic sale prices can be simulated as described by equation 3.

$$(3) \quad S_p = PM + (\sigma_{PM} * N(0,1))$$

Where: S_p is the March 3 sell price that is linked to the buy price; PM is the interpolated average price margin; and σ_{PM} is the interpolated standard deviation of the price margin.

Simulations

Yield, stocking density, and average daily gain information provided by the growers were combined with budgeted cost estimates and price distributions to simulate expected net returns for each production system. As noted, two steer purchase weights, 450 and 550 pounds, were considered for DP wheat enabling the comparison of two DP strategies, DP450 (DP wheat stocked with steers with an initial weight of 450 pounds) and DP550 (DP wheat stocked with steers with an initial weight of 550 pounds). For these simulations production costs, buy weights, days owned, stocking density, buyer fees, shipping costs,

veterinary costs, soybean meal based supplement, and interest costs were held constant. Wheat yield, average daily gain during the 112 day fall-winter grazing season (and thus steer sale weight), wheat price, steer purchase price, and the margin between steer sale and steer purchase price (and thus the steer sale price) were treated as stochastic variables. Wheat harvest and hauling cost and the cost of nitrogen fertilizer were adjusted with the stochastic wheat yields. Based on responses to the survey, average daily gain and grain yield are assumed to be independent. GO and DP wheat grain yields were assumed to be perfectly correlated. The SIMETAR Excel add-in was used to simulate each system 1,000 times to reflect 1,000 growing seasons (Richardson, Schumann, and Feldman 2001).

Results

Survey Results

The surveyed producers reported average targeted planting dates of September 13 for DP wheat and October 4 for GO wheat. Comparatively, True et al. (2001) reported a target date for DP of September 17 and for GO of September 27. Similarly, the Hossain et al. (2004) survey reported a target planting date of September 20 for DP and October 2 for GO wheat. The average planting date for the variety trials was September 7 for DP and October 20 for GO (Edwards et al. 2005-2009). The DP planting date in the variety trials has been earlier than the farmer's reported target date and average GO planting date has been later than the target reported by farmers in all three surveys.

Other survey results are reported in Table 1. The producers reported an expected average yield in a GO wheat system of 42.2 bushels per acre. The surveyed producers reported an expected average yield in a DP wheat system of 36.4. By this measure, the expected yield from GO wheat is 15.9 percent greater than the expected yield of DP wheat.

The net returns from winter grazing must be sufficient to offset both the expected yield loss of 5.8 bushels per acre (rather than 11 bushels per acre as estimated by the variety trials) and the cost of the additional inputs required to produce DP wheat.

The grain yield response to planting date function reported by Epplin et al. (2000) predicts a 19.4 percent (6.8 bushels) decrease in grain yield from an October 4 planting date relative to a September 13 planting date. Similarly, the response function reported by Hossain et al. (2004) predicts a 15.5 percent (6.2 bushels) decrease. The average finding of 15.9 percent (5.8 bushels) as reported by the surveyed producers is consistent with the findings of the prior studies based on small plots. However, it is substantially less than the reported yield difference of 32 percent (11 bushels) found in the variety trials (Edwards et al. 2005-2009). Some of the yield difference can be attributed to differences in planting date. The DP variety trial plots were planted on average nine days earlier and the GO plots 20 days later than target planting dates reported by farmers. The grain yield response to planting date functions show that the earlier planting date is not good for grain yields (Epplin et al. 2000; Hossain et al. 2004).

For every bushel of wheat yield in the GO system, producers expect DP wheat to yield 0.88, 0.86, and 0.83 bushels, for good, average, and poor years. The producers estimates are expected to include both the planting date effect and the grazing effect of DP relative to GO. However, over the five years for which wheat variety trial data are available that include both effects, the DP to GO wheat yield ratio was 0.62 (Edwards et al. 2005-2009).

