# WHOLE-FARM ECONOMIC EVALUATION OF CONSERVATION TILLAGE WINTER SMALL GRAINS FORAGE PRODUCTION IN ARKANSAS

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## ABSTRACT

Winter grazing of stocker cattle on small grain pastures may be a profitable income option for cattle and wheat producers in Arkansas. However, a large portion of land that could potentially benefit from this production system is highly erodible. This study evaluates the profitability of conservation tillage winter wheat/rye pasture production and grazing for a 100-head cow-calf operation. The study uses Mixed Integer Programming (MIP) to maximize whole-farm returns and select the optimal machinery complement for hay and winter forage production. Results indicate that no-till winter small grains forage production can enhance profitability for a cow-calf operation if steer calves are retained past weaning and placed on winter forage and if additional steer calves are purchased to fully utilize available winter forage capacity. However, profitability is highly dependent on the amount of capital available for purchase of additional steers.

## INTRODUCTION

Winter wheat is one of the most common winter annuals grown in the United States due to its high forage quality and adaptability to a wide rage of climates. Soft red winter wheat is the common wheat type grown in the southern United States and is the primary wheat type produced in Arkansas. Soft red winter wheat is almost exclusively produced for grain in the state, with nearly 80 percent of total wheat area planted in eastern Arkansas.

Production systems that integrate stocker cattle with soft red winter wheat may have value both in Arkansas and the southern United States. Research conducted from 1996 to 2001 at the Livestock and Forestry Branch Station (LFBS) near Batesville, Arkansas demonstrated that stocker calves can be productively grazed on soft red winter wheat during the winter (Daniels et. al., 2002). However, conventional "clean till" planting methods were used exclusively in this research. Much of the land area that could potentially be used for production of winter wheat forage in Arkansas is highly erodible, and practices that maintain surface residue such as reduced till or no-till may be more appropriate in areas susceptible to soil erosion.

A second study conduced from Fall 2003 - Spring 2006 at the LFBS used partial budget analysis to evaluate the profitability of grazing stocker calves on soft red winter wheat and rye forage planted with conservation tillage methods (Gadberry et al., 2007). Steer weight gain and forage production data were used to calculate returns and costs to Clean-Till (CT), Reduced Till (RT), and No-Till (NT). The NT system produced the largest average return per acre during the study period ($69.18/acre), followed by the RT system ($40.15/acre). The CT system had a negative average return over the study period (-$16.69/acre). Lower forage production costs and higher fall weight gains were the primary reasons for greater profitability of the conservation tillage systems relative to the CT system.

The latter study demonstrated that conservation tillage systems can be more profitable than clean till systems in the production of winter small grains forage but provided no evidence that such systems would enhance profitability for a typical cattle operation in Arkansas. Cow-calf operations account for the majority of cattle operations in the state, with most calves born in the spring and sold at weaning in the fall (Troxel et al., 2004). Winter small grains forage production may allow some cow-calf operators to retain ownership of their calves beyond the fall or purchase additional calves to be sold in the spring when the winter pasture is grazed out. However, production of winter small grains forage requires additional machinery and equipment that may not be available on most Arkansas cattle farms.

This study uses Mixed Integer Programming (MIP) to evaluate the whole-farm profitability of conservation tillage winter wheat/rye pasture production and grazing for a 100-head cow-calf operation. The MIP model incorporates steer weight gain and forage dry matter yield data from the ongoing LFBS conservation tillage study and selects the optimal machinery complement for hay and winter small grains forage production, the optimal number of pasture, hay, and grazeout acres, and the optimal number of animal units sold to maximize whole-farm returns for the 100-head cow-calf operation.

## MATERIALS AND METHODS

A 100-head cow-calf operation is modeled using secondary data from Hogan et al. (2006) and King Brister et al. (2002a). The model cow-calf operation has 250 pasture acres, owns its own hay equipment, and harvests it own hay. Eighty-seven animal units of various types are sold each year for the cow-calf operation. Additional details on pasture acres and types of animal units sold for the cow-calf operation are presented in Table 1.

