A Return-Risk Analysis of Traditional Row-Crop and Sod-Based Rotation Enterprises in the Wiregrass Region of Alabama

by

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Abstract

This study seeks to determine whether the sod-based rotation system provides farmers with a system that outperforms the traditional production system with respect to returns and risk. If the sod-based rotation system is not found to be a lower risk, higher return production system, then we want to determine which rotation is the optimal system to be adopted by farmers in the Wiregrass region. A Target MOTAD model was developed for this study to evaluate the return-risk relationships of seven enterprises for the Wiregrass Region of Alabama. The enterprises selected by the model were rain-fed traditional peanut-cotton rotation with government payments, irrigated land rented out, rain-fed land rented out, and the irrigated traditional peanut-cotton rotation. The sod-based rotation produces slightly more risk and less returns than the irrigated traditional peanut-cotton rotation for producers. The best use of land in the Wiregrass is the rain-fed traditional peanut-cotton rotation with government payments.

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Chapter I

Introduction

Row-crop and cattle production enterprises are economically important to Alabama. Together they generated approximately $884,000,000 of production in Alabama during 2010 (United States Department of Agriculture 2011). Over time the increased demand for agricultural products has resulted from: (1) an increasing U.S. population, (2) increases in both real and nominal U.S. consumer incomes, and (3) shifts in the use of resources in the agricultural sector to provide food, fiber, and energy among others. Additionally, economic events have contributed to the profit improvement of these enterprises. Profit improvements have resulted from many factors including: (1) technological changes in equipment, (2) agri-chemicals, (3) genetically modified seeds, and (4) the receipt of government payments.

Historically, the integration of row-crop and livestock enterprises were common for Alabama farmers. After advancements in plant genetics, machinery, cultural practices, and the availability of cheap energy a shift occurred from the diversification of agricultural enterprises to specialized production enterprises (Janick et al. 1996). However, more recently there is a growing awareness that the economic and ecological stability of agricultural land is being impaired by the specialization and concentration of row-crops (Franzluebbers 2007).

During the 1950-60's, Alabama farms were more diversified and had cattle as a part of mixed row-crop and cattle operations (United States Department of Agriculture 1997). Despite changes, there continues to be mixed enterprise farms in Alabama. Approximately one-half of the 48,000-plus farms in Alabama have cattle (United States Department of Agriculture 2011).

The average farm size in Alabama is about 186 acres. Currently, there is approximately 1.3 million head of cattle in the state that could be integrated into row-crop systems.

The southeast corner of Alabama is commonly known as the Wiregrass Region (Byrd 2009). This region's name originated from the spindly wiry grass that settlers found growing plentifully under tall longleaf pine forests. As with other studies, the geographic boundaries of this region will vary depending on who defines it. For the purpose of this study, the region will include Coffee, Covington, Dale, Geneva, Henry, and Houston counties of Alabama. The counties that are considered to make up the Wiregrass region for this study are highlighted in figure 1.

Figure 1. Wiregrass Region of Alabama

Source: Byrd 2009.

The traditional row-crop enterprises in the Wiregrass Region of Alabama have been peanuts and cotton (Byrd 2009). Farmers have typically rotated between these two crops year after year. Recent research at the Wiregrass Research and Extension Center in Headland, AL has focused on improving the performance of this traditional rotation. They have implemented an irrigated Sod-Based Rotation System (SBR) which includes row-crops, bahiagrass, and cattle. The system includes two years of bahiagrass followed by peanuts and then cotton. Therefore, the acreage is divided into four sections. The row-crops are rotated annually. The cattle utilized two sections of bahia in the warm season and three sections of winter annuals during the winter.

Research has shown that the yield of crops, such as peanuts and soybeans, can be improved by planting after perennial grasses such as bahiagrass (Wright et al. 2012). The yield improvement is generally greater than that obtained when planted after an annual crop such as cotton or corn (Brenneman et al. 2012). Greater yields per acre require an increase in the available crop nutrients, improved soil, and better crop management strategies. Therefore, alternative solutions may be needed in order to help improve the efficiency, recovery, and recycling of nutrients in our farmland (Zilberman 2013). A crop rotation system that includes bahiagrass has the potential to improve crop yield, soil health, risk management, and total farm income.

A sod-based rotation system which incorporates bahiagrass can be used to support beef cattle. It also provides annual winter cover crops and crop residues that can be used by the beef cattle. Integrating beef cattle into a sod-based rotation is believed to greatly increase the farm's overall profit potential, beyond simply producing bahiagrass hay for sale (Prevatt et al. 2008). Adding beef cattle to the system helps increase both production and income.

Changes in weather and the supply of water are a major concern for farmers in the Wiregrass Region. Crops require water at critical times of their growing cycle (Al-Kaisi and Broner 2009). The adoption of irrigation helps farmers guard their crops from dry weather losses. The adoption of irrigation has been increasing because of higher output prices, improved efficiency leading to higher yields, and to reduce the risk from higher input costs. Additionally, irrigation may be needed because of the reduced soil moisture holding capacity due to land that has lost organic matter from constant cropping and weather aberrations (Gassen and Gassen 1996). The adoption of irrigation has the potential to reduce the risk of climate variability by improving yields in years where drought persists. Yet, with the benefit of irrigation comes increased input costs. It is important to note that although farmers are increasingly adopting irrigation, most crops produced in the Wiregrass receive rain water only (Hollis 2011).

Background Situation

This section provides a general overview of United States economic conditions and three of the major agricultural enterprises produced in the Wiregrass region of Alabama. The following calculations will be provided from the statistics in each table: percent change from 1980 to 2011, average annual percent change, average value, and standard deviation for each measure.

Table 1 shows the general U.S. economic conditions including the annual U.S. Population, U.S. nominal per capita income, U.S. real per capita income, U.S. per capita cotton consumption, U.S. per capita peanut consumption, and U.S. per capita beef consumption, between 1980 and 2011. Although there have been fluctuating changes, the percentage change from 1980 to 2011 and average annual percentage changes were all positive, except for U.S. per capita beef consumption. The percentage change and average annual percentage change of U.S. per capita beef consumption was -25 percent and -0.9 percent, respectively. The decline in U.S. per capita beef consumption has been largely due to consumers substituting cheaper meat sources for beef, health issues, and a growing elderly population (Ward 2005).

The percentage change from 1980 to 2011 and the average annual percentage change for the U.S. per capita consumption of cotton was 86 percent and 2.3 percent, while for peanuts was 6 percent and 0.8 percent, respectively. Increasing incomes has supported increases in U.S. per capita consumption of cotton and peanuts (Marshall 1890). Additionally, other factors that have contributed to the increase in demand include tastes and preferences, price substitutes, and government policy changes.

Table 1. Percentage change in population, per capita nomial income, per capita real income, and per capita consumption United States, 1980-2011

Year	US Population	US Per Capita Nomial Income	US Per Capita Real Income	US Per Capita Cotton Consumption (lbs.)	US Per Capita Peanut Consumption (lbs.)	US Per Capita Beef Consumption (lbs.)
1980	227,225,000	$10,091	$10,091	14.6	12.8	76.4
1981	229,466,000	$11,209	$10,161	14.4	15.9	77.2
1982	231,664,000	$11,901	$10,162	13.5	14.4	76.9
1983	233,792,000	$12,583	$10,410	15.9	15.2	78.5
1984	235,825,000	$13,807	$10,950	16.8	15.2	78.3
1985	237,924,000	$14,637	$11,209	17.7	19.8	79.0
1986	240,133,000	$15,338	$11,531	20.3	14.7	78.7
1987	242,289,000	$16,137	$11,705	23.9	15.6	73.7
1988	244,499,000	$17,244	$12,011	21.7	16.3	72.5
1989	246,819,000	$18,402	$12,228	23.9	16.8	68.9
1990	249,623,000	$19,354	$12,202	23.6	14.6	67.5
1991	252,981,000	$19,818	$11,990	24.7	18.0	66.4
1992	256,514,000	$20,799	$12,216	27.8	15.6	65.9
1993	259,919,000	$21,385	$12,195	29.2	14.2	64.4
1994	263,126,000	$22,297	$12,397	30.3	15.9	66.1
1995	266,278,000	$23,262	$12,577	29.7	15.2	66.4
1996	269,394,000	$24,442	$12,836	29.4	13.9	67.0
1997	272,647,000	$25,654	$13,171	31.9	13.3	65.5
1998	275,854,000	$27,258	$13,780	33.4	13.0	66.5
1999	279,040,000	$28,333	$14,013	34.1	14.9	67.3
2000	282,172,000	$30,318	$14,508	34.4	12.8	67.5
2001	285,082,000	$31,145	$14,491	31.7	14.4	66.0
2002	287,804,000	$31,462	$14,411	33.8	13.9	67.5
2003	290,326,000	$32,271	$14,452	33.6	13.6	64.8
2004	293,046,000	$33,881	$14,779	33.8	13.8	65.9
2005	295,753,000	$35,424	$14,946	36.4	14.0	65.4
2006	298,593,000	$37,698	$15,408	36.3	14.0	65.7
2007	301,580,000	$39,392	$15,658	35.8	14.0	65.0
2008	304,375,000	$40,166	$15,372	33.0	13.6	62.1
2009	307,007,000	$39,138	$15,032	29.0	13.9	60.8
2010	309,330,000	$40,584	$15,336	32.1	14.2	59.4
2011	311,592,000	$41,663	$15,262	27.1	13.6	57.4
Percent Change 1980 to 2011	37%	313%	51%	86%	6%	-25%
Average Annual Percent Change	1.0%	4.7%	1.4%	2.3%	0.8%	-0.9%
Average	268,177,250	$25,222	$13,047	27.3	14.7	68.5
Standard Deviation	26,825,083	$9,884	$1,777	7.2	1.5	5.9

Sources: U.S. Census Bureau, U.S. Bureau of Economic Analysis, U.S. Department of Labor Statistics.

Table 2 describes the percentage change in cotton planted acres, harvested acres, total pounds of production, nominal production dollar value, yield, and the nominal average price. The percentage change from 1980 to 2011 and average annual percentage change were positive each year, except for the column entitled harvested acres. The percentage change from 1980 to 2011 for harvested acres was negative 28%. This was due to a severe drought in 2011 which limited harvested acres. The increases in the other variables document the significant improvements in cotton production. Particularly note the large increase in yield per acre between 1980 and 2011 of 96 percent and the average annual percentage change of 3 percent. The technology used to produce cotton has led to yield doubling over the last three decades (Mal et al 2012). The annual percentage change in the nominal dollar value of production and nominal average price per pound was 6.2% and 2.9%, respectively.

