DUAL-PURPOSE WINTER WHEAT

AND STOCKER PRODUCTION

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
MAY, 2007

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AND STOCKER PRODUCTION

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ACKNOWLEDGEMENT

Many people have contributed to the success of this dissertation. I would like to begin by thanking my major advisor, Dr. Francis Epplin, for his wonderful guidance and continuous support in completing this research project. He was always extremely helpful and I appreciate his ongoing inspiration, friendship, and humor during my PhD program. I would also like to thank Dr. Brorsen for his teaching and assistance in helping me complete this dissertation. His door was always open and his knowledgeable suggestions and advice enabled me to accomplish my goal. A thank you also goes out to Dr. Gerald Horn from the Animal Science department. His data and insightful comments were very useful and working with him has been a real pleasure. The fourth member of my committee, Dr. Peel, also deserves great appreciation in providing me with insight about the research topic and assisting me in better understanding the industry. Overall, I would like to thank my committee for their encouragement, constant guidance, and expertise. It has been a great pleasure to work with such knowledgeable and experienced professors.

A special thank you also goes out to the Department of Agricultural Economics for providing me with this research opportunity and financial support for my graduate program. All the faculty and staff in the department have contributed to the success of my academic accomplishments. I have learned invaluable skills from the professors who taught my classes and am glad that I chose OSU to pursue my degree. Every professor was always friendly, warm, and welcomed any questions that I had. I also thank Gracie

Teague for helping me with any computing needs that I had as well as assisting in formatting my research.

I would also like to send a huge thank you to my family, especially my husband, Kevin. He has been extremely supportive and patient during my time at OSU. I appreciate his encouragement and thank him for him ongoing love and support. I thank him for believing in me and not letting me give up. His unconditional support and confidence in me has helped me pursue my interests and be successful.

I have enjoyed my time at OSU and being a part of the Agricultural Economics department. It has been wonderful to meet and become friends with so many friendly and kind people. I wish success to all the other agricultural economics graduate students, faculty, and staff. It has been a great pleasure to get to know everyone. I treasure the friendships that I have made during my PhD program and look forward to maintaining these relationships in the future.

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PAPER I

VALUE OF MONENSIN SUPPLEMENTS AND VALUE OF AN EXTENDED GRAZING SEASON FOR STOCKER CATTLE GRAZING WINTER WHEAT PASTURE

Abstract

This study was conducted to determine the value of two monensin supplementation strategies for steers and heifers pastured on fall-winter wheat relative to the value of a free-choice mineral supplement containing no monensin. A second objective was to determine the value of extending the fall-winter wheat pasture grazing season by either one or two weeks.

Introduction

The use of dual-purpose crops is important to many countries all over the world. In the Southern Plains of the United States, dual-purpose winter wheat is used to pasture young steers and heifers as well as produce a grain crop. During the fall and winter season, lush pastures offer a valuable source of forage for beef cattle. Six million acres are seeded annually to winter wheat in Oklahoma. Two-thirds of the winter wheat planted in the region is intended to produce both fall-winter forage for grazing and grain

(True et al. 2001). In a dual-purpose wheat forage plus grain system, wheat is planted in early September and is available for grazing by livestock from mid-November until development of the first hollow stem, usually in late February or early March. First hollow stem is the stage when the stems begin to elongate or hollow stem begins forming just above the roots (Redmon et al. 1995). An illustration of the wheat plant during FHS can be seen in Figure 1. If cattle are removed prior to development of first hollow stem, the wheat will mature and produce a grain crop for harvest in June.

Research has found that grazing past the first hollow stem growth stage decreases grain yield (Redmon et al. 1996). The occurrence of first hollow stem depends on several climatic factors including temperature and precipitation. Most winter wheat pasture is stocked with young steers or heifers that may be purchased in the fall and sold at the end of the winter grazing season in late February or early March. If the general trend in prices is increasing, the activity can be quite profitable. However, if the general trend in prices is decreasing; that is, if cattle prices decline during the relatively brief period of ownership, the activity can incur losses.

Several factors have motivated this study to determine differences in expected wheat stocker net returns across gender, beginning weight, supplementation strategy, and sale date. Dual-purpose winter wheat and stocker producers are faced with several key decisions that influence the final weight (and value) of the animals, and when these animals are removed from pasture. Several key issues impact the final weight and value of the animals: seasonal price pattern, supplementation, and length of the grazing season.

Seasonal Price Pattern

As noted, in a dual-purpose (forage and grain) winter wheat system, the wheat plant growth stage defined as first hollow stem is the threshold for livestock removal (Redmon et al. 1996). The occurrence of first hollow stem is weather dependent and in a given year occurs throughout the Southern Plains during a relatively small time window. Thus, many animals in the region are removed from winter wheat pastures and sold over a relatively short time period. This results in seasonal price consequences.

Since 1992, the USDA has been reporting Oklahoma City steer and heifer prices in 50-pound increments (USDA 2006). Figure 2 illustrates the seasonal prices of steers for three weight classes occurring in a calendar year. Price trends during the critical first hollow stem stage (late February – early March) differ depending upon weight. Figure 3 illustrates the seasonal prices of steers for the same three weight classes during the critical first hollow stem period. Historically, prices for heavy (900-950 pound) steers trend down, whereas prices for lighter steers (600-650 pound) trend up in the first hollow stem period. These price patterns suggest that the profitability of wheat pasture stockers may depend critically upon the weight of animals purchased in the fall, rate of gain, and the February-March date of sale. Therefore, the value of a pound of gain in a given region depends more upon animal weight during the first hollow stem period than at any other time of the year.

Supplement Strategy

The type of supplement that a wheat pasture stocker producer chooses to feed influences the final weight and value of the stockers. Most producers in the Southern

Plains region provide cattle access to a mineral supplement (Hossain et al. 2004). In general, wheat forage contains an inadequate amount of calcium for growing cattle. Horn et al. (2005) report that because the calcium is of primary concern in wheat pasture grazing situations, wheat pasture stockers should be supplemented with at least 0.353 ounces (10 grams) of calcium per day per stocker. This is based on a 496-pound stocker gaining 2.2 pounds per day possessing a daily calcium requirement of 1.09 ounces (31 grams).

Producers may choose to provide a free-choice high calcium mineral supplement or they may choose to supplement wheat pasture stockers with an ionophore. An ionophore is an organic compound that facilitates the transport of ions across cell membranes. Monensin is a polyether ionophore antibiotic, which is produced by fermentation of *Streptomyces cinnamonensis*. In ruminants with developed forestomachs, monensin increases the rate of weight gain. In wheat pasture situations monensin is more effective at reducing bloat than alternative ionophores (Horn 2006; Horn et al. 2005). However, it is toxic to horses and some producers that also provide feed to horses are reluctant to include monensin in mixed feeds. Feeding a monensin containing supplement influences the weight gain and final weight of the stocker cattle. Because the weight of the cattle impacts their selling price, the supplementation strategy followed is important. Given the price patterns, the marginal value of monensin induced weight gain may be minimal and may differ depending upon initial weight and gender.

Grazing Termination

Part of the winter wheat breeding program in the Southern Plains is devoted to the development of dual-purpose varieties. A recently released variety will provide an additional week of pre first hollow stem grazing (Carver et al. 2006). The value of this extra week of grazing may depend critically upon the stocker price patterns. A dual-purpose variety may be required to sacrifice grain yield for either enhanced forage yield or an extended grazing season. Estimates of the value of an additional week of grazing during the critical late February to early March period could be used to provide guidance to the wheat variety development program.

Objectives

This study has two objectives. The first objective is to determine the expected value of two monensin supplementation strategies for steers and heifers pastured on fall-winter wheat pasture with alternative beginning weights, relative to the value of a free-choice high-calcium mineral supplement (containing no monensin). The second objective is to determine the expected value of extending the fall-winter wheat pasture grazing season by either one or two weeks.

Risk is important in agricultural production. Producers are faced with business decisions that will affect their returns. Several studies of dual-purpose winter wheat and stocker production have been conducted (Epplin et al. 2001; Horn et al. 2005; Kaitibie et al. 2003a, 2003b). Because of the Southern Plains' competitive advantage that comes from the ability to graze cattle on wheat through the winter months when other areas are unable to do so, stocker production has become very important to the regional agricultural economy. Research in this area is appropriate to better understand the industry and to keep the industry thriving.

Previous studies have provided some results to assist producers in maximizing economic returns. Peel (2003) describes different beef growing and backgrounding programs. Hossain et al. (2004) identified the wheat production and management practices used by Oklahoma grain and livestock producers. Katibie et al. (2003a) found the optimal stocking density for dual-purpose winter wheat and stocker production. Redmon et al. (1996) showed that dual-purpose wheat grain yield is maximized when grazing is terminated at first hollow stem. Paisley et al. (1998) and Horn (2006) have evaluated various supplementation strategies for steers on wheat pasture. They found that stocker weights increase when fed monensin. Epplin et al. (2001) determined and compared the historical net returns from grain-only wheat with the historical net returns from dual-purpose wheat. However, limited research has been done comparing net returns of stocker production by using different purchase weights and sex, different supplementation (i.e.. monensin) strategies, and various sell dates. This paper examines net returns of different supplementation strategies and liquidation strategies. Research to determine the net returns of wheat pasture stocker production from alternative purchase weights and gender, and alternative supplementation strategies, and sell dates, has not been previously conducted. This study was undertaken to answer two research questions. The first is, are monensin supplements economical for steers and heifers pastured on winter wheat? And, the second is, what is the additional value of a winter wheat variety that provides an equivalent grain yield but provides an additional one or two weeks of fall-winter grazing?

Procedures

A total of 81 stocker production strategies were defined. This includes nine purchasing strategies, three supplementation strategies, and three selling dates. Figure 4 includes a flow chart of the strategies. The typical dual-purpose winter wheat stocker grazing season begins in mid-November, after the stocker calves have been through a three week receiving program. During the receiving program the calves are treated with medication and prepared to be placed on wheat pasture. Average daily gain is assumed to be one pound per head per day for a period of 21 days.

Kaitibie et al. (2003b) reported that the average placement date for stocker cattle on wheat pasture over a 12-year period at the Wheat Pasture Research Unit in North Central Oklahoma was November 12. Using this information, it is assumed that producers purchase stockers 21 days prior to the placement date. That is, stocker cattle are assumed to be purchased on October 22. Hossain et al. (2004) found the Oklahoma state average for beginning weights for pasture steers was 460 pounds and 447 pounds for heifers. The present study considers five different beginning weights for steers (375, 425, 475, 525, and 575 pounds) and four for heifers (375, 425, 475, and 525 pounds).

Daily weight gain of the stockers is an important measure because it affects net returns. Producers aim to increase daily gain to increase the overall revenue generated from the sale of their stockers at the end of the season. To increase rate of gain in stocker systems, an ionophore such as monensin, can be fed. Producers have a choice of whether to feed monensin, as well as which method of feeding. In this study three supplementation strategies are evaluated: free-choice feeding of a high-calcium mineral supplement without monensin; hand feeding a monensin-containing energy supplement

(Oklahoma Green Gold (OKGG)); and the free-choice feeding of a monensin-containing high-calcium mineral supplement (R1620).

Considerable variation occurs in the mineral composition of wheat forage, including inadequate amount of calcium for growing cattle. To meet the daily calcium requirements of stocker cattle, producers can feed a free choice high-calcium mineral. The market price of high- calcium mineral supplement is $380 per ton. The average consumption rate when fed free choice is 0.45 pounds per animal per day. This results in an expected daily cost of $0.09 per head.

The Oklahoma Green Gold (OKGG) supplementation program is a monensin containing energy supplement designed to be hand fed at a level of four pounds per head every other day to obtain an average intake of two pounds per head per day (Horn et al. 2005). Designed experiments have found that the OKGG program increases average daily gain of steers and heifers on fall-winter wheat pastures by 0.42 pounds per head per day (Horn et al. 2005). The market price of OKGG is $150 per ton. The average feeding rate of two pounds per animal per day results in an expected daily cost of $0.15 per head. This does not include the labor and management cost of feeding the supplement.

In recent years, several feed manufacturers have marketed a monensin-containing mineral mixture for stocker cattle. This mixture is typically referred to as an "R1620" formulation and contains 1,620 grams of monensin per ton. Results of studies conducted over three years relative to the used of R1620 mineral mixtures for wheat pasture stocker cattle have been reported by Horn (2006). In general, intake of the mineral mixture averaged about 0.15 pounds per steer per day (123 mg of monensin per steer per day) and daily weight gains were increased by 0.23 pounds compared with steers given free-choice access to the carrier mineral mixture without monensin. This study assumes that average daily gain of animals on fall-winter wheat pasture increases by an average of 0.23 pounds per head per day when supplemented with R1620. The market price of R1620 is $580 per ton. Given an expected consumption rate of 0.15 pounds per head per day, the estimated daily cost is $0.04 per head. This does not include the labor cost to feed the supplement. Producers must also effectively manage the intake of R1620 to achieve desired results of increased weight gain and bloat reduction.

Labor and management cost of feeding supplements differs across farms depending upon pasture size, distance from the headquarters to the pasture, and the opportunity cost of labor for individual producers. For this analysis, rather than include a cost for labor, the value of feeding trips necessary to hand feed the OKGG monensin strategy are estimated. It is assumed that the quantity of feed needed for a given pasture could be hauled in a single trip by a single vehicle.

After the fall-winter grazing season, the producer has a decision to either sell stockers early at a lighter weight or sell the stockers later at a heavier weight. Three different sell dates are considered: February 25, March 4, and March 11.

Production data from experiment station trials were used to prepare estimates of expected input requirements and production levels for each of the 81 strategies. Table 1 includes a summary of production assumptions for stocking density, average daily gain, death loss, and veterinary medicine expenses for each beginning weight and gender alternative modeled.

Net returns for each strategy in each year were calculated using:

(1) $$NR = \left[(P_S \times W_S) \times (1 - DL) - (P_P \times W_P) - C\right] \times [SD],$$

where NR equals net returns per acre ($), P_S represents the selling price ($/cwt), W_S is the selling weight (cwt), DL is the estimated death loss (%), P_p is the purchase price ($/cwt), W_p is the purchase weight (cwt), C represents costs other than the cost of land, labor, and management ($/head), and SD equals the stocking density (head/acre). Stocking density was calculated using two methods: actual and metabolic. Actual stocking density is based on one 550-pound steer pastured on two acres. Thus, actual stocking density is assumed to be 275 pounds (initial weight) per acre and is adjusted with weight. The stocking density for animals with an initial weight of 375 (575) pounds is 0.73 (0.48) head per acre. In other words, by assumption, 500 acres of winter wheat pasture could provide sufficient forage for 365 375-pound animals, but for only 240 575-pound animals. Metabolic stocking density is found by the following formula:

(2) $$SD_{Met} = \frac{\left(550^{.75}\right)/2}{\left(W_P + W_S/2\right)^{.75}},$$

where metabolic stocking density (SD_{Met}) represents metabolic weight per acre and metabolic weight is based on average weight to the .75th power (National Research Council 2000). Selling prices are available from USDA (2006) reports in 50-pound increments from 1992 to the present. The prices were linearly interpolated to obtain prices for precise weights. The various values were used as inputs into the base budget to calculate the net returns generated from each strategy for each year.

A base enterprise budget was constructed for each strategy for each year or state of nature. To illustrate how the enterprise budgets were used an example is provided in Table 2. Table 2 includes the base enterprise budgets for steers with a beginning weight of 375 pounds sold on March 11 for each of the three supplementation strategies. The budgets for heifers are similar. Budgets were prepared for each of the 81 strategies for each year from 1992-2006 using the appropriate linearly interpolated stocker prices.

The budgets provided a value of net returns generated from each stocker strategy for each year. These data enabled the construction of empirical distributions of net returns that account for price variability from 1992-2006 for each of the 81 strategies. Stochastic efficiency with respect to a function (SERF) was used to compare the strategies (Hardaker et al. 1997). SERF enables the comparison of all alternatives simultaneously. SERF orders a set of risky alternatives in terms of certainty equivalents for a specified range of attitudes to risk (Hardaker et al. 2004). The model is based on the subjective expected utility (SEU) hypothesis. This means that for each risky alternative and utility function, the utility for net income can be calculated, depending on the degree of risk aversion and the distribution of net farm returns. In equation form, the SEU hypothesis is:

(3) $$U(w) = EU(w) = \int U(w) f(w) dw = \int U(w) dF(w),$$

where U is utility, and w represents a wealth variable (i.e. net returns) (Hardaker et al. 2004, p.256). Thus, the SEU hypothesis means that the utility of any risky alternative is equal to its expected value.

SERF can be applied for any utility function for which the inverse function can be computed based on ranges in the absolute, relative, or partial risk aversion coefficient, whichever is appropriate. A negative exponential utility function was assumed:

(4) $$U(w) = -\exp(-r_a w),$$

where w represents a random wealth variable (i.e. net returns), and r_a is the absolute risk aversion coefficient (ARAC). A negative exponential utility function exhibits constant absolute risk aversion (CARA), which is a reasonable assumption in this study. The exact shape of the utility function is unknown, so the decision maker, in this case, the producer's exact risk aversion is not specified. The problem is solved by finding where the absolute, relative or partial risk aversion function, $r(w)$, of the decision maker lies between the lower and upper bounds, denoted by $r_L(w)$ and $r_U(w)$. Furthermore, for convenience, utility may be converted to certainty equivalents (CEs) by taking the inverse of the utility function:

$$CE(w,r) = U^{-1}(w,r)\,. \tag{5}$$

CEs are more easily interpreted because they are expressed in money terms, unlike utility values. For a risk-averse decision maker, the estimated CE is typically less than the expected money value (EMV). The difference between the EMV and the CE is the risk premium. The general rule for SERF analysis for the given assumptions is that the efficient set contains only those alternatives that have the highest (or equal to highest) CE for some value of risk in the relevant range. The range of risk aversion used in the SERF analysis is crucial. Strategies that are efficient over a certain range of risk aversion levels are determined, so the efficient strategies found are dependent on the risk aversion range they cover. The Pratt-Arrow measure of absolute risk aversion defined as $r(w) = \frac{-U''(w)}{U'(w)}$ is well known. Raskin and Cochran (1986) show that scale matters. The appropriate risk aversion coefficient range differs depending upon the level of wealth or income variable. In this study, returns are measured on an acre basis and the risk aversion range is from 0 (risk neutral) to 0.1 (risk averse).

Results

Estimates were computed for both risk neutral (RAC of 0) and risk averse (RAC of 0.1) situations. To conduct some sensitivity analysis, the estimates were performed using actual stocking density as well as metabolic stocking density. Table 3 includes average net returns for each of the nine gender-beginning weight alternatives for each of the three supplementation strategies with a March 11 selling date for a risk neutral and risk averse producer, based on actual stocking density. Table 4 illustrates similar figures using metabolic stocking density. These values were used to determine the additional returns from feeding either R1620 or OKGG to wheat pasture stocker steers and heifers, relative to feeding a high-calcium mineral supplement. The values in Tables 3 and 4 are in dollars per acre and dollars per head. The results shown in Tables 3 and 4 are illustrated in Figures 5 and 6. Based upon the assumptions regarding cost of the supplements and actual stocking density, for a risk neutral producer, the assumed increase in average daily gains, a March 11 sale date, and 1992-2006 market prices, the value of monensin fed as OKGG ranges from $7 per head for steers with a beginning weight of 375 lb to approximately $18 for 525 lb heifers. On the other hand, the value of monensin fed as R1620 ranges from $11 per head for 375 lb steers to approximately $19 per head for 525 lb heifers. However, for a risk averse producer, the assumed increase in average daily gains, a March 11 sale date, actual stocking density, and 1992-2006 market prices, the value of monensin fed as OKGG ranges from $12 per head for 375 lb steers to $18 for 525 lb heifers. The value of R1620 ranges from $15 per head for 375 lb steers to $20 per head for 525 lb heifers.

However, when stocking density is based on metabolic weight the results change slightly. Based upon the assumptions regarding cost of the supplements and stocking density, for a risk neutral producer, the assumed increase in average daily gains, a March 11 sale date, metabolic stocking density, and 1992-2006 market prices, the value of monensin fed as OKGG ranges from $4 per head for steers with a beginning weight of 375 lb to approximately $16 for 525 lb heifers. On the other hand, the value of monensin fed as R1620 ranges from $10 per head for 375 lb steers to approximately $19 per head for 525 lb heifers. However, for a risk averse producer, the assumed increase in average daily gains, a March 11 sale date, metabolic stocking density, and 1992-2006 market prices, the value of monensin fed as OKGG ranges from $10 per head for 375 lb steers to $17 for 525 lb heifers. The value of R1620 ranges from $13 per head for 375 lb steers to $19 per head for 525 lb heifers.

The net returns generated based on metabolic stocking density are lower than when found using actual stocking density. The reason for this difference is because actual stocking density rates are higher, resulting in higher returns per head and per acre. However, in both stocking density methods the light weight steers have the lowest net returns and heavier weight heifers have the highest net returns. Furthermore, as reported in Tables 3 and 4, and reflected in Figures 5 and 6, for every gender and weight combination, the estimated return from feeding R1620 exceeds the estimated return from feeding OKGG. The estimated increase in daily gain is greater for OKGG. However, OKGG is more expensive per stocker per day. These estimates may be used to determine if it would be economical for a specific producer to supplement with monensin (OKGG or R1620). For example, OKGG is designed to be hand fed every other day. The March

11 sale date follows from the assumption of 119 days on wheat pasture. A producer who followed the OKGG system would be required to hand feed 59 times during the pasture season. The values in Tables 3 and 4 provide information regarding the potential benefits from feeding either of the two monensin supplements. However, these benefits must be weighed against the labor costs that are specific to the farm and pasture situation. Tables 5 and 6 report the returns of feeding OKGG, depending on the size of the operation and stocking density.

Table 5 shows the estimated return per trip of feeding OKGG, with a March 11 sale date and a risk averse producer, as compared to feeding a high calcium mineral supplement (containing no monensin). For a 160-acre pasture that was stocked with 525-pound steers at an actual stocking density of 0.52, the pasture would be fully stocked with 83 steers. The expected additional return to labor from feeding OKGG per head is $15.10. The expected additional return for the 83 steers is $1,253. The expected return for each of the 59 feeding trips is $21. A 40-acre pasture would be fully stocked with 21 525-pound steers. The expected additional return for the 21 steers is $317 or $5 per feeding trip. With large pastures, more animals can be fed with a single trip and the returns per feeding trip are greater.

Tables 7 and 8 include the estimated returns from keeping stockers on wheat pasture for both one and two additional weeks after February 25, depending on stocking density. These estimates were computed based upon the cost and gain assumptions associated with the R1620 strategy. Estimates of the value of an extra week or two weeks of grazing for a risk averse producer are reported in Tables 9 and 10 in dollars per acre as well as in terms of bushels of grain. The value of extending the grazing season in terms of bushels of wheat is based upon an assumed wheat price of $3 per bushel. By finding the returns generated from grazing stockers one or two additional weeks and using an assumed wheat price, the returns can be compared with bushels of wheat. This enables the calculation of the value of an extra week or two of additional grazing in terms of bushels of grain, and the information may assist wheat variety development programs.

Figures 7 and 8 include charts of the additional expected returns from grazing wheat for one and for two weeks after February 25 for each of the nine stocker steer and heifer situations (when stockers are supplemented with R1620). In general, the value in terms of dollars per acre of one additional week of grazing from February 25 to March 4 is less for steers than for heifers. Based on actual stocking density and a risk neutral situation, it ranges from $3 per acre for steers with a beginning weight of 575 pounds to $10 per acre for heifers with a beginning weight of 375 pounds. In a risk averse situation, the value of an extended week of grazing from February 25 to March 4 is between $3 per acre for 575-pound steers and $11 per acre for 375-pound heifers. When returns are found based on metabolic stocking density, the values of extended grazing were lower, but followed a similar pattern. Results indicate that extension of the grazing seasons adds value to the stocker enterprise. However, at some point, as the wheat plant develops, grazing decreases grain yield. Grain yield loss is not calculated in this study.

Figures 7 and 8 also show the additional expected returns from grazing wheat for two weeks from February 25 to March 11 for each of the nine steer and heifer situations. In general, the value in terms of dollars per acre of two additional weeks of grazing after February 25 is less for steers than for heifers, and the second week is not as valuable as the first. For example, in risk neutral situations and using actual stocking density, for steers with a starting weight of 525 pounds the first week February 25 to March 4 is worth $4 per acre. However, the second week, March 4 to March 11 adds only $3 per acre. Thus, the estimated value of feeding a 525-pound steer two extra weeks, from February 25 to March 11, is $7 per acre. A steer with a purchase weight of 525 pounds will weigh different amounts depending on the supplementation strategy that is followed as well as the selling date. For example, if a 525-pound steer is fed high calcium mineral supplement, the steer will weigh 772 pounds on February 25, 788 pounds on March 4, and 804 pounds on March 11. If this same 525-pound steer is supplemented with OKGG (R1620), it will weigh 816 pounds (796 pounds) on February 25, 834 pounds (813 pounds) on March 4, and 853 pounds (831 pounds) on March 11. The returns generated from the various supplementation and selling strategies are reflected in the selling price of the stocker, which depends on the weight of the stocker at sale time.

The seasonality of prices has a significant affect on the value of the stocker on sale day. Figures 2 and 3 illustrate seasonal stocker prices. The heavier stockers have a lower selling price ($/cwt) than the lighter stockers. However, the total value of the stocker at sell date is affected by the selling price and the selling weight. Depending on the seasonality of the prices, lighter stockers with higher selling prices may be more valuable than heavier stockers with a lower selling price. The reverse is also true, lighter stockers with high selling prices may hold less value than heavier stockers with lower selling prices. The expected weight of a 525-pound steer is between 772 to 851 pounds, differing from the result of supplementation and sale date. If the steer is fed OKGG and sold on the last sale date, March 11, it will weigh 851 pounds, selling at a lower price per pound than lighter stockers.

The returns generated from feeding OKGG are generally lower than feeding R1620 for a variety of reasons, one of which is the price pattern of stockers. OKGG generates higher average daily gains than R1620, has a higher cost, and results in a higher selling weight. Because the higher selling weight stocker receives a lower selling price, the overall returns from OKGG are often lower than R1620. The stocker fed R1620 may not be as heavy, but it will receive a higher price per pound; resulting in higher returns. Thus, the returns generated from the various strategies are dependent on the seasonality of prices. The selling date is also crucial to the value of the stocker. If the stocker is sold earlier, it will have a lower selling weight. The reduction of size of the added worth of the second week of grazing is a function of the seasonal movement in prices as large numbers of stocker cattle move from wheat fields to sale barns.

The main findings from this study are that lighter stockers fed monensin and sold at a later date generate more income per acre. By purchasing light weight stockers, the producer lowers the initial purchase value of the stocker and can increase the number of animals stocked. Furthermore, by feeding monensin, the average daily gain increases; and by selling at a later sell date, the stockers are heavier and more valuable. However, as a result of the seasonal price patterns, the value of additional weeks of grazing are influenced by starting weight. Potential reductions in grain yield that may result from the additional weeks of grazing have not been considered.

Summary and Conclusions

The first objective was to determine the expected value of two monensin supplementation strategies for steers and heifers pastured on fall-winter wheat pasture with alternative beginning weights, relative to the value of a free-choice calcium mineral supplement (containing no monensin). It was determined that for every gender and weight combination, the estimated return from feeding monensin as R1620 exceeds the estimated return from feeding OKGG. In risk neutral situations based on actual stocking density, the expected return from feeding R1620 above the expected net return from feeding a free-choice high-calcium mineral supplement, ranged from $11 per head ($8 per acre) for steers with a beginning weight of 375 pounds to $19 per head ($10 per acre) for heifers with a beginning weight of 525 pounds for a March 11 sale date. Labor and management cost of feeding R1620 was not included. The expected net returns are lower when based on metabolic stocking density because stocking rates are lower.

The expected return from feeding OKGG above the expected return from feeding a free choice high-calcium mineral, ranged from $7 per head ($5 per acre) for steers with a beginning weight of 375 pounds to $18 per head ($9 per acre) for heifers with a beginning weight of 525 pounds, using actual stocking density, and a March 11 sale date in a risk neutral environment. Benefits from feeding OKGG must be weighed against the labor costs that are specific to the farm and pasture situation. The expected return above the return from the free-choice high-calcium supplement for alternate day feeding on pastures fully stocked with steers with a beginning weight of 525 pounds was found to be $21 per feeding trip for a 160-acre pasture, but only $5 per feeding trip for a 40-acre pasture.

The second objective was to determine the expected value of extending the fall-winter wheat pasture grazing season by either one or two weeks. In general, the value in terms of dollars per acre of one additional week of grazing from February 25 to March 4 is less for steers than for heifers. In a risk neutral environment using actual stocking density, it ranges from $3 per acre for steers with a beginning weight of 575 pounds to $10 per acre for heifers with a beginning weight of 375 pounds. On average, extension of the grazing season adds value to the stocker enterprise. However, at some point, as the wheat plant develops grazing may reduce grain yield.

In general, the value in terms of dollars per acre of two additional weeks of grazing after February 25 is less for steers than for heifers, and the second week is not as valuable as the first. It ranges from $6 per acre for steers with a beginning weight of 575 pounds to $16 per acre for heifers with a beginning weight of 375 pounds. For steers with a starting weight of 525 pounds the first week February 25 to March 4 is worth $4 per acre. However, the second week, March 4 to March 11 adds only $3 per acre. If the additional two weeks of grazing reduced wheat grain yield by three bushels and if the net value of wheat is $3 per bushel, the cost of additional grazing in terms of lost grain value would exceed the benefits. These findings suggest that the dual-purpose wheat variety development program should not sacrifice much wheat grain to obtain one or two additional weeks of pre first hollow stem grazing.

Further research is needed to address several limitations of the study. First, feeding a supplement containing monensin has reduced the incidence of bloat, which decreases death loss. However, data are not available to precisely estimate the effect of monensin on death loss due to bloat. Second, research is necessary to more precisely determine the wheat grain yield consequences of extending the grazing season beyond the first hollow stem stage (Fieser et al. 2006).

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First Hollow Stem (FHS)

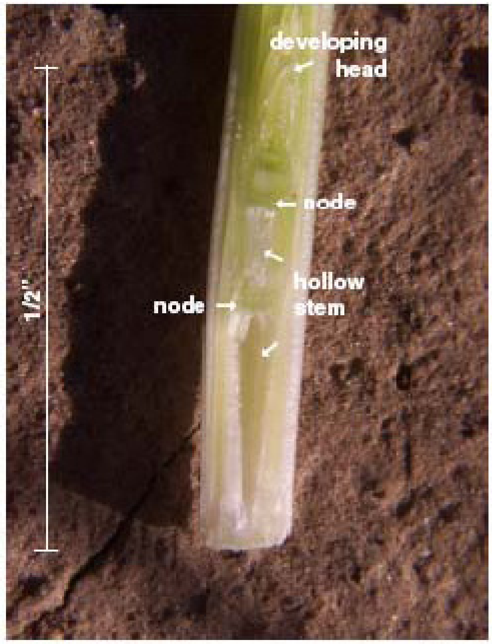


Figure I-1. Illustration of the occurrence of first hollow stem (FHS) for a winter wheat plant.