A stocker enterprise is modeled for the cow-calf operation to allow steers to be grazed on winter wheat/rye pasture from mid-November through April. Steer calves in the stocker enterprise are grazed both in the fall and the spring. During the fall grazing period, steer calves from the cow-calf operation may be retained and placed on grazeout pasture with additional steer calves purchased as needed to fully utilize fall grazeout pasture. Additional steers may also be purchased during the spring grazing period to fully utilize spring grazeout pasture capacity. All additional steers are purchased using borrowed capital at 9% interest. Fall steers (retained and purchased) are placed on grazeout pasture beginning in mid-November and sold at the end of April. Additional spring purchased steers are placed on grazeout pasture at the beginning of March and sold at the end of April. Information on the purchase weights, sell weights, and prices used in the stocker enterprise are presented in Table 1.

The MIP model selects optimal machinery complements for both hay production and winter small grains forage production. Three possible systems are allowed for winter small-grains forage production: Clean-Till (CT); Reduced Till (RT); and No-Till (NT). The CT strategy consists of chisel plowing to a depth of 10 inches and heavy disking followed by use of a light disc or cultivator for weed control. Winter wheat and rye seed are planted into the prepared seedbed using a grain drill. The RT strategy consists of applying glyphosate one week prior to planting, followed by no more than two light disking passes with 50 percent residue remaining on the soil surface. A broadcast spreader is used to plant winter wheat and rye seed, and a harrow is used to drag the field to cover the seed. The NT strategy controls weeds exclusively using one application of glyphosate 2 weeks prior to planting. Wheat and rye seed is planted directly into the stubble using a no-till drill.

Annual machinery ownership expenses (depreciation, interest, housing, insurance, and taxes) are estimated for each tractor and implement using American Society of Agricultural Engineers (ASAE) standard formulas (ASAE, 2003a,b) and are adjusted downward by the ratio of the used price to list price to reflect used rather than new equipment. Machinery complements and annual ownership expenses for the cow-calf operation with and without winter small grains pasture are presented in Table 2. Machinery operating expenses are also estimated using ASAE standard formulas. Machinery operating expenses include repairs and maintenance, fuel, engine oil, and labor. Balance rows are included in the model to purchase machinery labor at $8.12/hr and off-road diesel at $2.20/gallon. An additional $0.33/gallon is added to the off-road diesel price to account for oil expenses. Non-machinery operating expenses related to seed, fertilizer, and herbicides are estimated based on average input data from the experimental winter small grains pastures at the LFBS.

Fall and spring wheat/rye forage production for the three tillage treatments is modeled using forage dry matter yield data from the LFBS (Bowman et al. 2005). Pasture utilization is estimated to be 73% for fall forage and 78% for spring forage based on the amount of forage left in the field as non-consumptive losses reported in Krenzer et al. (1996). The amount of fall and spring forage demanded per steer is estimated by multiplying the average grazing days for the LFBS study during the fall 2003–spring 2006 period by a forage consumption rate of 14 lbs per day obtained from Krenzer et al. Dry matter yields, pasture utilization, and pasture forage demand data for fall, spring, summer, and hay pasture in the cow-calf operation are obtained from King Brister et al. (2002a). Steer receiving expenses used in the MIP model for fall purchased steers, spring purchased steers and retained steers are presented in Table 3. Steer receiving expenses are estimated based on historical receiving data from the LFBS and data reported in King Brister et al. (2002b). Other operating expense data for the cow-calf operation (salt and minerals, vaccination, health management, yardage, and other miscellaneous expenses) are obtained from Hogan et al.

## RESULTS AND DISCUSSION

Two scenarios are modeled in the study: Scenario 1 – no rented pasture included; and Scenario 2 – rented pasture included. For Scenario 1, the model selects the optimal number of grazeout acres from existing pasture for the stocker operation with available pasture held constant at 250 acres. For Scenario 2, additional pasture may be rented at $22/acre to ensure the total number of cow-calf animal units sold is held constant at 87 animals for a 100-head cow-calf operation. Cash rent for pasture is estimated as the average of the pasture rent reported for Missouri and that reported for Louisiana in 2005 by the USDA National Agricultural Statistics Service (USDA, NASS, 2006).