Additionally, government policy programs changes have influenced the acres planted to cotton. Significant changes occurred in the farm bill of 1985, 1996, and 2002 that affected the acreage planted to cotton (Westcott et al 2002).

Table 2. Percentage change in cotton planted acres, harvested acres, total pounds, dollar value, yield, and average price, United States, 1980-2011

Year	Planted Acres	Harvested Acres	Total Pounds of Production	Nomial Dollar Value of Production	Yield Lbs./Acre	Nomial Avg. Price $/Lb.
1980	14,533,800	13,214,800	5,338,779,200	$3,986,678,000	404	$0.75
1981	14,330,100	13,841,200	7,501,930,400	$4,075,403,000	542	$0.54
1982	11,345,400	9,733,900	5,743,001,000	$3,422,370,000	590	$0.60
1983	7,926,300	7,347,500	3,732,530,000	$2,482,802,000	508	$0.67
1984	11,145,400	10,379,100	6,227,460,000	$3,670,508,000	600	$0.59
1985	10,684,600	10,229,000	6,444,270,000	$3,628,112,000	630	$0.56
1986	10,044,600	8,468,400	4,674,556,800	$2,449,111,000	552	$0.52
1987	10,397,200	10,030,300	7,081,391,800	$4,555,017,000	706	$0.64
1988	12,514,800	11,948,200	7,395,935,800	$4,190,488,000	619	$0.57
1989	10,586,600	9,537,700	5,856,147,800	$3,877,888,000	614	$0.66
1990	12,348,100	11,731,600	7,437,834,400	$5,075,826,000	634	$0.68
1991	14,052,100	12,959,500	8,449,594,000	$4,913,244,000	652	$0.58
1992	13,240,000	11,123,300	7,786,310,000	$4,273,935,000	700	$0.55
1993	13,438,300	12,783,300	7,746,679,800	$4,520,908,000	606	$0.58
1994	13,720,100	13,322,300	9,432,188,400	$6,796,654,000	708	$0.72
1995	16,931,400	16,006,700	8,595,597,900	$6,574,612,000	537	$0.76
1996	14,652,500	12,888,100	9,086,110,500	$6,408,144,000	705	$0.71
1997	13,898,000	13,406,000	9,022,238,000	$5,975,585,000	673	$0.66
1998	13,392,500	10,683,600	6,677,250,000	$4,119,911,000	625	$0.62
1999	14,873,500	13,424,900	8,148,914,300	$3,809,560,000	607	$0.47
2000	15,517,200	13,053,000	8,249,496,000	$4,260,417,000	632	$0.52
2001	15,768,500	13,827,700	9,748,528,500	$3,121,848,000	705	$0.32
2002	13,957,900	12,416,600	8,257,039,000	$3,777,132,000	665	$0.46
2003	13,479,600	12,003,400	8,762,482,000	$5,516,761,000	730	$0.63
2004	13,658,600	13,057,000	11,163,735,000	$4,993,565,000	855	$0.45
2005	14,245,400	13,802,600	11,469,960,600	$5,695,217,000	831	$0.50
2006	15,274,000	12,731,500	10,363,441,000	$5,013,238,000	814	$0.48
2007	10,827,200	10,489,100	9,219,918,900	$5,652,907,000	879	$0.61
2008	9,471,000	7,568,700	6,153,353,100	$3,021,485,000	813	$0.49
2009	9,149,500	7,528,700	5,849,799,900	$3,787,971,000	777	$0.65
2010	10,974,200	10,698,700	8,687,344,400	$7,348,062,000	812	$0.85
2011	14,735,400	9,460,900	7,474,111,000	$7,262,941,000	790	$0.97
Pecent Change 1980 to 2011	1%	-28%	40%	82%	96%	30%
Average Annual Percent Change	1.3%	0.6%	3.9%	6.2%	3.0%	2.9%
Average	12,847,306	11,553,041	7,743,060,297	$4,633,071,875	672	1
Standard Deviation	2,189,444	2,122,976	1,792,927,922	$1,307,989,006	110	0.13

Source: National Agriculture Statistics Service.

Table 3 describes the percentage change in peanut planted acres, harvested acres, total pounds of production, nominal production dollar value, yield and the nominal average price. The percentage change from 1980 to 2011 and average annual percentage change were positive for each except the harvested acres. This was due to a severe drought in 2011 which limited harvested acres. The increases in the other variables document the significant improvements in peanut production. Particularly note the large increase in yield per acre between 1980 and 2011 of 101 percent and the average annual percentage change of 3.5 percent. The technology used to produce peanuts has led to yield doubling over the last three decades (Bader and Sumner 2012). The nominal annual percentage change in dollar value of production and average price per pound was 4.8% and 1.0%, respectively.

Additionally, government policy program changes have influenced the acres planted to peanuts. Significant changes occurred in the farm bill of 2002 with the elimination of the peanut quota which affected the acreage planted to peanuts (Westcott et al. 2002).

Table 3. Percentage change in peanuts planted acres, harvested acres, total pounds, dollar value, yield, and average price, United States, 1980-2011

Year	Planted Acres	Harvested Acres	Total Pounds of Production	Nomial Dollar Value of Production	Yield Lbs./Acre	Nomial Avg. Price $/Lb.
1980	1,521,400	1,399,800	2,302,671,000	$578,635,000	1,645	$0.25
1981	1,514,000	1,488,700	3,982,272,500	$1,069,526,000	2,675	$0.27
1982	1,311,400	1,277,400	3,440,038,200	$862,686,000	2,693	$0.25
1983	1,411,000	1,373,500	3,295,026,500	$814,579,000	2,399	$0.25
1984	1,558,600	1,528,000	4,405,224,000	$1,230,774,000	2,883	$0.28
1985	1,490,400	1,467,400	4,123,394,000	$1,003,412,000	2,810	$0.24
1986	1,564,700	1,535,200	3,696,761,600	$1,073,279,000	2,408	$0.29
1987	1,567,400	1,547,400	3,616,273,800	$1,021,870,000	2,337	$0.28
1988	1,657,400	1,628,400	3,981,438,000	$1,115,202,000	2,445	$0.28
1989	1,665,200	1,644,700	3,990,042,200	$1,118,875,000	2,426	$0.28
1990	1,846,000	1,815,500	3,603,767,500	$1,249,899,000	1,985	$0.35
1991	2,039,200	2,015,700	4,926,370,800	$1,392,041,000	2,444	$0.28
1992	1,686,600	1,669,100	4,284,579,700	$1,285,361,000	2,567	$0.30
1993	1,733,500	1,689,800	3,393,118,400	$1,030,904,000	2,008	$0.30
1994	1,641,000	1,618,500	4,246,944,000	$1,229,012,000	2,624	$0.29
1995	1,537,500	1,517,000	3,461,794,000	$1,013,323,000	2,282	$0.29
1996	1,401,500	1,380,000	3,661,140,000	$1,029,774,000	2,653	$0.28
1997	1,434,000	1,413,800	3,538,741,400	$1,002,703,000	2,503	$0.28
1998	1,521,000	1,467,000	3,963,834,000	$1,125,919,000	2,702	$0.28
1999	1,534,500	1,436,000	3,829,812,000	$971,608,000	2,667	$0.25
2000	1,536,800	1,336,000	3,265,184,000	$896,097,000	2,444	$0.27
2001	1,541,200	1,411,900	4,276,645,100	$1,000,512,000	3,029	$0.23
2002	1,353,000	1,291,700	3,320,960,700	$599,714,000	2,571	$0.18
2003	1,344,000	1,312,000	4,144,608,000	$799,428,000	3,159	$0.19
2004	1,430,000	1,394,000	4,287,944,000	$813,551,000	3,076	$0.19
2005	1,657,000	1,629,000	4,869,081,000	$843,435,000	2,989	$0.17
2006	1,243,000	1,210,000	3,464,230,000	$612,798,000	2,863	$0.18
2007	1,230,000	1,195,000	3,672,235,000	$758,626,000	3,073	$0.21
2008	1,534,000	1,507,000	5,162,982,000	$1,193,617,000	3,426	$0.23
2009	1,116,000	1,079,000	3,691,259,000	$793,147,000	3,421	$0.21
2010	1,288,000	1,255,000	4,156,560,000	$938,611,000	3,312	$0.23
2011	1,140,600	1,097,600	3,636,348,800	$1,024,949,000	3,313	$0.28
Percent Change 1981 to 2011	-25%	-22%	58%	77%	101%	12%
Average Annual Percent Change	-0.3%	-0.1%	3.7%	4.8%	3.5%	1.0%
Average	1,513,203	1,468,823	3,872,739,755	$982,868,323	2,662	$0.25
Standard Deviation	187,162	192,830	565,252,560	$203,675,510	411	$0.04

Source: National Agriculture Statistics Service.

Table 4 describes the percentage change in U.S. cattle inventory, cows calved, calf crop, total beef production, beef production per carcass, and the nominal slaughter cattle price. U.S. cattle and calves inventory, cows calved, and calf crop have all declined significantly between 1980 and 2011. However, total beef production, beef production per carcass, and the nominal slaughter cattle price have all increased over the last three decades. The average annual percent change of the inventory and beef production provides that we have increased the efficiency in our cowherds. This increase in efficiency makes up for the decline in cattle inventory. United States beef producers are able to produce more pounds of beef in 2011 than in 1980 with a cowherd that is 18% smaller. The average annual percentage change in the nominal slaughter cattle price per hundredweight was 2.0%.