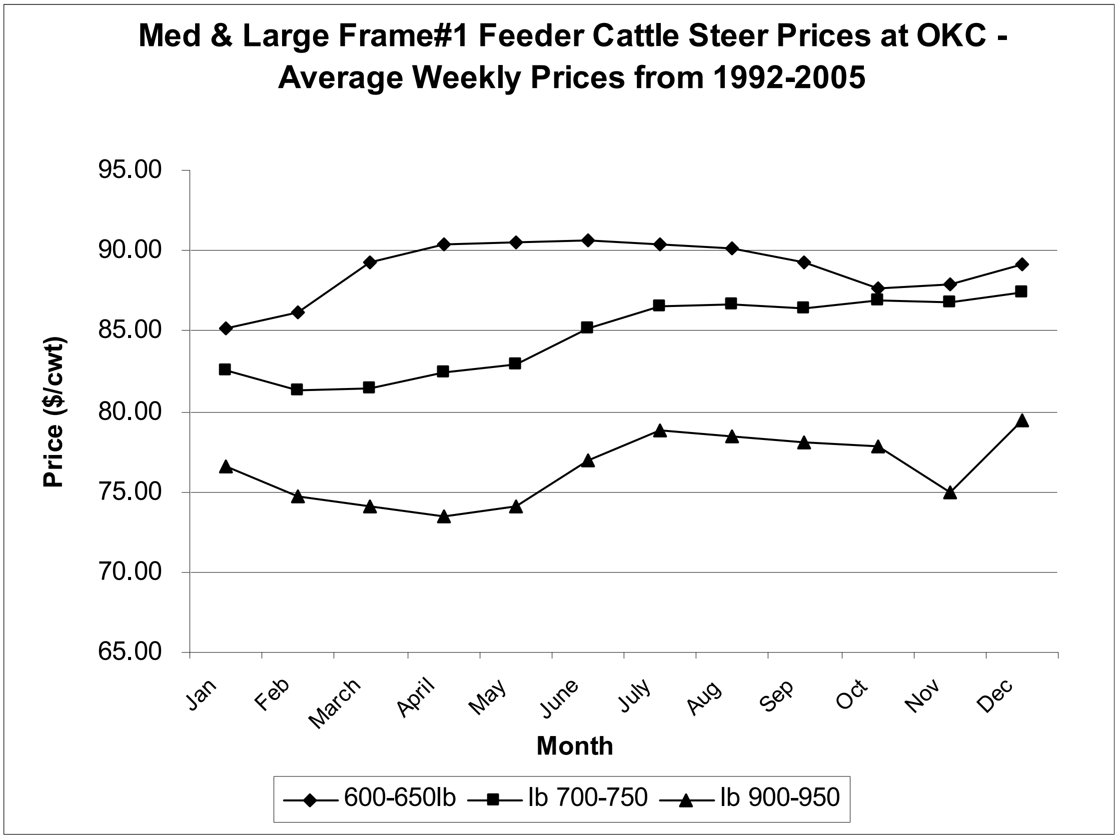


Figure I-2. Seasonal steer price chart illustrating the price pattern of 600-650 lb, 700-750 lb, and 900-950 lb steers based upon Oklahoma City prices from 1992 to 2005.

Note: The weekly prices were averaged to achieve a monthly price, which was averaged from 1992-2005, resulting in the average price.

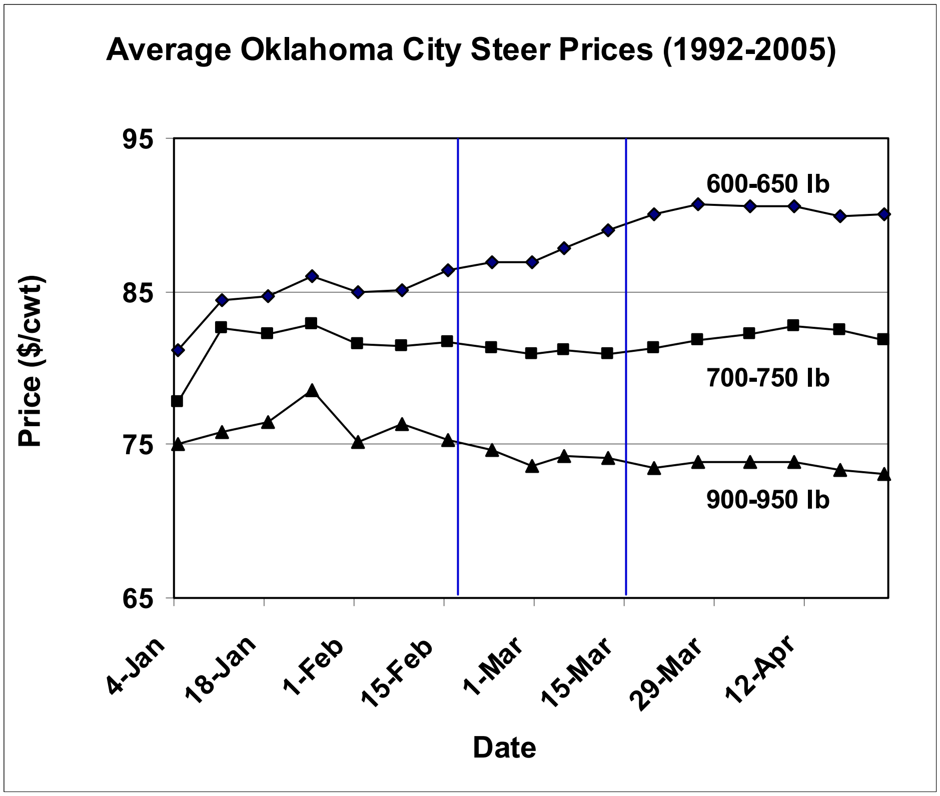


Figure I-3. Seasonal steer price chart denoting the steer prices at the critical first hollow stem stage of wheat plant growth (mid-February to mid-March).

Strategy Flowchart

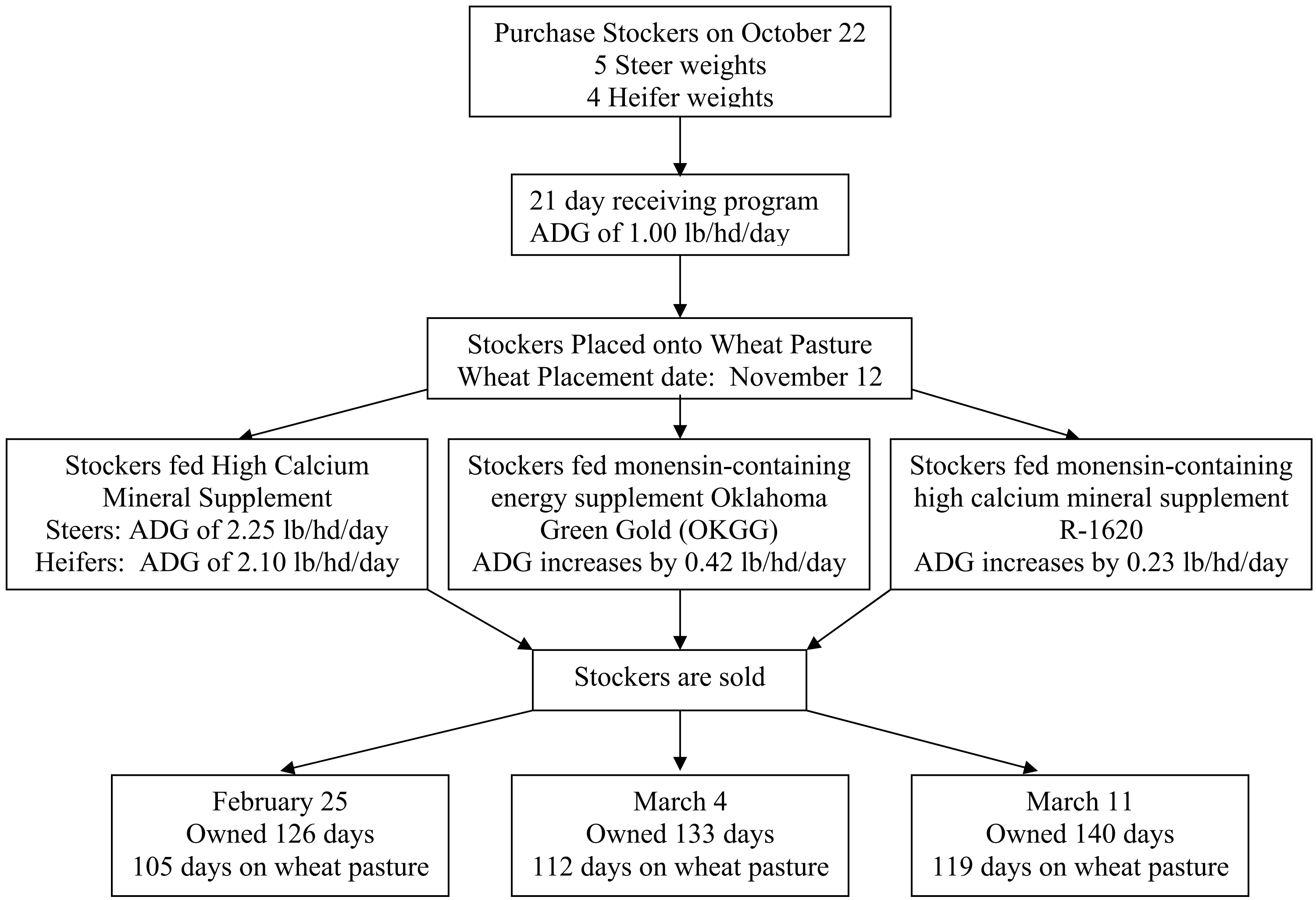


Figure I-4. Flow chart of stocker purchase, supplementation, and liquidation strategy alternatives and assumptions.

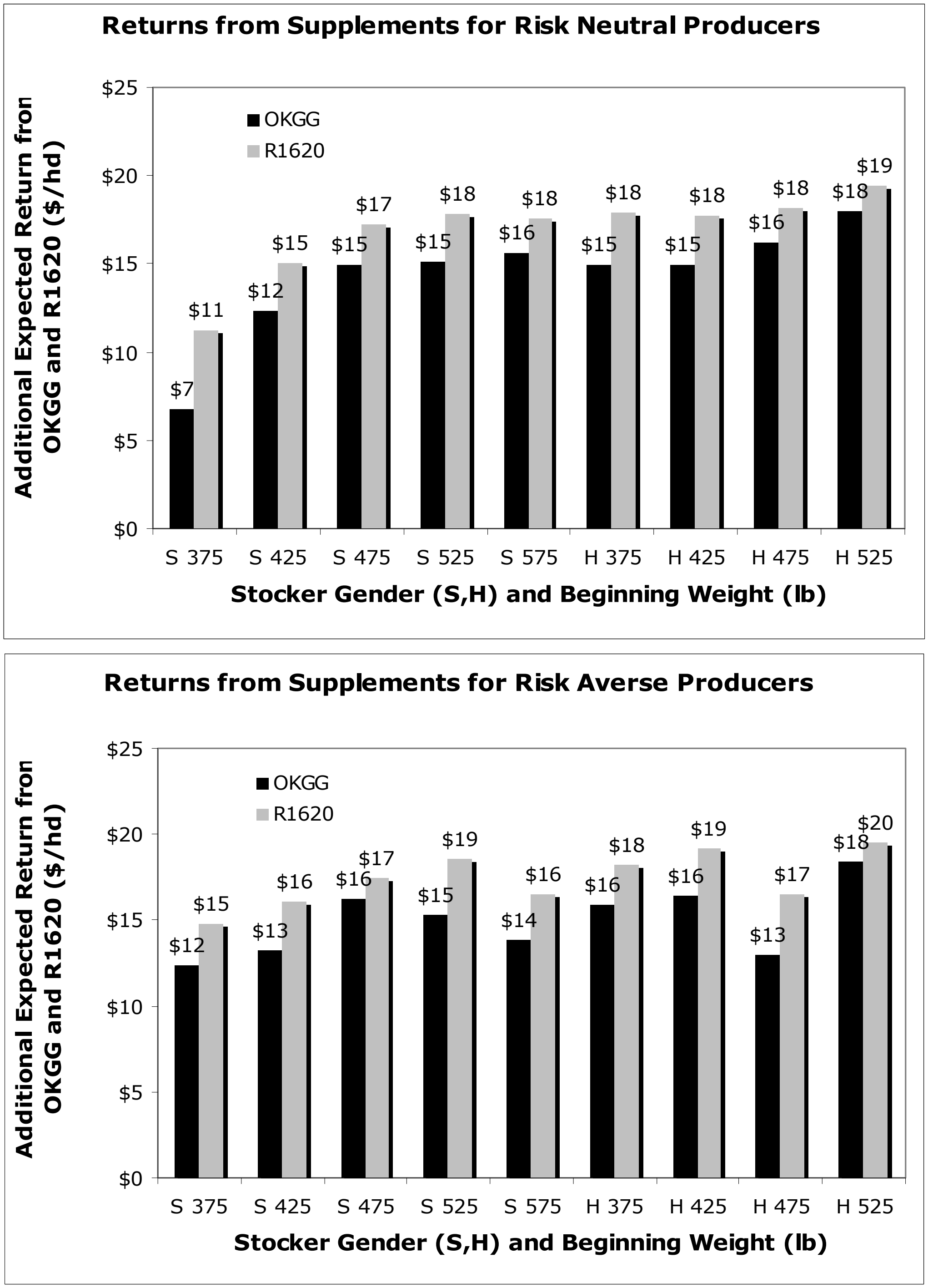
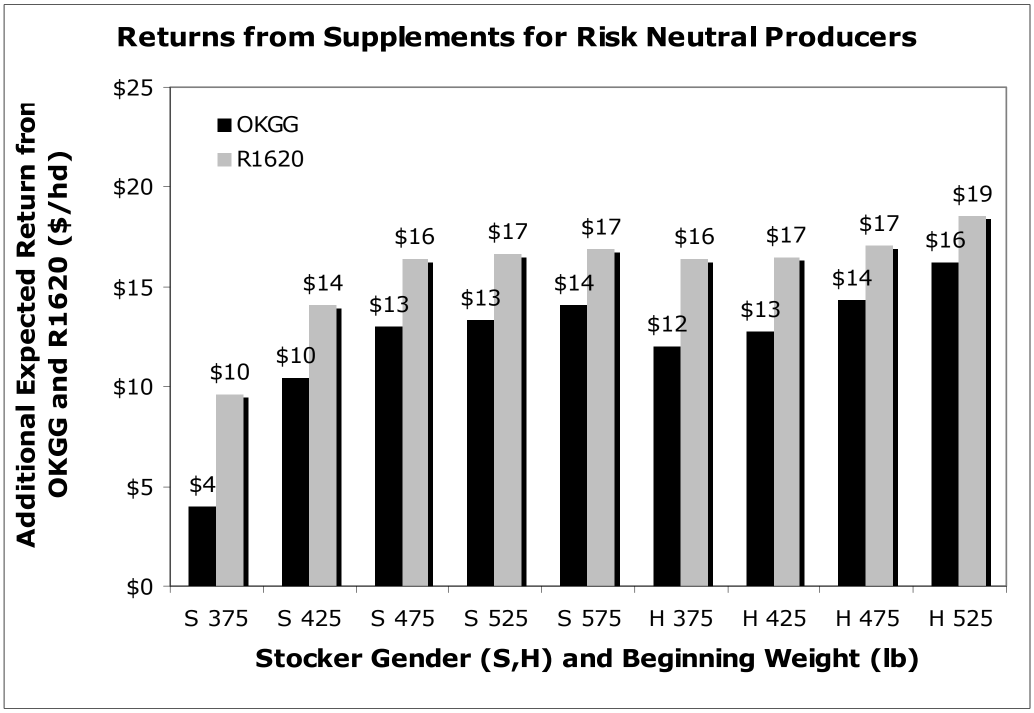


Figure I-5 a & b. Return to land, labor, management, and overhead ($/hd) from feeding a monensin containing supplement (OKGG and R-1620), relative to feeding a high calcium mineral supplement, for steers (S) and heifers (H) purchased on October 22, stocked on fall-winter wheat pasture with alternative beginning weights, and a sale date of March 11 for risk neutral and risk averse producers. (based on actual stocking density**)**



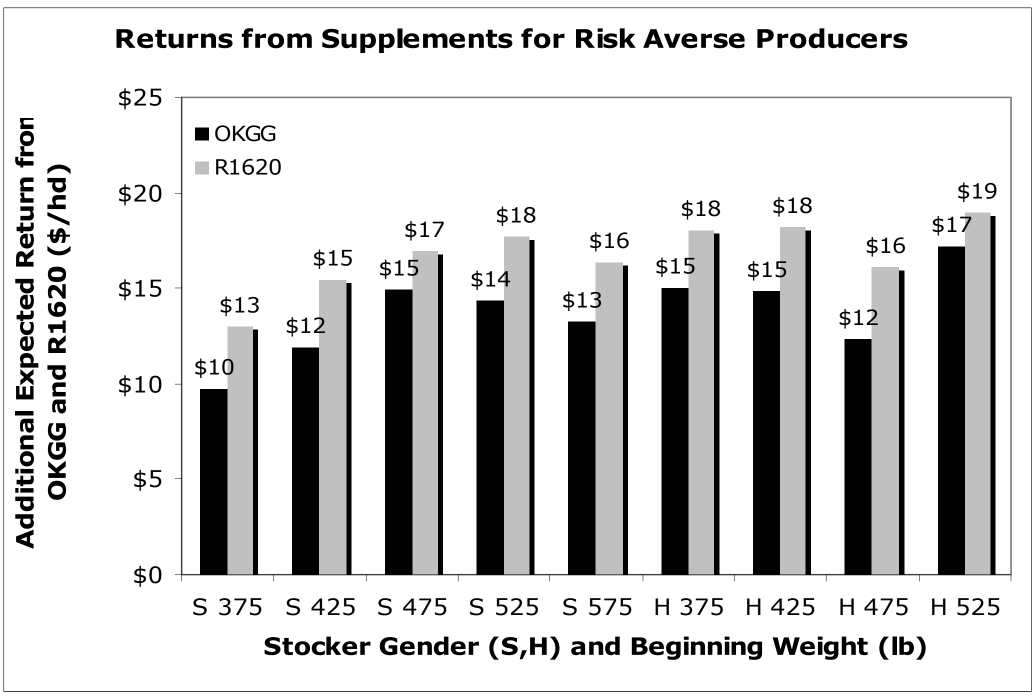
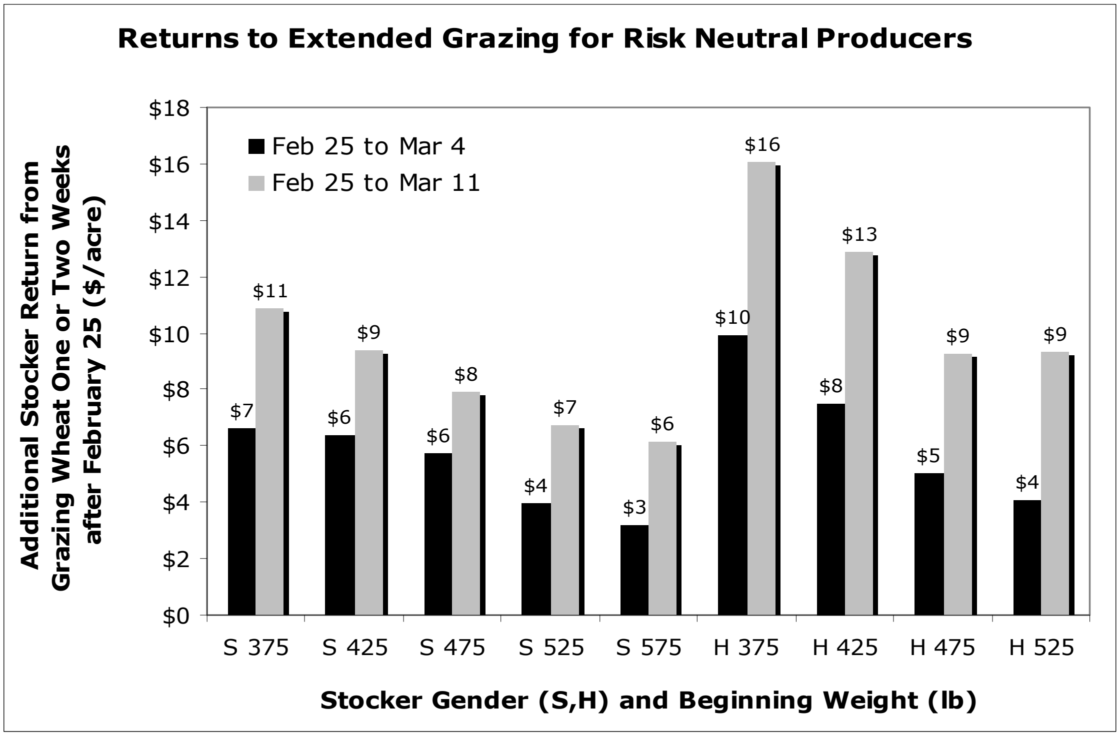


Figure I-6 a & b. Return to land, labor, management, and overhead ($/hd) from feeding a monensin containing supplement (OKGG and R-1620), relative to feeding a high calcium mineral supplement, for steers (S) and heifers (H) purchased on October 22, stocked on fall-winter wheat pasture with alternative beginning weights, and a sale date of March 11 for risk neutral and risk averse producers. (based on metabolic stocking density**)**



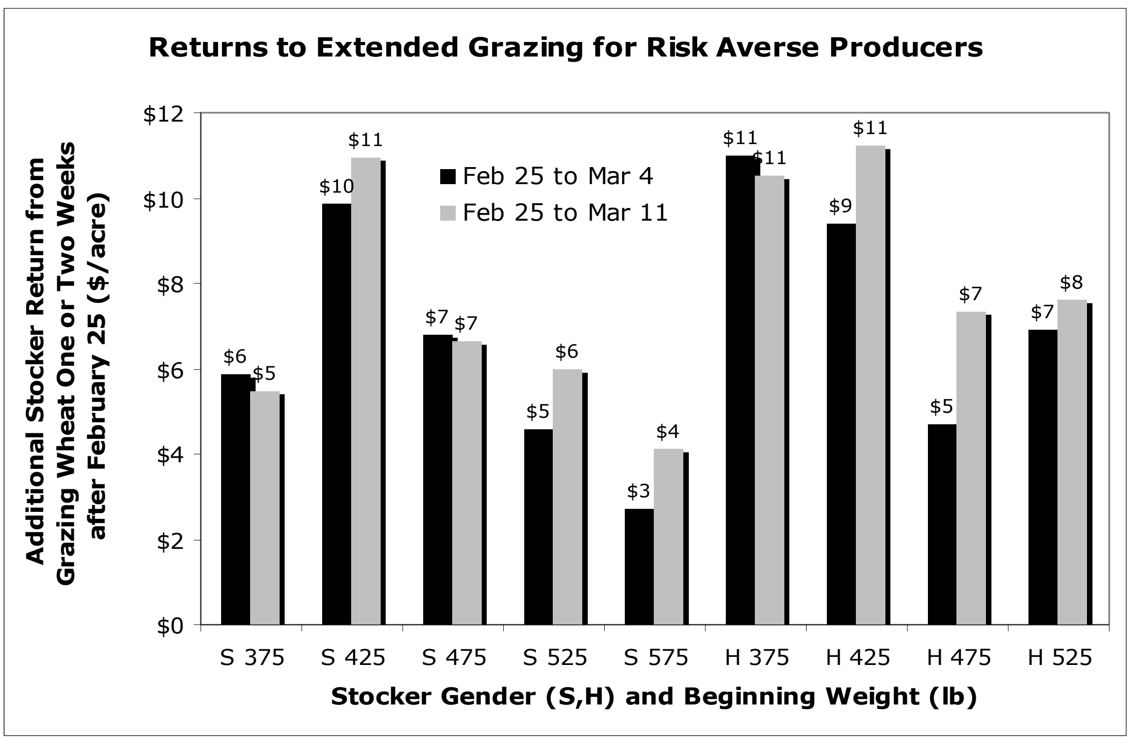


Figure I-7 a & b. Return to land, labor, management, and overhead ($/ac) from grazing wheat for one and for two weeks after February 25, for stocker steers (S) and heifers (H) purchased on October 22 and supplemented with R1620 with alternative beginning weights for risk neutral and risk averse producers. (based on actual stocking density**)**

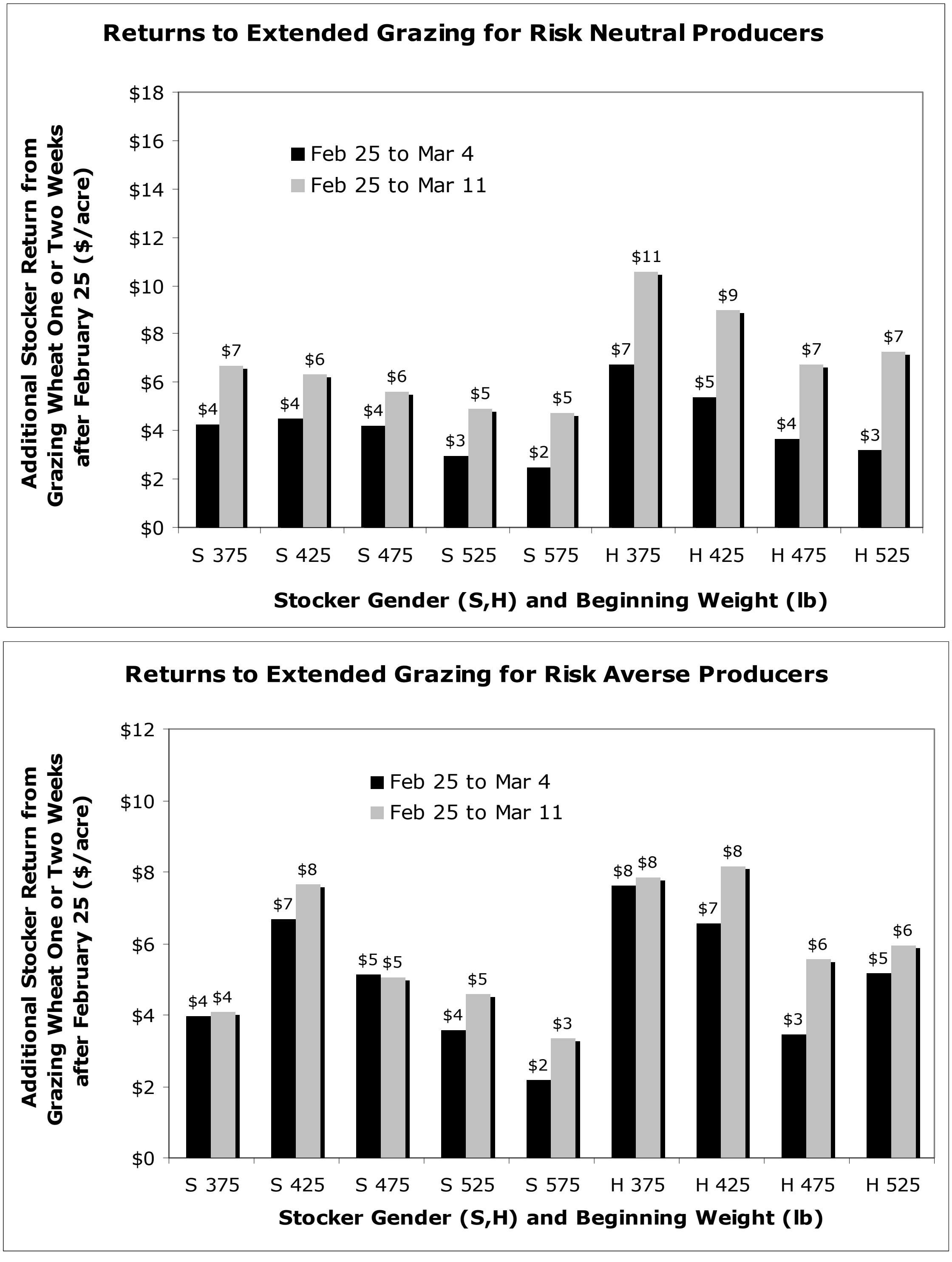


Figure I-8 a & b. Return to land, labor, management, and overhead ($/ac) from grazing wheat for one and for two weeks after February 25, for stocker steers (S) and heifers (H) purchased on October 22 and supplemented with R1620 with alternative beginning weights for risk neutral and risk averse producers. (based on metabolic stocking density)

Table I-1. Production Assumptions for Stocking Density, Average Daily Gains, Death Loss, and Veterinary Medicine Expenses for Each Beginning Weight and Stocker Gender Alternative Modeled

Stocker Gender and Beginning Weight (lb)	Stocking Density (hd/ac)[a]	Stocking Density (hd/ac)[b]	Gain with High Calcium Mineral Supplement (no monensin) (lb/day)	Gain with OKGG (lb/day)	Gain with R1620 (lb/day)	Death Loss (%)	Vet -Med Cost ($/hd)
Steers 375	0.73	0.51– 0.54	2.25	2.67	2.48	2.00	20.0
Steers 425	0.65	0.48 – 0.50	2.25	2.67	2.48	1.75	17.5
Steers 475	0.58	0.45 – 0.47	2.25	2.67	2.48	1.50	15.0
Steers 525	0.52	0.42 – 0.44	2.25	2.67	2.48	1.25	12.5
Steers 575	0.48	0.40 – 0.42	2.25	2.67	2.48	1.00	10.0
Heifers 375	0.73	0.52 – 0.55	2.10	2.52	2.33	2.50	24.0
Heifers 425	0.65	0.48 – 0.51	2.10	2.52	2.33	2.25	21.5
Heifers 475	0.58	0.45 – 0.48	2.10	2.52	2.33	2.00	19.0
Heifers 525	0.52	0.43 – 0.45	2.10	2.52	2.33	1.75	16.5

[a] Stocking density is based on one 550-pound animal per two acres (275 pounds per acre).
[b] Stocking density is based on metabolic weight (range due to various average stocker weights).

Table I-2. Base Enterprise Budget for Steers with a Beginning Weight of 375 Pounds Sold on March 11 for Each Supplementation Strategy (High Calcium Mineral, OKGG, and R1620)
Average purchase and selling prices were used from 1992-2006.

Assumed Death Loss	%	2%	2%	2%
Days on Wheat	days	119	119	119
Days owned	days	140	140	140
ADG	lb/hd/day	2.25	2.67	2.48
Purchase Weight	cwt/hd	3.75	3.75	3.75
Average Purchase Price from 1992-2005	$/cwt	108.34	108.34	108.34
Selling Weight	cwt/hd	6.50	6.99	6.77
Average Selling Price from 1993-2006	$/cwt	88.50	84.50	86.20
Actual Stocking Density	hd/ac	0.73	0.73	0.73
Metabolic Stocking Density	hd/ac	0.53	0.51	0.52

Item	Unit	Price	Quantity	Value with High Calcium Mineral Supplement	Value with OKGG Supplement	Value with R-1620 Supplement
Gross receipts:						
Steers (based on death loss of 2%)	cwt	$89.43	Selling weight	$575.67	$591.04	$583.83
Operating costs:						
Stocker calves	cwt	$108.34	3.75	$406.28	$406.28	$406.28
Order buyer fee	cwt	$0.50	3.75	$1.88	$1.88	$1.88
Shipping to pasture	$/hd	$10.00	1	$10.00	$10.00	$10.00
Receiving program (21 days):						
Veterinary and medicine	$/hd	$20.00	1	$20.00	$20.00	$20.00
Hay (2% of initial purchase weight in lb/hd/day)	lb	$0.03	157.5	$4.73	$4.73	$4.73
Soybean meal based supplement (2 lb/hd/day)	lb	$0.09	42	$3.62	$3.62	$3.62
Other:						
Shipping to market, sales commission, etc	cwt	$2.00	Selling weight	$13.01	$13.99	$13.55
Machinery fuel, lube, and repairs	$	$10.00	1	$10.00	$10.00	$10.00
Hay during bad weather (assume 2 bad days)	lb	$0.03	24	$0.72	$0.72	$0.72
High calcium mineral mixture	lb	$0.19	53.55	$10.17	$0.00	$0.00
Monensin supplement - OKGG	lb	$0.08	2	$0.00	$17.85	$0.00
Monensin supplement - R-1620	lb	$0.29	0.15	$0.00	$0.00	$5.18
Interest on Stocker calves	$	$0.0625	155.83	$9.74	$9.74	$9.74
Interest on other operating expenses	$	$0.0625	Operating Exp.	$1.78	$1.98	$1.67

Table I-2. Base Enterprise Budget for Steers with a Beginning Weight of 375 Pounds Sold on March 11 for Each Supplementation Strategy (High Calcium Mineral, OKGG, and R1620)
Average purchase and selling prices were used from 1992-2006.