Producers reported an overall average steer purchase weight of 464.5 pounds. True et al. (2001) and Hossain et al. (2004) reported purchase weights of 460 and 466 pounds,

respectively. (Kaitibie et al. (2003b) reported approximate purchase weights of 550 pounds for steers used in research trials at the Marshall Wheat Pasture Research Unit.) Rather than treating purchase weight as a stochastic variable, two DP wheat systems were evaluated, one based on an initial steer weight of 450 pounds (DP450) and another with an initial steer purchase weight of 550 pounds (DP550).

The producers reported an average stocking density of 333 pounds per acre. The surveys of True et al. (2001) and Hossain et al. (2004) reported an average stocking density of 196 pounds per acre. Kaitibie et al. (2003a) used data produced at the Marshall Wheat Pasture Research Unit from 1989 to 2000 to estimate an optimal stocking density. They found that the optimal stocking density, given the planting dates used would have been 305 pounds per acre.

The average reported low (1 in 6), average, and high (1 in 6) average daily gains were 1.54, 2.11, and 2.70 pounds. Producers surveyed by True et al. (2001) reported an average daily gain for steers of 1.9 pounds. In the more recent survey by Hossain et al. (2004) producers reported an average daily gain for steers of 2.3 pounds. Kaitibie et al. (2003b) reported that the average daily gain for steers at the Marshall Wheat Pasture Research Unit from 1989 to 2000 across all stocking densities was 2.22 pounds.

To determine if grain yield is correlated with average daily gain the producers were asked "...if the yield of wheat is (low, average, or high) what level would you expect the average daily gain levels to be (low, average, or high)?..." The producers responded that years that result in high average daily gains do not necessarily produce high wheat grain yields. Based on the responses to this question, average daily gain was assumed to be uncorrelated with wheat grain yield.

Simulation Results

The estimated pre-harvest cash costs for the average budgeted yield of 42.2 bushels per acre for GO wheat is \$222 per acre. DP wheat requires more nitrogen and more seed and has budgeted cash costs of \$241 per acre for the average DP wheat yield of 36.4. The price required to break-even for the GO system given the average yield of 42.2 bushels per acre is \$5.26 per bushel. At the budgeted prices and input levels, and a nominal mean wheat price of \$3.61 (the 1992-2008 average), GO wheat producers in the region (in the absence of government subsidies) would lose \$69 per acre.

Results of the simulations are provided in Table 2. The DP system generated the greatest net returns at both buy weights the majority of the 1,000 simulated seasons. The DP systems reflect a stocking density of 333 pounds per acre. Based on the growers distribution of average daily gains and yields combined with the distribution of historical wheat and cattle prices, DP450 wins 76.3 percent of the time and has an average net return of \$18.34 per acre at budgeted input prices. DP550 wins 21.6 percent of the time with an average net return of negative \$27.69 per acre at budgeted input prices. GO wheat has an average net return of negative \$73.69 per acre at budgeted input prices.

Based on budget and simulation results, DP450 at a stocking density of 333 pounds per acre, generates an expected net return of \$92 per acre more than GO wheat. Similarly, the expected net returns from DP550 and the same stocking density is \$46 more per acre than the expected net returns from GO wheat.

Figure 2 includes a chart of the CDFs for the distributions of net returns per acre from the simulations for each production system. Given the budgeted input prices and simulated wheat prices, the GO system has a probability of 0.92 of resulting in negative net

returns. DP550 has a probability of 0.69 of producing negative net returns. DP450 has a probability of 0.46 of resulting in negative net returns. Income from government payments is not included.

The greatest discrepancy in findings between the current survey and the surveys reported by True et al. (2001) and Hossain et al. (2004) is for stocking density. The current survey found an average stocking density of 333 pounds per acre versus an average stocking density of 196 pounds per acre reported by True et al. (2001) and Hossain et al. (2004). To determine the consequence of stocking density, a simulation was conducted with a stocking density of 196 rather than 333 pounds per acre. With the decrease in stocking density, the relative economics of the three production systems remains unchanged. DP450 produced the highest net returns per acre 738 out of 1,000 simulations with an average net return of negative \$36 per acre. The change in stocking density from 333 to 196 pounds per acre results in a decrease in expected net return of \$53 per acre for the DP450 system. DP550 remained the runner-up with 184 wins and an average net return per acre of negative \$63, \$35 per acre less than when the stocking density is assumed to be 333 pounds per acre. With the lower stocking density, the average advantage for DP450 relative to GO is \$37 per acre and the average advantage for DP550 relative to GO is only \$10 per acre. Stocking density is clearly a key management decision.