Table 4. Percentage change in U.S. Cattle Inventory, Cows Calved, Calf Crop, Beef Production, Slaughter Cattle Price, 1980-2011

Year	Cattle & Calves Inventory (Head)	Cows Calved (Head)	Calf Crop (Head)	Beef Production (Billion Pounds)	Beef Production (Pounds/Carcass)	Nomial Slaughter Cattle Price ($/cwt.)
1980	110,961,000	47,865,000	44,938,000	21.5	635	$67.91
1981	115,013,000	49,622,000	44,666,000	22.2	636	$65.37
1982	115,444,000	50,216,000	44,200,000	22.4	624	$65.81
1983	115,001,000	48,987,000	43,885,000	23.1	629	$64.35
1984	113,360,000	48,543,000	42,470,000	23.4	623	$66.72
1985	109,582,000	46,183,000	41,050,000	23.6	649	$60.78
1986	105,378,000	44,869,000	41,182,000	24.2	649	$59.40
1987	102,118,000	44,411,000	40,152,000	23.4	657	$66.83
1988	99,622,000	43,494,000	39,317,900	23.4	668	$71.57
1989	98,065,000	42,625,000	38,816,900	23.0	678	$74.44
1990	98,162,000	42,469,000	38,613,300	22.6	681	$78.89
1991	98,896,000	42,485,000	38,583,200	22.8	697	$74.83
1992	99,559,000	42,735,000	38,933,000	23.0	699	$75.61
1993	99,176,000	43,023,000	39,369,200	22.9	688	$76.83
1994	100,974,000	44,110,000	40,104,500	24.3	710	$69.45
1995	102,785,000	44,672,000	40,263,700	25.0	705	$66.57
1996	103,548,000	44,739,000	39,823,000	25.5	695	$64.79
1997	101,656,000	43,776,000	38,960,900	25.5	700	$65.82
1998	99,744,000	43,084,000	38,812,100	25.7	723	$61.84
1999	99,115,000	42,878,000	38,796,400	26.4	730	$65.88
2000	98,198,000	42,759,000	38,630,600	26.8	740	$69.88
2001	97,277,000	42,569,900	38,300,400	26.1	738	$72.26
2002	96,704,000	42,239,300	38,223,700	27.1	758	$67.51
2003	96,100,000	42,125,000	37,592,800	26.2	739	$83.30
2004	94,882,000	41,518,800	37,260,400	24.5	750	$84.52
2005	95,848,000	41,677,900	37,106,100	24.7	762	$86.99
2006	97,102,000	41,806,400	37,015,700	26.2	776	$85.47
2007	97,003,000	41,788,700	36,758,700	26.4	771	$91.89
2008	96,035,000	41,692,000	36,152,500	26.6	773	$91.53
2009	94,521,000	41,045,000	35,939,000	26.0	779	$82.44
2010	93,701,000	40,456,000	35,694,800	26.3	768	$94.32
2011	90,682,000	40,014,000	35,313,200	26.2	769	$115.05
Percent Change 1980 to 2011	-18%	-16%	-21%	22%	21%	69%
Average Annual Percent Change	-0.6%	-0.6%	-0.8%	0.7%	0.6%	2.0%
Average	101,131,625	43,764,938	39,278,906	25	706	75
Standard Deviation	6,662,000	2,670,453	2,559,345	2	51	12

Source: National Agriculture Statistics Service.

Table 5 describes the correlation results of crop and cattle price data for Alabama between 2001 and 2010. In this table correlation measures the statistical relationship between two agricultural commodities. A negative correlation suggests that one commodity moves up while the other moves down. Alternatively, a positive correlation suggests that there is a tendency for the pair of commodities to move together in the same direction. Lastly, a correlation that is close to 0.0 suggests that the two markets move in random.

Crop prices were positively correlated, except for cotton and peanuts, which were negatively correlated. Crops and cattle were negatively correlated, but were not significant. The prices for the following commodities were highly positively correlated and significant: corn and soybeans, corn and wheat, soybeans and wheat, cattle and calves, cattle and steers/heifers., and calves and steers/heifers. Factors that help explain the positive correlation between soybeans and corn would be because they share the same growing season, climate, and are commonly grown in rotation with each other. In another scenario, steers and heifers and corn are negatively correlated with each other because corn is an input for steers and heifers. As the price of corn increases, the price of feeder cattle (steers and heifers) prices decline due to the increased cost to finish steers and heifers with corn. There were not any commodity prices that were highly negatively correlated. Diversification of enterprises (selecting more than one enterprise to produce) is an excellent risk management strategy to help reduce the risk of adversely low market prices (Kandulu 2011). Ideally, the enterprises produced should be negatively correlated, which improves the chances that a catastrophic loss in one enterprise might be offset by a higher price in another enterprise. Also, cattle and crops are mostly negatively correlated and could help reduce the chances of a catastrophic income loss.

Table 5. Correlation results of crop and livestock price data, Alabama, 2001-2010

	Corn	Cotton	Peanuts	Soybeans	Wheat	Cattle	Calves	Strs./Hfr.
Corn	1.00							
Cotton	0.55	1.00						
Peanuts	0.32	-0.20	1.00					
Soybeans	0.91***	0.75**	0.17	1.00				
Wheat	0.95***	0.49	0.20	0.91***	1.00			
Cattle	0.01	0.00	-0.34	0.04	0.15	1.00		
Calves	-0.20	-0.13	-0.45	-0.16	-0.04	0.97***	1.00	
Strs./Hfr.	-0.11	-0.04	-0.40	-0.05	0.05	0.99***	0.97***	1.00

Significance Level: 1% ***, 5% **.
Source: Alabama Agricultural Statistics, Bulletin 53, 2011.

Statement of the Problem

In the southeastern United States, peanuts and cotton are major summer agronomic crops. However, farmers in this region face great challenges in maintaining crop yields and profitability. The major challenges faced by these farmers include multiple pests, soil erosion, marginal soils, low soil organic matter, and limited water holding capacity (Wright et al. 2012). A traditional peanut-cotton crop rotation only utilizes the land for about 155 days per year leaving the soil exposed to water, wind erosion, and weed infestation. For the rest of the year without the peanut crop the soil has a limited capacity to improve the organic matter as the harvesting method of peanuts results in soil inversion, which will increase organic matter decomposition (Bader and Sumner 2012). Legumes, such as peanuts and even legume cover crops contribute very little to the long-term enhancement of soil organic matter and soil structure because of the rapid break down of the plant material and the increase of nitrogen available for plant growth. Including bahiagrass in a crop rotation system is known to improve the soil characteristics in order to help overcome the previously mentioned soil limitations to achieve profitable yields of peanuts.

The sod-based rotation has been promoted as a production system that will improve yields and reduce production costs when compared with the traditional peanut-cotton rotation system in the Wiregrass region. This study seeks to determine whether the sod-based rotation system provides farmers with a system that outperforms the traditional production system with respect to economic returns and risk. If the sod-based rotation system is not found to be a lower risk, higher return production system, then we want to determine which Wiregrass rotation is the economically optimal system to be adopted by farmers in the Wiregrass region.

The Objectives

The objective of this study was to maximize the expected return from the production of 7 row-crop and cattle production enterprises in the Wiregrass region of Alabama, subject to a given minimum level of risk associated with a predetermined target income level. This study was based on the hypothesis that economic and ecological conditions are rapidly changing and farmers need to reevaluate the profitability and risk associated with farm enterprises. The seven enterprises examined included an irrigated sod-based rotation of crops with cattle, irrigated traditional peanuts-cotton rotation, rain-fed traditional peanuts-cotton rotation, rain-fed traditional peanuts-cotton rotation with government payments, rain-fed wheat-soybeans-corn rotation, irrigated land rental, and rain-fed land rental.

In order to accomplish the objective of this study, the following specific sub-objectives were identified.

1. To develop an enterprise budget for each enterprise,
2. To develop a Target MOTAD Model to evaluate the returns and risks of the seven identified enterprises

3. To estimate the return-risk levels associated with three target income levels,
4. To develop risk-efficient frontiers based on three target return levels, and
5. To determine the operating capital requirements for various levels of risk associated with each target return level.

The accomplishment of the above specific objectives will provide optimal economic information about row-crop and cattle production enterprises involved in a sod-based rotation system in comparison with a traditional system. This economic information will furnish Alabama farmers, extension specialists, researchers, public agencies, and agribusiness representatives with a better understanding of the potential economic risk and returns associated with row-crop and cattle enterprises in a sod-based rotation system.

Procedure and Organization of the Study

Fulfilling the objectives described above entailed the collection of row-crop and cow-calf production data including (a) seasonal market price data from the Federal and State market news service (Montgomery, Alabama) (b) row-crop and cow-calf budgets for the Wiregrass Region of Alabama, (c) row-crop yield data for Alabama from unpublished scientific research data compiled by the Auburn University Wiregrass Research and Education Center.

Once the row-crop and cow-calf production and marketing data were obtained, the first specific objective was accomplished by preparing enterprise budgets for each farm enterprise. The second specific objective was achieved by organizing the technical data and developing a Target MOTAD ("minimization of total absolute deviations") model to estimate the return-risk levels for a given target return level which incorporates the net returns from the enterprise budgets. The third specific objective was attained by using the Target MOTAD model to estimate the returns and risks associated with three target income levels. Tables and graphs of the risk-efficient frontiers associated with the three target return levels were developed from the analytical results. The Target MOTAD model included operating capital requirements that were estimated and included for various levels of risk associated with each target return level.

This study is organized into 5 chapters. Following Chapter I, Chapter II provides a literature review of previous applications of Target MOTAD and describes the economics of the theory supporting profit maximization and the concept of incorporating risk in agricultural enterprise analyses using the Target MOTAD methodology. Chapter III presents the specification of the Target MOTAD model and describes the activities, objective function, constraints, target levels, and coding. Chapter IV reports the results of the Target MOTAD model analyses and provides a comparison of return-risk relationships among target levels. Lastly, Chapter V summarizes the study and offers general conclusions, limitations of the study, and suggestions for further research.

Chapter II

Literature Review and Methodology

Literature Review of Target MOTAD Return-Risk Analyses

In recent studies for agriculture on the return-risk analysis, the Target MOTAD (MOTAD, “minimization of total absolute deviations”) approach has been widely used by many researchers in a variety of situations. A review of the available literature as described below revealed various articles have been published analyzing the economic significance of a row-crop enterprise or a cattle enterprise. To date, there have been few studies that have used a target MOTAD return-risk analysis on farm’s in the southeastern United States.

Davis et al. (2003) studied a crop enterprise selection in the southeastern region of the United States using a target MOTAD model. The model was used to determine the risk-efficient crop-mix for alternative price and yield expectations for different row-crops. The results of the study suggest that there is a great potential for increased peanut production in the Southeast. Peanuts were in the optimal crop mix regardless of price and yield expectations. The study found that risk neutral producers may choose to produce both cotton and peanuts.