Optimal results under Scenario 1 are presented by capital level for the cow-calf operation in Table 4. The optimal net return for the 100-head cow-calf operation without winter grazeout is $5,041, with 136 spring and fall pasture acres, 82 summer pasture acres, and 32 hay acres. The optimal solution remains unchanged when zero capital if available. However, when available capital is set at $10,000 or more, the operation includes winter grazeout with NT always chosen as the optimal forage production method. Weaned steers from the cow-calf operation are retained for the stocker operation in all instances where capital funds are available. However, additional steers must be purchased either in the spring or in both the spring and the fall to achieve maximum returns. Optimal winter grazeout acres increase as available capital increases. However, grazeout acres are taken from available pasture acres, leaving fewer acres available for the cow-calf operation. The number of cow-calf units sold as well as the number of retained steers declines as available capital increases. Optimal net farm income ranges from $5,041 at zero capital available to $10,068 at $50,000 capital available.

Optimal results under Scenario 2 are presented by capital level for the cow-calf operation in Table 5. Rented pasture relaxes pasture acreage constraints for the cow-calf operation and allows additional pasture acres to enter the optimal solution. The number of cow-calf animal units sold remains constant across alternative capital levels, allowing the full allotment of weaned steers to be retained for the stocker enterprise. Winter grazeout acres enter the optimal solution even with no capital available to purchase additional steers. At zero capital available, the optimal solution calls for the operation to rent 33 pasture acres, produce 30 winter grazeout acres using NT, and retain all 43 weaned steers for the stocker enterprise. Additional capital available allows more pasture acres to be rented, increases the number of optimal winter grazeout acres, and allows the operation to purchase additional steers in either the spring or in both the fall and the spring. Optimal net farm income is enhanced by additional rented pasture acres and ranges from $5,496 with zero capital available to $12,438 with $50,000 capital available.

## CONCLUSION

The results provide evidence that grazing stocker cattle on no-till winter small grains forage can enhance profitability for a cow-calf operation. The farm operator may hold steer calves beyond weaning and graze them on winter grazeout pasture for sale in the spring rather than in the fall. However, the whole-farm profitability of grazing stocker cattle on no-till winter small grains forage appears to be highly dependent on the amount of capital available for purchase of additional steers. The results imply that additional steers must be purchased to fully utilize available winter forage capacity and achieve maximum returns. Available capital is very important for overall whole-farm profitability even when additional pasture acres may be rented to relax pasture constraints for the cow-calf operation. Thus the practice may not be profitable in instances where cow-calf operators lack the necessary capital to purchase additional steers.

## REFERENCES


ASAE. 2003a. ASAE standards, agricultural machinery management. St. Joseph, Michigan: ASAE-The Society for Engineering in Agriculture, Food, and Biological Systems, ASAE Publication No. EP496.2, 2003a.

ASAE. 2003b. ASAE standards, agricultural machinery management data. St. Joseph, Michigan: ASAE-The Society for Engineering in Agriculture, Food, and Biological Systems, ASAE Publication No. D497.4, 2003b.

Bowman, M.T., P.A. Beck, K.S. Lusby, S.A. Gunter, and D.S. Hubbell, III. 2005. No-till, reduced tillage, and conventional tillage systems for small-grain forage production. Ark. Animal Science Department Report 2005, Ark. Agri. Exp. Stat. Res. Series 535:80-82.

Cheney, S. and T. Troxel. 2006. Livestock market news roundup 1985-2005. Arkansas Livest. Grain Market News Serv. Arkansas Coop. Ext. Ser. Little Rock.

Daniels, L.B., K.F. Harrison, D.S. Hubbell, III, Z.B. Johnson, T.E. Windham, E.B. Kegley, and D. Hellwig. 2002. Production systems involving stocker cattle and soft red winter wheat. Ark. Agri. Exp. Stat. Res. Rep. 967.

Gadberry, S., M. Anders, P. Beck, and B. Watkins. 2007. Impact of conservation tillage practices on winter wheat production for grazing stocker cattle. Arkansas Coop. Ext. Ser. FSA3116-PD-4-07N.

Hogan, R. Jr., S. Gadberry, S. Gunter, and C. DeArmond. 2006. Estimating 2006 income and costs of production, cow-calf budget-100 cow herd, purchase replacement heifers. Arkansas Coop. Ext. Service. AG-969-4-06.

King Brister, S.K., M.P. Popp, and C. West. 2002a. Beef cow-calf production budgets for Arkansas, 2002. University of Arkansas, Department of Agricultural Economics and Agribusiness.

King Brister, S.K., M.P. Popp, and C. West. 2002b. Feeder cattle production budgets for Arkansas, 2002. University of Arkansas, Department of Agricultural Economics and Agribusiness.