Assumed Death Loss	%	2%	2%	2%
Days on Wheat	days	119	119	119
Days owned	days	140	140	140
ADG	lb/hd/day	2.25	2.67	2.48
Purchase Weight	cwt/hd	3.75	3.75	3.75
Average Purchase Price from 1992-2005	$/cwt	108.34	108.34	108.34
Selling Weight	cwt/hd	6.50	6.99	6.77
Average Selling Price from 1993-2006	$/cwt	88.50	84.50	86.20
Actual Stocking Density	hd/ac	0.73	0.73	0.73
Metabolic Stocking Density	hd/ac	0.53	0.51	0.52

Item	Unit	Price	Quantity	Value with High Calcium Mineral Supplement	Value with OKGG Supplement	Value with R-1620 Supplement
Total operating costs	**$/head**			$491.92	$500.78	$487.35
Fixed costs for steer production:						
Machinery and equipment – Depr., taxes and insurance	$	$5.50	1	$5.50	$5.50	$5.50
Machinery and equipment – Interest	$	$0.0625	2.11	$0.13	$0.13	$0.13
Total fixed costs, $/head				$5.63	$5.63	$5.63
Total costs, $/head				$497.55	$506.41	$492.98
Return to land, labor, and management	**$/head**			$78.12	$84.63	$90.85
Return to land, labor, and management [a]	**$/acre**			$57.29	$62.06	$66.62
Return to land, labor, and management [b]	**$/acre**			$41.40	$43.16	$47.24

[a] Based on actual stocking density of one 550 lb stocker for 2 acres (i.e. 275 lb/ac).
[b] Based on metabolic stocking density of weight to the 0.75^{th} power.
1) Order buyer fee is based on $0.50/cwt.
2) Shipping to pasture is based on $3/loaded mile. $10 is used as a base price.
3) Hay price is based on premium large round bales of grass hay in Central & Eastern Oklahoma of $60/ton Source: www.ams.usda.gov/mnreports/OK_GR310.txt.
4) Soybean meal is based on $172.50/ton. Consistent with prices reported at http://www.ams.usda.gov/LSMNpubs/pdf_weekly/dc_grain.pdf.
5) Shipping to market is based on $2/cwt.
6) Machinery costs for lube and repairs is assumed to be $10/hd.
7) High calcium mineral mixture is based on $380/ton. Source: Animal Science Department at Oklahoma State University
8) OKGG monensin supplement is based on $150/ton.
9) R-1620 monensin supplement is based on $580/ton.
This Budget is adapted from Kaitibie et al. (2003b).

Table I-3. Estimated Net Returns to Land, Labor, Overhead and Management from Steers and Heifers Stocked on Dual-Purpose Winter Wheat Pasture for Three Supplement Strategies with Alternative Beginning Weights and a March 11 Selling Date (based on actual stocking density)

Stocker Gender and Beginning Weight (lb)	High-Calcium Mineral Supplement ($/ac)	OKGG[a] Supplement ($/ac)	R1620[b] Supplement ($/ac)	Added Value of OKGG ($/ac)	Added Value of OKGG ($/hd)	Added Value of R1620 ($/ac)	Added Value of R1620 ($/hd)
				Risk Neutral			
Steers 375	57.47	62.42	65.67	4.95	6.78	8.20	11.23
Steers 425	38.06	46.09	47.81	8.03	12.35	9.75	15.00
Steers 475	35.36	44.01	45.36	8.65	14.91	10.00	17.24
Steers 525	33.06	40.91	42.31	7.85	15.10	9.25	17.79
Steers 575	30.46	37.95	38.89	7.49	15.60	8.43	17.56
Heifers 375	56.01	66.93	69.06	10.92	14.96	13.05	17.88
Heifers 425	45.40	55.13	56.93	9.73	14.97	11.53	17.74
Heifers 475	39.38	48.80	49.89	9.42	16.24	10.51	18.12
Heifers 525 [c]	29.57	38.94	39.66	9.37	18.02	10.09	19.40
				Risk Averse			
Steers 375	34.27	43.31	45.05	9.04	12.38	10.78	14.77
Steers 425	22.74	31.36	33.20	8.62	13.26	10.46	16.09
Steers 475	21.53	30.93	31.66	9.4	16.21	10.13	17.47
Steers 525	21.19	29.14	30.83	7.95	15.29	9.64	18.54
Steers 575	20.67	27.29	28.57	6.62	13.79	7.90	16.46
Heifers 375	25.88	37.51	39.19	11.63	15.93	13.31	18.23
Heifers 425	29.31	39.99	41.77	10.68	16.43	12.46	19.17
Heifers 475	28.26	35.77	37.83	7.51	12.95	9.57	16.50
Heifers 525 [c]	21.71	31.28	31.85	9.57	18.40	10.14	19.50

[a] OKGG is a hand-fed monensin-containing energy supplement.
[b] R1620 is a free-choice fed monensin-containing high calcium mineral supplement.
[c] Prices for heifers with a purchase weight of 525 pounds were only available for 2000-2006. All other prices are from 1992-2006.

Table I-4. Estimated Net Returns to Land, Labor, Overhead and Management from Steers and Heifers Stocked on Dual-Purpose Winter Wheat Pasture for Three Supplement Strategies with Alternative Beginning Weights and a March 11 Selling Date (based on metabolic stocking density)

Stocker Gender and Beginning Weight (lb)	High-Calcium Mineral Supplement ($/ac)	OKGG[a] Supplement ($/ac)	R1620[b] Supplement ($/ac)	Added Value of OKGG ($/ac)	Added Value of OKGG ($/hd)	Added Value of R1620 ($/ac)	Added Value of R1620 ($/hd)
	Risk Neutral						
Steers 375	41.30	43.32	46.29	2.02	3.96	4.99	9.60
Steers 425	28.89	33.89	35.66	5.00	10.42	6.77	14.10
Steers 475	28.13	33.99	35.51	5.86	13.02	7.38	16.40
Steers 525	27.39	32.98	34.53	5.59	13.31	7.14	16.60
Steers 575	26.15	31.77	32.92	5.62	14.05	6.77	16.93
Heifers 375	40.88	47.13	49.42	6.25	12.02	8.54	16.42
Heifers 425	34.96	41.09	43.05	6.13	12.77	8.09	16.51
Heifers 475	31.74	38.18	39.59	6.44	14.31	7.85	17.07
Heifers 525 [c]	24.80	31.77	32.76	6.97	16.21	7.96	18.51
	Risk Averse						
Steers 375	27.79	32.74	34.57	4.95	9.71	6.78	13.04
Steers 425	19.05	24.75	26.46	5.70	11.88	7.41	15.44
Steers 475	18.71	25.43	26.34	6.72	14.93	7.63	16.96
Steers 525	18.71	24.75	26.32	6.04	14.38	7.61	17.70
Steers 575	18.58	23.88	25.14	5.30	13.25	6.56	16.40
Heifers 375	22.45	30.28	31.82	7.83	15.06	9.37	18.02
Heifers 425	24.51	31.65	33.43	7.14	14.88	8.92	18.20
Heifers 475	23.86	29.42	31.27	5.56	12.36	7.41	16.11
Heifers 525 [c]	18.98	26.39	27.13	7.41	17.23	8.15	18.95

[a] OKGG is a hand-fed monensin-containing energy supplement.
[b] R1620 is a free-choice fed monensin-containing high calcium mineral supplement.
[c] Prices for heifers with a purchase weight of 525 pounds were only available for 2000-2006. All other prices are from 1992-2006.

Table I-5. Estimated Return per Trip of Hand Feeding OKGG, Relative to a self-fed High Calcium Mineral Supplement with a March 11 Sale Date and a Risk Neutral Producer (based on actual stocking density)

Size of Pasture (ac)	Steer 375	Steer 425	Steer 475	Steer 525	Steer 575	Heifer 375	Heifer 425	Heifer 475	Heifer 525
	Return Per Trip ($/trip)								
40	$3	$5	$6	$5	$5	$7	$7	$6	$6
80	$7	$11	$12	$11	$10	$15	$13	$13	$13
160	$13	$21	$23	$21	$20	$30	$26	$25	$25
320	$27	$43	$47	$43	$40	$59	$52	$51	$51
	Stocking density (hd/ac)								
	0.73	0.65	0.58	0.52	0.48	0.73	0.65	0.58	0.52

Notes:
It is assumed that the quantity of supplement required for a pasture could be delivered in a single trip.
OKGG is fed every two days and stockers are kept on winter wheat for 119 days, resulting in 59 feeding times.

Table I-6. Estimated Return per Trip of Hand Feeding OKGG, Relative to a self-fed High Calcium Mineral Supplement with a March 11 Sale Date and a Risk Neutral Producer (based on metabolic stocking density)

Size of Pasture (ac)	Steer 375	Steer 425	Steer 475	Steer 525	Steer 575	Heifer 375	Heifer 425	Heifer 475	Heifer 525
	Return Per Trip ($/trip)								
40	$1	$3	$4	$4	$4	$4	$4	$4	$5
80	$3	$7	$8	$8	$8	$8	$8	$9	$9
160	$5	$13	$16	$15	$15	$17	$16	$17	$19
320	$11	$27	$32	$30	$30	$34	$33	$35	$37
	Stocking density (hd/ac)								
	0.51	0.48	0.45	0.42	0.40	0.52	0.48	0.45	0.43

Notes:
It is assumed that the quantity of supplement required for a pasture could be delivered in a single trip.
OKGG is fed every two days and stockers are kept on winter wheat for 119 days, resulting in 59 feeding times.

Table I-7. Estimated Returns from Keeping Stockers on Wheat Pasture One or Two Additional Weeks after February 25 for Stockers Supplemented with R1620 (based on actual stocking density)

Stocker Gender and Beginning Weight (lb)	Selling on Feb. 25 ($/ac)	Selling on 4-Mar ($/ac)	Selling on 11-Mar ($/ac)	Return from Grazing one week from Feb 25 to Mar 4 ($/ac)	Return from Grazing two weeks from Feb 25 to Mar 11 ($/ac)
	Risk Neutral				
Steers 375	54.84	61.45	65.67	6.61	10.83
Steers 425	38.45	44.84	47.81	6.39	9.36
Steers 475	37.46	43.18	45.36	5.72	7.90
Steers 525	35.61	39.58	42.31	3.97	6.70
Steers 575	32.73	35.91	38.89	3.18	6.16
Heifers 375	53.01	62.95	69.06	9.94	16.05
Heifers 425	44.09	51.61	56.93	7.52	12.84
Heifers 475	40.63	45.62	49.89	4.99	9.26
Heifers 525 [a]	30.34	34.42	39.66	4.08	9.32
	Risk Averse				
Steers 375	39.58	45.46	45.05	5.88	5.47
Steers 425	22.25	32.10	33.20	9.85	10.95
Steers 475	25.00	31.79	31.66	6.79	6.66
Steers 525	24.84	29.41	30.83	4.57	5.99
Steers 575	24.45	27.15	28.57	2.70	4.12
Heifers 375	28.68	39.68	39.19	11.00	10.51
Heifers 425	30.56	39.96	41.77	9.40	11.21
Heifers 475	30.50	35.18	37.83	4.68	7.33
Heifers 525 [a]	24.24	31.17	31.85	6.93	7.61

[a] Prices for heifers with a purchase weight of 525 pounds were only available for 2000-2006. All other prices are from 1992-2006.

Table I-8. Estimated Returns from Keeping Stockers on Wheat Pasture One or Two Additional Weeks after February 25 for Stockers Supplemented with R1620 (based on metabolic stocking density)

Stocker Gender and Beginning Weight (lb)	Selling on Feb. 25 ($/ac)	Selling on 4-Mar ($/ac)	Selling on 11-Mar ($/ac)	Return from Grazing one week from Feb 25 to Mar 4 ($/ac)	Return from Grazing two weeks from Feb 25 to Mar 11 ($/ac)
			Risk Neutral		
Steers 375	39.62	43.84	46.29	4.22	6.67
Steers 425	29.33	33.82	35.66	4.49	6.33
Steers 475	29.93	34.14	35.51	4.21	5.58
Steers 525	29.63	32.61	34.53	2.98	4.90
Steers 575	28.21	30.68	32.92	2.47	4.71
Heifers 375	38.83	45.57	49.42	6.74	10.59
Heifers 425	34.07	39.45	43.05	5.38	8.98
Heifers 475	32.86	36.53	39.56	3.67	6.70
Heifers 525 [a]	25.52	28.69	32.76	3.17	7.24
			Risk Averse		
Steers 375	30.50	34.48	34.57	3.98	4.07
Steers 425	18.81	25.49	26.46	6.68	7.65
Steers 475	21.31	26.43	26.34	5.12	5.03
Steers 525	21.72	25.29	26.32	3.57	4.60
Steers 575	21.81	23.98	25.14	2.17	3.33
Heifers 375	23.96	31.57	31.82	7.61	7.86
Heifers 425	25.28	31.83	33.43	6.55	8.15
Heifers 475	25.73	29.20	31.27	3.47	5.54
Heifers 525 [a]	21.20	26.36	27.13	5.16	5.93

[a] Prices for heifers with a purchase weight of 525 pounds were only available for 2000-2006. All other prices are from 1992-2006.

Table I-9. Estimate of the Value of an Extra One and Two Weeks of Grazing Stockers Supplemented with R1620 for a Risk Neutral Producer (based on actual stocking density)

	Value of an Extra Week or Two Weeks of Grazing								
	Steer 375	**Steer 425**	**Steer 475**	**Steer 525**	**Steer 575**	**Heifer 375**	**Heifer 425**	**Heifer 475**	**Heifer 525**
	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)
Feb. 25 – Mar. 4	$6.61	$6.39	$5.72	$3.97	$3.18	$9.94	$7.52	$4.99	$4.08
Feb. 25 – Mar. 11	$10.83	$9.36	$7.90	$6.70	$6.16	$16.05	$12.84	$9.26	$9.32

If grain is valued at $3/bushel, the value of an extra week or two weeks could be expressed in terms of bushels of grain.

	Value of an Extra Week or Two Weeks of Grazing, in terms of Bushels of Grain								
	Steer 375	**Steer 425**	**Steer 475**	**Steer 525**	**Steer 575**	**Heifer 375**	**Heifer 425**	**Heifer 475**	**Heifer 525**
	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)
Feb. 25 – Mar. 4	2.20	2.13	1.91	1.32	1.06	3.31	2.51	1.66	1.36
Feb. 25 – Mar. 11	3.61	3.12	2.63	2.23	2.05	5.35	4.28	3.09	3.11

Table I-10. Estimate of the Value of an Extra One and Two Weeks of Grazing Stockers Supplemented with R1620 for a Risk Neutral Producer (based on metabolic stocking density)

	Value of an Extra Week or Two Weeks of Grazing								
	Steer 375	Steer 425	Steer 475	Steer 525	Steer 575	Heifer 375	Heifer 425	Heifer 475	Heifer 525
	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)
Feb. 25 - Mar. 4	$4.22	$4.49	$4.21	$2.98	$2.47	$6.74	$5.38	$3.67	$3.17
Feb. 25 - Mar. 11	$6.67	$6.33	$5.58	$4.90	$4.71	$10.59	$8.98	$6.70	$7.24

If grain is valued at $3/bushel, the value of an extra week or two weeks could be expressed in terms of bushels of grain.

	Value of an Extra Week or Two Weeks of Grazing, in terms of Bushels of Grain								
	Steer 375	Steer 425	Steer 475	Steer 525	Steer 575	Heifer 375	Heifer 425	Heifer 475	Heifer 525
	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)	(bu)
Feb. 25 - Mar. 4	1.41	1.50	1.40	0.99	0.82	2.25	1.79	1.22	1.06
Feb. 25 - Mar. 11	2.22	2.11	1.86	1.63	1.57	3.53	2.99	2.23	2.41

PAPER II

OPTIMAL GRAZING TERMINATION DATE FOR DUAL-PURPOSE WINTER WHEAT PRODUCTION

Abstract

Dual-purpose winter wheat production is important to the agricultural economies of south-western Kansas, eastern New Mexico, western Oklahoma, south-eastern Colorado, and the Texas Panhandle of the United States. Producers want to maximize returns generated from both cattle and wheat revenues and one of the most economically important decisions encountered by dual-purpose small grain producers is when to terminate grazing. The objective of the research is to determine the optimal grazing termination date that maximizes expected net returns from dual-purpose winter wheat production. This study also determines the value of information of knowing the occurrence of first hollow stem (FHS). The expected return function is found using a quadratic cattle price response function and a wheat yield plateau function. Results indicate that grazing should be terminated at or before FHS to generate the highest expected net returns in a dual-purpose winter wheat production enterprise. The value of different levels of information of knowing FHS may assist producers in determining when to remove cattle from grazing pastures.

Introduction

Dual-purpose use of small grains is practiced in many countries throughout the world and is important to the agricultural economies of south-western Kansas, eastern New Mexico, western Oklahoma, south-eastern Colorado, and the Texas Panhandle of the United States. The main cash crop in Oklahoma is hard red winter wheat. Oklahoma is the second ranking state of winter wheat production, growing over six million acres annually of winter wheat (True et al. 2001). Two thirds of this wheat crop is intended for dual-purpose, in which the wheat is used as forage by grazing cattle as well as harvested for grain after the cattle are removed. Dual-purpose winter wheat is important because the state's leading agricultural product is beef, with an inventory of over 5.1 million cattle annually, accounting for over $2 billion dollars in annual agricultural cash receipts (Oklahoma Department of Agriculture 2006). In Southern Plains dual-purpose winter wheat enterprises, wheat is planted in early September and is available for grazing by livestock from mid November through the winter. Most winter wheat pastures are stocked with young steers or heifers that are purchased in the fall and sold at the end of the winter grazing season in the spring. After the cattle are removed from pasture, the wheat continues to grow and is harvested in June. To maximize net returns of a dual-purpose enterprise, both cattle and wheat revenues must be considered.

One of the most economically important decisions encountered by dual-purpose grain producers is when to terminate grazing. Previous studies have been conducted to aid producers in determining the best time to remove cattle from grazing (Fieser et al. 2006; Horn 2006; Redmon et al. 1995, 1996). Prior research has shown that to maximize grain yields, grazing should be terminated at the first hollow stem (FHS) growth stage, occurring at the end of February or early March (Redmon et al. 1996). FHS is the growth stage when the stems of the ungrazed wheat plants begin to elongate and the stem just above the roots, and below the developing head, becomes hollow. The wheat plant is said to be at FHS when the hollow stem portion of the plant is one half of an inch (or 1.5 cm) long. Figure 1 illustrates how the wheat plant looks at FHS. The occurrence of FHS depends on several climatic factors including temperature, precipitation and wheat variety. If the livestock are removed prior to or at development of FHS, the wheat will mature and produce a grain crop. However, if the cattle are left on pastures significantly after the development of FHS, the wheat plant is not able to recover from grazing and grain yields will significantly decrease. To achieve maximum wheat yield, knowing the correct time to terminate grazing is an important factor in optimizing returns from wheat grain. Producers want to maximize economic returns from the combined wheat grazing and wheat grain production system. Thus, maximizing returns in a dual-purpose wheat system involves a potential tradeoff between grain and cattle production.

This study is intended to determine the optimal time to terminate grazing, relative to FHS that maximizes the sum of the expected returns from both cattle and wheat production. This research also determines the value of different levels of information in the occurrence and distribution of FHS. The results of the research will aid producers in deciding when to remove the cattle from pasture, and the value of different levels of information will assist extension economists in knowing the value of providing producers with information on FHS.

Many studies of Oklahoma dual-purpose wheat and stocker production industry have been conducted (Epplin et al. 1999, 2000, 2001; Hossain et al. 2004; Kaitibie et al.

2003a, 2003b; Horn et al. 1995, 2005). These previous research studies may aid producers in determining how many stockers and at what weight of stockers to graze on their wheat pasture; however, it does not answer the very critical question of when to remove stocker cattle from the wheat pasture. The importance of this study stems from the inconsistent findings of prior research regarding the optimal grazing termination time. Previous research by Redmon et al. (1996) as well as Krenzer and Horn (1997) reported that cattle must be removed before or at FHS to achieve maximum grain yield. They found that if cattle are removed after FHS, grain yield will fall dramatically (as much as 1.25 bushels per day FHS) (Redmon et al. 1996). Since grain yield loss is far too great to graze cattle past FHS, so producers were encouraged to closely monitor the occurrence of FHS. More recent research reported by Fieser et al. (2006) found that in times of high cattle prices, it may be optimal to graze stockers past FHS to maximize economic returns. The authors determined the effect on steer weight gain and grain yield of grazing steers past FHS. Their findings were that grain yield did not decrease linearly with days grazed past FHS, indicating that there may be a "safety zone" of removing cattle without drastically reducing grain yields. Thus, indicating that the grain yield loss of grazing past FHS may not be as severe as previously determined. Furthermore, findings of Fieser et al. (2006) showed very high weight gains of cattle being grazed past FHS (average daily gains of over 3 pounds per day). These findings indicate that perhaps FHS may not be the optimal time to remove stockers. It is the optimal time to remove cattle to maximize grain yields, but may not be optimal to maximize expected returns from the whole operation.

The similarities between the two claims is that the authors believe that grazing termination is a key management variable in maximizing income from dual-purpose winter wheat enterprises. The authors also agree that grazing past FHS decreases grain yields, but the significance of the findings regarding the grain yield decline were inconsistent. There are some very important differences between these previous studies. Specifically, the functional form of the response functions used to evaluate grain yield and weight gain were different between the studies. Redmon et al. (1996) used a linear spline function to determine wheat yields over a four-year study period. Because weight gain of cattle was not measured directly, an average daily gain of 2.4 lb (1.1 kg) was assumed. Fieser et al. (2006), on the other hand, used a quadratic wheat yield response function to determine wheat yields over a two-year study period, and measured cattle weight gains before and after FHS. Neither study estimated a cattle price response function or analyzed the distribution of the occurrence of FHS. Thus, there is a need to re-evaluate weight gain and grain yield in estimating how cattle and grain returns are affected by grazing past FHS. Previous research conducted in this area clearly indicates that performing an economic analysis of the tradeoff relationship between extended grazing past FHS and grain yield loss is necessary to answer the question of when to optimally terminate grazing. Therefore, the objective of this paper is to find an optimal grazing termination date that maximizes dual-purpose stocker and grain returns, including a cattle price response function, the distribution of FHS and a unique wheat yield function.

In the model developed in this paper, determining the optimal grazing termination date is found using expected return maximization. A variety of models are estimated to determine the distribution of FHS. Response functions for cattle prices, cattle gains, and wheat yields are derived. The random nature of the occurrence of FHS is captured in a plateau model estimating wheat yields. Misspecification tests were performed to test normality of errors, heteroskedasticity, and year random effects.

Theory

Dual-purpose wheat producers are assumed to maximize expected return of the overall operation (stocker and wheat production). To determine the optimal time to terminate grazing, the gain in value from grazing must be weighed against the value of grain loss from grazing the wheat beyond FHS, the critical physiological stage that damages grain yield. The expected profit optimization equation is:

(1) $$\underset{d}{\mathrm{Max}}\,\mathrm{E}(\pi) = \{\mathrm{E}[\mathrm{P_C}(d, W(d))] \bullet \mathrm{E}[W(d)] - C_C\} \bullet SD + \mathrm{E}[P_Y] \bullet \mathrm{E}[Y(d, FHS)] - C_Y,$$

where E(π) represents expected profits of a dual-purpose winter wheat and stocker enterprise ($/acre), *d* is removal/selling time in days (where *d* is equal to 1 on January 1), $E[P_C]$ is the expected sale price of cattle ($/cwt), $E[W]$ is the expected weight of cattle on sale day (cwt/head), C_C represents the costs of purchasing the cattle, bringing them to market and other costs incurred besides cost of the pasture ($/head), *SD* is stocking density (head/acre), $E[P_Y]$ is the expected sale price of wheat ($/bushel), $E[Y]$ is the expected wheat yield (bushel/acre), *FHS* is the day of FHS, and C_Y represents the costs of producing wheat ($/acre). The expected price of cattle on sale day is a function of the number of days the steers are fed and their weight. Generally, steers with a higher weight have a lower sale price. Weight of the steers on sale day is a function of the number of days because the longer cattle are grazed on pasture, the higher their sale weights will be.

The returns of cattle production is multiplied by the stocking density because returns must be calculated on a per acre basis. Previous research has determined that stocking density has no effect on grain yield, so in this study the stocking density is assumed to affect cattle returns only and will be held constant (Redmon et al. 1996 and Katibie et al. 2003b).

To find the optimal grazing termination date, the derivative of the expected profit function must be taken with respect to *d*. This first order condition can be shown as:

$$(2) \qquad \frac{\partial \mathrm{E}(\pi)}{\partial d} = \frac{\partial \{\mathrm{E}[P_C(d, W(d)) \bullet \mathrm{E}(W(d)) \bullet SD\}}{\partial d} + \frac{\partial \{\mathrm{E}[P_Y] \bullet \mathrm{E}[Y(d, FHS)]\}}{\partial d},$$

where the variables are as previously defined. The first order condition is set equal to zero and solved to find a numerical solution, *d**, the optimal grazing termination date.

Value of Information

The distribution of FHS is needed to determine expected returns when FHS date is not known. FHS occurs in late February or early March. The date of FHS is important because if cattle graze wheat pasture past FHS, the cattle eat the leaves of the wheat plant that produce photosynthate, a chemical product of photosynthesis, required to grow the upper leaves of the plant and enable the head to grow and fill (Edwards et al. 2007). If cattle are grazed significantly past FHS, the wheat crop will have fewer heads per acre as well as smaller and lighter heads than expected. From continued grazing the wheat plant will become stressed and may not have enough photosynthate to produce a full grain crop. Thus, knowing the occurrence of FHS and removing cattle may add value to producers by protecting their grain yields.

Mathematically, the value of information of FHS is defined as follows:

(3) $$Value\ of\ \ Information = \mathrm{E}(\pi / \Omega, I_M) - \mathrm{E}(\pi / \Omega, I_1)\,,$$

where *Value of Information* represents the value of information, $\mathrm{E}(\pi/\Omega,I_M)$ is the expected profit given the information set (Ω and I_M), I_M is the level of available information based on the model of the distribution of FHS, M represents the number of models of different levels of information ($M = 1,\ldots,8$), and $\mathrm{E}(\pi/\Omega,I_1)$ is the expected profit given no information. The eight models of FHS are based on information about year, variety, and growing conditions of the wheat plant.

Data

Information on the distribution of FHS, prices of cattle and wheat, weight gains of cattle, and wheat yields were required to perform this study. Data were obtained from five separate sources. The distribution of FHS data were obtained from Oklahoma State University wheat trials performed in Stillwater, OK and reported by Edwards et al. (2006a). They recorded FHS and heading dates for 64 winter wheat cultivars over a period from 1998 to 2005. These data include the wheat variety, date of FHS, heading date, and the cumulative thermal units present at both the time of FHS and heading. Of the reported 64 wheat varieties, information on the date of FHS over the eight-year period was available for 52 wheat varieties. The eight plots studied in this experiment were 15 centimeters wide by 12 meters long and sown within two days of September 15 in each year. FHS data were collected at three-day intervals beginning February 15 of each year by digging plants from approximately 0.5 meters of each row at random locations in each plot. The varieties were considered to be at FHS growth stage when the average hollow stem was at least 0.5 inch (1.5 cm). Temperature data were collected using an on-site weather station. For a scatterplot diagram of the dates of FHS for the 52 wheat varieties see Figure 2.

The expected prices of both cattle and wheat were required for this study. The cattle price response function was estimated using steer cash and futures prices, reported by the Livestock Market Information Center (USDA 2005). Cash prices were available in 50-pound increments from 1992 to 2006. The average cash price over the 14-year period was $81.52/cwt for an average steer weight of 800 pounds. Cattle futures prices are based on the month of April during the study period. The average futures price over the 14-year period is $81/cwt for an average steer weight of 800 lb. The expected price of wheat was estimated at $2.89/bushel, which represents the five-year average Oklahoma cash price received during June and July from 2000 to 2005 (USDA 2006).

Data to estimate the livestock weight gain function and the wheat grain yield response function were obtained from designed Oklahoma State University Experiment Station trials conducted at the Wheat Pasture Research Unit near Marshall, Oklahoma. A two-year study was conducted by Fieser et al. (2006), and a four-year study was conducted by Redmon et al. (1996). The first year of the Fieser et al. (2006) study is based on a 2002-2003 period, in which fifty-two Angus steers were grazed past FHS on four clean-tilled dryland winter wheat pastures (variety 2174). FHS occurred on March 13 and steers were grazed up to 35 days past FHS. In the second study period of 2004-2005, thirty-four steers were grazed past FHS on four pastures seeded with winter wheat (variety OK102). FHS occurred on March 5 and steers were grazed up to 52 days past FHS. Grain yields and steer weights were measured during the grazing periods. The stocking density was 1.1 steers/acre (2.74 steers/ha) in 2003 and 0.71 steers/acre (1.75

steers/ha) in 2005. In this study, steers were heavy at grazing turnout, averaging 894 ± 66 lb (405 ± 30 kg) for 2003 and 785 ± 92 lb (357 ± 42 kg) in 2005. Steers were weighed on March 13 and 21, and April 1 and 17 in 2003; and March 7 and 18, and April 4, 18, and 26 in 2005. Average daily gain after FHS was 3.5 lb/head (1.6 kg/head) in 2003 and 3.3 lb/head/day (1.5 kg/head/day) in 2005. Wheat grain was harvested on June 19, 2003 and June 22, 2005. Overall, grain yields were less in 2005 than in 2003. Graphs of grain yields from the Fieser et al. (2006) study for 2003 and 2005 are shown in Figures 3 and 4. Fieser et al. (2006) estimated a quadratic wheat yield response function shown in Figure 5.

Wheat yields from the Redmon et al. (1996) four-year study are shown in Figures 3 and 4. The winter wheat was seeded during the first two weeks of September. Wheat variety 2157 was planted in the first two years, and variety Karl was planted in the last two years. Stocking densities ranged from 0.42 to 0.83 steers/acre (1.03 to 2.04 steers/ha). Steers were grazed for a total of 110 days, if they were retained until FHS. The steers were removed from pastures at a variety of dates from mid January, through February and March, until as late as April 4. FHS dates were closely monitored. The authors reported an average daily gain of 2.42 lb/head (1.1 kg/head). Redmon et al. (1996) estimated a wheat yield function based on a linear spline function illustrated in Figure 6.

Wheat yields from both the Fieser et al. (2006) and Redmon et al. (1996) studies were combined to generate a larger data set, covering six years. Separate grain yield response functions were estimated using only Fieser et al. (2006) data and Redmon et al. (1996) data and are shown in Figure 7a and 7b, respectively. The estimated wheat yield function based on combined data is shown in Figure 8 and will be explained in further detail later in the paper.

Redmon et al. (1996) and Fieser et al. (2006) reported different levels of grain yield loss from grazing past FHS. Different functional forms were used in each of the studies, and it is not known how much forage was standing in the field and available to cattle after FHS in each of the study periods. Furthermore, the size of the cattle that were grazing past FHS was different. The cattle in the Fieser et al. (2006) study were significantly larger than in the Redmon et al. (1996) study.

The occurrence of FHS depends on variety, planting date, and weather conditions. The date of FHS can vary by as much as one month from year to year. Between 1998 and 2005 FHS occurred between February 10 and March 28 across 52 winter wheat variety. Within a variety, Jagger, FHS dates ranged from February 15 to March 20 over 8 years . One of the factors involved in determining FHS is weather, especially the temperatures in January, February and March. Maximum, minimum, and average temperatures during the six-year study periods (1990-94 and 2003/05) were gathered from the Oklahoma Mesonet for the wheat pastures in Marshall, Oklahoma (Carlson 2007).

Procedure

Determining when to terminate grazing is critical to maximizing expected returns. Producers can sell cattle early at a lower weight, sell cattle at FHS, or continue to graze the cattle and sell them after FHS at a higher weight. It has been recognized that to maximize grain yields, grazing should be terminated at FHS. However, the occurrence of

FHS is stochastic because it is affected by uncontrolled variables such as weather and precipitation, but a distribution of FHS can be estimated.

Distribution of FHS

A survey was conducted in March 2000 by Hossain et al. (2004) in which 4,815 Oklahoma wheat producers were randomly selected to complete a four-page questionnaire regarding their production and management practices. Producers were asked which factors they used to determine when to terminate fall-winter grazing. The state-wide average results indicated that 58% of producers used calendar date to determine when to terminate grazing, while 17% pulled cattle off pasture at FHS of ungrazed wheat and 14% removed cattle from pasture at FHS of grazed wheat, with 12% of producers using other reasons. This indicated that over half of wheat pasture stocker producers removed their cattle according to calendar date and 31% relied on the date of FHS.