Hakobyan (2001) evaluated a Target MOTAD return-risk analysis of feeder cattle marketing strategies. This study evaluated the return-risk relationships based on fall and spring stocker production programs and stocker cattle marketing strategies from 1990-2000. The study also evaluated the impact of segmenting the 1990-2000 time period based on the cattle cycle and utilizing load lot feeder cattle sales on return-risk relationships. The results of this study revealed that the use of futures market contracts improved expected returns and lowered risk for the stocker enterprises.

Mckissick et al. (1991) also evaluated stocker marketing strategies using futures and options contracts. He included combinations of seasonal indicators with moving average indicators, which means the marketing of feeder cattle takes place when the moving average indicates an opportunity to sell. Mckissick's Target MOTAD model was used to construct risk-efficient frontiers using 151 feeder cattle marketing alternatives.

Maleka (1993) used a Target MOTAD model to indicate an optimal cropping pattern for the Gwembe Valley in Zambia. The purpose of this study was to evaluate whether return-risk of the existing cropping patterns provided the greatest expected returns and lowest risk. The findings suggested that policy programs were necessary to adopt other cropping enterprises that would increase the levels of expected returns and lower the levels of risk.

Novak et al. (1990) used a Target MOTAD model to assess the risk and returns of the sustainable cotton crop rotations from Auburn University's 92-year "Old Rotation" (1990). The study analyzed rotations of continuous cotton with and without winter legumes; two years of cotton-winter legumes-corn, with and without nitrogen fertilization; and three years of cotton-winter legumes-corn and rye-soybeans double cropped over a ten year period. The study revealed that diversification in rotations resulted in the least risk for a specific level of target income.

Prevatt et al. (1992) conducted a Target MOTAD return-risk analysis of fresh vegetable enterprises. He evaluated seven single and eight double cropped enterprises using semi-closed sub irrigation and drip irrigation systems. He found that the adoption of the drip-irrigation system for single- and double- cropped production alternatives resulted in lower levels of expected returns and higher levels of risk. The double cropped enterprises with sub-irrigation resulted in the highest expected returns.

Zimet and Spreen (1986) analyzed a typical crop and livestock farm in North Florida using a Target MOTAD analysis. The enterprises included peanuts, watermelons, irrigated soybeans, purchased stockers, brood cows, and native brood cows. The results found that when risk is ignored, peanuts, watermelon, and stocker cattle enterprises entered the optimal solution. When income risk is included in the analysis the optimal solution included peanuts, watermelon, stocker cattle, cow-calf, and irrigated soybeans. The results implied that a combination of crops and beef cattle enterprises provided higher level of expected returns and lower levels of risk.

In summary, Target MOTAD has been used to evaluate the returns and risk of numerous agricultural enterprises and various resources. This approach allows us to account for the fluctuations of returns for a given set of resources. However, the results of the target MOTAD analysis are specific for each farm and farm operations. Thus, careful considerations must be made when extending this information to other farmers.

Firm Theory

This study takes a firm level approach to determine the optimal row-crop and cow-calf enterprises and the production levels which maximizes expected returns subject to a given level of risk in order to achieve a given level of target income for a Alabama row-crop and cow-calf farm. The objective of this study involves selecting the optimal allocation of resources and enterprises for a sod-based rotation or traditional alternatives over a given period of time which is the normative problem. For this study, a normative approach was taken, meaning it is understood that the solution is the prescribed route to be followed when the end or objective takes on a particular form (Weymark 2004).

The variability of prices and yields of agricultural commodities creates a great deal of uncertainty for producers. Generally, agricultural producers tend to face varying input prices and very uncertain output prices. Additionally, largely due to the variability of the weather, producers face uncertainty with regard to the quantity and quality of their output. The theory of the firm facing uncertainty has been used to analyze these types of problems for producers.

The theory of the firm regarding supply involves the determination of the optimal combination of different forms of outputs, the optimal combination of variable factors for a given output, and the optimal rate of production (Moses 1958). The determination of the optimal output levels depends on market conditions, production technology, and the supply of the factors of production. The producer is generally capable of varying the levels of the outputs and factors, which allows them to change production levels under output and factor price variability (Hart 1988). The functions that are necessary to determine the optimal economic levels of output under risk are gross revenue, production yield, and costs (Baumol and Bradford 1970). Assuming that both the factor and product markets are perfectly competitive, these functions are used to calculate the optimal level of production which will maximize producer profits.

According to theory, under perfect competition firms exist and make decisions in order to maximize profits and utility (Coase 1937). The aggregate supply of firms interacts with the market demand to determine a market clearing price. Individual firms allocate their labor and capital resources in order to maximize profits. The firm is assumed to have complete information of the market. The focus of the firm is on long-run profit sustainability in a competitive system (Simon 1949).

In the real world, the firm's production process usually starts when there is little knowledge and only expectations about the market price of the output to be produced. However, the firm has some knowledge about the past probability distribution of market prices and the optimal output will be influenced by the uncertainty of those market prices (Watkins 2013).

When uncertainty exists in a perfectly competitive market, the rule of producing at the point where marginal cost is equal to the market price can only be achieved in an imperfect manner (Mansfield 1971). The firm's response to uncertainty is to adjust input levels to achieve a hoped for output level. The optimal production for the firm will be reached at a point when marginal value product is equal to marginal factor cost. Thus, this establishes the principal of profit maximization.

The total revenue received for a commodity is given by the total output sold multiplied by the unit price received (Varian 1992). The total cost is the sum of each individual factor price multiplied by the level of factor use. The producer's profit (π) is the difference between total revenue (TR) and total cost (TC).

Mathematically for the farm firm expressed as,

$$TR_t = \sum_j P_{jt} \, Q_{jt} \qquad (1)$$

TR_t = total revenue in time period t,

Q_{jt} = the quantity of the j^{th} product in time period t,

P_{jt} = price per unit of the j^{th} product in time period t,

and

$$TC_t = \sum_i \sum_j E_{it} \; X_{ijt} \qquad (2)$$

TC_t = total cost in time period t,

X_{ijt} =the quantity of the i^{th} factor used to produce the j^{th} product in time period t,

E_{it} = price per unit of the i^{th} factor in time period t, therefore,

$$\pi_t = TR_t - TC_t \quad (3)$$

π_t = profit in time period t,

or

$$\pi_t = \sum_j P_{it} Q_{it} - \sum_i \sum_j E_{it} X_{ijt}$$

when t > 1, then

$$\pi^* = \sum \pi_t \quad (4)$$

π^* = sum of the profits in t time periods.

The inclusion of multiple time periods in the profit maximization problem involves a more complex analysis than in the case of a single time period (Luenberger and Ye 2008). However, time is an important consideration. The following equations express both the effect with and without the concept of time opportunity costs.

When t > 1, r (time preference described by the discount rate) is ≥ 0.

If r > 0, then

$$\sum \pi^* = \sum \pi_t \ / \ (1 + r)_t \quad (5)$$

or

$$\pi^* = \sum [\sum P_{jt} Q_{jt} / (1 + r)t - \sum \sum E_{it} X_{ijt} / (1 + r) \ t - 1]$$

If r =0 (implying no time preference), then

$$\pi^* = \sum_t \pi_t \quad (6)$$

Or

$$\pi^* = \sum_t (\sum P_{jt} Q_{jt} - \sum \sum E_{it} X_{ijt})$$

Using the profit function presented in equation (6), the following example will illustrate the profit maximizing conditions.

Given,

time period t = 1, 2,

factor i = 1, 2,

product j = 1, 2,

and the production function,

$$Q_{jt} = f\ (X1jt\ ,\ X2jt) \quad (7)$$

The substitution of the production function into the profit equation describes profits as a function of factor quantities, prices, and time (Cobb and Douglas, 1928).

The first order conditions for profit maximization of a perfectly competitive firm are derived by taking the partial derivatives of the profit equation with respect to each of the factors of production and setting them equal to zero (6). The following equations are calculated by taking the partial derivatives of the profit equation (6) with respect to X_{ijt}.

$$\frac{d\pi^*}{dX_{111}} = P_{11} \frac{dY_{11}}{dX_{111}} - E_{11} = 0$$

$$\frac{d\pi^*}{dX_{211}} = P_{11} \frac{dY_{11}}{dX_{211}} - E_{21} = 0$$

$$\frac{d\pi^*}{dX_{121}} = P_{21} \frac{dY_{21}}{dX_{121}} - E_{11} = 0$$

$$\frac{d\pi^*}{dX_{221}} = P_{21} \frac{dY_{21}}{dX_{221}} - E_{21} = 0$$

$$\frac{d\pi^*}{dX_{112}} = P_{12} \frac{dY_{12}}{dX_{112}} - E_{12} = 0$$

$$\frac{d\pi^*}{dX_{212}} = P_{12} \frac{dY_{12}}{dX_{212}} - E_{22} = 0$$

$$\frac{d\pi^*}{dX_{122}} = P_{22} \frac{dY_{22}}{dX_{122}} - E_{12} = 0$$

$$\frac{d\pi^*}{dX_{222}} = P_{22} \frac{dY_{22}}{dX_{222}} - E_{22} = 0 \quad (8)$$

Where, dQ_{jt} / dX_{ijt} are the marginal products (MP_{ijt}) of the i^{th} factor used to produce the i^{th} factor used to produce the j^{th} product in time period t. Shifting the factor price, E_{it}, to the right side of equation (8) provides:

$$P_{jt}\ MP_{ijt}\ =\ E_{it} \tag{9}$$

The price of the product, P_{jt}, multiplied by MP_{ijt} is the marginal value product ($P_{jt}\ MP_{ijt}$), also known as the value of the marginal product (the value of the product produced by the last unit of X_{ijt}), assuming a perfectly competitive product market. The first order condition for unconstrained maximization requires that each factor be utilized up to the point where the marginal value product equates to the factor price (Lima 2013). The producer can increase profit as long as the addition to revenue from the use of an additional unit of input X_{ijt} exceeds the cost of that last unit, E_{it}. Thus, a producer will generate more output until the point where marginal value product is equal to marginal factor cost (Beattie and Taylor 1985).