To address the question of whether a high wheat price would mitigate the advantage of DP, a third set of simulations was conducted with the highest reported wheat price from 1992-2008 of \$7.93 per bushel, rather than the mean wheat price of \$3.61. DP450 reported the highest net return per acre 745 of 1,000 simulations and an average net return of \$189. DP550 remained the runner-up with 196 wins and an average net return per acre of \$143.

GO won 59 times with an average net return per acre of \$124. For the relatively high wheat price of \$7.93, the expected returns from DP450 are \$65 per acre greater than the expected returns from GO. The expected returns from DP550 are \$19 per acre greater than the expected returns from GO. For a 333 pound per acre stocking density, and a 5.8 bushel per acre average yield difference between GO and DP, the price of wheat would have to reach \$18.34 per bushel before overtaking both DP systems.

Discussion

Revealed production patterns of producers suggest that the expected net returns of DP exceed the expected net returns of GO. Based on prior research findings and historical prices, the value of fall-winter grazing of DP wheat had been estimated to average \$64 per acre which is more than sufficient to offset the expected lower yield from DP and the additional costs required to produce DP wheat. However, more recent experiment station variety trials reported that the expected grain yield of a DP system is 11 bushels per acre less than the expected yield from a GO system. For average wheat prices, the cost of this yield loss would offset the benefits of grazing and GO wheat would be preferred.

A survey of producers was conducted to enable construction of triangular distributions of key production parameters. These data were combined with historical prices to simulate three systems; GO, DP450, and DP550. The main findings are (a) the estimated expected net value of the DP450 system is from \$38 to \$92 per acre greater than that of the GO system. This finding is consistent with revealed production patterns. (b) The planting dates used in the variety trials are not consistent with targeted planting dates used by producers. The DP plots were on average planted nine days earlier than producers target for DP. This earlier planting date explains some of the yield discrepancy. (c) The expected

grain yield of GO wheat is 15.9 percent greater than the expected grain yield of DP wheat when both are seeded at their respective target planting dates. However, for most states of nature the value of winter grazing more than compensates for the lower yield and additional production cost and DP wheat generates greater expected net returns than GO wheat. (d) Stocking with steers with an initial weight of 450 pounds is a better strategy than stocking with steers with an initial weight of 550 pounds for most states of nature. (e) A high wheat price (e.g. \$8 per bushel) reduces the advantage for DP450, but does not eliminate it. (f) The economic success of DP depends critically on stocking density.

Earlier surveys reported an average stocking density of 196 pounds per acre. The survey conducted for this study found an average stocking density of 333 pounds per acre which is close to the optimal stocking density estimated by Kaitibie et al. (2003a) of 305 pounds per acre. However, the change in stocking density did not change the relative ranking among the three systems. Increasing the stocking density from 196 to 333 pounds per acre, increases the expected net returns by \$54 per acre for DP450 and by \$35 per acre for DP550. One caveat is that this estimate is contingent on the assumption that the expected grain yield loss from grazing does not change when stocking density is increased from 196 to 333 pounds per acre.

To our knowledge, no field trials have been conducted that enable determination of the grazing effect on grain yield separate from the planting date effect. The variety trials that were referenced enable an estimate of the combined effects since the DP plots were planted early and grazed and the GO plots were planted later and not grazed. The small plot planting date trials that were referenced enabled an estimate of the planting date effect, but since they did not have complementary plots that were grazed, they did not provide

information regarding the grazing effect. To obtain a more precise estimate of the economics of DP relative to the economics of GO, a more precise estimate of the planting date and the grazing effect will be required. In addition, given the importance of stocking density for the economics of DP, future trials should consider designing studies to capture the planting date effect, and the grazing effect for several levels of stocking density.

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Table 1. Expected Average, High, and Low Estimates For Wheat Yield, Purchase Weight, Stocking Density, and Average Daily Gain.