Hossain et al. (2004) also found that two-thirds of dual-purpose wheat producers did not reveal a correct understanding of the term "first hollow stem". Dual-purpose stocker and grain producers were also asked their average grazing termination date. The state average was March 3 (ranging from February 29 to March 6).

Data reported by Edwards et al. (2006a) was used to determine the FHS distribution over an eight-year period. Figure 2 illustrates the occurrence of FHS and shows that FHS occurred between February 10 and March 28 over the 1998-2005 study periods, depending on variety. To estimate the distribution of FHS, eight models of FHS distribution were estimated, with eight different levels of information. The models are summarized in Table 1. Information on FHS and stocker production practices are not always readily available, so the distribution of FHS may be estimated using an annual average. The first model is based on knowing no information and can be shown mathematically as:

(4) $$FHS_i = \alpha_0 + \varepsilon_i ,$$

where FHS_i is based only on the intercept, α_0, because no additional information is available, and an error term represented by ε_i where $\varepsilon_i \overset{iid}{\sim} N(0, \sigma_\varepsilon^2)$. To achieve a numerical value of this intercept, the simple average of FHS is calculated. Thus, the first model of no information is estimated to be the average date of FHS across years.

The second model is based on estimating FHS when only the year is known. This can be found by reading the local extension newsletter that publishes the date of FHS by region. The model can be written mathematically as:

(5) $$FHS_{it} = \alpha_0 + \sum_{t=1}^{T-1} \beta_t D_{it} + \varepsilon_{it} ,$$

where FHS_{it} is the date of FHS as a function of year, α_0 represents the intercept, β_t is the effect of year on FHS to be estimated (t = 1,…,T-1), D_{it} is an indictor variable for year t (where t is over the range 1998 to 2005), and ε_{it} is an error term with $\varepsilon_{it} \overset{iid}{\sim} N(0, \sigma_{it}^2)$.

The wheat variety also affects when the plant reaches FHS. The data includes 52 varieties of wheat. The varieties were separated into four classifications relative to their occurrence of FHS (i.e. early, middle, late and unknown). The classification was based on the Wheat Variety Comparison Chart (Edwards et al., 2006b). If the variety classification was not available, the variety was classified as unknown (14 out of 52 varieties are classified as unknown). The third model is defined as follows:

(6) $$FHS_{ij} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \varepsilon_{ij},$$

where FHS_{ij} is the date of FHS as a function of variety, β_j is the effect of variety on FHS to be estimated (j = 1,…,J-1), V_{ij} represents an indicator variable for the variety of wheat relative to timing of FHS (where j is equal to 1 for "early", j is equal to 2 for "middle", j is equal to 3 for "late", and j is equal to 4 for "unknown"), ε_{ij} is an error term with $\varepsilon_{ij} \overset{iid}{\sim} N(0,\sigma_{ij}^2)$, and the other variables are as previously defined.

The fourth model is based on knowing the variety as well as the year and can be written mathematically as:

(7) $$FHS_{ijt} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \sum_{t=1}^{T-1} \beta_t D_{it} + \varepsilon_{ijt},$$

where FHS_{ijt} is the date of FHS as a function of variety and year, ε_{ijt} is an error term with $\varepsilon_{ijt} \overset{iid}{\sim} N(0,\sigma_{ijt}^2)$, and the other variables have been defined previously. Information about FHS is often limited; therefore, the fifth model assumes that the only information available is the cumulative thermal units present at FHS. The fifth model can be shown mathematically as:

(8) $$FHS_i = \alpha_0 + \beta_F FHSTU_i + \varepsilon_i,$$

where FHS_i is the date of FHS as a function of thermal units, $FHSTU_i$ represents the cumulative thermal units present on the day of FHS in units of cd [1], ε_i is an error term with $\varepsilon_i \overset{iid}{\sim} N(0,\sigma_i{}^2)$, and the other variables are as defined previously. The cumulative

[1] Cd stems from the Latin word *Candela* for "candle". It is a unit measurement of the intensity of light. An ordinary wax candle generates approximately one candela. More specifically, one candela (cd) is the monochromatic radiation of 540THz with a radiant intensity of 1/683 watt per steradian in the same direction.

thermal units are a weather indicator in which larger values represent higher temperatures and more favorable wheat growing conditions resulting in earlier FHS date.

The sixth model includes information on variety as well as the cumulative thermal units present at the time of FHS. Mathematically, the sixth model is shown as:

$$(9) \qquad FHS_{ij} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \beta_F FHSTU_i + \varepsilon_{ij},$$

where FHS_{ij} is the date of FHS as a function of variety and FHS thermal units, ε_{ij} is an error term with $\varepsilon_{ij} \overset{iid}{\sim} N(0, \sigma_{ij}^2)$, and other variables are as defined previously. The different levels of available information may be combined into one model.

The seventh model includes the most information. It is based on knowing the variety and year, as well as the cumulative thermal units present at FHS. It can be shown mathematically by the following equation:

$$(10) \qquad FHS_{ijt} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \sum_{t=1}^{T-1} \beta_t D_{it} + \beta_F FHSTU_i + \varepsilon_{ijt},$$

where FHS_{ijt} is the date of FHS as a function of variety, year and thermal units, ε_{ijt} is an error term with $\varepsilon_{ijt} \overset{iid}{\sim} N(0, \sigma_{ijt}^2)$, and the other variables are as previously defined.

The last (eighth) model is based on knowing the occurrence of FHS with perfect information. If perfect information is available, the model is expressed as:

$$(11) \qquad FHS_{it} = \overline{FHS}_{it},$$

where FHS_{it} is the date of FHS and is equal to the average FHS. In this case, certainty is assumed and FHS date can be estimated as:

$$(12) \qquad \overline{FHS}_{it} = \begin{pmatrix} FHS_{it=1998} + FHS_{it=1999} + FHS_{it=2000} + FHS_{it=2001} + FHS_{it=2002} \\ +FHS_{ijt=2003} + FHS_{it=2004} + FHS_{it=2005} \end{pmatrix} / 8,$$

where $\overline{FHS}_{it}$ represents the annual mean FHS during the study period from 1998 to 2005 across all 52 winter wheat varieties.

Models 2 through 7 were estimated using analysis of variance (ANOVA) in SAS with the PROC MIXED command. The Shapiro-Wilk test was performed to test for normality and confirmed that the error terms are normally distributed. The Breusch-Pagan test was conducted to test for heteroskedasticity. Heteroskedasticity was corrected by weighting each of the years equally. Thus, in determining the expected date of FHS, the estimated mean FHS for each year is determined and the eight years are given equal weighting. Each of the eight models of FHS were estimated, corrected for heteroskedasticity, and used in the equations to find the optimal grazing termination date, depending on the varying levels of information.

Price Response Functions

The time to terminate grazing is not only driven by the occurrence of FHS, but also by the prices and weight of cattle being sold after they are removed from wheat pasture. After grazing is terminated and the cattle are sent to market, seasonal price patterns in the region may be influenced since many animals are marketed during the spring and the relatively narrow time period of FHS. Therefore, the prices and weight of cattle must be closely monitored. Occurrence of FHS, prices of cattle, wheat yields, weight of cattle on date of sale, and wheat prices all impact the optimal grazing termination date that maximizes profits of a dual-purpose winter wheat and stocker production enterprise.

The price response function of cattle must be determined to find the expected returns resulting from cattle production. The price of cattle changes over time and is affected by the weight of cattle and the time the cattle are sold. The number of days that the steers are grazed also impacts their final weight. The longer steers are grazed, the higher their sale weight will be and heavier cattle tend to have a lower price per pound than lighter cattle. To estimate the cattle price response function, a quadratic functional form was defined in which the change in the basis (cash – futures) price was estimated as a function of weight and selling date, accounting for a random year effect. The price of cattle is based on the following equation:

$$(13)\ Basis\%_{Wdt} = \ln\left\{\frac{P_C(W(d),d,t)}{P_F(t)}\right\}\times 100 = \gamma_0 + \gamma_1 + \gamma_2 W^2 + \alpha d + \beta_1 Wd + \beta_2 Wd^2 + \varepsilon_{Wdt} + \mu_t$$

where *Basis %* represents the basis change in a percentage, P_C is the cash price of steers as a function of weight (*W*), removal date (*d*), and year (*t*) in \$/cwt, P_F is the April futures price of steers (\$/cwt), γ_0, γ_1, γ_2, α, β_1, and β_2 are the parameters to be estimated, ε_{Wdt} is a random error term with $\varepsilon_{Wdt} \overset{iid}{\sim} N(0,\sigma_\varepsilon^2)$, and μ_t is a year random effect with $\mu_t \overset{iid}{\sim} N(0,\sigma_\mu^2)$. To find the value of producing livestock in a dual-purpose enterprise, the expected cash price of steers on sale day must be estimated. The expected price of cattle may be calculated using:

$$(14)\qquad \mathrm{E}[P_C(W(d),d,t)] = \exp\left(\left\{\gamma_0 + \gamma_1 W + \gamma_2 W^2 + \alpha d + \beta_1 Wd + \beta_2 Wd^2 + \sigma_\varepsilon^2/2\right\}/100\right) \bullet P_F,$$

where the variables are as defined previously. The price function was estimated using maximum likelihood estimation and the PROC MIXED command in SAS. The model included year random effects and testing for heteroskedasticity. The steer cash price was found from weekly prices reported at the Oklahoma City auction market from 1992 to 2006. The cash prices represent weight ranges in 50-pound increments between 600 to 1000 pounds from the first week in January to the last week in April (i.e. the time frame that the cattle would be sold). The futures price is based on April futures prices from the period 1992 to 2006. The futures price was required in the price function because cash prices are affected by the futures price as well as the basis (i.e. cash price is equal to the futures price adjusted by the basis). To estimate the steer price response function over 1870 observations were used. Heteroskedasticity was corrected by transforming the price observations by taking the natural log (as shown in the *Basis %* equation).

The expected price of wheat was required to estimate the returns generated from grain production. An expected wheat price of $2.89/bushel was assumed, representing the five-year average Oklahoma cash price received during June and July from 2000 to 2005 (USDA 2006).

<u>Cattle Gain and Wheat Yield Response Functions</u>

The weight of the cattle on sale day was estimated based on a linear response function. The expected weight of cattle on sale day was found using the following mathematical model:

(15) $$\mathrm{E}[W(d)] = W_P + ADG \times d \,,$$

where W is the weight of cattle on sale day (cwt/head), W_P is the steer weight on January 1 (cwt/head), and ADG is the average steer daily gain (cwt/head). The grazing season generally begins in mid November. Approximately 30% of stocker producers purchase stocker cattle in October or November with beginning weights for steers of 426 lb

(Hossain et al. 2004). The assumed value of ADG was based upon a number of studies. The state-wide survey reported an average daily gain of 2.3 lb/head/day (Hossain et al. 2004). However, Fieser et al. (2006) reported an average daily gain of 3.5 lb/head (1.6 kg) in 2003 and 3.3 lb/head (1.5 kg) in 2005. Redmon et al. (1996) reported an ADG value of 2.43 lb/head/day (1.1 kg) for their 1990-1994 study. The research performed by Kaitibie et al. (2003a) was consistent with Redmon et al.'s (1996) ADG, estimating expected gain at 2.59 lb/head/day (1.174 kg). For the purposes of this paper, results are reported for average daily gains of 2.5, 2.75, 3.0 and 3.5 lb/head.

An initial steer weight at January 1 was assumed. If steers were turned out to pasture on November 15 and gained 2.75 lb/day they would weigh approximately 550 pounds on January 1 (i.e. 426 lb/head + 2.75 lb/head/day $\times$ 45 day $\approx$ 550 lb/head). The expected price of cattle and the expected weight of the cattle on removal day are multiplied to determine the revenues from cattle production.

To determine the revenues from grain production, a number of functions must be estimated. The expected yield of wheat is of particular interest. In previous studies Fieser et al. (2006) used a quadratic function (see Figure 5), while Redmon et al. (1996) used a spline function (see Figure 6). In this study, the functional form used nests the functional forms from both previous studies. The yield of wheat is a function of the time the cattle are removed as well as the occurrence of FHS. Two wheat yield functions were estimated with known and unknown switching points. The expected wheat yield was estimated using the following plateau model with a known switching point at FHS:

$$(16)\quad Y(d_{it}, FHS_{it}) = \begin{cases} \overline{Y} + \nu_{it} + u_t & \text{if } d_{it} \le FHS_{it} \\ \overline{Y} + \rho_1(d_{it} - FHS_{it}) + \rho_2(d_{it} - FHS_{it})^2 + \nu_{it} + u_t & \text{if } d_{it} > FHS_{it} \end{cases}$$

where Y is the grain yield (bushels/acre), d_{it} is the grazing termination date for observation i in year t, FHS_{it} is the date of FHS, $\overline{Y}$ is the maximum wheat yield which will differ by year as it is influenced by weather, precipitation, etc. (bushels/acre), ρ_1 and ρ_2 are the parameters to be estimated, ν_{it} is an error term where $\nu_{it} \overset{iid}{\sim} N(0, \sigma_\nu^2)$, and u_t is a year random effect term with $u_t \overset{iid}{\sim} N(0, \sigma_u^2)$. Independence is assumed between the two variance components, σ^2_u and σ^2_ν.

The estimate the wheat yield response function, combined data from Fieser et al. (2006) and Redmon et al.'s (1996) research trials are used. Fieser et al.'s (2006) study is based on wheat yields collected from four wheat pastures during two years, whereas the data from Redmon et al.'s (1996) study is based on mean wheat yields for four years. Dickens (1990) writes in his article that the variance of the individual error component should be weighted depending on the number of individuals in a group. Because the data points from the data two sources used in this study have different numbers of replications in each year, the variances need to be weighted. Thus, in order to avoid heteroskedasticity, the weighted variance of the error is $\text{var}(\nu_{it}) = \sigma_u^2 + \sigma_\nu^2 / N$, where N is the number of replications in each year (N is equal to four for the data sources from the Redmon et al. (1996) study and equal to one for data sources from the Fieser et al. (2006) study) (Dickens 1990). The estimates were determined using a nonlinear mixed model and maximum likelihood estimation.

To nest the plateau function used by Redmon et al. (1996) and the quadratic function of Fieser et al. (2006), it was necessary to estimate a wheat yield model with an unknown switching point. The switching point is specified relative to the date of FHS.

Estimated wheat yield may also be determined using the following plateau model with unknown switching points:

$$(17)\quad Y(d_{it}, FHS_{it}) = \begin{cases} \bar{Y} + \nu_{it} + u_t & \text{if } d_{it} \leq FHS_{it} - \delta \\ \bar{Y} + \rho_1 (d_{it} - FHS_{it} - \delta) + \rho_2 (d_{it} - FHS_{it} - \delta)^2 + \nu_{it} + u_t & \text{if } d_{it} > FHS_{it} - \delta \end{cases}$$

where δ represents an unknown value (days), and all other variables are as previously defined. This model was also estimated as a nonlinear mixed model with year random effects and corrected for heteroskedasticity.

Wheat Yield and Growing Degree Days

As previously mentioned, the occurrence of FHS is a function of planting date, variety, and weather. In an attempt to illustrate how weather may have an impact on wheat yield, growing degree days have been calculated. Growing degree days can be represented mathematically as:

$$(18)\qquad GDD = \frac{(MaxTemp + MinTemp)}{2} - Baseline,$$

where *GDD* is growing degree days, *MaxTemp* represents the maximum temperature for the day (Fahrenheit), *MinTemp* is the minimum daily temperature, and *Baseline* is an adjustment factor equal to 32 degrees Fahrenheit. GDDs are then cumulated over time, relative to FHS. That is, cumulative GDDs begin from zero at FHS and increase for the days following FHS. Conversely, cumulative GDDs are cumulatively negative for days before FHS. These cumulative GDDs can then used to determine how temperature affects wheat yields. Figure 12 illustrates a graph of cumulative GDDs by year and wheat yields. We tested the significance of cumulative GDDs on wheat yield by first including the cumulative GDDs after FHS in the wheat yield response function (equation

16); however it was found not to be significant. Thus, when finding the affect of grazing past FHS and cumulative GDDs on wheat yield, the temperature variable did not have a significant affect on wheat yield. However, cumulative GDDs can be modeled another way, by only looking at the affect of cumulative GDDs on wheat yield. Mathematically, this can be shown as:

$$(19) \quad Y(CGDD_{it}) = \begin{cases} \overline{Y} + \nu_{it} + \mu_t & \text{if } CGDD_{it} \geq FHS_{it} \\ \overline{Y} + \alpha(CGDD_{it}/10) + b(CGDD_{it}/10)^2 + \nu_{it} + \mu_t & \text{if } CGDD_{it} > FHS_{it} \end{cases}$$

where *Y* is the grain yield (bushels/acre), $CGDD_{it}$ is the cumulative growing degree days present past FHS, *a* and *b* are the parameters to be estimated, ν_{it} is an error term where $\nu_{it} \overset{iid}{\sim} N(0,\sigma_{\nu}^2)$, u_t is a year random effect term with $u_t \overset{iid}{\sim} N(0,\sigma_u^2)$, *d*, *FHS*, and $\overline{Y}$ are as previously defined. The estimates were determined using a nonlinear mixed model and maximum likelihood estimation. In order to avoid heteroskedasticity, the variance of the error is $\text{var}(\nu_{it}) = \sigma_u^2 + \sigma_{\nu}^2 / N$ (Dickens 1990).

Wheat Yield Estimation

To estimate the wheat yield, the following integration is computed:

$$(20) \qquad \text{E}[Y(d_{it}, FHS_{it})] = \int_{-\infty}^{\infty} Y(d_{it}, FHS_{it}) f(FHS_{it}) \text{d}FHS_{it},$$

where the integral of wheat yield is from negative to positive infinity, given the various models determined for the distribution of FHS. Because the distribution of FHS is based on eight years of data, the following mathematical application must be performed to find expected yield:

(21) $$\mathrm{E}[Y(d_{it},FHS_{ijt})]=\sum_{j=1}^{J}\frac{1}{4}\sum_{t=1}^{T}\int_{-\infty}^{\infty}\left\{\left(Y(d_{it},FHS_{ijt})f(\varepsilon)\mathrm{d}\varepsilon\right)\right\}/T,$$

where there are J number of wheat variety categories and T number of years. By inserting the estimated wheat yield response function (15), the following equation is found:

(22) $$\mathrm{E}[Y(d_{it},FHS_{ijt})]=\sum_{j=1}^{J}\frac{1}{4}\sum_{t=1}^{T}\int_{-\infty}^{\infty}\left\{\min\left(\overline{Y},\overline{Y}+\rho_1(d_{it}-FHS_{ijt})+\rho_2(d_{it}-FHS_{ijt})^2\right)f(\varepsilon)\mathrm{d}\varepsilon\right\}/T$$

Based on the distribution assumption of FHS, the normal density function of ε is expressed as:

(23) $$f(\varepsilon)=\frac{1}{\sqrt{2\pi\sigma_{\varepsilon}^{2}}}\exp\left(-\frac{\varepsilon^{2}}{2\sigma_{\varepsilon}^{2}}\right),$$

where $\varepsilon \overset{iid}{\sim} N(0,\sigma_{\varepsilon}^{2})$ and the other variables are as defined previously.

Total expected returns were optimized to find a numerical solution for d, the optimal grazing termination date that maximizes expected returns.

Profit Maximizing Grazing Termination Date

The objective of the study is to determine the optimal grazing termination date that will maximize expected returns from a dual-purpose (wheat and cattle) stocker enterprise. Given the expected price response function (14), the expected weight function (15), and the expected yield function (20), the complete profit function can be found. The expected return model is:

$$(24)\quad \underset{d}{\text{Max}}\,\mathrm{E}(\pi) = \begin{bmatrix} P_F \bullet \exp\left(\left\{\gamma_0 + \gamma_1 W + \gamma_2 W^2 + \alpha d + \beta_1 W d + \beta_2 W d^2 + \sigma^2/2\right\}/100\right) \\ \bullet \{W_P + ADG \times d\} - C_C \end{bmatrix} \bullet SD$$

$$+ P_Y \left[\sum_{j=1}^{4} \frac{1}{4} \sum_{t=1}^{8} \int_{-\infty}^{\infty} \left\{ \min\left(\bar{Y}, \bar{Y} + \rho_1 (d_{it} - FHS_{ijt}) + \rho_2 (d_{it} - FHS_{ijt})^2 \right) f(\varepsilon) d\varepsilon \right\} / 8 \right] - C_Y$$

To achieve a numerical answer a number of assumptions can be made. We assume P_F is equal to \$81/cwt, which represents the mean April futures price of steer cattle from 1992 to 2006. We propose that W_P is equal to 550 lb., average gains are set at 2.5, 2.75, 3.0 and 3.5 lb/head/day, P_Y is equal to \$2.89, the five year average price of wheat in June and July, and the stocking density of steers is 0.64 steer/acre, the average stocking density from previous studies (see Table 2). The optimal removal/selling date, d^*, is found by differentiating the expected return function with respect to d and finding an optimum level of d^*. In the return maximizing function, the distribution of FHS is included. As previously presented, eight models were estimated to find the distribution of FHS. The expected profit model is optimized for each of the eight models of FHS distribution. The estimated profit model can be expressed as:

$$(25)\quad \underset{d_M}{\text{Max}}\,\mathrm{E}(\pi) = \begin{bmatrix} 81 \bullet \exp\left(\left\{49.33 - 9.54W + 0.43W^2 + 0.3d - 0.04Wd + 0.000025Wd^2 + 8.38/2\right\}/100\right) \\ \bullet \{550 + 2.74d\} - C_C \end{bmatrix} \bullet 0.64$$

$$+ 2.89 \left[\sum_{j=1}^{4} \frac{1}{4} \sum_{t=1}^{8} \int_{-\infty}^{\infty} \left\{ \min\left(31.87, 31.87 - 1.00(d - \hat{FHS}_{jt}) + 0.011(d - \hat{FHS}_{jt})^2 \right) f_M(\varepsilon) \mathrm{d}\varepsilon \right\} / 8 \right] - C_Y$$

where W is the selling weight, d_{it} is the optimal grazing termination date, $\hat{FHS}_{jt}$ is the estimated date of FHS depending on variety (j) and year (t), and $f_M(\varepsilon)$ is the distribution of the error term of eight FHS models. This profit optimization model is performed in MAPLE for each of the eight FHS models.

To find the optimal grazing termination date, we find the first order condition.

(26)

$$\frac{\partial E(\pi)}{\partial d_M} = \frac{\partial}{\partial d}\left[81 \bullet \exp\left(\{49.33 - 9.54W + 0.43W^2 + 0.3d - 0.04Wd + 0.000025Wd^2 + 8.38/2\}/100\right) \bullet \{550 + 2.75d\}\right] \bullet 0.64$$
$$+ \frac{\partial}{\partial d} 2.89\left[\sum_{j=1}^{4}\frac{1}{4}\sum_{t=1}^{8}\int_{-\infty}^{\infty}\left\{\min\left(31.87,\ 31.87 - 1.00(d - F\hat{H}S_{jt}) + 0.011(d - F\hat{H}S_{jt})^2\right) f_M(\varepsilon)\mathrm{d}\varepsilon\right\}/8\right]$$
$$= 0$$

The optimal grazing removal date, *d**, was found for each of the eight models of FHS. A first order condition was not found, rather the expected profit for each of the eight models of FHS were graphed in MAPLE and using a grid search, the optimal grazing termination date, *d**, for each model was found. Then the value of information was calculated for each of the eight levels of information.

Results

The date of FHS differs significantly from year to year. So, information about FHS is valuable to illustrate how grain yields and returns are affected. In this study, eight models of FHS were estimated with different levels of information. The results are shown in Table 4. The seventh model based on the highest level of information (including year, variety, and thermal units at FHS) produced the highest level of model fit, with the highest level of R^2, being 0.99. The regression is not intended to be used to forecast the occurrence of FHS in future years, rather to illustrate distributions of FHS over time and estimate FHS based on differing levels of information. The estimated values of FHS are included in the expected return maximization equations to find the value of different levels of information.

The estimated steer price function is shown in Table 5. The function indicates that heavier weight steers receive a lower price per pound, which is expected. The estimates of basis percent possess the expected signs and can be used to determine the expected cash price. After determining the cash price of steers, the weight of cattle on removal/selling date was estimated. The expected weight of cattle at the time of sale was assumed to be:

$$\text{(27)} \qquad \mathrm{E}[W(d)] = 5.50 + (ADG/100)d\,,$$

assuming that the steers weigh 550 lbs on January 1. Results were computed for average gains of 2.5, 2.75, 3.0, and 3.5 lb/head/day. Selling weight depends on average daily gain.

The expected wheat yield was determined using a plateau function. The results for the expected yield function when FHS is known are in Table 6. This table compares the expected yield found using three different data sources; however, the estimates based on combined data are of most importance. The parameter estimates had the expected signs and indicated that for each day cattle are grazed past FHS, wheat yields would decrease by one bushel and continue to fall at a decreasing rate as grazing continues.

The wheat yield function has been graphed in Figure 8. The functional form estimated in this model may also be used to re-estimate both Fieser et al. (2006) and Redmon et al.'s (1996) findings as shown in Figure 7 a & b. Using our unique functional form, wheat yield loss in Fieser et al.'s (2006) study is significantly smaller than those reported when the data was combined, approximately 0.25 bu/ac/day with grain yields declining at an increasing rate, with a more smooth spline point around FHS. On the other hand, when our functional form is applied to Redmond et al.'s (1996) data set, the grain yield loss is very large, showing a decline in grain yield of 1.68 bu/ac/day of extended grazing past FHS, declining at a declining rate, with a clear spline point at FHS.

Our findings present a compromise in not only the functional form of determining wheat yield, but also in the grain yield loss that occurs by grazing steers past FHS. Figures 9 a & b illustrate the wheat yield function from previous studies and our unique estimated one. Figure 10 illustrates how well the wheat yield function fits to the means of the six years of data. Figure 11 then shows how grain yield is affected by grazing one week and two weeks past FHS. Results clearly show that by grazing one week past FHS, grain yields decrease from 32 bu/ac to 26 bu/ac. At a price of $2.89/bu, this represents a loss in grain returns of $17.34/ac. At an average daily gain of 2.75 lb/head/day, a stocking density of 0.64 steers/ac, and prices of $81/cwt, grazing one extra week generates $9.98/ac in additional cattle revenue. This clearly indicates that the increase in cattle gains cannot compensate for grain yield losses from grazing past FHS. With a wheat grain loss of $17.34/ac by grazing one week past FHS, the breakeven stocking density would be 1.11 steers/ac when average daily gain are 2.75 lb/head/day and a stocking density of 0.87 steers/ac when daily gains are 3.5 lb/head/day. This means that in order to break even from grazing cattle past FHS ample forage must be available so that increased stocking densities are possible.

A plateau model of wheat yield was also estimated with an unknown switching point. The premise behind constructing this model is to test whether the date of FHS is the appropriate point for the function to spline. Results are shown in Table 7. The estimated value of δ was -2.00 days. However, it was not significantly different from zero. This means that the spline point of wheat yield (i.e. the point when wheat yields begin to significantly decrease) is approximately at occurrence of FHS, as expected.

Wheat yield was also modeled as a function of cumulative GDDs. The results can be seen in Table 8. This indicates that when steers are grazed past FHS, wheat yields fall. Wheat yields as a function of cumulative GDDs relative to FHS is illustrated in Figure 12. Figure 12 shows that in 2003 wheat yields were higher when grazing past FHS than in any of the other years. The hypothesis is that if cumulative GDDs are higher (i.e. it is warmer), wheat yields will be higher than if cumulative GDDs are lower (i.e. colder temperatures). Thus, if after FHS, the temperatures are high allowing the wheat to continue to grow, grazing past FHS will result in less grain yield losses than if cattle are grazed past FHS in cooler temperatures. Therefore, if there is enough forage for the cattle to graze past FHS and the weather is warm allowing the wheat to continue to grow, extended grazing past FHS may not result in drastic grain yield losses. By performing the regression analysis, it can be seen that grazing after FHS causes wheat yields to decline. Grazing past FHS, rather than cumulative growing degree days, has a greater impact on wheat yields. We can support this conclusion by comparing the variance of the error terms and the log likelihood ratios between estimating yield as a function of grazing past FHS (Table 6) and estimating yield as a function of growing degree days. The log likelihood ratio is higher and the variance of error is smaller when estimating wheat yield as a function of grazing past FHS, compared to growing degree days. Thus, we can conclude that to estimate wheat yields, using grazing days relative to FHS provided a better model fit than growing degree days.

After the expected prices, weights and wheat yields were found, the expected return model could be maximized to find the optimal time to terminate grazing. A numerical solution was not found, rather an analytical solution using a grid search was conducted to determine the point at which gross returns from cattle and grain operations were at a maximum. MAPLE software performed this process using the different models of FHS for each of the four levels of average daily gain. Results are shown in Table 9. In almost all cases, it is optimal to remove cattle at or before FHS.

One finding that was not expected was for Model 3, when the distribution of FHS is based on variety; for heavy steers it was optimal to remove them from grazing at or two days after FHS. The illustration for this finding is shown in Figure 13. The reason for this finding is due to the weight of the cattle. If the steers are lighter, the optimal removal date is at or before FHS. On the other hand, if the steers are heavier, the return maximum curve is not as peaked and the optimal time to remove cattle is around (rather than precisely at) FHS. Thus, it may be the case that in some situations when the cattle are heavy, have extremely high daily gains, and there is sufficient forage available, it is possible that the return maximizing grazing termination date may be after FHS. However, in almost all cases the optimal time to terminate grazing is at or before FHS. This conclusion can be seen in Figure 14. With perfect information, the optimal time to terminate grazing that maximizes gross returns is at FHS.

The value of information regarding FHS was computed for different levels of information. These results can be seen in Table 9. The findings indicate that the more producers know about FHS, the better off they are. This is as expected. Knowing when FHS occurs is crucial in maximizing the returns of dual-purpose enterprises.

Determining FHS is not always an easy task and not necessarily without cost. Wheat plants of the same variety and planted on the same day as the wheat in the pasture must be removed from the soil of an ungrazed region (or exclosure), opened, and analyzed. On grazed pastures, FHS generally occurs later and if producers wait to find FHS in the grazed fields, grain yield losses may have already been incurred. Thus, the key indicator of when to terminate grazing is FHS. Producers are provided information about occurrence of FHS from newsletters that are prepared and distributed by extension agronomists and county agents. They can also check the field themselves to ensure they know when the plants reach FHS. The value of information determined in this study clearly shows that the more that is know about FHS, the better.

It was important to calculate the marginal values from extending grazing relative to FHS in terms of increase cattle returns and reduced wheat returns. These finding are shown in Table 11. The marginal values indicate that by grazing one day past FHS cattle returns increase between $1.42 and $1.92 per acre, while wheat returns are decreased by $2.92 per acre. This tradeoff value can be represented in the marginal ratio between -1.5 and -2.1 of wheat loss relative to cattle gains incurred from one post-FHS day of grazing. Weekly marginal values tell a similar story in which one additional week of grazing after FHS generated additional cattle returns between $10.56 and $11.32 per acre, while decreasing wheat returns by $21.65 per acre (i.e. a marginal ratio between -1.9 and 2.1). Thus, while post-FHS grazing increases cattle returns, it is generally not enough to offset the wheat yields that are lost from extended grazing.

Research Limitations

The results found in this research are not without limitations. The information presently available on FHS and used in this research is based on 52 winter wheat varieties over 8 years in which the date of FHS was found for one plot in Oklahoma. Thus, the distribution of FHS over time and variety is based on a single replication each year. It does not account for special variability between different wheat plots in different locations. Because FHS is a function of weather, moisture, planting date, etc. the occurrence of FHS may differ across different locations or even within a field. Presently, the information of FHS within a single field is not measured. Once FHS is reached in a particular location for a particular variety, it is reported and sent out in an agricultural extension newsletter. This information is available for producers to assist in informing them when FHS has occurred, indicating that it's time to remove the cattle from pasture. Whether the information in the newsletter is an accurate assessment of FHS on a particular producer's wheat field is not known. Thus, for a particular producer to know the exact time of FHS on his/her pasture, an exclosure area may be set up so they can personally determine when FHS occurs. The value of knowing the date of FHS has been estimated in this study. However, if more data on FHS were available across space and time, more accurate estimates could be achieved.