The first order condition is a necessary condition for profit maximization, but it is not a sufficient condition by itself. The second order condition for profit maximization requires that

$$d^2\pi\ /\ dX_{ijt^2}\ <\ 0 \tag{10}$$

This condition implies that the profit function must be strictly concave in the neighborhood of the solution of the first order condition. Lastly, the total condition for optimal profit maximization requires that the total value product (TVP = Price * Total Physical Product) must be greater than or equal to the cost of production and may be expressed as:

$$TVP\ \geq\ C \tag{11}$$

Given the satisfaction of these three conditions, optimal maximum profit can be determined. However, these three conditions do not guarantee an optimal solution. An optimal solution may only occur when maximum profit is a non-negative real number. This means that a negative maximum profit solution is not optimal and the firm should not produce.

Enterprise Budgeting

Enterprise budgets are a method of developing a financial assessment of expected costs and returns for a given production system when producing a specific output (Carkner 2000). This method is used to analyze situations at the farm level involving variable operating costs, yields, and production returns. Each budget may consist of a different combination of resources and inputs depending on the production system of the enterprise. A major use of enterprise budgets is to compare the costs and returns across different enterprises. Budgeting also helps farmers make decisions about what inputs to use and in determining the costs of production and returns associated with a specific enterprise.

The enterprise budgets used in the model were developed with the best information available from researchers involved in the sod-based rotation project at the Wiregrass Agricultural Research and Extension Center. The returns are understood as being from the output sales of row-crops and cattle. The net returns are gross margin, calculated as the total returns minus the variable costs of crop and livestock production.

The variable costs included in the enterprise budgets include seed, fertilizer, lime, chemicals, fuel, feed, veterinary supplies, hired labor, marketing expenses, normal repairs, custom-hire operations, and the machinery and equipment operating expenses. The variable costs of hired labor included labor whether it was associated with machinery and equipment or as a manual labor operation. This is due to row-crops being very labor intensive from cultivating, planting, spraying, irrigating, and harvesting. Thus, labor is one of the larger variable costs. The cost of irrigation is very important when making the decision on whether or not to adopt an enterprise with irrigation. The type of irrigation system used to prepare the budgets utilized a reservoir and center-pivot system. The cost of irrigating applies only to the crops that were irrigated. The rain-fed crops do not have irrigation costs. For this study, irrigation labor, fuel, repairs, and maintenance are considered variable costs. These costs will be different for each crop and will depend mainly upon the amount of water applied per acre and the efficiency of the system. These variable costs were obtained from the enterprise budgets, as shown in Appendix A, Tables A1-A13).

While budgets alone can be very useful tools, they have their limitations. The reliability planning of budgets can be limited since many budgets are based on the predictions of output and input prices. Thus, individual budgets indicate an approximation of commodity net returns but very little regarding the optimal resource allocation of farm production.

Linear Programming

Mathematical programming has been used extensively in farm management and production economic studies as a way to achieve maximum profits. Linear programming is a simplified application of firm theory where segments of the production function are assumed to be linear and examined for profit maximization (Yahya et al. 2013).

In agriculture, linear programming is a technique used to solve optimization problems that seek to determine the optimal resource allocation, by either maximizing returns or minimizing costs, subject to a set of constraints (Duffy et al. 2004). Linear programming is a form of mathematical programming commonly used for decision-making analysis to solve optimal resource allocation problems under resource constraints (Schulze 2013). It can determine a profit maximizing combination of farm enterprises that are feasible with respect to the set of constraints. A linear programming model assumes that decision making is done with certainty. Linear programming allocates the limited resources of a farm in order to maximize profits or minimize costs in producing an optimal combination of enterprises. The income obtained from a linear programming framework reflects the maximum attainable income given the existing available resources of the farm, estimated costs, and estimated returns (Lewis 2008).

The general form of a linear programming model used for profit maximization may be written as:

$$\text{Maximize} \sum_j R_j X_j \tag{12}$$

Subject to

$$\sum_j a_{ij} \ x_j \leq \ b_1 \text{ and } x_j \ \geq \ 0 \ ,$$

for all

j = 1, 2, … , n ,

i = 1, 2, … , m ,

where

R_j = the objective value of one unit of activity j.

x_j = the quantity of the j^{th} activity

a_{ij} = the technical coefficient relating the use of the i^{th} constraint in the j^{th} activity, and

b_i = the total amount of the i^{th} constraint available.

By employing a linear programming framework users are able to take advantage of the speed and reliability of the linear programming model (Arsham 1994). However, a limitation of linear programming is the absence of risk. Linear programming calculates the optimal results from the absolute values specified without the consideration of risk (McCarl and Spreen 2012). For farm decision making, maximizing profits would be an appropriate action by farmers, if no risks were involved. Given that linear programming ignores the potential risk associated with a given enterprise, it may provide misleading results to farmers in a real farm decision making environment. Hazell and Norton (1986) suggested that the neglect of risk in linear programming analysis can result in the overstatement of output levels of risky enterprises. The results of a linear programming analysis may be of little use to farmers who are risk adverse. Thus, the element of yield and price risk need to be included in analysis.

A limitation of maximization models is often incurred when the independent variables are not permitted to take on all possible values (Henderson and Quandt 1971). In this situation, the constrained maximum model may be evaluated for only the relevant values of the independent variables. Therefore, results of the constrained and unconstrained models will be different. The results of a constrained maximization model will be lower than an unconstrained maximization model.

Target MOTAD

Target MOTAD is a modification of the basic linear programming model. Target MOTAD is a method formulated by Tauer (1983) to incorporate risk programming in a linear model which is computationally efficient and to generate a subset of feasible solutions capable of satisfying the second degree stochastic dominance criteria with a linear programming framework. Target MOTAD is a modification of MOTAD that minimizes only the negative deviations from the specific target income (Hazell 1971). Tauer describes the model as a two-attribute model used to address risk and returns for decision making purposes.

In agriculture, the overall objective of the Target MOTAD model is to maximize returns while finding the optimal combination of production practices subject to variable technical and income constraints. Target MOTAD is a method used for evaluating risk in decision analysis. Farmers often wish to maximize expected returns but are concerned about returns falling below a critical target level of income (McCarl and Spreen 2012). Thus, risk constraints were added in order to incorporate net return risk based on the deviations from the target level of income. Target MOTAD model insures that the farmer will attain a minimum prescribed level of income subject to an allowed variability parameter. That is, the expected returns are maximized subject to a given allowed level of negative deviations from a set target income level. Target MOTAD maximizes the mean returns subject to a limit on the total negative deviations measured from a fixed target rather than from the mean.

The purpose of this analysis is to examine the trade-off between returns and risk of rotation systems in the Wiregrass region of Alabama. The development of a Target MOTAD technique assumes two parameters, the target levels of income and a maximum allowable risk aversion coefficient (Berbel 1990). Thus, the model is constructed to identify farming enterprises which will provide an optimal balance between returns and risk for different degrees of risk aversion.

The Target MOTAD model meets the requirements of the second degree stochastic dominance. The stochastic dominance criteria allows the model to establish a ranking of the possible solutions based on risk preference (Boisvert and McCarl 1990). The application of Target MOTAD requires the decision maker to select a target level of return. The optimal solutions can be calculated for different levels of risk given the target level of return. The risk is often a combination of price and yield variability that farmers face by using this approach. The negative deviations from the target level of the firm are weighted by the probability of occurring.

The mathematical notation of the Target MOTAD model may be described as:

$$\text{Max } E(z) = \sum_{j=1}^{n} k_j x_j \qquad \text{(for all } j = 1,\ldots, n) \qquad (16)$$

subject to

$$\sum_{j=1}^{n} a_{kj} x_j \leq b_k \qquad \text{(for all } k = 1,\ldots, m) \qquad (17)$$

$$T - \sum_{j=1}^{n} c_{rj} x_j - y_r \leq 0 \qquad \text{(for all } r = 1,\ldots, s) \qquad (18)$$

$$\sum_{r=1}^{s} p_r y_r = \lambda = G \qquad G = M \qquad (19)$$

For all $x_j \geq 0$ and $y_r \geq 0$.

Where,

E(z) = the expected return of the solution;

k_j = net return from the j^{th} activity;

x_j = the level of the j^{th} activity;

n = number of activities;

a_{kj} = technical coefficient of j^{th} activity for the k^{th} constraint;

b_k = level of resource for the k^{th} constraint;

T = target return;

c_{rj} – return of j^{th} activity for observation r;

y_r – deviation below target return for observation r;

S = the number of states of nature/observation (years in this study);

p_r = probability of occurring of observation r;

G = constant associated with the level of risk (sometimes written as λ and parameterized from zero to unbounded in order to generate a risk efficient set);

M = an arbitrary large number

Risk is measured in dollars as the expected sum of negative deviations of the optimal solution from some target income level.

This method implies the recognition that the survival of a firm is a function of not only the level of returns, but also the variability of returns (Chamberlain 1989).

Chapter III

Specification of the Target MOTAD Model

A typical mixed enterprise farm located in the Wiregrass region of Alabama is hypothesized for this study. A Target MOTAD model was developed for this farm to evaluate the return-risk relationships of using traditional row-crop enterprises of the Wiregrass Region along with the relatively new sod-based rotation system.

The irrigated sod-based rotation system with cattle consists of 160 acres (32 acres of cotton, 32 acres of peanuts, and 80 acres of bahiagrass for cattle grazing). The irrigated traditional peanut-cotton rotation consists of 160 acres (64 acres of cotton and 64 acres of peanuts). The traditional rain-fed peanut-cotton rotation with and without government payments is included in the model as an alternative. Both consist of 160 acres which are rotated between 80 acres of cotton and 80 acres of peanuts. The wheat, soybeans, and corn rotation consists of 160 acres (53.33 acres of wheat, 53.33 acres of soybeans, and 53.33 acres of corn). The model can also choose to rent out the available irrigated land and rain-fed land.

These enterprises are currently part of a research and extension study for Alabama to evaluate production parameters and economic performance. The basic assumptions of the study include:

1. The mixed enterprise farm is a viable commercial entity large enough to efficiently use the selected technology.
2. Producers have the management skills to utilize the latest production technology.
3. Producers desire to implement sound financial management plans (willing to produce the most profitable crops)

4. The objective of the producer is to maximize profit.

If the above assumptions are not met, this analysis is not needed to be done.