Item	Units	Expected Average	Expected High (1 of 6 years)	Expected Low (1 of 6 years)
Grain-Only Wheat Yield	bu/acre	42.2	60	28
Dual-Purpose Wheat Yield	bu/acre	36.4	52.9	23.2
Purchase Weight	lbs/hd	464.5	551.8	375.3
Stocking Density	lb/acre	332.84	475.69	236.41
ADG of Steers on Wheat	lbs/day	2.11	2.70	1.54

Estimates reported in this table are the averages as reported by a surveyed group of Oklahoma wheat producers.

Table 2. Results of simulating net returns from 1,000 seasons of grain-only (GO) wheat, dual-purpose (DP) wheat stocked with steers with an initial weight of 450 pounds (DP450), and dual-purpose wheat stocked with steers with an initial weight of 550 pounds (DP550).

Production System	Base Assumptions ^a		Base Assumptions Except for 196 lb/ac Stocking Density		Base Assumptions Except for Expected Wheat Price \$7.93/bu	
	"Wins"	Expected Returns ^b (\$/ac)	"Wins"	Expected Returns (\$/ac)	"Wins"	Expected Returns (\$/ac)
GO; Grain-Only Wheat	2% ^c	-\$74	8%	-\$74	6%	\$124
DP450; Dual-Purpose Wheat Stocked with Steers with an Initial Weight of 450 pounds	76%	\$18	74%	-\$36	75%	\$189
DP450; Dual-Purpose Wheat Stocked with Steers with an Initial Weight of 550 pounds	22%	-\$28	18%	-\$63	20%	\$143
		Expected Net Value of DP Relative to GO (\$/ac)				
Difference (DP450 - GO)		\$92 ^d		\$38		\$65
Difference (DP550 - GO)		\$46		\$11		\$19

^a Base assumptions include October 21 purchase date; 21 day receiving program; 112 days on wheat; March 3 sale date; mean average daily gain of one during receiving program and 2.11 during wheat grazing; mean wheat yield of 36.4 for DP and 42.2 for GO; stocking density of 333 pounds per acre.

^b Mean net return to land, overhead, and management. Income from government subsidies and insurance is not included.

^c Wheat yield, average daily gain during the 112 day fall-winter grazing season (and thus steer sale weight), wheat price, steer purchase price, and the margin between steer sale and steer purchase price (and thus the steer sale price) were treated as stochastic variables. Under the base assumptions, GO wheat produced greater net returns than the other two alternatives two percent of the time.

^d For the base assumptions including an expected grain yield advantage of 5.8 bushels per acre for GO, the expected net returns are \$92 per acre more for DP450 than for GO.