Conclusions and Discussion

Results of this study have found that the optimal time to remove cattle from grazing in an average year is at or before occurrence of FHS. On average the grain yield loss of grazing past FHS, and steer price side, is too great to be offset by additional steer weight gain. Previous research conducted in this area has reached inconsistent conclusions. Redmon et al. (1996) found that grazing past FHS decreases grain yield linearly by 1.25 bu/ac/day. Fieser et al. (2006), on the other hand, concluded that grain yields follow a quadratic shape and that in time of high cattle gains and high cattle prices, grazing past FHS may be economically feasible.

This study used data produced in previous trials to estimate a unique wheat yield function and return maximization model to determine that grazing past FHS decreases overall returns of dual-purpose wheat enterprises. Producers do not have to have the livestock trucks parked at the gate, but knowing when FHS is and planning to get the cattle off as soon as possible is the best approach to maximizing returns. Possible reasons that previous studies have found conflicting results is that wheat variety, steer weights, daily gains, and forage availability were not consistent throughout all studies. Fieser et al. (2006) had extremely high forage mass in the 2003 study period (more than twice the amount of forage mass than in their 2005 study period). This coupled with unusual wheat growing conditions and heavy steers may have contributed results inconsistent with those found by Redmon et al. (1996).

The current study extended the prior research by combining information from both prior studies, estimating a unique linear response stochastic plateau function, determining a price response function, and calculating the value of information regarding FHS. The results add credence to the importance of educating dual-purpose winter wheat producers about FHS.

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First Hollow Stem (FHS)

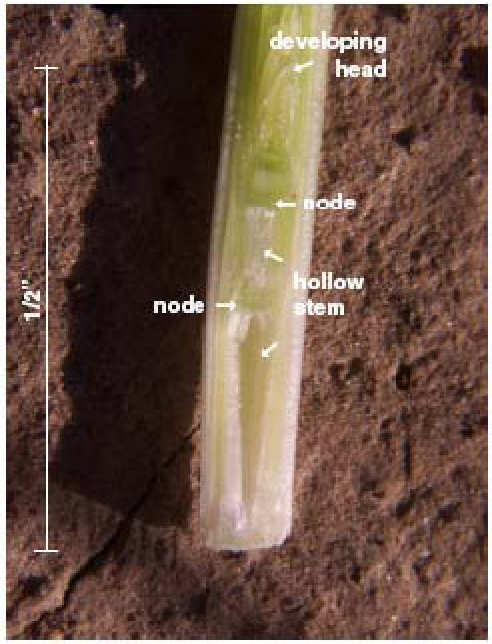


Figure II-1. Illustration of the occurrence of first hollow stem (FHS) for a winter wheat plant.

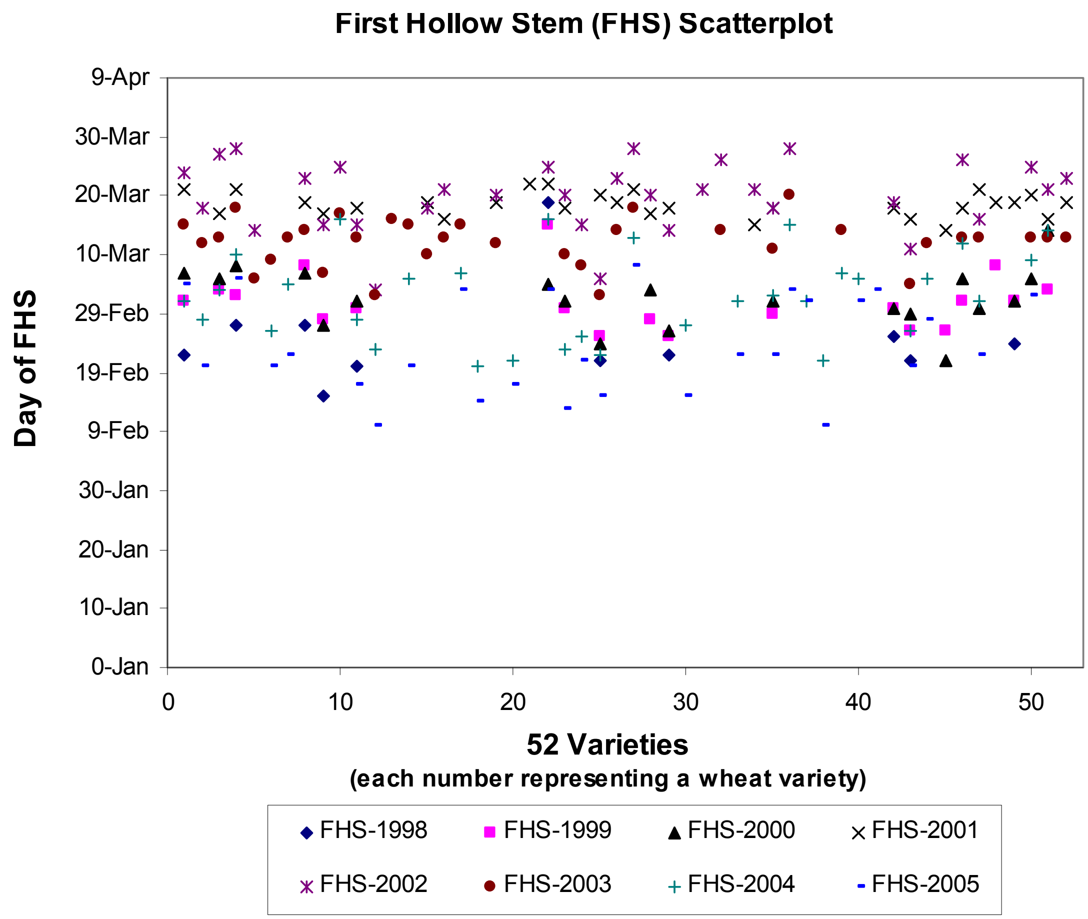


Figure II-2. Date of first hollow stem (FHS) shown for 52 varieties from 1998 to 2005.

Wheat Yields of Six Study Period Relative to First Hollow Stem (FHS)

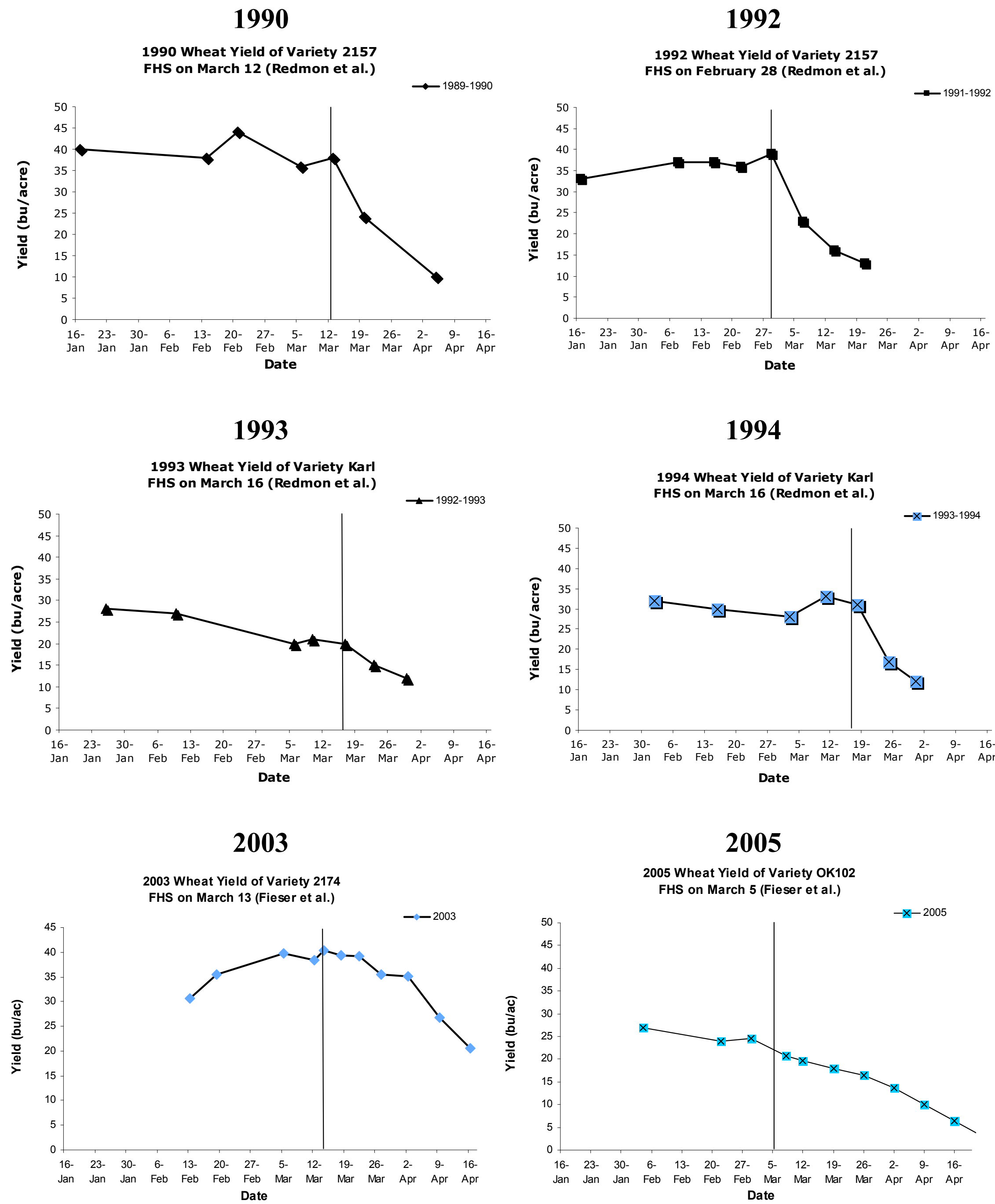


Figure II-3. Wheat yields relative to first hollow stem (FHS) and date of grazing termination for six production seasons at the Wheat Pasture Research Unit, Marshall, OK.

Source: Fieser et al. (2006) and Redmon et al. (1996).

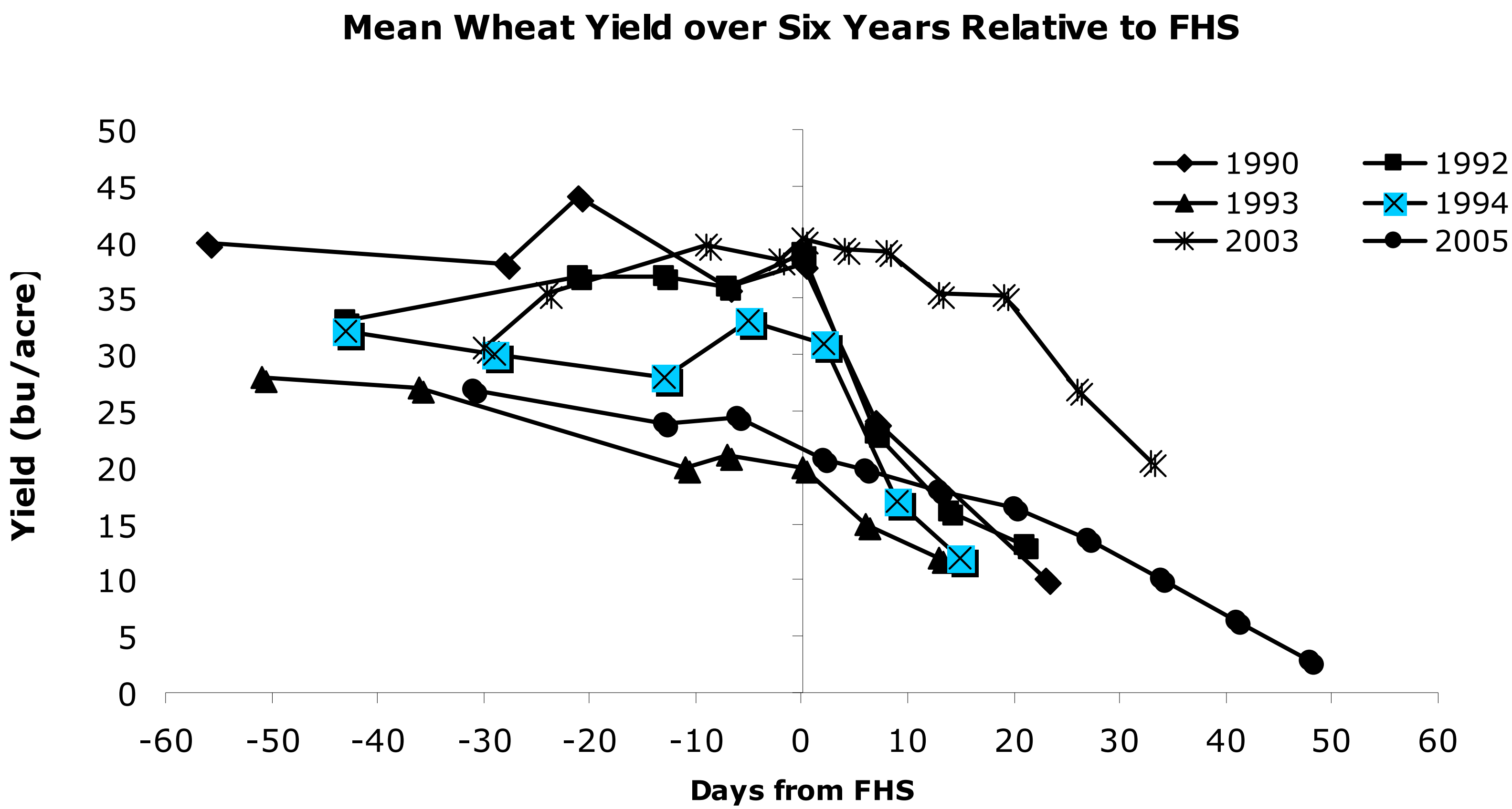


Figure II-4. Mean wheat yields of Redmon et al. (1996) and Fieser et al.'s (2006) six year studies relative to first hollow stem (FHS) and date of grazing termination.

Fieser et al.'s Estimated Wheat Yield Response Function

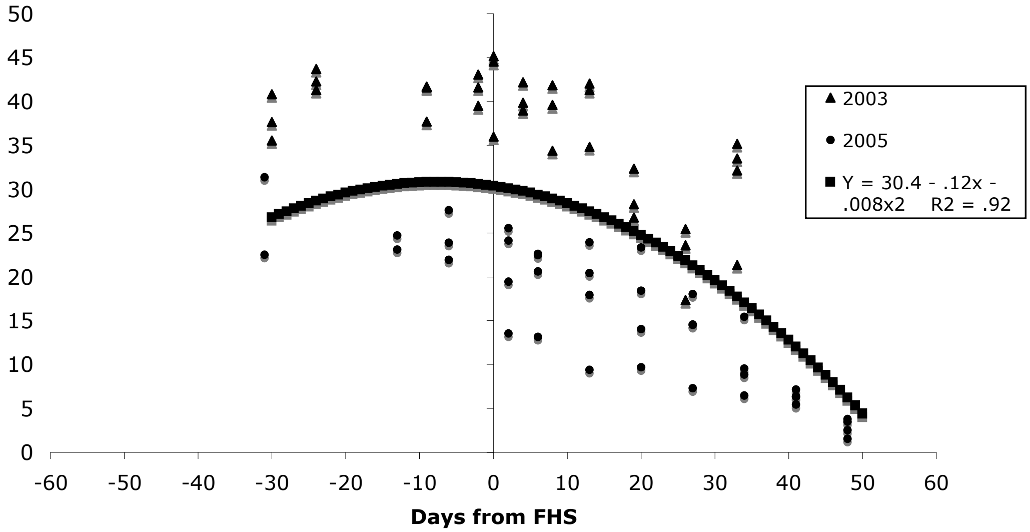


Figure II-5. Fieser et al.'s (2006) estimated wheat yield response to different grazing termination dates expressed as days before (-) or after (+) first hollow stem (FHS).

Redmon et al.'s Estimated Wheat Yield Response Function

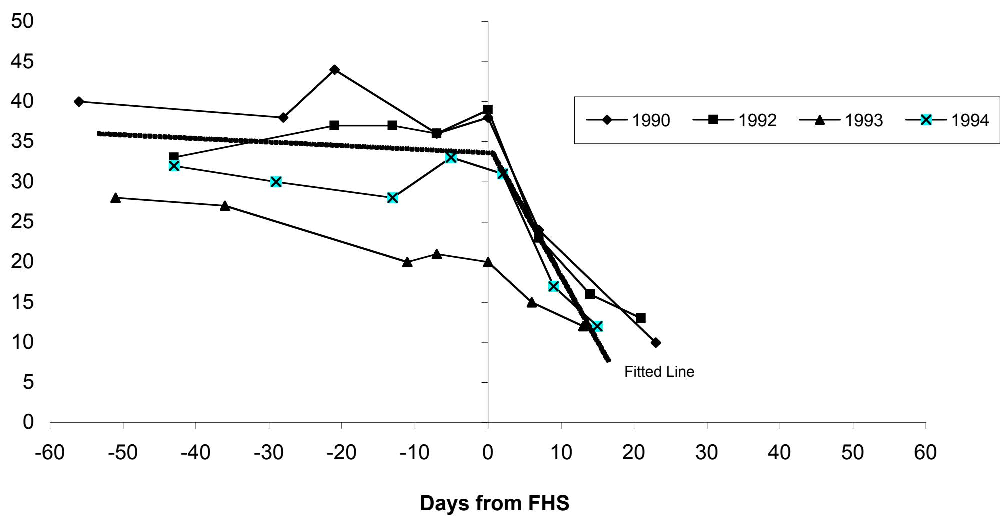


Figure II-6. Redmon et al.'s (1996) estimated wheat grain yield relative to FHS of ungrazed wheat and date of grazing termination over a four year period (1989-1990, 1991-1992, 1992-1993, and 1993-1994) near Marshall, Oklahoma.

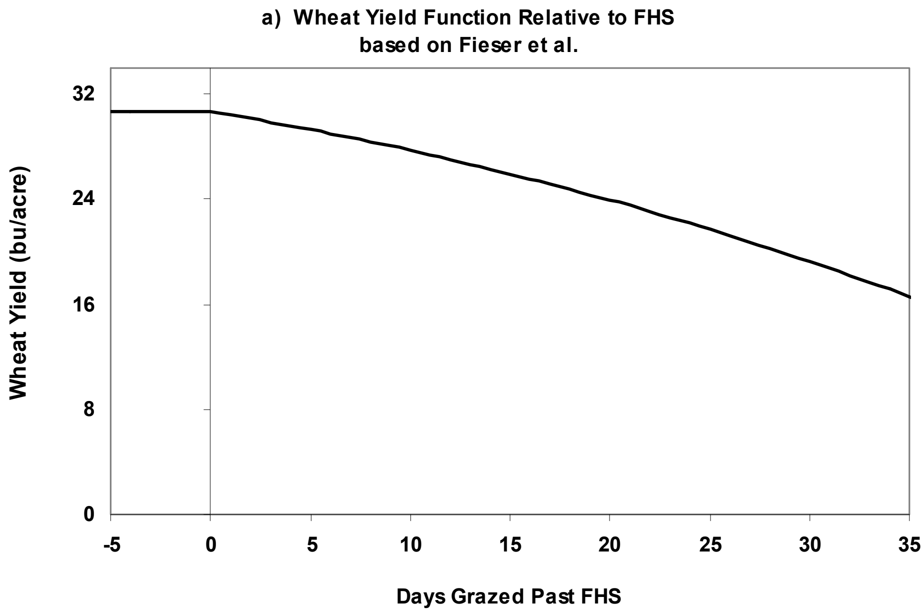


Figure a: Wheat Yield Function based on Fieser et al. (2006) data:

$$Y(d, FHS_{it}) = \begin{cases} 30.62 & \text{if } d \leq FHS_{it} \\ 30.62 - 0.25(d - FHS_{it}) - 0.004(d - FHS_{it})^2 & \text{if } d > FHS_{it} \end{cases}$$

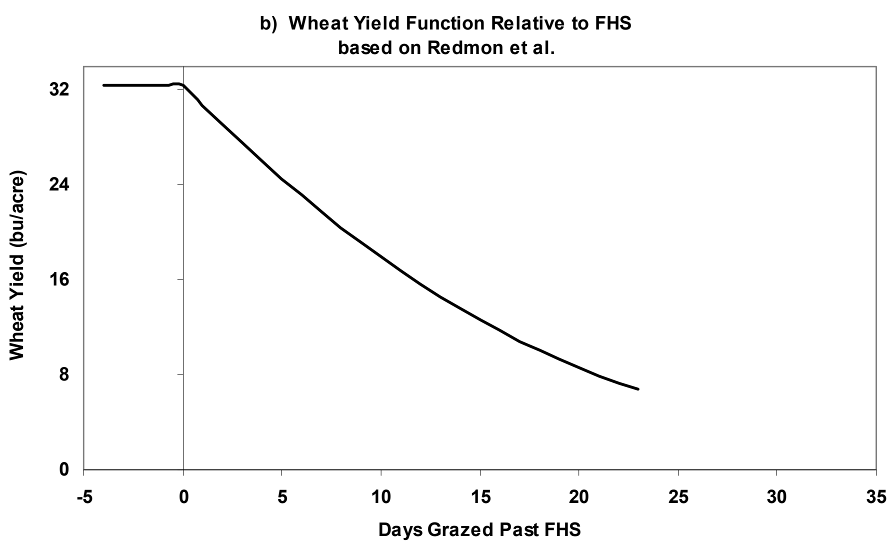


Figure b: Wheat Yield Function based on Redmon et al. (1996) data:

$$Y(d, FHS_{it}) = \begin{cases} 32.42 & \text{if } d \leq FHS_{it} \\ 32.42 - 1.700(d - FHS_{it}) + 0.025(d - FHS_{it})^2 & \text{if } d > FHS_{it} \end{cases}$$

Figure II-7 a & b. Estimated wheat yield function relative to first hollow stem (FHS) and days grazed past FHS based on Fieser et al.'s (2005) study period 2003 and 2005 and Redmon et al's (1996) study period 1990-1994.

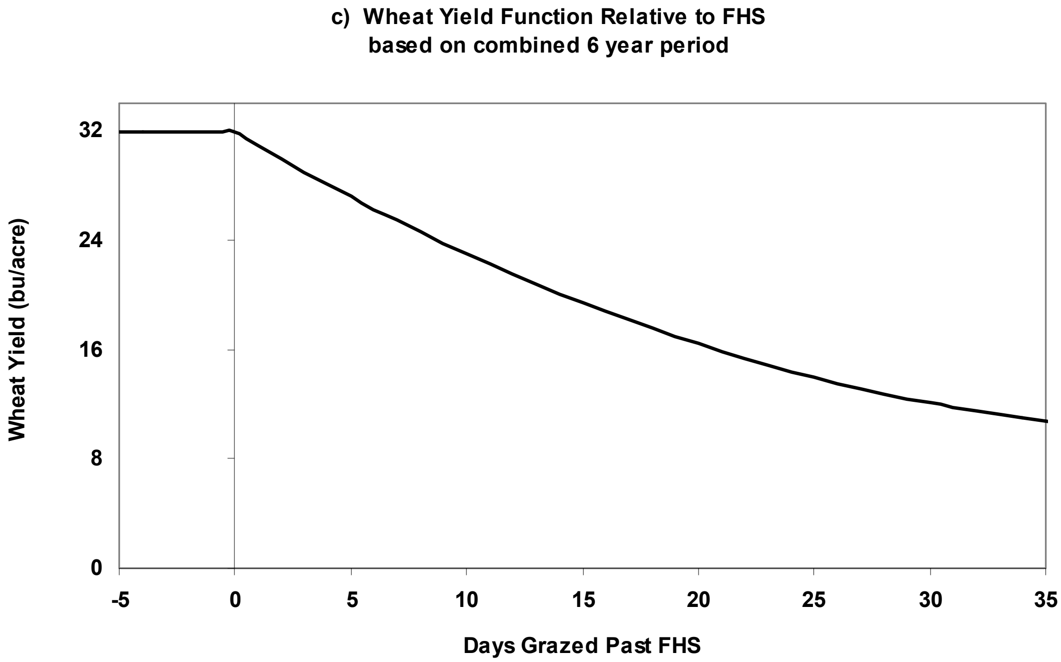


Figure c: Wheat Yield Function based on combined data:

$$Y(d, FHS_{it}) = \begin{cases} 31.87 & \text{if } d \le FHS_{it} \\ 31.87 - 1.00(d - FHS_{it}) - 0.011(d - FHS_{it})^2 & \text{if } d > FHS_{it} \end{cases}$$

Figure II-8. Estimated wheat yield function relative to FHS based on the combined (Fieser et al. 2006; Redmon et al. 1996) 6 year study period.

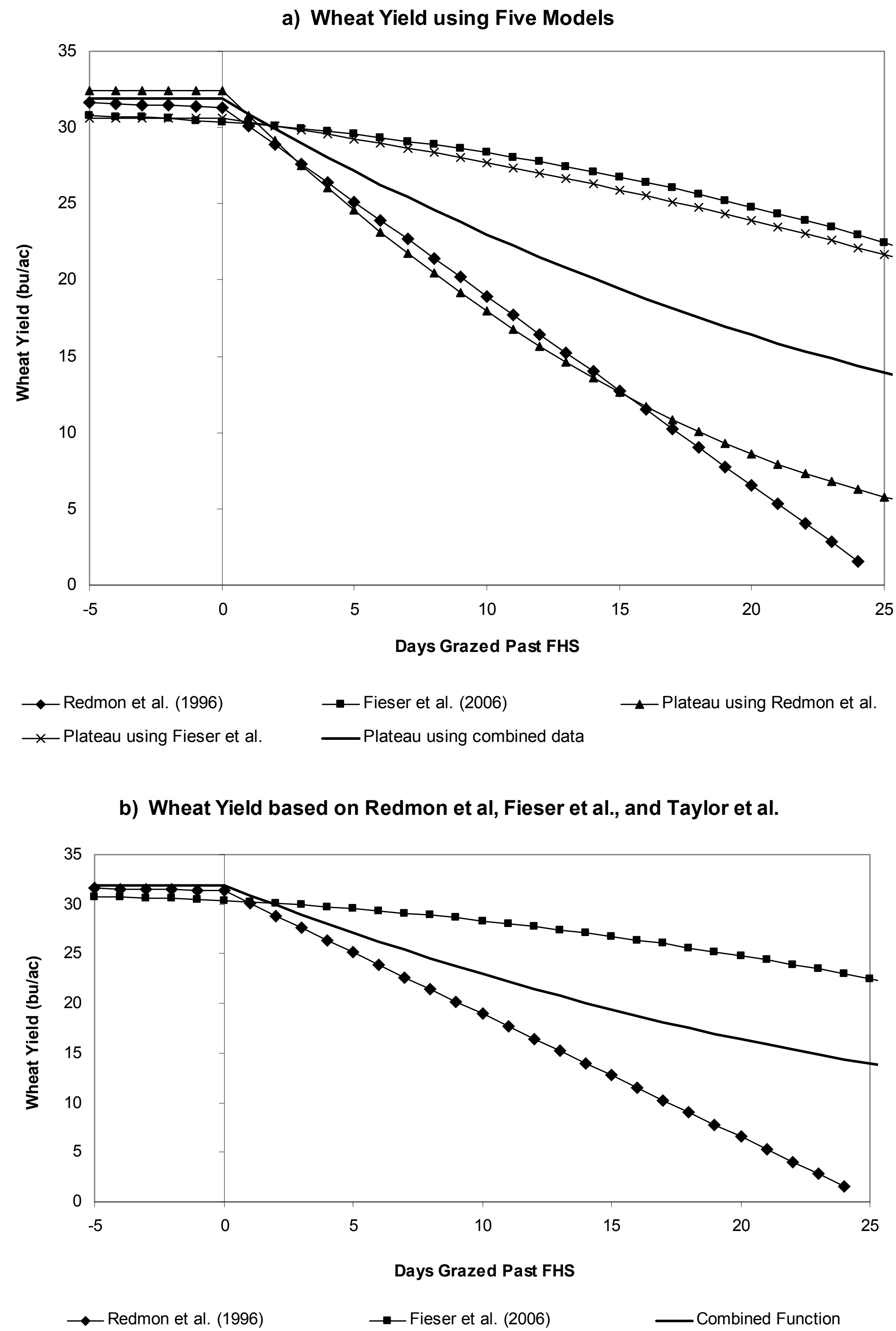


Figure II-9 a & b. Estimated wheat yield function based on five models.

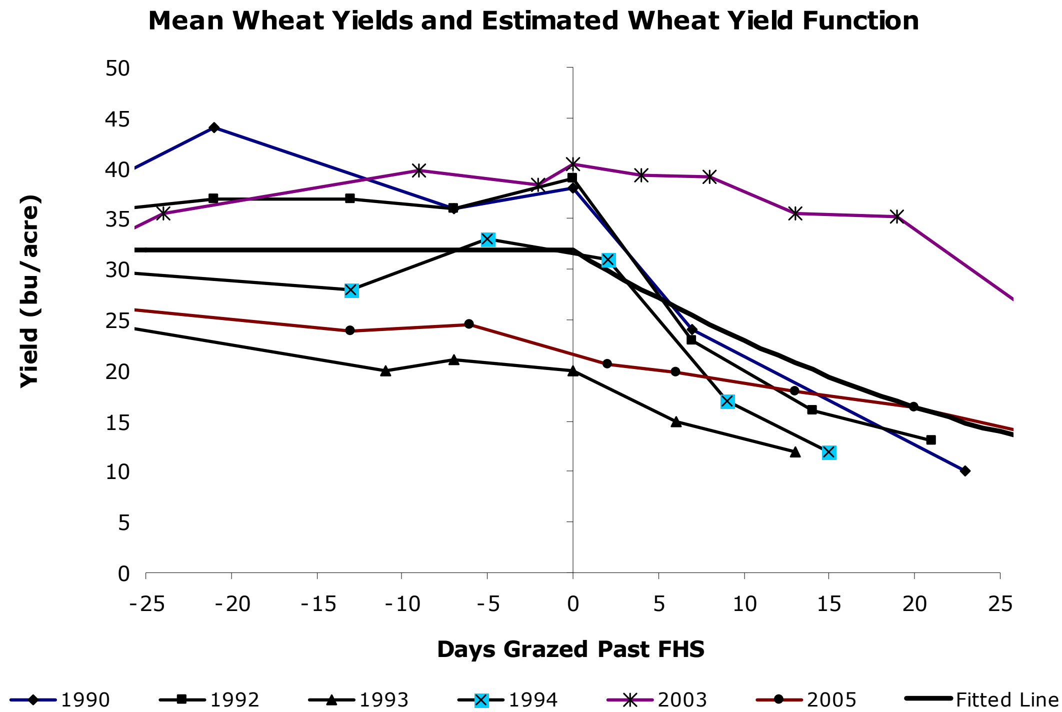


Figure II-10. Wheat yield function and wheat yields as a function of FHS and grazing termination.