Data

This research was conducted as a part of the Economic Viability and Agro-ecology of Integrating Beef Cattle and Short Term Perennial Grasses into Peanut and Cotton Rotations grant. The data for this study were obtained from the Wiregrass Research and Extension Center in Headland, Alabama for the years 2007-2012, as shown in table 6. Though a longer time may be desirable, it is assumed that a six-year period adequately captures price fluctuations. Thus, a production strategy is developed presenting six years of observations.

The yields and costs for traditional systems were collected from plots and farms in the Wiregrass region of Alabama. The yields for rain-fed crops grown in the Wiregrass region were obtained through the Alabama Extensions Farm Analysis Program. The National Agricultural Statistics Service (NASS) data was not used in this study due to the Farm Analysis data reflecting more of the actual conditions faced by Wiregrass producers. No identifying information was obtained when using the actual farm related data.

Table 6 includes the basic data for the Target MOTAD model. For each enterprise a description is given for the acres used, production units, total production, mean yield, mean price, mean gross revenue, mean variable costs, and the mean returns over variable cost.

Table 6. Basic data for the Target MOTAD Model

Type of Enterprise	Acres	Units	Total Production	Mean Yield	Mean Price $/Unit		Mean Gross Revenue	Mean Variable Costs	Mean Returns Over Var. Costs
Sod-based Rotation - Irrigated									
Peanuts	32 Acres	Pounds	166,347	5198	0.23	*	$ 38,248.88	$ 29,085.26	$ 9,899.07
Cotton	32 Acres	Pounds	38,421	1201	0.73	*	$ 28,179.43	$ 32,401.37	$ (2,847.18)
Beef Cattle	64 Acres	Pounds	41,682	651	1.12	*	$ 46,736.69	$ 34,709.03	$ 12,027.66
						*			
Traditional Peanuts and Cotton - Irrigated						*			
Peanuts	64 Acres	Pounds	301,297	4708	0.23	*	$ 69,278.76	$ 52,675.10	$ 17,932.20
Cotton	64 Acres	Pounds	73,547	1149	0.73	*	$ 53,941.47	$ 56,226.62	$ (711.92)
						*			
Traditional Peanuts and Cotton - Rainfed						*			
Peanuts	80 Acres	Pounds	358,587	4482	0.23	*	$ 82,451.53	$ 54,175.14	$ 29,263.48
Cotton	80 Acres	Pounds	77,253	966	0.73	*	$ 56,660.05	$ 62,443.97	$ (6,429.30)
						*			
Traditional Peanuts and Cotton - Rainfed w/ Gov't Payments						*			
Peanuts	80 Acres	Pounds	358,587	4482	0.24	*	$ 87,396.07	$ 54,175.14	$ 34,446.82
Cotton	80 Acres	Pounds	77,253	966	0.77	*	$ 59,731.14	$ 62,443.97	$ (2,846.53)
						*			
Traditional Wheat, Soybeans, Corn - Rainfed						*			
Wheat	53.3 Acres	Bushels	3,469	65	5.77	*	$ 20,032.12	$ 23,301.06	$ (4,656.24)
Soybeans	53.3 Acres	Bushels	1,954	37	11.13	*	$ 21,742.45	$ 18,355.30	$ 3,727.97
Corn	53.3 Acres	Bushels	6,039	113	5.21	*	$ 31,473.46	$ 29,301.57	$ (485.73)
						*			
Irrigated Land Rented Out	160 Acres				86.33	*	$ 13,812.25		$ 13,429.43
						*			
Rainfed Land Rented Out	160 Acres				46.69	*	$ 7,470.07		$ 7,259.21

The data obtained from these field trials were used to develop enterprise budgets for row-crop and cow-calf enterprises. The budgets are shown in Appendix A, Tables A1-A13. The application of a Target MOTAD model requires the use of enterprise budgets to estimate the returns and the cost of production for each enterprise which will be used in the objective function. The returns were estimated using yearly prices reported by NASS. The returns for each activity denoted in this study are returns above variable costs. The revenues and costs for the six-year period were normalized to 2011 using the consumer price index (CPI, 2011=100) as shown in Appendix A, Table A16-17. The CPI is used to adjust the producers income payments and expenses in order to prevent inflation induced increases (United States Department of Labor 2013).

Objective Function

The objective function of the Target MOTAD model is to maximize net returns subject to a set of resource constraints and return variability given target level of income. Additionally, the solution of the Target MOTAD model requires that the returns will not fall below the target level of income for a given level of risk. The objective function is the sum of the optimal output levels multiplied by the expected return for the enterprise. Revenues and variable costs were normalized to 2011 using the consumer price index (2011=100) as shown in Appendix A, Table A16-17.

Activities of the Target MOTAD Model

A Target MOTAD model was developed for a typical Wiregrass mixed enterprise farm to evaluate the return-risk tradeoffs for several enterprise combinations. A typical row-crop and cow-calf farm located in the Wiregrass region of Alabama was hypothesized for this firm-level study. These enterprises are currently included as a part of a research and extension grant project for Alabama, and Florida to evaluate production alternatives and economic performance. The enterprises included in this analysis were irrigated cotton, irrigated peanuts, and two years of bahiagrass for cattle grazing, rain-fed cotton, rain-fed peanuts, irrigated rental land, and rain-fed rental land. The activities modeled were described using code abbreviation, activity description, and unit of measurement, as shown in Table 7.

Table 7. Activities of the Target MOTAD Model

Code	Activity Description	Unit
SBR-IRR	Sob-based rotation - irrigated activity	160 acres
TPC-IRR	Traditional peanuts and cotton - irrigated activity	160 acres
TPC-RF	Traditional peanuts and cotton - rainfed activity	acre
TPC-RF, GP	Traditional peanuts and cotton - rainfed with government payments activity	acre
TWSC-RF	Traditional wheat, soybeans, and corn - rainfed	acre
IRRLNDRT	Irrigated land rented out	acre
RFLNDRT	Rain-fed land rented out	acre
$HLABOR_i$	Hire labor for the i^{th} month	$/hour

Constraints of the Target MOTAD Model

The target MOTAD model maximizes expected returns over variable costs subject to technical constraints that limit the level of resource use. The technical constraints of the model describe the resource base that is available for use. These are shown in Table 8. The technical coefficients of the constraints were identified using the enterprise budgets. For this study, the resource constraints in the model are irrigated land, rain-fed land, operating capital, operator labor, and hired labor. The resources constraints ensure that the use of any given resource does not exceed its availability.

Table 8. Constraints of the Target MOTAD Model

Code	Description	Constraint	RHS	Unit
OBJ-ROVC	Objective function (returns over variable costs)	MAX		
LND-IRR	Irrigated land used	L	640	160 acres
LND-RF	Rain-fed land used	L	640	160 acres
OPERCAP	Traditional peanuts and cotton - rainfed activity	G	0	acre
OPRLAB-JAN	Operator labor available during January	L	160	hour
OPRLAB-FEB	Operator labor available during February	L	160	hour
OPRLAB-MAR	Operator labor available during March	L	160	hour
OPRLAB-APR	Operator labor available during April	L	160	hour
OPRLAB-MAY	Operator labor available during May	L	160	hour
OPRLAB-JUN	Operator labor available during June	L	160	hour
OPRLAB-JUL	Operator labor available during July	L	160	hour
OPRLAB-AUG	Operator labor available during August	L	160	hour
OPRLAB-SEP	Operator labor available during September	L	160	hour
OPRLAB-OCT	Operator labor available during October	L	160	hour
OPRLAB-NOV	Operator labor available during November	L	160	hour
OPRLAB-DEC	Operator labor available during December	L	160	hour
HIRELAB-JAN	Hired labor during January	GE	0	hour
HIRELAB-FEB	Hired labor during February	GE	0	hour
HIRELAB-MAR	Hired labor during March	GE	0	hour
HIRELAB-APR	Hired labor during April	GE	0	hour
HIRELAB-MAY	Hired labor during May	GE	0	hour
HIRELAB-JUN	Hired labor during June	GE	0	hour
HIRELAB-JUL	Hired labor during July	GE	0	hour
HIRELAB-AUG	Hired labor during August	GE	0	hour
HIRELAB-SEP	Hired labor during September	GE	0	hour
HIRELAB-OCT	Hired labor during October	GE	0	hour
HIRELAB-NOV	Hired labor during November	GE	0	hour
HIRELAB-DEC	Hired labor during December	GE	0	hour
T6j	Return for the jth year	GE		dollar
MAXDEV[a]	Maximum deviation below the target	LE		dollar
TARGET[a]	Target level of income	GE		dollar

[a]The right-hand-side coefficients for these contraints were selected for each run of the Target MOTAD Model.

Land is a constraint in the model. On any farm, the availability of acreage is limited. The maximum acreage allocated for the cultivation of all crops and grazing acres of cattle must not exceed the total amount of land available. For this study, land is assumed to be limited to 1,280 acres. Consultation with researchers and extension specialists indicated that economies of scale for row-crop and cow-calf farms are realized between 750 and 1,500 acres. This reflects a farm used by Alabama farmers and is large enough to be a sustainable business which could pay for land, labor, and capital. Within the available 1,280 acres, there are basically two types of land: rain-fed land and irrigated land. Thus, acre constraints were placed on each type of land. For a 160-acre block, a center-pivot irrigation system is able to cover 128 of 160 acres as irrigated land (Appedix A, Table A13). The farm is split evenly between irrigated and rain-fed land. After accounting for the dry acres in the irrigated block of land, the model produces the following land constraints: 768 acres of rain-fed land are available and 512 acres of irrigated land are available. Thus, more rain-fed acres will exist than irrigated acres. For this study, land is assumed to be owned by the farmer, to be homogenous, and of average fertility (Dhuyvetter 2013).

Labor and management are assumed to be provided by the owner-operator. Producers are assumed to be able to effectively implement the latest production technologies and provide a finite number of labor hours. Hired labor is offered to meet the critical needs during the peak seasons, such as planting and harvesting. Hired labor is assumed to be available monthly at $12.00 per hour for a maximum of 160 hours per month (USDA 2012). Additionally, for this study all labor is considered to be homogenous and possess adequate skills. The model chooses the optimal amount of labor hours that need to be hired for a particular strategy. The capital used in the model was based upon the estimated amount needed to operate. These resource constraints are the factors that frequently limit producers from generating of additional income.