Krenzer, E.G., Jr., A. R. Tarrant, D.J. Bernardo, and G.W. Horn. 1996. An economic evaluation of wheat cultivars based on grain and forage production. J. Prod. Agric., 9(1):66-73.

Troxel, T., J. Jennings, S. Gadberry, J. Powell, and T. Windham. 2004. Beef Cattle Production. Arkansas Coop. Ext. Serv. MP184-PD-5-04RV.

USDA, NASS. 2006. Land values and cash rents 2006 summary. November 2006.

Table 1. Select Input Data Used by the Mixed Integer Programming Model

| 100-Head Cow-Calf Operation | Head[1] | Sell Weight (lbs)[1] | Sell Price ($/cwt)[2] | |
|---|---|---|---|---|
| Cull Cows | 18 | 1,000 | 43.76 | |
| Cull Bulls | 1 | 1,800 | 55.98 | |
| Open Replacement Heifers | 7 | 850 | 49.92 | |
| Weaned Steer Calves | 43 | 530 | 100.69 | |
| Weaned Heifer Calves | 18 | 500 | 96.04 | |
| Total Cow-Calf Units Sold | 87 | | | |
| **Stocker Enterprise** | **Purchase Weight (lbs)** | **Sell Weight (lbs)[3]** | **Purchase Price ($/cwt)[2]** | **Sell Price ($/cwt)[2]** |
| Fall CT Steers | 400 | 731 | 116.69 | 94.55 |
| Fall RT Steers | 400 | 737 | 116.69 | 94.55 |
| Fall NT Steers | 400 | 759 | 116.69 | 94.55 |
| Spring CT Steers | 525 | 735 | 98.33 | 94.55 |
| Spring RT Steers | 525 | 747 | 98.33 | 94.55 |
| Spring NT Steers | 525 | 743 | 98.33 | 94.55 |

| Pasture | Acres[1] |
|---|---|
| Spring-Fall (Fescue) | 136 |
| Summer (Bermuda) | 82 |
| Hay (Bermuda) | 32 |
| Total Pasture | 250 |

[1]Based on secondary data from Hogan et al. (2006) and King Brister et al. 2002.
[2]Five year average prices for the period 2001-2005 from Cheney and Troxel (2006).
[3]Derived from steer weight gain data reported in Gadberry et al. (2007).

Table 2. Machinery Complements and Annual Machinery Ownership Expenses for Cow-Calf Operation With and Without Winter Small Grains Forage Production.

| | | Winter Forage Production: | | |
|---|---|---|---|---|
| Tractor/Implement | Cow-Calf | With CT | With RT | With NT |
| 2wd 75 | 1 | 1 | 1 | 1 |
| Hay Disk Mower - 10' | 1 | 1 | 1 | 1 |
| Hay Tedder - 17' | 1 | 1 | 1 | 1 |
| Hay Rake, Double - 17' | 1 | 1 | 1 | 1 |
| Hay Bailer, Large Round | 1 | 1 | 1 | 1 |
| Fertilizer Spreader - 20' | 1 | 1 | 1 | 1 |
| Sprayer, Broadcast - 27' | | | 1 | 1 |
| Disk - 10 ' | | 1 | 1 | |
| Harrow - 12 ' | | 1 | | |
| Cultipacker - 12' | | 1 | 1 | |
| Grain Drill 12' | | 1 | | |
| No-Till Grain Drill - 10' | | | | 1 |
| Ownership Expense ($/year) | 8,043 | 9,396 | 8,924 | 9,625 |

Table 3. Receiving Expenses for Purchased and Retained Steers

| Expense Item | Fall Steers Purchased | Spring Steers Purchased | Retained Steers |
|---|---|---|---|
| | ($/steer) | | |
| Death Loss [1] | 16.34 | 18.07 | 0.00 |
| Shrinkage [2] | 21.06 | 21.04 | 21.06 |
| Labor (Pasture Checking) | 3.90 | 2.34 | 3.90 |
| Minerals | 4.28 | 3.55 | 1.47 |
| Vet and Medical | 12.00 | 8.00 | 0.00 |
| Checkoff | 1.00 | 1.00 | 1.00 |
| Hauling | 8.00 | 8.00 | 4.00 |
| Total | 66.57 | 61.99 | 31.43 |

[1] Death loss calculated as 3.5 percent mortality multiplied by steer purchase value.
[2] Shrinkage calculated as 3 percent of steer sale value. Shrinkage may occur during the sales process due to stress during transport (King Brister et al. 2002b).