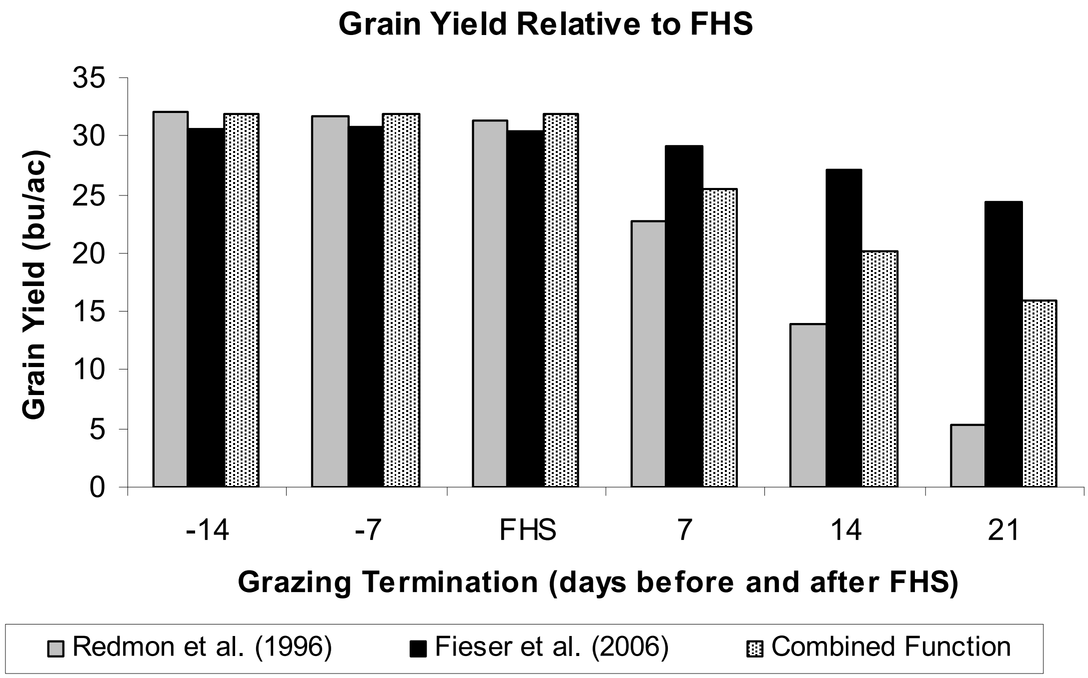


Figure II-11. Grain yield relative to first hollow stem (FHS) based on three studies.

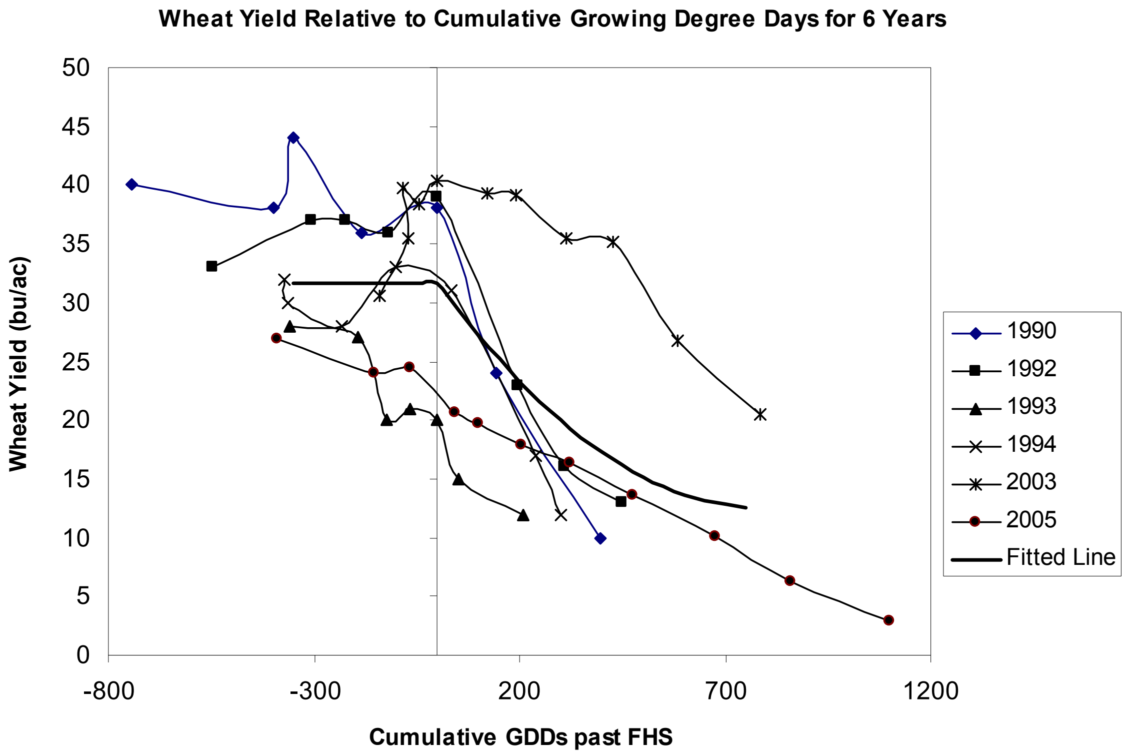
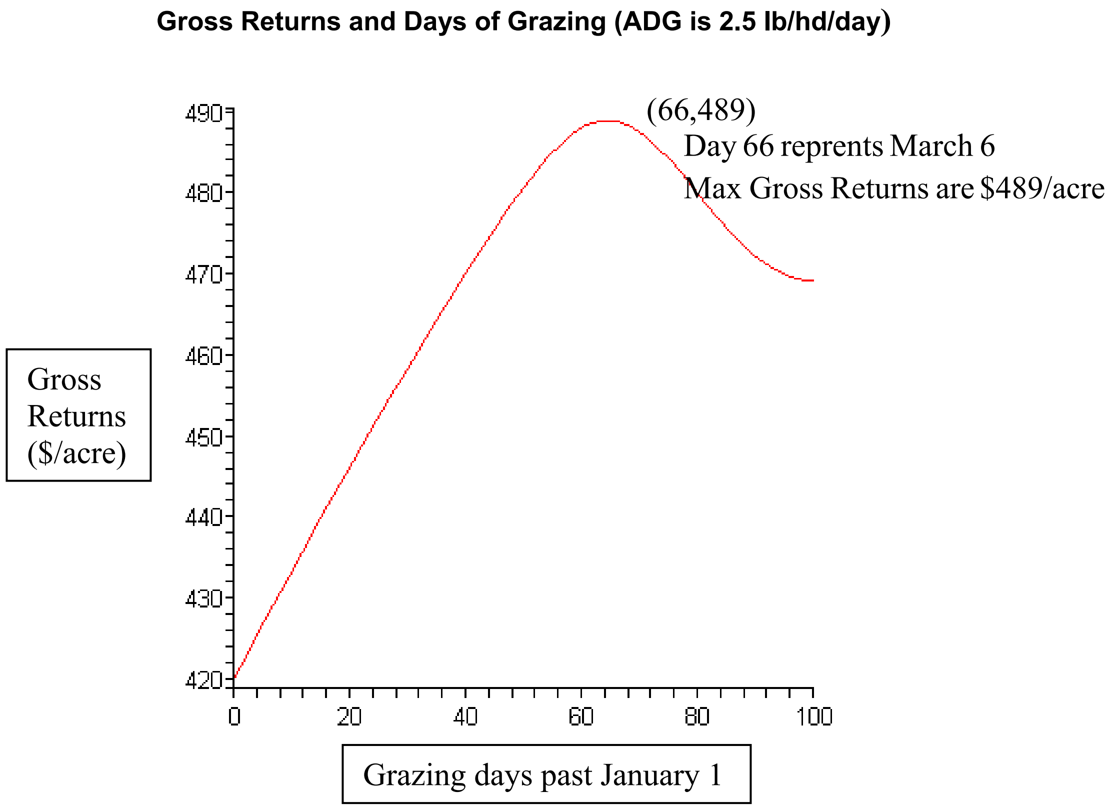


Figure II-12. Cumulative growing degree days (GDDs) relative to first hollow stem (FHS) over 6 study periods.



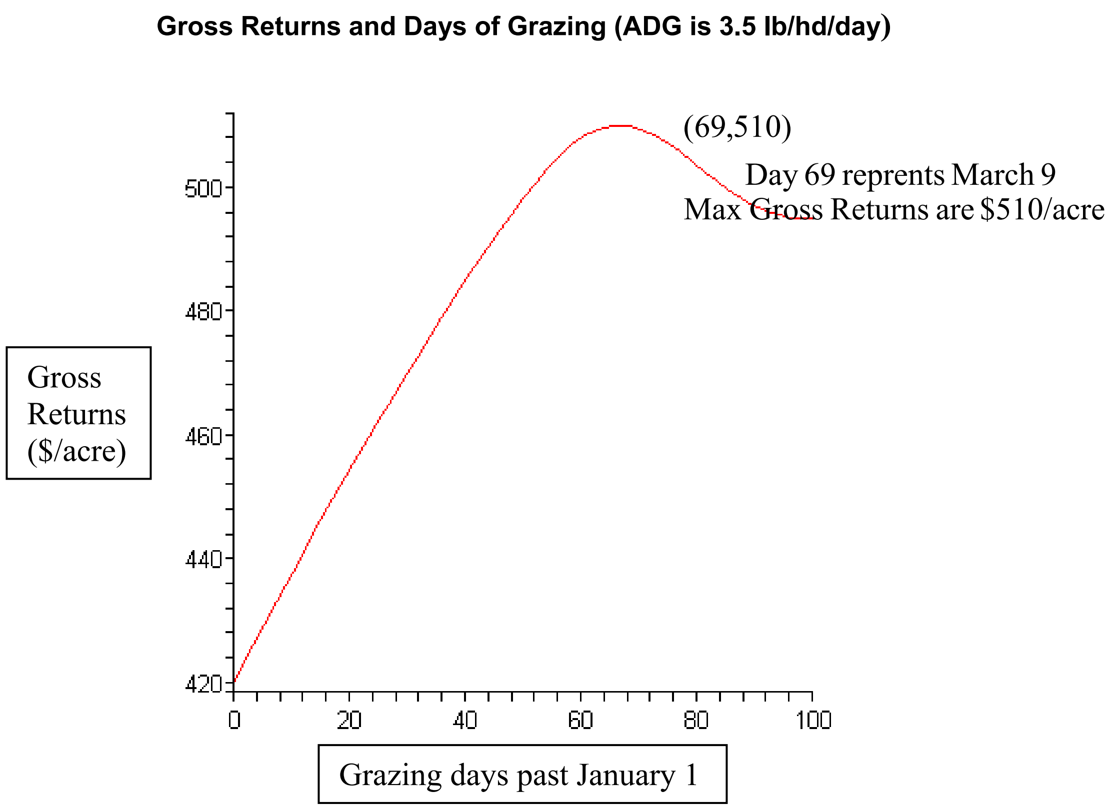
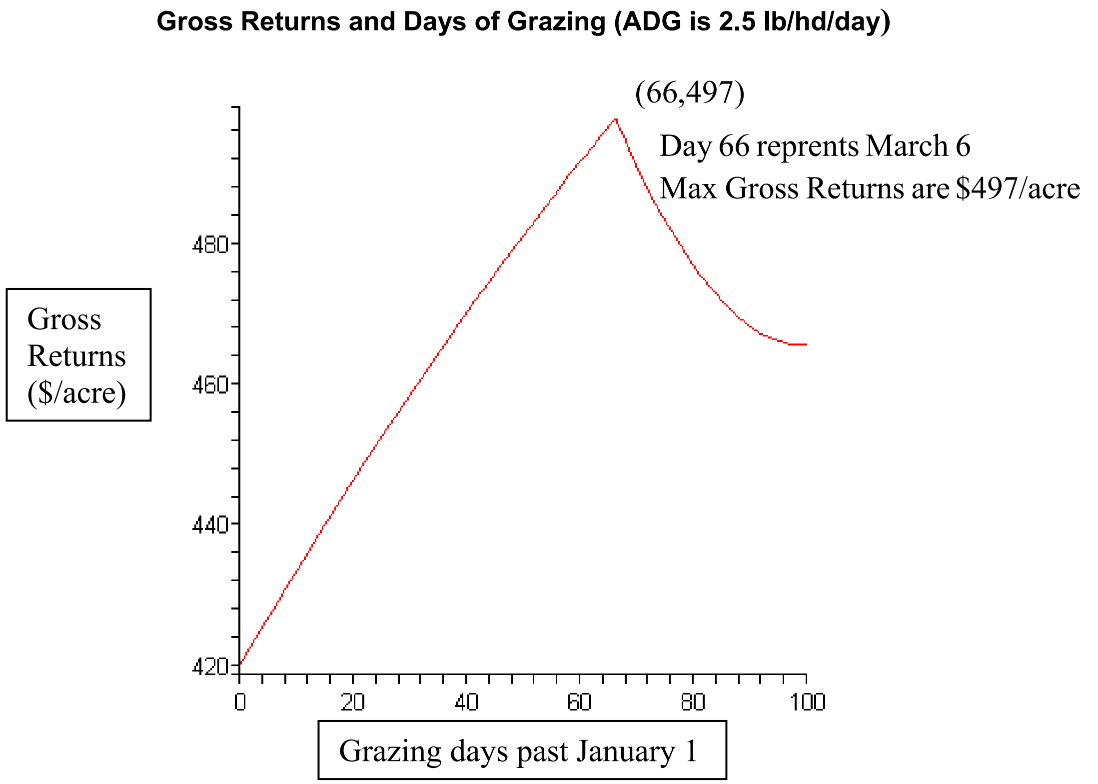


Figure II-13. Gross returns and grazing termination days based on FHS distribution of 52 winter wheat varieties with information of variety (Model 3).



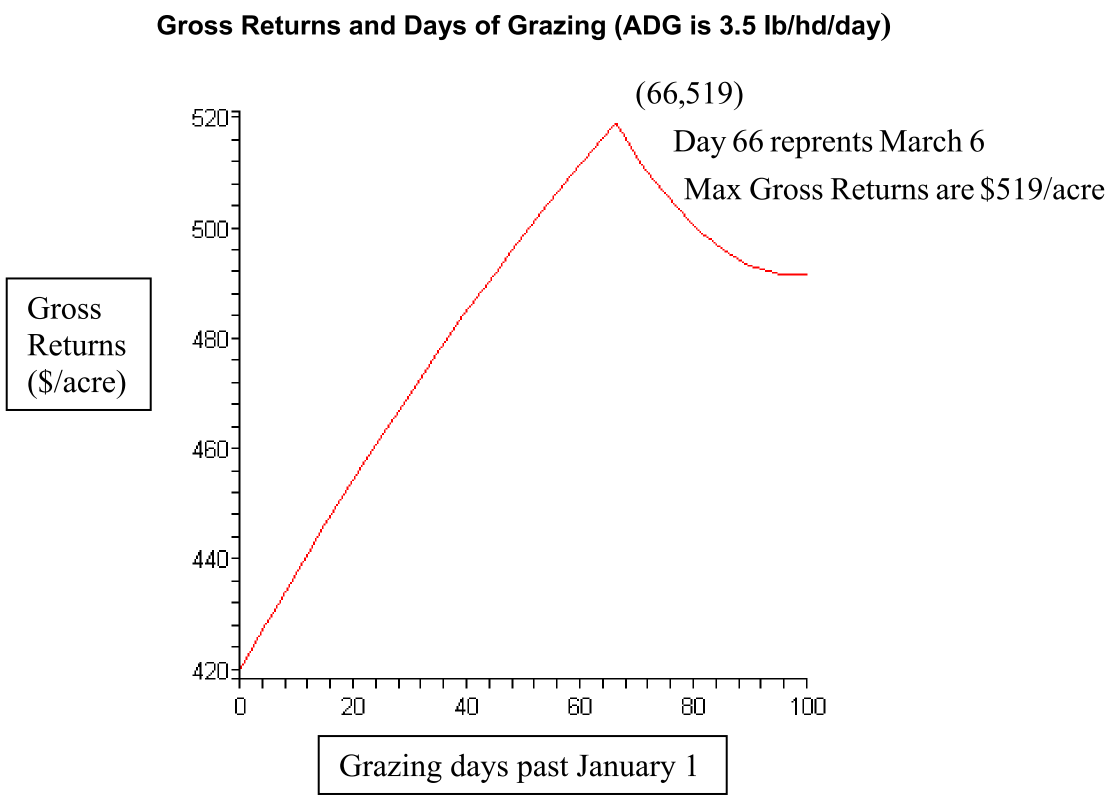


Figure II-14. Gross returns and grazing termination days based on FHS distribution of 52 winter wheat varieties with perfect information (Model 8).

Table II-1. Distribution of First Hollow Stem (FHS) for Different Levels of Information

Model	Equation
Model 1: *f*(*FHS*/No Information)	$FHS_i = \alpha_0 + \varepsilon_i$
Model 2: *f*(*FHS*/Year)	$FHS_{it} = \alpha_0 + \sum_{t=1}^{T-1} \beta_t D_{it} + \varepsilon_{it}$
Model 3: *f*(*FHS*/Variety)	$FHS_{ij} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \varepsilon_{ij}$
Model 4: *f*(*FHS*/Variety, Year)	$FHS_{ijt} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \sum_{t=1}^{T-1} \beta_t D_{it} + \varepsilon_{ijt}$
Model 5: *f*(*FHS*/*FHSTU*)	$FHS_i = \alpha_0 + \beta_F FHSTU_i + \varepsilon_i$
Model 6: *f*(*FHS*/Variety, *FHSTU*)	$FHS_{ij} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \beta_F FHSTU + \varepsilon_{ij}$
Model 7: *f*(*FHS*/Variety, Year, *FHSTU*)	$FHS_{ijt} = \alpha_0 + \sum_{j=1}^{J-1} \beta_j V_{ij} + \sum_{t=1}^{T-1} \beta_t D_{it} + \beta_F FHSTU_i + \varepsilon_{ijt}$
Model 8: *f*(*FHS*/Perfect Information)	$FHS_{it} = \overline{FHS}_{it}$

Table II-2. Average Daily Gain (ADG) and Stocking Density (SD) Rates from Previous Studies

Previous Studies	Average ADG Rate lb/head/day (kg/head/day)	Average SD Rate steer/acre (steer/ha)
Redmon et al. (1996)	2.43	0.56
	(1.10)	(1.39)
Kaitibie et al. (2003)	2.59	0.60
	(1.17)	(1.48)
Hossain et al. (2004)	2.30	0.48
	(1.04)	(1.18)
Fieser et al. (2006)	3.42	0.91
	(1.55)	(2.25)
Average	2.69	0.64
	(1.22)	(1.58)

Table II-3. History of First Hollow Stem in Oklahoma

Year	Date of FHS	Wheat Variety	Source
1990	March 12	2157	Redmon et al.
1992	February 28	2157	Redmon et al.
1993	March 16	Karl	Redmon et al.
1994	March 16	Karl	Redmon et al.
1998	February 25	Average of 52 varieties	Edwards et al.
1999	March 2	Average of 52 varieties	Edwards et al.
2000	March 3	Average of 52 varieties	Edwards et al.
2001	March 19	Average of 52 varieties	Edwards et al.
2002	March 20	Average of 52 varieties	Edwards et al.
2003	March 12	Average of 52 varieties	Edwards et al.
2003	March 13	2174	Fieser et al.
2003	March 18	2174	Edwards et al.
2004	March 3	Average of 52 varieties	Edwards et al.
2005	February 24	Average of 52 varieties	Edwards et al.
2005	March 5	OK102	Fieser et al.
2005	March 4	OK102	Edwards et al.
1998-2005 Average	March 8	Average of 52 varieties	Edwards et al.
1998-2005 Average	March 6	Average of 8 years	Edwards et al.
Surveyed Calendar Date	March 3	Unknown	Hossain et al.

Sources:
Edwards et al. (2006). Based on average FHS of 52 varieties grown in Stillwater, Oklahoma.
Fieser et al. (2006). Based on FHS of two varieties grown near Marshall, Oklahoma.
Hossain et al. (2004). Based on survey of Oklahoma producers.
Redmon et al. (1996). Based on two varieties grown near Marshall, Oklahoma.

Table II-4. Estimates of the Distribution of First Hollow Stem (FHS) using Six Models of Regression (Models 2-7)

		Estimates[a]					
Statistic	Definition	Model 2 *f*(*FHS*/Year)	Model 3 *f*(*FHS*/Variety)	Model 4 *f*(*FHS*/Variety, Year)	Model 5 *f*(*FHS*/*FHSTU*)	Model 6 *f*(*FHS*/Variety, *FHSTU*)	Model 7 *f*(*FHS*/Variety, Year, *FHSTU*)
α_0	Intercept	54.57* (1.56)	73.60* (1.59)	57.59* (1.14)	38.64* (2.49)	46.34* (2.85)	23.97* (0.59)
$\beta_{t=1998}$	1998	1.16 (2.99)	-	0.61 (2.15)	-	-	3.35* (1.00)
$\beta_{t=1999}$	1999	7.27* (1.90)	-	6.70* (1.25)	-	-	-7.71* (0.42)
$\beta_{t=2000}$	2000	8.18* (1.92)	-	7.28* (1.24)	-	-	-5.33* (0.48)
$\beta_{t=2001}$	2001	23.98* (1.60)	-	22.97* (1.17)	-	-	16.32* (0.26)
$\beta_{t=2002}$	2002	25.37* (1.88)	-	24.41* (1.24)	-	-	7.71* (0.38)
$\beta_{t=2003}$	2003	17.63* (1.71)	-	16.34* (1.12)	-	-	17.24* (0.32)
$\beta_{t=2004}$	2004	8.52* (2.05)	-	7.71* (1.33)	-	-	6.90* (0.23)
$\beta_{t=2005}$	2005	-	-	-	-	-	-
$\beta_{j=1}$	"Early" Variety	-	-10.74* (1.96)	-5.87* (0.63)	-	-7.07* (1.47)	-0.47* (0.21)
$\beta_{j=2}$	"Middle" Variety	-	-7.93* (2.72)	-1.93* (0.75)	-	-6.03* (2.40)	-0.03 (0.26)
$\beta_{j=3}$	"Late" Variety	-	-1.18 (1.89)	1.66* (0.67)	-	3.66* (1.50)	-0.25 (0.20)

Table II-4. Estimates of the Distribution of First Hollow Stem (FHS) using Six Models of Regression (Models 2-7)

Statistic	Definition	Estimates[a] Model 2 $f(FHS/\text{Year})$	Model 3 $f(FHS/\text{Variety})$	Model 4 $f(FHS/\text{Variety, Year})$	Model 5 $f(FHS/FHSTU)$	Model 6 $f(FHS/\text{Variety}, FHSTU)$	Model 7 $f(FHS/\text{Variety, Year}, FHSTU)$
$\beta_{j=4}$	"Unknown" Variety	-	-	-	-	-	-
β_F	FHS Thermal Units	-	-	-	0.08* (0.007)	0.08* (0.007)	0.11* (0.002)
σ^2	Variance of Error	27.70* (2.99)	96.33* (9.54)	10.99* (1.61)	69.74 (Mean Square Error)	58.44* (7.53)	1.30* (0.19)
R^2		0.71	0.20	0.86	0.42	0.46	0.99
Adj. R^2		0.70	0.19	0.86	0.41	0.45	0.99
Test for normality							
S-W	W statistic (p-value)	0.98 (0.02)	0.98 (0.001)	0.98 (0.03)	0.99 (0.03)	0.93 (0.0001)	0.84 (0.0001)
Test for heteroskedasticity							
B-P	F value (p-value)	71.52 (0.0001)	16.75 (0.0001)	124.19 (0.0001)	145.36 (0.0001)	43.41 (0.0001)	1233.27 (0.0001)

Notes:
FHSTU represents cumulative thermal units (cd) present after January 1 at the wheat growing location in Stillwater, Oklahoma.
The parameter estimates were estimated using an analysis of variance (ANOVA) model and PROC MIXED in SAS.
Normality tests were performed to test if the errors were normally distributed.
The Shapiro-Wilk (S-W) test confirms that all the errors are normally distributed.
Heteroskedasticity tests were done to test if the variance of the disturbance term is constant.
The Breusch-Pagan (B-P) test shows that heteroskedasticity exists, so regression was corrected.
[a] Asymptotic standard errors are shown in parentheses.
* Represents significance at the 5% level.

Table II-5. Steer Price Response as a Function of Weight (*W*) and Removal/ Selling Date (*d*)

Statistic	Definition	Estimates[a]
γ_0	Intercept	49.33* (4.02)
γ_1	Weight	-9.54* (1.00)
γ_2	Weight squared	0.43* (0.06)
α	Removal date	0.30* (0.02)
β_1	Weight × removal date	-0.04* (0.002)
β_2	Weight × removal date squared	2.5E-5* (9.7E-6)
σ_μ^2	Variance of year random effect	2.80* (1.08)
σ_ε^2	Variance of error term	8.38* (0.29)
-2LL	-2 Log likelihood	8601.3
R^2	Measure of fit	0.76
Adj. R^2	Adjusted measure of fit	0.76
Test for normality		
S-W	W statistic (p value)	0.99 (0.0001)
Test for heteroskedasticity		
B-P	F value (p-value)	1088.65 (0.0001)
Estimated response function		
Basis %	$49.33 - 9.54W + 0.43W^2 + 0.30d - 0.04Wd + 0.000025Wd^2$	

Notes:
The parameter estimates were estimated using PROC MIXED in SAS with year random effects and corrected for heteroskedasticity.
Normality tests were performed to test if the errors were normally distributed.
The Shapiro-Wilk (S-W) test confirms that all the errors are normally distributed.
Heteroskedasticity tests were done to test if the variance of the disturbance term is constant.
The Breusch-Pagan (B-P) test shows that heteroskedasticity exists, so regression was corrected.
[a] Asymptotic standard errors are in parentheses.
* Represents significance at the 5% level.

Table II-6. Plateau Model of Wheat Yield as a Function of First Hollow Stem (*FHS*) and Removal Date (*d*) with Known Switching Point

Statistic	Definition	Estimates[a]		
		Fieser et al. Data	Redmon et al. Data	Combined Data[b]
ρ_1	Parameter estimate of (*d-FHS*)	-0.25 (0.12)	-1.70* (0.27)	-1.00* (0.12)
ρ_2	Parameter estimate of $(d\text{-}FHS)^2$	-0.004 (0.003)	0.025 (0.01)	0.011* (0.003)
$\overline{Y}$	Expected wheat yield plateau	30.62 (5.22)	32.42* (2.67)	31.87* (2.53)
σ^2_u	Variance of year random effect	52.85 (53.60)	26.66 (19.76)	35.74 (21.47)
σ^2_v	Variance of error term	26.89 (4.22)	8.61* (2.44)	48.69* (6.69)
-2LL	-2 Log likelihood	517.6	157.3	732.1
$Y(d,FHS_{it})^{b}$	$\begin{cases} 31.87 & \text{if } d \le FHS_{it} \\ 31.87 - 1.00(d - FHS_{it}) - 0.011(d - FHS_{it})^2 & \text{if } d > FHS_{it} \end{cases}$			

Note: The parameter estimates were estimated using PROC NLMIXED in SAS with year random effects and corrected for heteroskedasticity.
[a] Asymptotic standard errors are in parentheses.
[b] Based on data from Fieser et al. (2006) and Redmon et al. (1996).
* Represents significance at the 5% level.

Table II-7. Plateau Model of Wheat Yield as a Function of First Hollow Stem (*FHS*) and Removal Date (*d*) with Unknown Switching Point

Statistic	Definition	Estimates[a b]
ρ_1	Parameter estimate of (*d-FHS*)	-0.90*
		(0.16)
ρ_2	Parameter estimate of $(d\text{-}FHS)^2$	0.009
		(0.004)
$\overline{Y}$	Expected wheat yield plateau	32.90*
		(2.71)
δ	Delta (in days)	-2.00
		(2.24)
σ^2_δ	Variance of delta	4.97
σ^2_u	Variance of year random effect	39.92
		(26.95)
σ^2_v	Variance of error term	42.20*
		(5.16)
-2LL	-2 Log likelihood	731.2
$Y(d,FHS_{it})$	$\begin{cases} 32.90 & \text{if } d \leq FHS_{it} + \delta \\ 32.90 - 0.90(d - FHS_{it}) + 0.009(d - FHS_{it})^2 & \text{if } d > FHS_{it} + \delta \end{cases}$	

Note: The parameter estimates were estimated using PROC NLMIXED in SAS with year random effects and corrected for heteroskedasticity.
[a] Asymptotic standard errors are in parentheses.
[b] Based on data from Fieser et al. (2006) and Redmon et al. (1996).
* Represents significance at the 5% level.

Table II-8. Plateau Model of Wheat Yield as a Function of Cumulative Growing Degree Days (*CGDD*)

Statistic	Definition	Estimates[a b]
a	Parameter estimate of ($CGDD$/10)	-0.48* (0.05)
b	Parameter estimate of $(CGDD/10)^2$	0.003* (0.0006)
$\overline{Y}$	Expected wheat yield plateau	31.68* (2.70)
σ^2_u	Variance of year random effect	41.23 (24.67)
σ^2_v	Variance of error term	50.69* (6.96)
-2LL	-2 Log likelihood	737.2
$Y(CGDD_{it})$	$\begin{cases} 31.68 \\ 31.68 - 0.48(CGDD_{it}/10) + 0.003(CGDD_{it}/10)^2 \end{cases}$	if $CGDD_{it} \leq FHS_{it}$ if $CGDD_{it} > FHS_{it}$

Note: The parameter estimates were estimated using PROC NLMIXED in SAS with year random effects and corrected for heteroskedasticity.
[a] Asymptotic standard errors are in parentheses.
[b] Based on data from Fieser et al. (2006), Redmon et al. (1996) and the Oklahoma Mesonet.
* Represents significance at the 5% level.

Table II-9. Estimated FHS, Expected Returns, Removal Date (*d*), Value of Information, and Cost of Grazing One Week Past FHS

Level of Information	Average Daily Gain (lb/hd/day)	Estimated Variance [a]	Estimated FHS (FHS_M)	Estimated Gross Returns $E(\pi)$ at d^* [b]	Value of Information $V(\Omega/I_M)$ [b]	Estimated Optimal Removal Date d^*	Cost of Grazing 1 week past FHS [c]
Model 1: *f*(*FHS*/No Information)	2.5	118.31	March 6	$487	-	65 – March 5	$3.48
	2.75			$492	-	66 - March 6	$3.05
	3.0			$498	-	66 - March 6	$2.52
	3.5			$508	-	68 – March 8	$2.00
Model 2: *f*(*FHS*/ Year)	2.5	27.70	March 6	$492	$5.12	65 - March 5	$6.80
	2.75			$497	$5.11	66 - March 6	$5.79
	3.0			$503	$5.12	66 - March 6	$5.64
	3.5			$513	$5.10	66 - March 6	$4.85
Model 3: *f*(*FHS*/Variety)	2.5	96.33	March 6	$489	$1.50	66 - March 6	$3.35
	2.75			$494	$1.72	66 - March 6	$2.65
	3.0			$500	$1.72	67 - March 7	$2.57
	3.5			$510	$1.53	69 - March 9	$1.46
Model 4: *f*(*FHS*/Variety, Year)	2.5	10.99	March 6	$494	$7.14	66 – March 6	$8.44
	2.75			$500	$7.40	66 - March 6	$7.49
	3.0			$505	$7.17	66 - March 6	$7.16
	3.5			$515	$6.89	66 - March 6	$6.19
Model 5: [d] *f*(*FHS*/*FHSTU*)	2.5	69.74	March 6	$489	$2.16	65 - March 5	$4.72
	2.75			$494	$2.10	66 - March 6	$3.87
	3.0			$500	$2.11	66 - March 6	$3.63
	3.5			$510	$2.04	67 - March 7	$2.93
Model 6: [d] *f*(*FHS*/Variety, *FHSTU*)	2.5	58.44	March 6	$490	$2.83	65 - March 5	$5.22
	2.75			$495	$3.02	65 - March 5	$4.63
	3.0			$501	$2.79	66 - March 6	$3.92
	3.5			$511	$2.72	67 - March 7	$3.54
Model 7: [d] *f*(*FHS*/Variety, Year, *FHSTU*)	2.5	1.30	March 6	$497	$9.21	66 - March 6	$10.68
	2.75			$502	$9.50	66 - March 6	$9.58
	3.0			$507	$9.59	66 - March 6	$9.35
	3.5			$518	$9.33	66 - March 6	$9.21
Model 8: *f*(*FHS*/Perfect Information)	2.5	0	March 6	$497	$10.05	66 - March 6	$11.09
	2.75			$503	$10.33	66 - March 6	$10.78
	3.0			$508	$10.14	66 - March 6	$10.33
	3.5			$519	$10.47	66 - March 6	$10.60

[a] Estimated Variance represents the variance of FHS dates between years 1998-2005 in Model 1, and the mean squared error estimates from the ANOVA models of the distribution of FHS in Models 2 through 7.
[b] Gross returns are based on $/ac. Returns include the revenues generated from cattle and wheat per acre. Returns do not include purchase or production costs of cattle or wheat.
[c] Cost of grazing one week past FHS is in $/ac.
[d] FHS based on models 5, 6, and 7 was calculated using average *FHSTU* of 350 cd.