Setting the Levels of the Target

The formulation of appropriate target levels of income and risk is an important step in using the Target MOTAD approach. However, establishing a target return and an appropriate level of risk for a row-crop and cow-calf enterprise is difficult. It implies understanding the nature and distribution of a farmer's attitude toward risk and their goals. The target level of an individual may be formulated as the return available from a safe investment, the target, which expects an acceptable performance of a farm, or it may be formulated for the farms long-run survival. The selection of a target level of income should designate a level of income which the decision maker wishes to attain on a routine basis.

Some economic models use either variable or total costs as the target level of income. The model presented in this study sets the target level of income as the sum of family living withdrawal, the debt payments of the farm for a row-crop and cow-calf enterprise, and the opportunity costs of owned assets, as presented in Table 9. Family living withdrawal reflects the opportunity costs associated with the operator's labor and management skills. The family living withdrawal for the farmer was assumed to be $50,000 per year. The debt payment was based on the investment costs associated with land, machinery, and equipment. The level of indebtedness for the representative farm was assumed to be $500,000. The level of indebtedness was assumed to be 30, 60, and 90 percent of the investment cost for targets 1, 2, and 3 return levels, respectively. The three respective debt levels were financed over 10 years using an annual percentage rate of interest of 6 percent. The opportunity cost of owned assets was based on a market value of assets and 2 percent earnings. The evaluation of the three target levels of income will provide an assessment of the increasing debt levels on the solutions of the model, their risk levels, labor requirements, and operating capital.

Table 9. Estimated target levels of income for the Target MOTAD Model.

Item	Target 1	Target 2	Target 3
Wages[a]	$50,000	$50,000	$50,000
Debt payment[b]	$20,380	$40,760	$61,141
Opportunity cost[c]	$37,000	$34,000	$31,000
Target totals	$107,380	$124,760	$142,141
Target selected	$100,000	$120,000	$140,000

[a] Wages reflect the opportunity cost associated with the operator's labor and management skills.

[b] The investment cost for machinery and equipment of a row-crop operation was assumed to be $500,000. The level of debt financed was estimated using 30, 60, and 90 percent of investment cost for target 1,2, and 3 return levels, respectively. The finance rate was assumed to be 6 percent with an estimated useful life of ten years.

[c]The opportunity cost of owned assets was based on a market value of assets and 2 percent earnings.

Chapter IV

Return Risk Analysis

This study utilized the Target MOTAD programming method to incorporate risk into a farmer's decision making process. The model was used to identify a farm plan which would maximize the expected net return for a given level of risk. For this study, we assume that producers are not only concerned with expected returns, but also the riskiness of various enterprises. We also assume that farmers desire to allocate scarce resources among the most efficient activities in order to maximize expected returns.

Presented in this chapter are the enterprise selections, production levels, and the maximum expected returns for various levels of risk. Additionally, these results were generated for each of the three target return levels. Lastly, these results were used to examine the return-risk comparisons among competing enterprises and target return levels.

Return-Risk Analysis

The objective of the Target MOTAD model was to maximize expected returns over variable costs subject to a given level of expected negative deviations below a predetermined target level of return (Prevatt 1992). The model was used to determine a set of feasible risk-minimizing crop rotations from the possible set of alternatives (Novak 1990). The expected return and the expected negative deviations below a predetermined target level of return determine a point on the risk-efficient frontier. Unlike enterprise budgets or linear programming, no single solution is obtained by using a Target MOTAD analysis. Instead an optimal solution is generated for each level of risk specified. Thus, a return-risk frontier may be traced to describe the various levels of expected net returns and risk. The risk-efficient frontier defines the set of feasible management plans.

Three target levels of return were evaluated for the model resulting in three risk-efficient frontiers. Each frontier and associated enterprise production levels are presented, below. The economic returns were measured as the sum of the expected economic returns over variable costs per unit of activity multiplied by individual activity levels. Risk was defined as the negative deviations below the target level of returns. The “best” solution will depend on a farmer’s preferred for risk.

The six years of observations of returns (2007-2012) are each assumed to have an equal probability of occurrence in the year denoted in the model. They are each assigned the value of 0.167 in the model reflecting a 1 in 6 probability of occurrence. The riskiness of an enterprise’s return is measured by the probability weighted average of the negative deviations. The last row in the matrix calculates the sum of annual negative deviations and provides a method of calculating the return-risk efficient solutions by changing the risk measure in the model.

The solver analysis package in the MS Excel program produces the results of the return-risk analysis and performs the following simultaneously to solve the algorithm (find the maximum expected net return). First, the model sets the sum of the resources used against the resource restrictions assigned as >, <, >=, or <= (Howitt 2002). Second, the model calculates the deviations below the target level of income in each time period. Third, the model multiplies the negative income deviations times their probability of occurrence and sums the total which must equal the parameterized risk level assigned. Fourth, the model sums the expected deviation below target income, in order to calculate the risk of a specific selection.

In theory, a risk efficient frontier (an efficient set of solutions) is obtained by varying the risk coefficient over a specific range to find alternative solutions (Qiu, Prato, and Kaylen 1998). In practice, the points on the return-risk frontier are found by increasing the right-hand side value of risk (λ) manually in increments as specified in the model by allowable increases or allowable decreases to find multiple solutions for the model while holding the target level of return constant and still maintaining feasibility. Risk, which controls the total amount of negative deviations from the target level of income, is increased systematically.

A map of alternative solutions over alternative risk preference levels is defined. Initially, the risk constraint is set to an initial value equal to zero or as close to zero as possible representing a no risk solution. When the risk aversion coefficient is equal to zero, no negative deviations are allowed in any time period (Zimet and Spreen 1986). Occasionally setting the risk parameter at zero or at very low levels of risk will result in an infeasible solution due to not meeting the target level of return. The next feasible solution is found by increasing risk by the allowable increase specified by the model. The lower the level of risk, the less risk-bearing combination of enterprises will be selected. The risk is then further increased to discover if there are other optimal solutions. As the level of risk increases, a new mix of production activities is associated with larger deviations and a larger potential for profit becomes optimal. As the risk allowed viabilities approaches a very large number, the optimal solution of the model becomes identical to that of a linear programming solution. This point reflects a risk loving behavior for producers where further increases in risk will not change the production enterprises selected.

On the return-risk frontier, each point provides a measurement of the maximum expected return and level of risk. For this given point there is an optimal solution of selected enterprises and resources utilized. The first and last points on the risk-efficient frontier represent the minimum level of risk and the maximum expected return, respectively. The interior points on the risk-efficient frontier represent intermediate risk solutions for which the points were chosen to further describe the risk-return tradeoff. For example, Points A, B, C, and D on a return-risk frontier represent the expected return and risk points for various optimal solutions. As would be expected, higher levels of expected return are associated with substantially higher levels of risk. The tableau created for this analysis can be found in the Appendix A, Table A14-15.

Model Results

The results of the Target MOTAD model evaluating the seven possible activities are presented in table 10. The Target MOTAD model was initially used to identify the maximum expected return from the selected enterprises for a target level of return of $100,000.

The solution at point A included traditional peanuts and cotton with government payments, irrigated land rented out, and rain-fed land rented out at 0.80, 4.00, and 3.20 units of 160 acres, respectively. The level of operating labor and hired labor for this solution was 215 and 0 hours, respectively. The level of operating capital used for this point was $96,006. Additionally, for point A for a risk level of $11,408, we determine the maximum expected return to be $102,201. This is the maximum expected return for this specific level of risk, other activities could have entered the solution at this level of risk, but they would not have been the maximum expected return. Allowing changes in risk levels (λ) allows the optimal solutions for points to be revealed. At points A, B, C, D, and E the optimal solution and the maximum expected return exceeded our target level of return of $100,000. For additional increases in the level of risk (as returned as the allowable increase in the model), the maximum expected return increased.

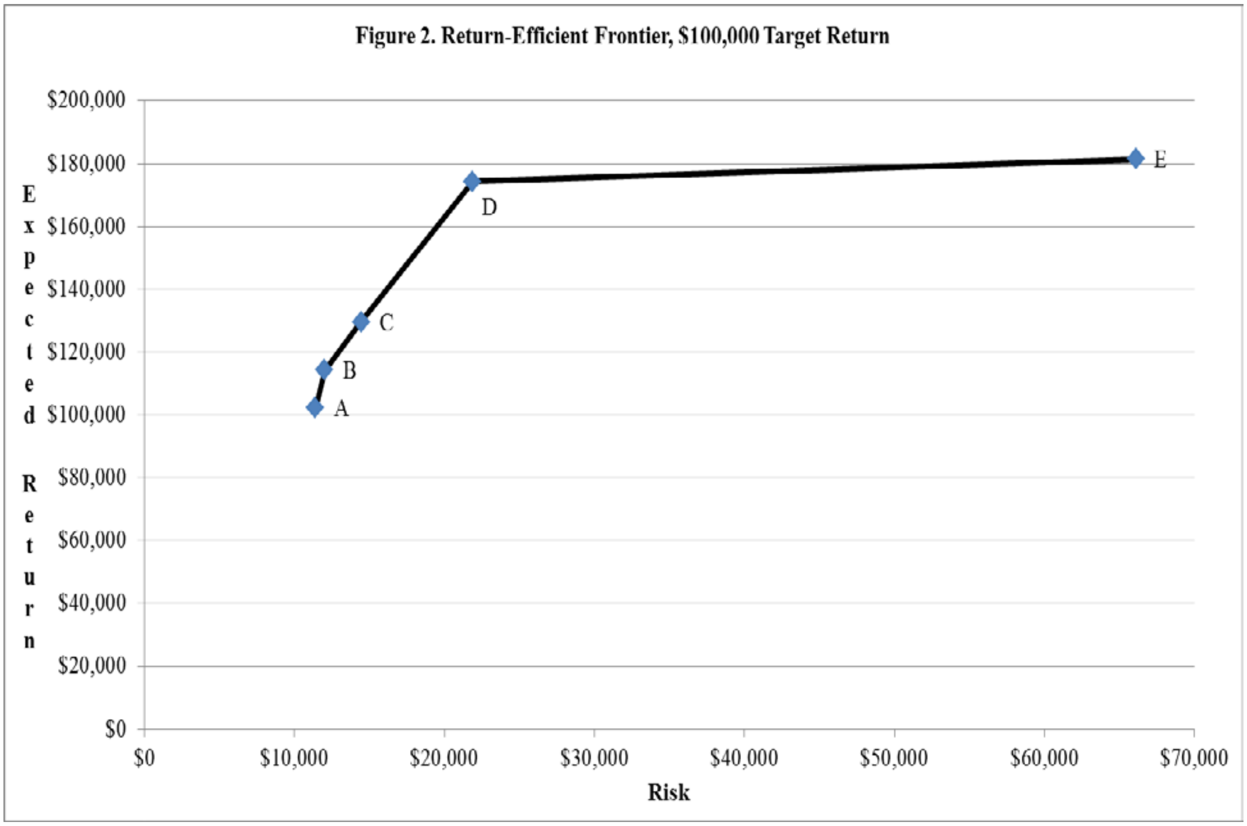
A return-risk ratio measurement was calculated between each of the points to develop a risk-efficient frontier as shown in figure 2. The return-risk measurements of $19.32, $6.30, $6.01 and $0.16 measures the increase in expected return for each additional dollar of risk incurred between the relevant points. For the points B, C, and D these values represent that the selection of these points would contribute more than a dollar of expected return for each additional dollar of risk. Point E represents a selection where this point would contribute less than a dollar of expected return for each additional dollar of risk. Therefore, if the farmer is particularly risk averse then point B would likely be selected. In addition, the operating capital dramatically increased between points (i.e. from $96,006 for point A to $929,538 for point E).