Table 4. Optimal Cow-Calf Operation MIP Model Output, Scenario 1 (No Rented Pasture)

| Output Item | 100-Head Cow-Calf Herd | Alternative Capital Levels ($) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 10,000 | 20,000 | 30,000 | 40,000 | 50,000 |
| | | Pasture (Acres) | | | | | |
| Spring and Fall (Fescue) Pasture | 136 | 136 | 120 | 119 | 115 | 110 | 106 |
| Summer (Bermuda) Pasture | 82 | 82 | 72 | 72 | 69 | 66 | 64 |
| Hay Land (Bermuda) | 32 | 32 | 31 | 33 | 34 | 35 | 35 |
| Winter Grazeout | 0 | 0 | 27 | 27 | 33 | 39 | 46 |
| Rented Pasture | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Pasture Used | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | Cow-Calf Units Sold (Head) | | | | | |
| Cows | 18 | 18 | 16 | 16 | 15 | 15 | 14 |
| Bulls | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Open Replacements | 7 | 7 | 6 | 6 | 6 | 6 | 5 |
| Weaned Steer Calves | 43 | 43 | 0 | 0 | 0 | 0 | 0 |
| Weined Heifer Calves | 18 | 18 | 16 | 16 | 15 | 15 | 14 |
| Number Cow-Calf Units Sold | 87 | 87 | 39 | 39 | 37 | 36 | 34 |
| | | Steers Grazed on Winter Grazeout (Head) | | | | | |
| CT Fall Weaned Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CT Fall Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CT Spring Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Fall Weaned Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Fall Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Spring Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NT Fall Weaned Steers | 0 | 0 | 38 | 37 | 36 | 35 | 33 |
| NT Fall Purchased Steers | 0 | 0 | 0 | 0 | 10 | 20 | 31 |
| NT Spring Purchased Steers | 0 | 0 | 19 | 39 | 49 | 59 | 69 |
| Total Steers Grazed on Winter Pasture | 0 | 0 | 57 | 76 | 95 | 114 | 133 |
| Whole Farm Net Return | 5,041 | 5,041 | 5,882 | 7,394 | 8,314 | 9,191 | 10,068 |

Table 5. Optimal Cow-Calf Operation MIP Model Output, Scenario 2 (Rented Pasture Included)

| Output Item | 100-Head Cow-Calf Herd | Alternative Capital Levels ($) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 10,000 | 20,000 | 30,000 | 40,000 | 50,000 |
| | | Pasture (Acres) | | | | | |
| Spring and Fall (Fescue) Pasture | 136 | 137 | 137 | 137 | 137 | 137 | 137 |
| Summer (Bermuda) Pasture | 82 | 82 | 82 | 82 | 82 | 82 | 82 |
| Hay Land (Bermuda) | 32 | 34 | 36 | 37 | 39 | 41 | 43 |
| Winter Grazeout | 0 | 30 | 30 | 30 | 35 | 42 | 49 |
| Rented Pasture | 0 | 33 | 35 | 37 | 43 | 52 | 60 |
| Total Pasture Used | 250 | 316 | 320 | 323 | 335 | 353 | 371 |
| | | Cow-Calf Units Sold (Head) | | | | | |
| Cows | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Bulls | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Open Replacements | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Weaned Steer Calves | 43 | 0 | 0 | 0 | 0 | 0 | 0 |
| Weined Heifer Calves | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Number Cow-Calf Units Sold | 87 | 44 | 44 | 44 | 44 | 44 | 44 |
| | | Steers Grazed on Winter Grazeout (Head) | | | | | |
| CT Fall Weaned Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CT Fall Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CT Spring Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Fall Weaned Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Fall Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RT Spring Purchased Steers | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NT Fall Weaned Steers | 0 | 43 | 43 | 43 | 43 | 43 | 43 |
| NT Fall Purchased Steers | 0 | 0 | 0 | 0 | 6 | 16 | 26 |
| NT Spring Purchased Steers | 0 | 0 | 19 | 39 | 53 | 63 | 74 |
| Total Steers Grazed on Winter Pasture | 0 | 43 | 62 | 82 | 102 | 122 | 142 |
| Whole Farm Net Return | 5,041 | 5,496 | 7,067 | 8,637 | 9,991 | 11,214 | 12,438 |