Table II-10. Estimated FHS, Expected Returns, Removal Date (*d*), Value of Information, and Cost of Grazing One Week Past FHS for Wheat Variety Jagger

Level of Information	Average Daily Gain (lb/hd/day)	Estimated Variance [a]	Estimated FHS (FHS_M)	Estimated Gross Returns $E(\pi)$ at d^* [b]	Value of Information $V(\Omega/I_M)$ [b]	Estimated Optimal Removal Date d^*	Cost of Grazing 1 week past FHS [c]
Model 1: *f*(*FHS*/No Information)	2.5	112.13	February 28	$480	-	58 - February 27	$2.54
	2.75			$485	-	58 - February 27	$2.53
	3.0			$490	-	60 - March 1	$2.49
	3.5			$500	-	60 - March 1	$1.55
Model 5: [d] *f*(*FHS*/*FHSTU*)	2.5	81.83	February 28	$482	$1.60	58 - February 27	$3.99
	2.75			$487	$1.60	58 - February 27	$3.23
	3.0			$491	$1.60	59 - February 28	$3.01
	3.5			$501	$1.05	60 - March	$2.37
Model 7: [d] *f*(*FHS*/Year, *FHSTU*)	2.5	87.21	February 28	$481	$1.10	58 - February 27	$3.78
	2.75			$486	$1.27	59 - February 28	$3.43
	3.0			$491	$1.06	60 - March 1	$2.77
	3.5			$501	$0.74	60 - March 1	$2.10
Model 8: *f*(*FHS*/Perfect Information)	2.5	0	February 28	$490	$9.98	59 - February 28	$11.41
	2.75			$495	$9.80	59 - February 28	$11.25
	3.0			$500	$10.06	59 - February 28	$10.42
	3.5			$510	$9.77	59 - February 28	$9.95

[a] Estimated Variance represents the variance of FHS dates between years 1998-2005 in Model 1, and the mean squared error estimates from the regressions in Models 5 and 7.
[b] Gross returns are based on $/ac. Returns include the revenues generated from cattle and wheat per acre. Returns do not include purchase or production costs of cattle or wheat.
[c] Cost of grazing one week past FHS is in $/ac.
[d] FHS based on models 5 and 7 was calculated using average *FHSTU* of 284 cd.

Note: The distribution of FHS for Wheat Variety Jagger is based on the following table.

FHS Dates for Wheat Variety Jagger

Year	Date of First Hollow Stem
1998	February 21
1999	February 25
2000	February 24
2001	March 20
2002	March 6
2003	March 3
2004	February 22
2005	February 15
Average	February 28

Table II-11. Marginal Values of One Additional Day and One Additional Week of Extended Grazing, Relative to First Hollow Stem (FHS)

Grazing Termination Date (d)	Average Daily Gain (lb/hd/day)	Cattle Returns ($/acre)	Wheat Returns ($/acre)	Cattle & Wheat Returns ($/acre)	Marginal Cattle Returns from Extended Grazing ($/acre)	Marginal Wheat Returns from Extended Grazing ($/acre)	Ratio of Wheat Loss to Cattle Gains from Extended Grazing
At FHS	2.5	$405	$92	$497	-	-	-
At FHS	2.75	$411	$92	$503	-	-	-
At FHS	3.0	$416	$92	$508	-	-	-
At FHS	3.5	$427	$92	$519	-	-	-
1 day after FHS	2.5	$406	$89	$496	$1.42	-$2.92	-2.1
1 day after FHS	2.75	$412	$89	$501	$1.54	-$2.92	-1.9
1 day after FHS	3.0	$418	$89	$507	$1.67	-$2.92	-1.7
1 day after FHS	3.5	$429	$89	$518	$1.92	-$2.92	-1.5
1 week after FHS	2.5	$416	$70	$486	$10.56	-$21.65	-2.1
1 week after FHS	2.75	$421	$70	$492	$10.86	-$21.65	-2.0
1 week after FHS	3.0	$427	$70	$498	$11.32	-$21.65	-1.9
1 week after FHS	3.5	$438	$70	$509	$11.05	-$21.65	-2.0

Note: The values in this table are representative of a "Perfect Information" scenario based on a cattle cash price between $85-$89/cwt (depending on ending weight) from the estimated price response function found in this study, a cattle stocking density of 0.64 head/acre, a wheat price of $2.89/bushel, and estimated average wheat yields of 52 varieties from the estimated wheat yield response function determined in this paper.

PAPER III

DUAL-PURPOSE WINTER WHEAT AND STOCKER PLANNER

Introduction

Winter wheat and stocker producers in the Southern Plains are faced with several management decisions each season. Depending on weather and market conditions, producers can consider three basic wheat grain and forage strategies: harvest wheat as grain only, harvest wheat for forage and grain, and/or use the wheat crop as forage only, winter grazing plus graze-out. For the purposes of this research, we assume that the winter wheat will be used as a dual-purpose crop. In a dual-purpose winter wheat system, the wheat is intended for use as fall-winter forage for grazing cattle and then harvested for grain.

Generally, the dual-purpose winter wheat grazing season begins in mid-October to mid-November, depending on planting date and moisture. If the wheat is intended for harvest as both forage and grain, the cattle are grazed throughout the fall and winter months and then removed from the wheat pasture in February or March. The stocker cattle are then sold and moved to a feedlot. The wheat is then harvested in June for grain. Alternatively, depending on climatic conditions, stocker producers may want to harvest a portion of their wheat as a forage only (fall-winter grazing plus graze-out) crop. In this case, if the winter wheat is intended to be used for forage only, grazing still begins in the fall and continues into the spring as late as the end of May. Stocking rates are generally increased in the spring relative to that of fall and winter grazing.

Producers may consolidate the cattle fed during the fall-winter season onto fewer acres for wheat graze-out and use the remaining acres of their operation for grain harvest. Therefore, the portion of wheat pasture that is used for graze-out is intended for forage use only with increased stocking density, and the portion of wheat pasture that is not grazed out is used for grain harvest.

Key management decisions are made throughout the wheat and stocker production process. Before the grazing season begins, stocker producers must determine when and what type of stocker cattle to purchase (i.e. which weight and gender of cattle to buy). They must also determine stocking density as well as supplementation strategy and calculate the costs of raising the cattle. Once the stocker cattle have been purchased in the fall, the next major decision is when to remove them from grazing pasture, and whether to extend grazing during a graze-out period. Previous research trials have found that to maximize grain yields, grazing must be terminated at or before first hollow stem (FHS), or jointing, of the wheat plant (Redmon et al. 1996). The occurrence of FHS depends on weather, precipitation, and variety. The wheat crop is said to be at FHS when the plant from an ungrazed wheat pasture begins to elongate and become hollow just above the roots. Typically, FHS occurs between mid-February and mid-March.

Because many management decisions must be made each year during the wheat and cattle growing season, it is important that producers are informed about the industry and their operation to make effective decisions. Knowing their production information and budgeting the costs of production are vital to making informed decisions. There is a need to develop a budgeting system that will assist producers and extension specialists make decisions to optimize the profitability of wheat and stocker production enterprises.

The objective of this study is to construct a dual-purpose winter wheat and stocker production planner. The stocker planner consists of two parts: a purchasing planner and a selling planner. The purchasing planner is intended to be used before the beginning of the grazing season (i.e. August and/or September) to help stocker producers determine the stocker purchase weight and gender that maximizes net returns, given specific production data. The selling planner is designed for use near the end of the winter grazing season (i.e. February) to let stocker producers determine the optimal time to terminate fall-winter grazing on wheat intended for grain harvest and the optimal time to concentrate animals on the proportion of wheat acres to be grazed-out. This stocker planner was developed to provide extension specialists and producers with a tool that will aid in making effective decisions to maximize overall net returns for the whole, cattle and grain, operation. The planner may also be used as a teaching tool to illustrate the expected economic consequences of several production parameters including stocking density, average daily gain, death loss, and the number of grazing days. A budgeting system was developed to calculate returns resulting from different scenarios, enabling producers to compare the profitability of different strategies so that an effective and informed decision can be made.

Previous decision aids have been created. Epplin, Horn, and Krenzer (1999) created a wheat and wheat-stocker production planner that enabled a user to describe farm-specific situations to compare the economic consequences of alternative uses of land seeded to wheat. Gill (2003) developed a decision tool intended to evaluate the purchase of cattle in a stocker cattle and pasture or wheat farming program. Both of these decision aids are Excel spreadsheets. However, neither decision tool compares the returns from purchasing different types of stocker cattle or addresses the issue of when to terminate grazing or begin graze-out. Thus, there is a need to develop a stocker production planner that will assist producers in determining the expected economic consequences of alternative purchase weights for both steers and heifers.

Theory

Wheat and stocker production enterprises differ across farms. Resource situations and management techniques vary from farm-to-farm. To develop a stocker production planner that could be used by extension specialists as well as producers, a budgeting system was constructed. By using this method, farm specific production data may be entered to generate the returns for each purchasing and selling strategy that would pertain to each unique operation. Enterprise budgets include the income and costs per head associated with owning cattle and grazing them on wheat pasture. Returns to livestock depend on many factors such as the purchase price of cattle, costs of production, cattle weight gains, death loss, stocking density, and the sale price of cattle. Factors that tend to have the largest effect on livestock profitability are purchase prices, average daily gains (ADG), grazing days, and sale prices. Break-even prices are sensitive to changes in ADG and cattle costs; therefore, it is important to analyze the feasibility of alternative purchasing programs at the beginning of each grazing season as well as determining when to sell the cattle at the end of the grazing season.

Procedures

The planner includes default values as well as options for producers to input their own cost and production information. The default values of production are based on expert opinion and Oklahoma State University Experiment Station trials, and may be altered to farm specific values. Prices are built into the model as default values (USDA 2007). Prices are based on weekly Oklahoma City auction market prices for steers and heifers in 50-pound increments and reported by the Livestock Market Information Center. However, users may insert their own actual or expected prices.

Options to insert specific data enable producers to customize the program for their unique operation. In the next section, we will explain the worksheets included in the stocker planner. The planner consists of two decision tools: purchasing and selling. Both planners include three sections. The first section is a summary section and the other sections provide more in depth analysis.

Worksheets

The stocker planner includes seven Excel worksheets. The first worksheet labeled *Objectives* explains the objectives of the stocker purchasing and selling planner. The second and third worksheets include the stocker purchasing and selling decision aids and will be explained in detail in the next section. The fourth worksheet labeled *OKC Prices* includes the Oklahoma City auction market weekly market prices for large and medium #1 frame steer and heifer prices in 50 lb increments (USDA 2007). This worksheet is reported by the Livestock Market Information Center and includes weekly pricing data from June 1999 to the present (i.e. March 2007)[2]. These prices may be regularly updated by pasting the new worksheet from LMIC over the existing one. A user may obtain the most recent LMIC data by contacting their local area extension economist. Thus, prices can be kept current. The fifth worksheet labeled *Weekly Futures* represents the weekly futures prices for eight months (January, March, April, May, August, September, October, and November) from November 1989 to the present (i.e. March 2007)[3]. These futures prices are also directly taken from the LMIC and can be updated with assistance from the local area extension economist. Of particular importance is the March contract month for the appropriate week. These values were used to calculate the selling prices in the stocker purchasing planner.

The sixth worksheet called *Basis* includes the Oklahoma City basis tables for four weight ranges (400-500, 500-600, 600-700, and 700-800 pound) for steers and heifers. This worksheet is also from the LMIC website and can be accessed by contacting the local area extension economist. These values were interpolated at 25-pound intervals and used to adjust the futures prices in the stocker purchasing planner. At the bottom of the *Basis* worksheet is a price-weight relationship table that was used to adjust the prices of stockers weighing over 1,000 pounds (see Figure 4 for the table).

The last (seventh) worksheet labeled *Price Indices* represents the weekly Oklahoma City cattle price indices. These price indices were calculated from OKC weekly steer and heifer prices from 2000 to 2007 for the first week in February to the last week in May. A price index relative to the price reported in the first week of February is

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[2] The Oklahoma weekly stocker price worksheet from LMIC is labeled "combined_auction_OK.xls" sheet A.
[3] The futures price worksheet from LMIC is labeled "feederfutures.xls" sheet B.

found for each week from February to May. This information is then used to adjust the selling prices in the stocker selling planner. The seasonality in weekly prices is important because as the selling date changes, the expected selling price must be calculated that pertains to the expected selling date.

Figure 8 illustrates the weekly seasonality in steer and heifer prices. It shows that prices during the weeks between February and May change for different weight ranges. It is important to address this seasonality and include it in the price calculation in the stocker planner.

Stocker Purchasing Planner

The objective of the stocker purchasing planner is to aid producers in determining the expected economic consequences of alternative beginning weights for both steers and heifers. The decision aid has three sections: summary section, steer analysis, and heifer analysis.

Stocker Summary Section 1

The first section of the stocker purchasing planner is a summary section. It includes the timing of the grazing season, the production data for steers and heifers, pricing information, and a projected budget explaining income and expenses. At the bottom of the first section is a summary table of the net returns and break-even prices for seven different weight categories of steers and heifers. The planner has default values, but the user will be able to alter the values to suit their own unique situation. Farm specific information may be entered in red font (or shaded) cells. Values in the blue font (or unshaded) cells are computed by the program, given the entered production and price information.

The user may begin by entering the projected stocker purchase date, followed by the number of days the stockers are put into a receiving program, and how long the stockers will be grazed on fall-winter wheat pasture. This information is then used to calculate when the stocker cattle are expected to be removed from wheat intended for grain harvest. The second step involves inputting production data. An approximate cattle purchase weight is entered for both steers and heifers along with average daily gains, death loss percent, stocking density, and costs of raising the cattle. After the production information has been entered, the most recent purchase and selling prices are found for the appropriate weight and gender of the stocker.

Default purchase prices are based on Oklahoma City cash prices reported in 50-pound increments for large and medium frame #1 steers and heifers from the Livestock Market Information Center (USDA 2007). Purchase prices are taken from the most current date available to the expected purchase date and are linearly interpolated for accuracy. These prices are included on the "OKC prices" worksheet. The default selling prices are based upon the March futures price of cattle corresponding to the current day and adjusted by the basis value from the Oklahoma City basis tables (USDA 2007). Futures contracts only consist of stocker cattle weights up to 800 pounds. Thus, to adjust for the heavier weight ranges, a price-weight relationship index is found from LMIC for prices from 1992-2005 (see Figure 4).

If the user wishes to enter their own price values, they may do so. However, they must enter a price for all the weight ranges. If an "own" price is entered, the planner will only use those prices. To use the default market prices, no "own" prices may be entered. The next section illustrates the projected income and expenses from purchasing steers and heifers based on the entered data. The summary table illustrates the net returns (per head and per acre) and break-even selling prices for seven weight categories for steers and heifers based on the entered production data. This enables decision makers to compare the expected net returns of purchasing steers and heifers stockers of different weights.

Steer Analysis Section 2

The second section of the stocker purchasing planner pertains to seven weight categories of steers (375, 425, 475, 525, 575, 625, and 675 lb steers). The section is divided into two parts: cost of gain analysis and profit analysis. The cost of gain analysis includes a list of expected costs. The user may input expected cost information in the red cells. The cost of gain value is then calculated. Cost of gain is to intended to include all stocker production costs in addition to those costs entered in the medical, marketing, and variable ($/month) cells and is expressed as a $/lb of gain value. This value can then be used as an input in the profit analysis.

The profit analysis portion of the section begins with purchase expenses. Production information is then expressed and production costs are entered. Revenues are then calculated based on the expected selling weight and expected selling price at the end of the grazing season. Net returns are then reported per head as well as per acre, based on the production and cost inputs. Break-even selling prices are then expressed. The objective of this section is to determine net returns and break-even values for all initial purchase weights of steers and their representative production inputs.

Heifer Analysis Section 3

The third section of this decision tool is an analysis of seven different weight categories for heifers (375, 425, 475, 525, 575, 625, and 675 lb heifers). It is in the same format as the steer analysis section; however, the production information and prices pertain to heifers, rather than steers.

Of particular importance in this analysis are the purchase prices, selling prices, and average daily gains. This decision aid allows users to input farm specific data and prices, as well as using default values for purchase and sell prices. All stocker prices will be linearly interpolated by weight, using the following formula:

$$(1) \qquad IP = P_{LW} - (AW - LW) \times \frac{(P_{LW} - P_{HW})}{(HW - LW)},$$

where IP is the interpolated price (\$/cwt), P_{LW} is the price of the lower weight value (\$/cwt), AW is the actual weight of the stocker (lb/head), LW is the lower weight value (lb/head), P_{HW} is the price of the higher weight value (\$/cwt), and HW is the higher weight value (lb/head). For example, if the purchase weight of a heifer is 500 lb, when the price of a 475 heifer is \$117.29 and the price of a 525 lb heifer is \$115.35, then the interpolated price would be \$116.32/cwt, calculated by:

$$(2) \qquad IP = \$117.29 - (500 - 475) \times \frac{(\$117.29 - \$115.35)}{(525 - 475)}.$$

The planner is designed to consider initial weights between 350 and 750 pounds, and final selling weights between 500 and 1100 pounds.

Stocker Selling Planner

The stocker selling planner has two main objectives. The first objective is to assist producers in determining the optimal time to terminate winter grazing, relative to first hollow stem (FHS). The second objective is to aid producers in deciding whether or not to continue grazing into the spring during a graze out period (for full season grazing), and when to begin this graze out period. The decision tool includes three sections: summary section, winter grazing analysis, and full season grazing (or graze out) analysis.

Summary Section 1

The first section of the stocker selling planner is a summary section. The planner is based on the assumption that the stocker cattle have been purchased and are grazing on winter wheat pasture. It includes the timing of the grazing season, the production data for stockers and wheat, pricing information, and a projected budget explaining income and expenses. At the bottom of the first section is a summary table of the expected net returns and break-even stocker sell prices for winter grazing and grain, as well as full season grazing (including graze-out and grain). The planner has default values, but the user will be able to alter the values to fit their situation.

Again, in the areas where the font is red are the places where farm specific information may be entered and the blue font (or unshaded cells) indicates the values that are then computed automatically, given the production information. The user may begin by entering the date that the stockers were purchased, followed by the number of days the stockers were placed into a receiving program, and how long the stockers are expected to be grazed on winter wheat pasture. This information is then used to calculate when the stocker cattle are expected to be removed from winter grazing. The second step involves inputting the production data for stockers on winter wheat pasture, during graze out, and wheat yield information.

Every stocker enterprise is different with varying management systems. Production information such as stocker purchase weight, average daily gains, stocking density, and costs of raising the cattle must be entered. After the production information has been entered, the purchase and selling prices are found for the appropriate weight range of the stocker. The purchase prices are based on Oklahoma City cash prices reported in 50-pound increments for large and medium frame #1 steers from the Livestock Market Information Center (USDA 2007). The purchase prices are taken from the closest date available to the purchase date and are linearly interpolated for accuracy. The selling prices represent the market price of cattle corresponding to the nearest date to the expected grazing termination date and are also based on OKC steer prices. Prices are only available for weight categories between 300 and 1000 pounds. Thus, to find price value of heavier cattle, prices have been indexed based on the price-weight relationship index reported by LMIC for prices from 1992-2005 (see Figure 4). Again, if the user wishes to enter their own price values, they may do so. However, they must enter a price for all the weight ranges. If an "own" price is entered, the planner will only use those prices. To use the given market prices, no "own" prices may be entered. The next section illustrates the projected income and expenses from winter grazing based on the production information entered and grazing terminated at FHS. The summary table illustrates the net returns (per head and per acre) and break-even selling prices for stocker cattle grazed on winter wheat for five different grazing termination dates, and stocker cattle grazed for the full season (winter grazing and graze-out) for five different graze out start dates.

Fall-Winter Grazing Analysis Section 2

The second section of the stocker selling planner pertains to five scenarios of winter grazing on wheat pasture, differentiated by grazing termination date relative to FHS. The section is divided into two sections: production data and partial enterprise budgets. The production data include information about winter grazing such as initial cattle purchase weight, daily gains, stocking density, and costs. The production data also include information about expected wheat yields and wheat yield loss due to grazing past FHS. The values are shown in blue font (or unshaded cells) because they are taken from the summary section. Changes may be made to the production data by entering values in the first section (in areas with the red font or shaded). The second section shows a projected income and expense budget for five scenarios, differing by grazing termination date. The objective of this section is to show the consequences of terminating grazing before or after FHS, based on the entered production data.

Full Season Grazing (Graze Out) Analysis Section 3

The third section of the stocker selling decision tool is an analysis of five scenarios where cattle are grazed for the full grazing season, meaning winter grazing and then grazed out into the spring. The scenarios differ by graze out start date. The graze-out starting dates correspond to the winter grazing ending dates (as described during the winter grazing analysis, section 2 of the stocker selling planner). This full season grazing analysis section includes the stocker and wheat production data during winter grazing and graze-out periods. The values are taken from the summary section. Projected income and expenses are then calculated for five scenarios based on the production information given.

The objective of the budget is to illustrate the economic consequences of beginning graze out for five different start dates. The dates are based on beginning graze out one to two weeks before or after FHS, and at FHS. FHS is assumed to be the same date as the expected fall-winter grazing termination date. The date of FHS is unique to each year and depends on climate and wheat variety. However, generally FHS occurs between mid-February to mid-March; thus, in this stocker planner, it is assumed that the date the cattle are expected to be removed from fall-winter grazing is the expected date of FHS. The date of FHS is crucial because if winter grazing is terminated after FHS, wheat yields decrease by a determined amount of bushels per day lost from extended winter grazing. It is assumed that during the graze out period, stocker cattle that were purchased in the fall and grazed on the entire field during the fall are consolidated onto a smaller portion of land. When graze-out begins, cattle are placed on a proportion of the total wheat acres, depending on wheat and winter grazing stocking density. This proportion is calculated based on stocking densities during fall-winter grazing and graze-out. The stocker planner assumes that no additional cattle are purchased during full-season grazing. Thus, after winter grazing ends and graze out begins, stocking density of cattle per acre (or lbs per acre) increases substantially. The proportion of the wheat that is used for graze out is used solely for forage and the remaining proportion of the wheat crop is harvested for grain. This decision tool assumes that no additional cattle are purchased before or during the full grazing season.

One limitation of the planner is that the stocker weights entered must be within reasonable ranges. The purchase weights must be between 350 and 800 pounds and selling weight must be between 650 to 1100 pounds. Prices are only available for certain weight ranges and if a stocker weight is not within the given range, Oklahoma City price data will not be available for that scenario. However, the user may enter "own" prices.

Summary and Conclusions

Harvesting wheat as grain and forage required judicious management to maximize expected net returns of the combined livestock and grain production activities. Producing wheat, as a forage crop as well as a grain crop, can be a way for wheat producers to enhance the income from their wheat enterprise. It is important for producers to budget and identify key production factors. Budgeting at multiple production levels can help producers examine their livestock and crop enterprise. After producers have identified the factors that most affect profitability, they can more easily manage their operations and work towards maximizing net returns.

In dual-purpose winter wheat and stocker production, wheat prices, stocker purchase prices, stocker sell prices, average daily gains, days available for grazing, and wheat yields are key factors that affect net returns. To maximize returns, producers must monitor these elements to make effective management decisions.

This stocker planner was developed to aid stocker and wheat producers determine what size and gender of cattle to purchase at the beginning of the grazing season, and when to terminate winter grazing (relative to FHS), and/or begin graze out that will result in maximum net returns. The stocker planner is planned to be available online to extension economists, country agents, and producers.

References

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Oklahoma State University Stocker Planner

SECTION 1

RED FONT --> Enter Production Data		NAME:	**NAME**
BLUE FONT --> Calculated Automatically		DATE:	**3-Apr-07**

Purchase Date 5-Oct-06 — Expected Selling Date 10-Mar-07

Number of days in Receiving Program: 21

Number of days grazed on Wheat Pasture: 135

Production Data	**Steers**	**Heifers**	
Cattle purchase weight	575	500	lb/head
Cattle cost per cwt	$120.60	$116.32	$/cwt
Cattle cost per head	$693.45	$581.60	$/head
Receiving Program ADG	2.0	2.0	lb/head/day
Average Daily Gain on pasture	2.4	2.4	lb/head/day
Death Loss	2%	2%	Percent
Stocking Density	0.5	0.5	head/acre
Stocking Density	287.5	250	lb/acre
Medical Costs	$20.00	$20.00	$/head
Marketing Costs	$10.00	$10.00	$/head
Variable Costs ($/month)	$3.00	$3.00	$/head
Cost of Gain (all other costs)	$0.25	$0.25	$/lb
Interest Rate	7.0%	7.0%	% annually

Pricing Information based on 29-Sep-06

Purchase Prices: Steers (lb/head)	Market $/cwt	Own $/cwt	Selling Prices: Steers (lb/head)	Futures $/cwt	Own $/cwt
300-350	$163.00		600-650	$128.44	
350-400	$146.93		650-700	$122.32	
400-450	$140.02		700-750	$115.45	
450-500	$132.10		750-800	$112.02	
500-550	$124.58		800-850	$109.55	
550-600	$120.60		850-900	$106.09	
600-650	$121.41		900-950	$103.21	
650-700	$119.69		950-1000	$100.48	
700-750	$118.63		1000-1050	$97.82	
750-800	$115.80		1050-1100	$95.24	
			1100-1150	$92.72	

Heifers (lb/head)	Market $/cwt	Own $/cwt	Heifers (lb/head)	Futures $/cwt	Own $/cwt
300-350	$137.58		600-650	$113.32	
350-400	$128.82		650-700	$107.59	
400-450	$121.17		700-750	$101.81	
450-500	$117.29		750-800	$98.92	
500-550	$115.35		800-850	$96.74	
550-600	$113.32		850-900	$93.69	
600-650	$112.69		900-950	$91.14	
650-700	$112.24		950-1000	$88.73	
700-750	$109.71		1000-1050	$86.38	
750-800	$104.59		1050-1100	$84.10	

PROJECTED INCOME AND EXPENSES

	Steers Total	**Steers** Daily	**Heifers** Total	**Heifers** Daily
EXPENSES:				
Stocker Purchasing Costs ($/head)	$693.45	$4.45	$581.60	$3.73
Expected weight gain (lb/head)	366.0	2.3	366.0	2.3
Costs of Gain ($/head)	$91.50	$0.59	$91.50	$0.59
Other Costs ($/head)	$45.60	$0.29	$45.60	$0.29
Interest Costs ($/head)	$24.85	$0.16	$21.50	$0.14
Total Costs ($/head)	$855.40	$5.48	$740.20	$4.74
INCOME:				
Stocker Selling Weight (lb/head)	941.0	6.0	866.0	5.6
Stocker Selling Price ($/cwt)	$102.34	$0.66	$94.24	$0.60
Stocker Revenue ($/head)	$943.75	$6.05	$799.76	$5.13
NET RETURNS ($/head)	$88.35	$0.57	$59.56	$0.38
NET RETURNS ($/acre)	$44.18	$0.28	$29.78	$0.19
BREAK-EVEN SELLING PRICE ($/cwt)	$92.76		$87.22	

OPTIMAL STOCKER PURCHASE WEIGHT:

Type (Weight & Gender)	**Net Returns ($/head)**	**Net Returns ($/acre)**	**Break-even Selling Price ($/cwt)**
375 lb Steers	$122	$91	$98
425 lb Steers	$108	$70	$97
475 lb Steers	$106	$64	$96
525 lb Steers	$104	$57	$93
575 lb Steers	$88	$44	$93
625 lb Steers	$45	$20	$95
675 lb Steers	$16	$6	$95
375 lb Heifers	$94	$70	$88
425 lb Heifers	$90	$58	$87
475 lb Heifers	$74	$45	$87
525 lb Heifers	$46	$25	$88
575 lb Heifers	$21	$11	$88
625 lb Heifers	-$12	-$5	$89
675 lb Heifers	-$48	-$19	$90

*** Optimal Stocker Weight and Gender by acre ***
375 lb Steers
Net Returns ($/acre) $91
BE Price ($/cwt) $98

*** Optimal Stocker Weight and Gender by head ***
375 lb Steers
Net Returns ($/head) $122
BE Price ($/cwt) $98

* Warning: Profits and Break-even selling prices are based on the entered production data. Confirm assumptions before making conclusions.

Figure III-1. **Stocker Purchasing Planner – Summary Section 1.**

SECTION 2

COST OF GAIN ANALYSIS:	Steers 375 lb	Steers 425 lb	Steers 475 lb	Steers 525 lb	Steers 575 lb	Steers 625 lb	Steers 675 lb
RECEIVING PROGRAM EXPENSES:							
Hay Costs (2% of purchase weight/head/day)	$4.73	$5.36	$5.99	$6.62	$7.25	$7.88	$8.51
Soybean supplement (2 lb/head/day)	$3.78	$3.78	$3.78	$3.78	$3.78	$3.78	$3.78
High Calcium Mineral mixture	$1.60	$1.60	$1.60	$1.60	$1.60	$1.60	$1.60
Shipping to Pasture	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Other Receiving Costs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Expenses of Receiving Program ($/head)	$25.11	$25.74	$26.37	$27.00	$27.63	$28.26	$28.89
ADDITIONAL EXPENSES:							
Order buyer fee ($/head)	$1.88	$1.88	$1.88	$1.88	$1.88	$1.88	$1.88
Equipment and Machinery Cost ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Management Fee ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Labor Cost ($/head/day)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Beef Check Off ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Options/Hedge Cost ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cost of Pasture ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Freight ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Implant Costs ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Mineral and Supplement Costs ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Feed Costs ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Total Additional Expenses	$66.88	$66.88	$66.88	$66.88	$66.88	$66.88	$66.88
Interest cost of receiving and additional expenses ($/head)	$2.75	$2.77	$2.79	$2.81	$2.83	$2.85	$2.87
Total Costs (excluding medica, marketing, & variable) ($/head)	$91.99	$92.62	$93.25	$93.88	$94.51	$95.14	$95.77
GAIN (lb/head)	366.0	366.0	366.0	366.0	366.0	366.0	366.0
COST OF GAIN (excl med, mkting, & var costs) ($/head)	$91.99	$92.62	$93.25	$93.88	$94.51	$95.14	$95.77
COST OF GAIN (excl. med, mkting, & var costs) ($/lb)	$0.25	$0.25	$0.25	$0.26	$0.26	$0.26	$0.26
OTHER EXPENSES:							
Stocker Purchase Costs	$550.99	$595.09	$627.48	$654.05	$693.45	$758.81	$807.91
Interest cost of stocker purchase ($/head)	$16.48	$17.80	$18.77	$19.57	$20.75	$22.70	$24.17
Medical Costs ($/head)	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00
Marketing Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Variable Costs ($/head/month)	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Interest cost of med, mkting, & var costs ($/head)	$1.36	$1.36	$1.36	$1.36	$1.36	$1.36	$1.36

PROFIT ANALYSIS:	Steers 375 lb	Steers 425 lb	Steers 475 lb	Steers 525 lb	Steers 575 lb	Steers 625 lb	Steers 675 lb
PURCHASING EXPENSES:							
Purchase Weight (lb)	375	425	475	525	575	625	675
Purchase Price ($/cwt)	$146.93	$140.02	$132.10	$124.58	$120.60	$121.41	$119.69
Stocker Purchase Costs	$550.99	$595.09	$627.48	$654.05	$693.45	$758.81	$807.91
PRODUCTION INFORMATION:							
Average Daily Gain during Receiving (lb/head/day)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Average Daily Gain on pasture (lb/head/day)	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Stocking Density (head/acre)	0.8	0.7	0.6	0.6	0.5	0.5	0.4
Stocking Density (lb/acre)	281.25	276.25	285	288.75	287.5	281.25	270
Death Loss %	2%	2%	2%	2%	2%	2%	2%
PRODUCTION COSTS:							
Medical Costs ($/head)	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00
Marketing Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Other Variable Costs ($/head/month)	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Cost of Gain (excl. med, mkting, & var costs) ($/head)	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Interest Rate (annual %)	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Interest Cost	$20.59	$21.91	$22.87	$23.67	$24.85	$26.80	$28.27
Total costs ($/head)	$708.67	$754.09	$787.45	$814.81	$855.40	$922.72	$973.28
REVENUE:							
Sale Weight (lb)	741.0	791.0	841.0	891.0	941.0	991.0	1041.0
Sale Price ($/cwt)	$114.36	$111.23	$108.44	$105.17	$102.34	$99.63	$97.00
Stocker Revenue ($/head)	$830.43	$862.23	$893.77	$918.34	$943.75	$967.60	$989.53
Other Revenue	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Revenue ($/head)	$830.43	$862.23	$893.77	$918.34	$943.75	$967.60	$989.53
NET RETURNS ($/head)	$121.76	$108.14	$106.32	$103.53	$88.35	$44.88	$16.25
NET RETURNS ($/acre)	$91.32	$70.29	$63.79	$56.94	$44.18	$20.20	$6.50
NET RETURNS PER lb OF GAIN ($/lb)	$0.33	$0.30	$0.29	$0.28	$0.24	$0.12	$0.04
BREAK-EVEN SELLING PRICE ($/cwt)	$97.59	$97.28	$95.54	$93.32	$92.76	$95.01	$95.40

Figure III-2. Stocker Purchasing Planner – Steer Analysis Section 2.