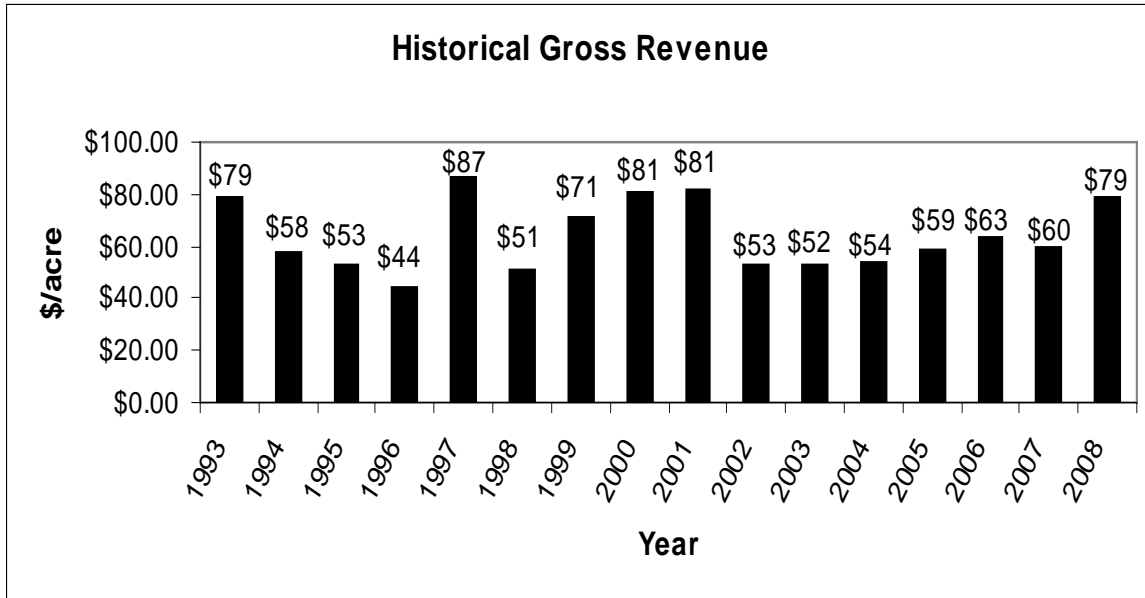


Figure 1. Gross revenue from grazing fall-winter wheat forage by steers with an initial weight of 450 pounds, average daily gain of one pound for a 21 day receiving period, a stocking density of 196 pounds per acre (2.3 acres per steer) and an average daily gain of 2.1 pounds for 112 days of grazing on wheat for a sale weight of 719 pounds, 1993-2008 (\$ per acre).

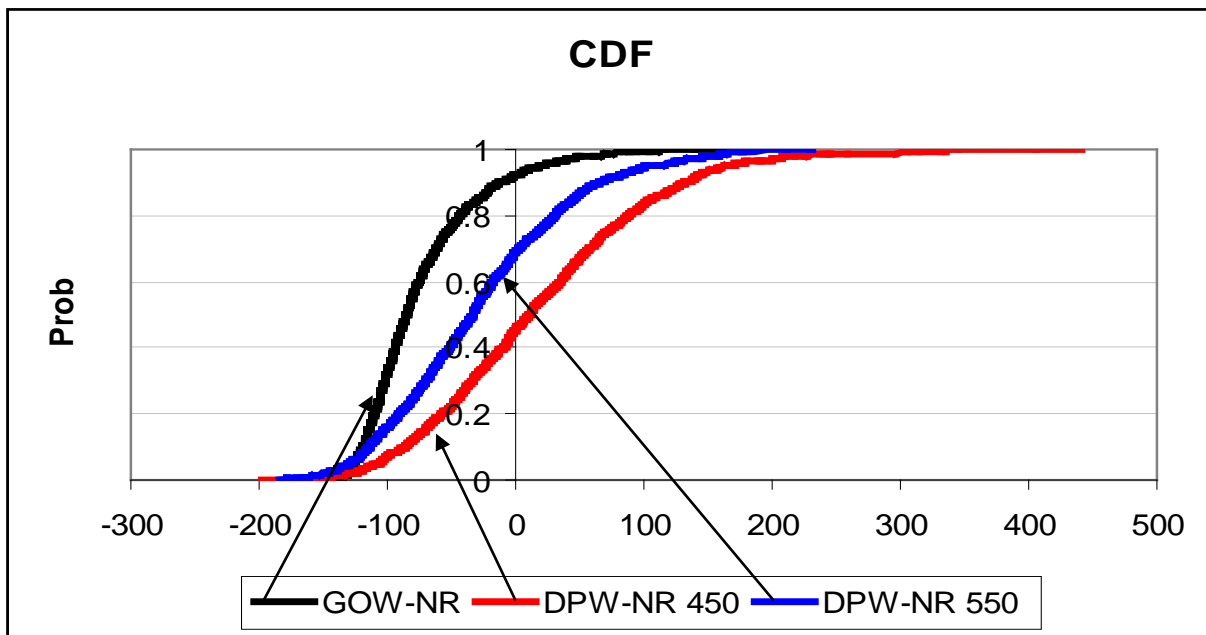


Figure 2. Cumulative distribution function of net returns for grain-only wheat, dual-purpose wheat grazed by steers with an initial weight of 450 pounds, and dual-purpose wheat grazed by steers with an initial weight of 550 pounds averaged across 1000 years of simulated yields, average daily gains, wheat prices, and cattle prices (\$ per acre).