SECTION 3

COST OF GAIN ANALYSIS:	Heifers 375 lb	Heifers 425 lb	Heifers 475 lb	Heifers 525 lb	Heifers 575 lb	Heifers 625 lb	Heifers 675 lb
RECEIVING PROGRAM EXPENSES:							
Hay Costs (2% of purchase weight/head/day)	$4.73	$5.36	$5.99	$6.62	$7.25	$7.88	$8.51
Soybean supplement (2 lb/head/day)	$3.78	$3.78	$3.78	$3.78	$3.78	$3.78	$3.78
High Calcium Mineral mixture	$1.60	$1.60	$1.60	$1.60	$1.60	$1.60	$1.60
Shipping to Pasture	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Other Receiving Costs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Expenses of Receiving Program ($/head)	$25.11	$25.74	$26.37	$27.00	$27.63	$28.26	$28.89
ADDITIONAL EXPENSES:							
Order buyer fee ($/head)	$1.88	$1.88	$1.88	$1.88	$1.88	$1.88	$1.88
Equipment and Machinery Cost ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Management Fee ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Labor Cost ($/head/day)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Beef Check Off ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Options/Hedge Cost ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cost of Pasture ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Freight ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Implant Costs ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Mineral and Supplement Costs ($/head)	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Feed Costs ($/head)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Total Additional Expenses	$66.88	$66.88	$66.88	$66.88	$66.88	$66.88	$66.88
Interest cost of receiving and additional expenses ($/head)	$2.75	$2.77	$2.79	$2.81	$2.83	$2.85	$2.87
Total Costs (excluding medica, marketing, & variable) ($/head)	$91.99	$92.62	$93.25	$93.88	$94.51	$95.14	$95.77
GAIN (lb/head)	366.0	366.0	366.0	366.0	366.0	366.0	366.0
COST OF GAIN (excl med, mkting, & var costs) ($/head)	$91.99	$92.62	$93.25	$93.88	$94.51	$95.14	$95.77
COST OF GAIN (excl. med, mkting, & var costs) ($/lb)	$0.25	$0.25	$0.25	$0.26	$0.26	$0.26	$0.26
OTHER EXPENSES:							
Stocker Purchase Costs	$483.08	$514.97	$557.13	$605.59	$651.59	$704.31	$757.62
Interest cost of stocker purchase ($/head)	$14.45	$15.41	$16.67	$18.12	$19.49	$21.07	$22.67
Medical Costs ($/head)	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00
Marketing Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Variable Costs ($/head/month)	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Interest cost of med, mkting, & var costs ($/head)	$1.36	$1.36	$1.36	$1.36	$1.36	$1.36	$1.36

PROFIT ANALYSIS:	Heifers 375 lb	Heifers 425 lb	Heifers 475 lb	Heifers 525 lb	Heifers 575 lb	Heifers 625 lb	Heifers 675 lb
PURCHASING EXPENSES:							
Purchase Weight (lb)	375	425	475	525	575	625	675
Purchase Price ($/cwt)	$128.82	$121.17	$117.29	$115.35	$113.32	$112.69	$112.24
Stocker Purchase Costs	$483.08	$514.97	$557.13	$605.59	$651.59	$704.31	$757.62
PRODUCTION INFORMATION:							
Average Daily Gain during Receiving (lb/head/day)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Average Daily Gain on pasture (lb/head/day)	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Stocking Density (head/acre)	0.8	0.7	0.6	0.6	0.5	0.5	0.4
Stocking Density (lb/acre)	281.25	276.25	285	288.75	287.5	281.25	270
Death Loss %	2%	2%	2%	2%	2%	2%	2%
PRODUCTION COSTS:							
Medical Costs ($/head)	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00
Marketing Costs ($/head)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Other Variable Costs ($/head/month)	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Cost of Gain (excl. med, mkting, & var costs) ($/head)	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Interest Rate (annual %)	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%	7.0%
Interest Cost	$18.55	$19.51	$20.77	$22.22	$23.60	$25.17	$26.77
Total costs ($/head)	$638.73	$671.58	$715.00	$764.91	$812.29	$866.59	$921.49
REVENUE:							
Sale Weight (lb)	741.0	791.0	841.0	891.0	941.0	991.0	1041.0
Sale Price ($/cwt)	$100.89	$98.22	$95.76	$92.87	$90.37	$87.98	$85.65
Stocker Revenue ($/head)	$732.61	$761.39	$789.25	$810.95	$833.39	$854.45	$873.81
Other Revenue	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Revenue ($/head)	$732.61	$761.39	$789.25	$810.95	$833.39	$854.45	$873.81
NET RETURNS ($/head)	$93.88	$89.81	$74.25	$46.04	$21.10	-$12.14	-$47.68
NET RETURNS ($/acre)	$70.41	$58.38	$44.55	$25.32	$10.55	-$5.46	-$19.07
NET RETURNS PER lb OF GAIN ($/lb)	$0.26	$0.25	$0.20	$0.13	$0.06	-$0.03	-$0.13
BREAK-EVEN SELLING PRICE ($/cwt)	$87.96	$86.64	$86.75	$87.60	$88.08	$89.23	$90.33

Figure III-3. Stocker Purchasing Planner – Heifer Analysis Section 3.

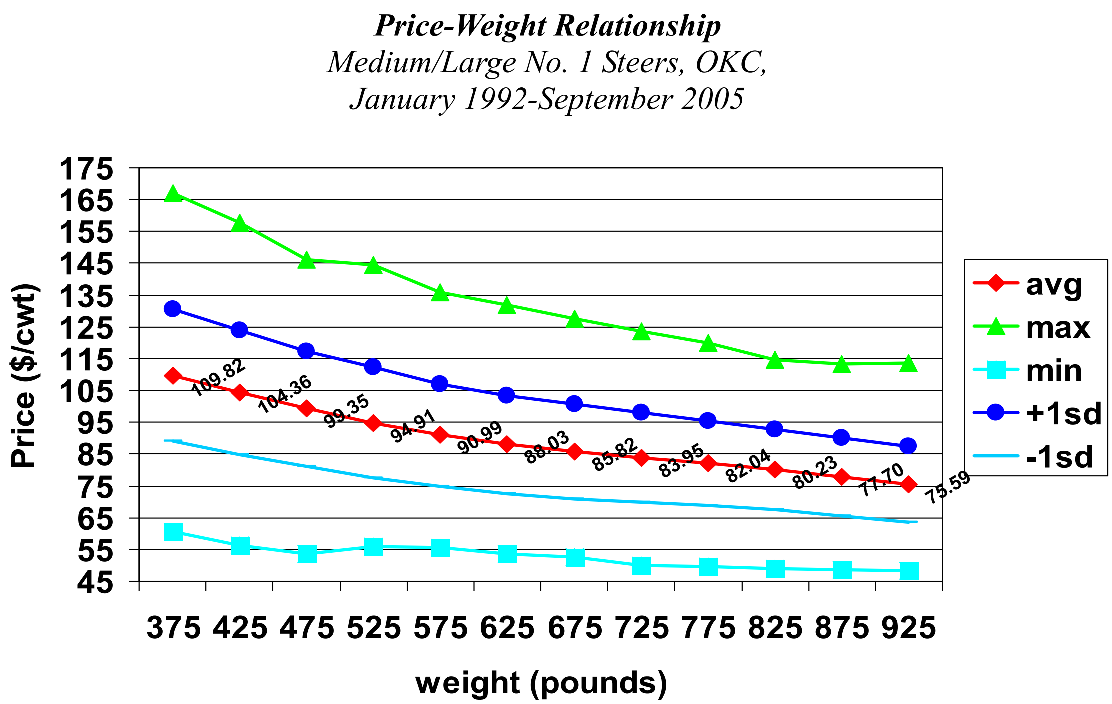


Figure III-4. **Price-Weight Relationship based on Oklahoma City Prices for Medium and Large Frame #1 Steers.**

Source: www.lmic.info

Oklahoma State University Stocker Planner

SECTION 1

RED FONT --> Enter Production Data — NAME: **NAME**

BLUE FONT --> Calculated Automatically — DATE: **1-Apr-07**

Assumption: Cattle are purchased in the fall and are currently grazing on Winter Wheat Pasture.

Purchasing and Selling Dates:

Stocker Purchase Date	1-Oct-06	
Number of days in Receiving Program	21	
Number of days grazed on Fall-Winter Wheat Pasture	135	

Expected Winter Grazing Termination Date 6-Mar-07

Stocker (Steer or Heifer) Production Data

Cattle purchase weight (lbs)	575	lb/head
Cattle cost per cwt	$120.60	$/cwt
Cattle cost per head	$693.45	$/head
Average Daily Gain (ADG) in Receiving	2.0	lb/head/day
Average Daily Gain (ADG) on Pasture	2.5	lb/head/day
Death Loss	2%	Percent
Stocking Density during Winter Grazing	0.5	head/acre
Stocking Density during Winter Grazing	287.5	lb/acre
Medical Costs	$20.00	$/head
Marketing Costs	$10.00	$/head
Variable Costs ($/month)	$3.00	$/head/month
Cost of Gain (all other costs)	$0.20	$/lb
Interest Rate	7.0%	Annual Percent

Purchase Prices

Stocker (lb/head)	Market $/cwt	Own $/cwt
300-350	$163.00	
350-400	$146.93	
400-450	$140.02	
450-500	$132.10	
500-550	$124.58	
550-600	$120.60	
600-650	$121.41	
650-700	$119.69	
700-750	$118.63	
750-800	$115.80	
800-850	$114.46	

Market prices based on 29-Sep-06

Selling Prices

Stocker (lb/head)	Market $/cwt	Own $/cwt
600-650	$111.00	
650-700	$105.75	
700-750	$102.07	
750-800	$99.49	
800-850	$96.77	
850-900	$94.93	
900-950	$93.72	
950-1000	$93.24	
1000-1050	$90.77	
1050-1100	$88.37	
1100-1150	$86.03	

Market prices based on 2-Mar-07

PROJECTED INCOME AND EXPENSES (Sold at FHS)

EXPENSES:	Total	Daily
Stocker Purchasing Costs ($/head)	$693.45	$4.45
Expected weight gain (lb/head)	379.5	2.4
Costs of Gain ($/lb)	$75.90	$0.49
Other Costs ($/head)	$45.60	$0.29
Interest Costs ($/head)	$24.38	$0.16
Total Costs ($/head)	$839.33	$5.38
STOCKER INCOME:		
Stocker Selling Weight (lb/head)	954.5	6.1
Stocker Selling Price ($/cwt)	$90.38	$0.58
Stocker Revenue ($/head)	$845.45	$5.42
STOCKER NET RETURNS ($/head)	$6.11	$0.04
STOCKER NET RETURNS ($/acre)	$3.06	$0.02
STOCKER NET RETURNS PER lb OF GAIN ($/lb)	$0.02	
BREAK-EVEN SELLING PRICE ($/cwt)	$89.73	
WHEAT INCOME:		
Wheat Selling Price ($/bushel)	$4.00	
Wheat Yield (bushels/acre)	34.0	
Wheat Harvest Cost ($/acre)	$0.00	
Wheat Income ($/acre)	$136.00	

STOCKER AND WHEAT NET RETURNS ($/acre)	$139.06	

* Warning: Based on given assumptions. *

Graze Out and Wheat Production Data

Date Winter Grazing Begins	22-Oct-06	
Stocking Density during Winter Grazing	0.5	head/acre
Stocking Density during Winter Grazing	287.5	lb/acre
Expected Winter Grazing Termination Date	6-Mar-07	
Expected Graze Out Start Date	6-Mar-07	
Number of Graze Out Days	45	days
Expected Stocker Sale Date (after Graze Out)	20-Apr-07	
Average Daily Gain during Graze Out	2.7	lb/head/day
Stocking Density during Graze Out	2.0	head/acre
Stocking Density during Graze Out	1870.8	lb/acre
Cost of Gain during Graze Out	$0.25	$/lb
Percent of Total Acres Grazed Out	25%	Percent Grazed Out
Expected Wheat Yield at or before FHS	34.0	bushels/acre
Expected Wheat Yield loss from ext. grazing	0.9	bushels/acre/day
Expected Wheat Price	$4.00	$/bushel
Wheat Harvest Cost	$0.00	$/acre

PROJECTED PROFIT OF WINTER GRAZING AND GRAZE OUT (RELATIVE TO FHS)

Winter Grazing & Grain			Full Season Grazing				
Winter Grazing Termination Date	Net Returns Winter Grazing & Grain ($/acre)	BE Selling Price ($/cwt)	Date Graze Out Begins	Graze Out End & Stocker Sale Date	Net Returns Full Grazing Season ($/acre)	BE Selling Price ($/cwt)	Net Returns Full Grazing Season & Grain ($/acre)
2 weeks before FHS	$143	$92	20-Feb-07	6-Apr-07	$28	$84	$115
1 week before FHS	$148	$91	27-Feb-07	13-Apr-07	$12	$83	$114
At FHS	$139	$90	6-Mar-07	20-Apr-07	$34	$82	$113
1 week after FHS	$122	$89	13-Mar-07	27-Apr-07	$20	$81	$96
2 weeks after FHS	$99	$88	20-Mar-07	4-May-07	$3	$80	$75

*** Optimal time to terminate Winter Grazing ***
1 week before FHS
Net Returns ($/acre) **$148**

*** Optimal time to end Winter Grazing and begin Graze Out ***
20-Feb-07
Net Returns ($/acre) **$115**

Figure III-5. Stocker Selling Planner – Summary Section 1.

SECTION 2

FALL-WINTER GRAZING ANALYSIS:

Stocker Data

Cattle purchase weight (lbs)	575	lb/head
Cattle cost per cwt	$120.60	$/cwt
Cattle cost per head	$693.45	$/head
Average Daily Gain (ADG) in Receiving	2.0	lb/head/day
Average Daily Gain (ADG) on Pasture	2.5	lb/head/day
Death Loss	2.0%	Percent
Stocking Density	0.5	head/acre
Medical Costs	$20.00	$/head
Marketing Costs	$10.00	$/head
Variable Costs ($/month)	$3.00	$/head/month
Cost of Gain (all other costs)	$0.20	$/lb
Interest Rate	7.0%	% annually

Winter Grazing Data

Date Winter Grazing Begins	22-Oct-06	
Winter Grazing Stocking Density	0.5	head/acre
Winter Grazing Stocking Denisty	287.5	lb/acre
Expected First Hollow Stem Date	6-Mar-07	
Expected Winter Grazing Termination Date	6-Mar-07	

Wheat Data

Expected Wheat Yield at or before FHS	34.0	bushel/acre
Wheat Yield loss from ext. grazing	0.9	bushel/acre/day
Expected Wheat Price	$4.00	$/bushel
Harvest Cost	$0.00	$/acre

PROJECTED INCOME AND EXPENSES - STOCKER AND WHEAT RETURNS RELATIVE TO FIRST HOLLOW STEM (FHS)

	2 weeks before FHS	1 week before FHS	At FHS	1 week after FHS	2 weeks after FHS
DATE:					
Stocker Removal and Selling Date	20-Feb-07	27-Feb-07	6-Mar-07	13-Mar-07	20-Mar-07
STOCKER EXPENSES:					
Stocker Purchasing Costs ($/head)	$693.45	$693.45	$693.45	$693.45	$693.45
Expected weight gain (lb/head)	344.5	362.0	379.5	397.0	414.5
Costs of Gain ($/head)	$68.90	$72.40	$75.90	$79.40	$82.90
Other Stocker Costs ($/head)	$44.20	$44.90	$45.60	$46.30	$47.00
Interest Costs ($/head)	$21.96	$23.17	$24.38	$25.61	$26.84
Total Stocker Costs ($/head)	$828.51	$833.92	$839.33	$844.76	$850.19
STOCKER REVENUE:					
Stocker Selling Weight (lb/head)	919.5	937.0	954.5	972.0	989.5
Stocker Selling Price ($/cwt)	$93.59	$93.49	$90.38	$90.95	$90.49
Stocker Revenue ($/head)	$843.35	$858.44	$845.45	$866.35	$877.52
Stocker Revenue ($/acre)	$421.68	$429.22	$422.72	$433.17	$438.76
NET RETURN ($/head)	$14.84	$24.52	$6.11	$21.59	$27.32
NET RETURN ($/acre)	$7.42	$12.26	$3.06	$10.80	$13.66
NET RETURN PER lb OF GAIN ($/lb)	$0.04	$0.07	$0.02	$0.05	$0.07
BREAK-EVEN SELLING PRICE ($/cwt)	$91.94	$90.81	$89.73	$88.68	$87.68
WHEAT INCOME:					
Wheat Price ($/bushel)	$4.00	$4.00	$4.00	$4.00	$4.00
Wheat Yield (bushels/acre)	34.0	34.0	34.0	27.7	21.4
Wheat Harvest Cost ($/acre)	$0.00	$0.00	$0.00	$0.00	$0.00
Wheat Income ($/acre)	$136.00	$136.00	$136.00	$110.80	$85.60
STOCKER AND WHEAT NET RETURN ($/acre)	$143.42	$148.26	$139.06	$121.60	$99.26
NET RETURN loss/gained relative to FHS ($/acre)	$4.36	$9.20	-	-$17.46	-$39.80

Optimal Time to Terminate Grazing and
*** Sell Stocker Cattle ***
1 week before FHS
Net Return ($/acre) $148.26

* Warning: Profits and Break-even selling prices are based on the entered production data. Confirm assumptions before making conclusions.

Figure III-6. Stocker Selling Planner – Fall-Winter Grazing Analysis Section 2.

SECTION 3

FULL SEASON GRAZING (GRAZE OUT) ANALYSIS:

Stocker Data (during Winter Grazing)

Cattle purchase weight (lbs)	575	lb/head
Cattle cost per cwt	$120.60	$/cwt
Cattle cost per head	$693.45	$/head
Average Daily Gain (ADG) in Receiving	2.0	lb/head/day
Average Daily Gain (ADG) on Pasture	2.5	lb/head/day
Death Loss	2.0%	Percent
Stocking Density during Winter Grazing	0.5	head/acre
Stocking Density during Winter Grazing	287.5	lb/acre
Medical Costs	$20.00	$/head
Marketing Costs	$10.00	$/head
Variable Costs ($/month)	$3.00	$/head/month
Costs of Gain (all other costs)	$0.20	$/lb
Interest Rate	7.0%	% annually

Stocker Data (during Graze Out)

Expected FHS Date	6-Mar-07	
Expected Graze Out Start Date	6-Mar-07	
Number of Graze Out Days	45	days
Expected Graze Out End Date	20-Apr-07	
Average Daily Gain during Graze Out	2.7	lb/head/day
Stocking Density during Graze Out	2.0	head/acre
Expected Weight on Graze Out Start Date	954.5	
Stocking Density during Graze Out	1909.0	lb/acre
Cost of Gain during Graze Out	$0.20	$/lb
Percent of Total Acres Grazed Out	25%	Percent Grazed Out

Wheat Data:

Expected Wheat Yield at or before FHS	34.0	bushel/acre
Wheat Yield loss from ext. grazing	0.9	bushel/acre/day
Expected Wheat Price	$4.00	$/bushel
Wheat Harvest Cost	$0.00	$/acre

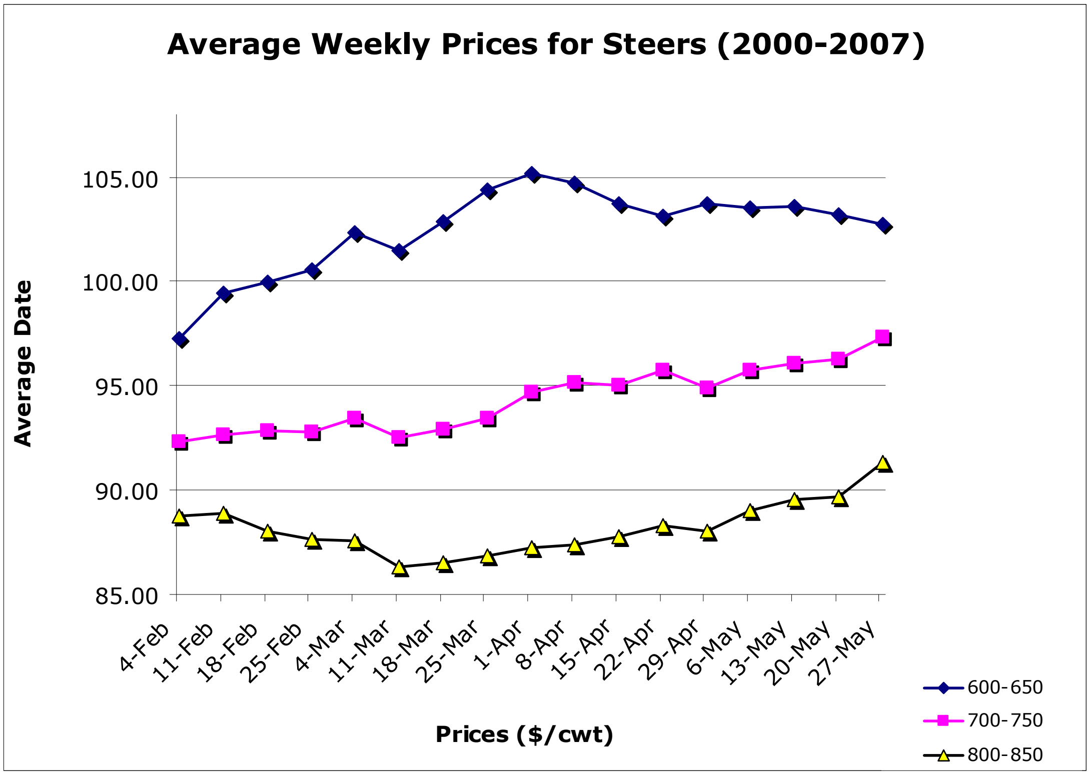
PROJECTED INCOME AND EXPENSES - STOCKER AND WHEAT RETURNS

Expected Graze Out Start Date	20-Feb-07	27-Feb-07	6-Mar-07	13-Mar-07	20-Mar-07
Expected Weight on Graze Out Start Date	919.5	937.0	954.5	972.0	989.5
Expected Graze Out End Date	6-Apr-07	13-Apr-07	20-Apr-07	27-Apr-07	4-May-07
Expected Weight on Graze Out End Date	1041.0	1058.5	1076.0	1093.5	1111.0
STOCKER EXPENSES:					
Stocker Purchasing Costs ($/head)	$693.45	$693.45	$693.45	$693.45	$693.45
Expected weight gain during Winter Grazing(lb/head)	344.5	362.0	379.5	397.0	414.5
Cost of Gain during Winter Grazing ($/head)	$68.90	$72.40	$75.90	$79.40	$82.90
Expected weight gain during Graze Out (lb/head)	121.5	121.5	121.5	121.5	121.5
Cost of Gain during Graze Out ($/head)	$24.30	$24.30	$24.30	$24.30	$24.30
Other Stocker Costs ($/head)	$44.20	$44.90	$45.60	$46.30	$47.00
Interest Costs ($/head)	$22.17	$23.38	$24.59	$25.82	$27.05
Total Stocker Costs ($/head)	$853.02	$858.43	$863.84	$869.27	$874.70
STOCKER REVENUE:					
Stocker Selling Weight (lb/head)	1,041.0	1,058.5	1,076.0	1,093.5	1,111.0
Stocker Selling Price ($/cwt)	$86.09	$85.09	$83.96	$83.57	$82.35
Stocker Revenue ($/head)	$878.26	$882.68	$885.29	$895.52	$896.62
NET RETURN FROM WINTER GRAZING & GRAZE OUT($/head)	$25.24	$24.25	$21.45	$26.25	$21.92
NET RETURN FROM WINTER GRAZING & GRAZE OUT ($/grazed acre)	$28.21	$11.72	$33.72	$20.11	$2.85
BREAK-EVEN SELLING PRICE ($/cwt)	$83.62	$82.75	$81.92	$81.12	$80.34
NET RETURN FROM GRAZE OUT ONLY ($/head)	$10.40	-$0.27	$15.33	$4.66	-$5.40
NET RETURN FROM GRAZE OUT ONLY ($/grazed acre)	$20.80	-$0.54	$30.67	$9.31	-$10.81
NET RETURN PER lb OF TOTAL GAIN ($/lb)	$0.05	$0.05	$0.04	$0.05	$0.04
WHEAT INCOME:					
Wheat Selling Price ($/bushel)	$4.00	$4.00	$4.00	$4.00	$4.00
Wheat Yield (bushels/acre)	34.0	34.0	34.0	27.7	21.4
Wheat Harvest Cost ($/acre)	$0.00	$0.00	$0.00	$0.00	$0.00
Wheat Income ($/acre)	$136.00	$136.00	$136.00	$110.80	$85.60
NET RETURN FROM FULL SEASON GRAZING & WHEAT ($/acre)	$114.62	$114.13	$112.72	$96.22	$75.16

Optimal Time to Start
*** Graze Out ***
20-Feb-07
Net Return ($/acre) $115

* Warning: Profits and Break-even selling prices are based on the entered production data. Confirm assumptions before making conclusions.

Figure III-7. Stocker Selling Planner – Full Season Grazing (Graze-Out) Analysis Section 3.



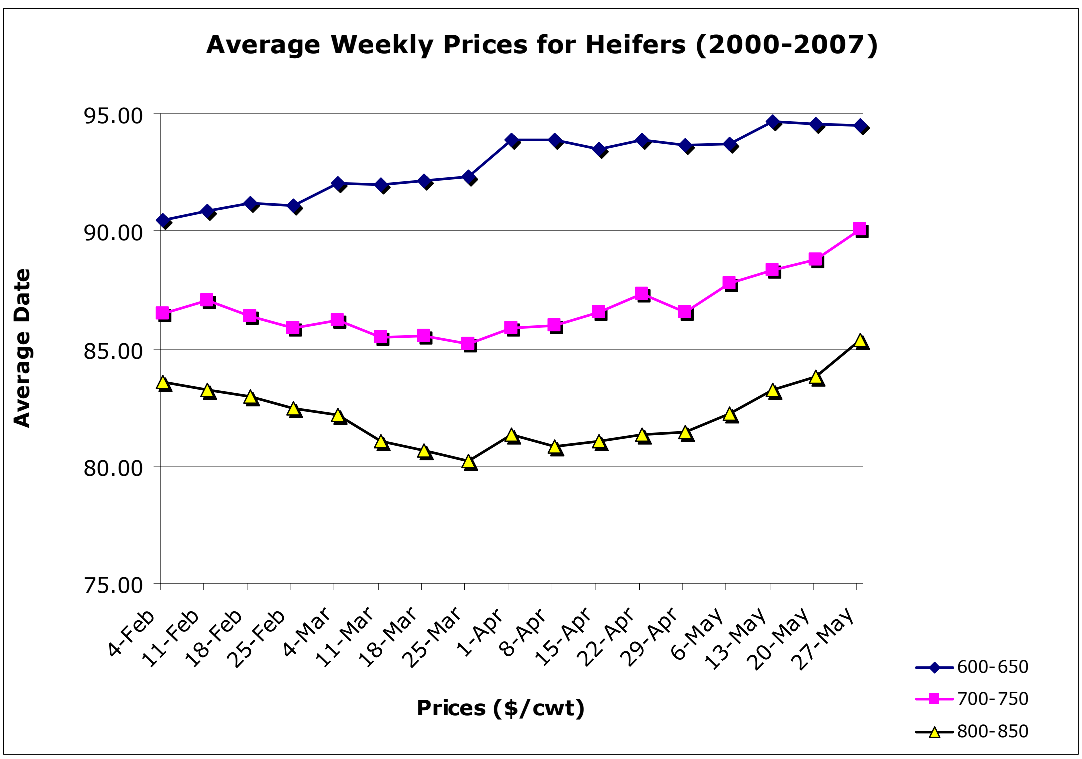


Figure III-8. **Weekly Oklahoma City Prices for Medium and Large Frame # 1 Steers and Heifers (2000-2007).**

VITA

Karen Wiebke Taylor

Candidate for the Degree of

Doctor of Philosophy

Thesis: DUAL-PURPOSE WINTER WHEAT AND STOCKER PRODUCTION

Major Field: Agricultural Economics

Biography:

Personal Data: Born in Dawsen Creek, British Columbia, Canada, on August 12, 1978, the daughter of father Theodor Peters and mother Lena Peters.

Education: Graduated from Wetaskiwin Composite High School, Wetaskiwin, Alberta, June 1996; received a Bachelor of Arts degree in Business Economics from the University of Saskatchewan, Saskatoon, Saskatchewan, August 2000; received a Master of Business Administration from the University of Guelph, Guelph, Ontario, February 2003; completed the requirements for the Doctor of Philosophy at Oklahoma State University in May 2007.

Experience: Graduate Research Assistant, Oklahoma State University Department of Agricultural Economics, August 2004 to May 2007; Senior Agricultural Account Manager, Royal Bank of Canada, May 2003 to August 2004; Financial and Customer Service Representative, Surrey Metro Savings, January 2001 to August 2002; Rentals Agent, Traveland Recreational Vehicle Supercentre, summers of June 1997 to September 2000.

Name: Karen W. Taylor Date of Degree: May 2007

Institution: Oklahoma State University

Title of Study: DUAL-PURPOSE WINTER WHEAT AND STOCKER PRODUCTION

Pages in Study: 126 Candidate for the degree of Doctor of Philosophy

Major Field: Agricultural Economics

Scope and Method of Study: The purpose of this study was to research the dual-purpose winter wheat and stocker industry in the Southern Plains. Three research studies were conducted. The first study was performed to determine the value of two monensin supplementation strategies for stocker cattle pastured on fall-winter wheat relative to the value of a free-choice mineral supplement containing no monensin. A second objective was to determine the value of extending the fall-winter wheat pasture grazing season by either one or two weeks. An enterprise budgeting framework was used to simulate returns values and then stochastic efficient with respect to a function (SERF) was performed to find risk efficient production strategies. The second study determined the optimal grazing termination date for dual-purpose winter wheat that maximizes the returns of cattle and wheat production. A second objective was to determine the value of information regarding the occurrence of first hollow stem (FHS). A profit maximization model was used. Price response functions to determine stocker sale prices and a unique plateau function to find wheat yields were found. Econometric analysis was performed and a grid search was done to determine the optimal grazing termination date. The third study constructed a dual-purpose winter wheat and stocker production planner. The stocker planner is intended to aid stocker producers determine the optimal purchase stocker weight and gender that maximizes net returns, given specific production data. The decision tool is also designed to determine the optimal time to terminate fall-winter grazing on wheat intended for grain harvest and the optimal time to concentrate animals on the proportion of wheat acres to be grazed-out. Budgets were used to perform income analysis based on production information that is entered by the user.

Findings and Conclusions: The first study found that returns are greater when stocker cattle are fed a monensin containing supplement compared to high-calcium mineral. The value of grazing one or two additional weeks increased stocker returns at a decreasing rate, indicating that grazing a second additional week is less valuable that the first additional week, and was less for steers than heifers. The second study found that the optimal time to terminate grazing is at or before first hollow stem (FHS). However, the costs per acre of grazing past FHS may be minimal depending on cattle and wheat prices, forage availability, cattle gains, wheat yields, and the weight of cattle. The third study is an online decision aid.

Advisor's Approval ______________________________