Table 10. Target MOTAD model solutions and activity levels, $100,000 target return

Item	Point A	Point B	Point C	Point D	Point E
			Number of 160 Acre Units		
SBR-IRR					
TPC-IRR					4.00
TPC-RF					
TPC-RF, GP	0.80	1.29	1.96	4.00	4.00
TWSC-RF					
IRRLNDRT	4.00	4.00	4.00	4.00	
RFLNDRT	3.20	2.71	2.04		
Total[a]	8.00	8.00	8.00	8.00	8.00
	***	***	***	***	***
OPRLAB	215	348	450	584	827
HIRELAB	0	0	78	493	1,155
	***	***	***	***	***
Operating Capital ($)	$96,006	$155,150	$235,647	$480,682	$929,538
Expected return ($)	$102,201	$114,182	$129,545	$174,205	$181,417
Change in expected return ($)		$11,981	$15,363	$44,660	$7,212
Risk ($)	$11,408	$12,028	$14,467	$21,892	$66,099
Change in risk ($)		$620	$2,439	$7,425	$44,207
Return-risk ratio[b]		$19.32	$6.30	$6.01	$0.16

[a]Acreage total may not sum exactly due to rounding error. Total acreage may be calculated by multiplying the total unit above by 160 acres.

[b]Return-risk ratio is the dollar value increase in expected return for each additional dollar of risk incurred between the two relevant points.
between the two relevant points.



The results of the Target MOTAD model evaluating the six possible activities are presented in table 11. The Target MOTAD model was used to identify the maximum expected return from the selected enterprises for a target level of return of $120,000.

The solution at point A included traditional peanuts and cotton with government payments, irrigated land rented out, and rain-fed land rented out at 1.40, 4.00, and 2.60 units of 160 acres, respectively. The level of operating labor and hired labor for this solution was 367 and 10 hours, respectively. The level of operating capital used for this point was $168,369. Additionally, for point A for a risk level of $22,186, we determine the maximum expected return to be $116,734. This is the maximum expected return for this specific level of risk, other activities could have entered the solution at this level of risk, but they would not have been the maximum expected return. At point A the maximum expected return is less than our target expected return at $120,000. At points B, C, D, E, and F the optimal solution and the maximum expected return exceeded our target level of return of at $120,000. For additional increases in the level of risk (as returned as the allowable increase in the model), the maximum expected return increased.

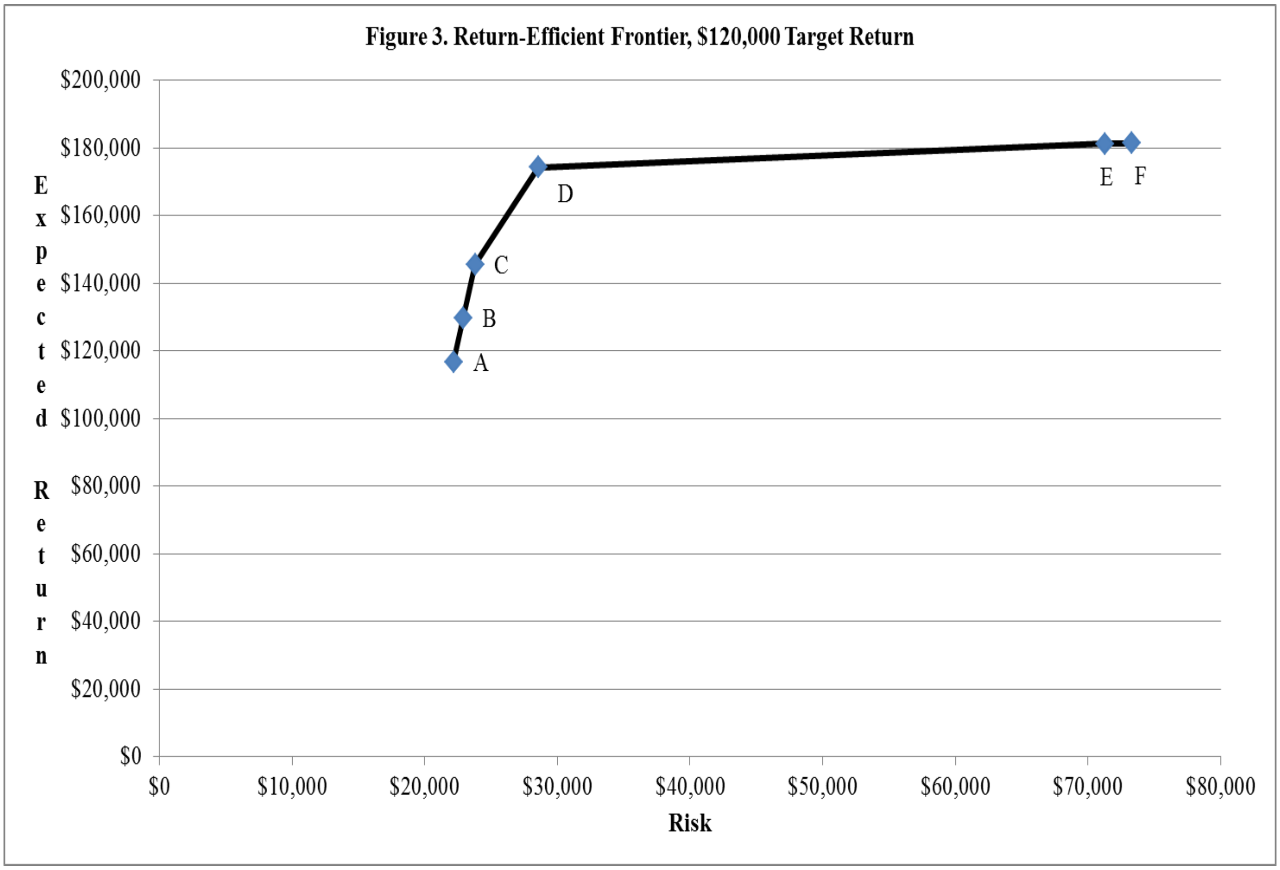
A return-risk ratio measurement was calculated between each of the points to develop a risk-efficient frontier as shown in figure 3. The return-risk measurements of $18.18, $17.39, $6.01, $0.16, and $0.12 measures the increase in expected return for each additional dollar of risk incurred between the relevant points. For the points B, C, D, and E these values represent that the selection of these points would contribute more than a dollar of expected return for each additional dollar of risk. Point F represents a selection where this point would contribute less than a dollar of expected return for each additional dollar or risk. Therefore, if the farmer is particularly risk averse then points B and C would likely be selected. In addition, the operating capital dramatically increased between points (i.e. from $168,369 for point A to $929,538 for point E).

Table 11. Target MOTAD model solutions and activity levels, $120,000 target return.

Item	Point A	Point B	Point C	Point D	Point E	Point F
			Number of 160 Acre Units			
SBR-IRR						
TPC-IRR					3.86	4.00
TPC-RF						
TPC-RF, GP	1.40	1.96	2.69	4.00	4.00	4.00
TWSC-RF						
IRRLNDRT	4.00	4.00	4.00	4.00	0.14	
RFLNDRT	2.60	2.04	1.31			
Total[a]	8.00	8.00	8.00	8.00	8.00	8.00
	***	***	***	***	***	***
OPRLAB	367	450	498	584	818	827
HIRELAB	10	79	227	493	133	1,155
	***	***	***	***	***	***
Operating Captial ($)	$168,369	$235,673	$323,635	$480,682	$914,091	$929,538
Expected return ($)	$116,734	$129,550	$145,582	$174,205	$181,169	$181,417
Change in expected return ($)		$12,816	$16,032	$28,623	$6,964	$248
Risk ($)	$22,186	$22,891	$23,813	$28,572	$71,257	$73,293
Change in risk ($)		$705	$922	$4,759	$42,685	$2,036
Return-risk ratio[b]		$18.18	$17.39	$6.01	$0.16	$0.12

[a]Acreage total may not sum exactly due to rounding error. Total acreage may be calculated by multiplying the total unit above by 160 acres.

[b]Return-risk ratio is the dollar value increase in expected return for each additional dollar of risk incurred between the two relevant points.
between the two relevant points.



The results of the Target MOTAD model evaluating the six possible activities are presented in table 12. The Target MOTAD model was used to identify the maximum expected return from the selected enterprises for a target level of return of $140,000.

The solution at point A included traditional peanuts and cotton with government payments, irrigated land rented out, and rain-fed land rented out at 2.00, 4.00, and 2.00 units of 160 acres, respectively. The level of operating labor and hired labor for this solution was 452 and 87 hours, respectively. The level of operating capital used for this point was $240,828. Additionally, for point A for a risk level of $32,965, we determine the maximum expected return to be $130,490. This is the maximum expected return for this specific level of risk, other activities could have entered the solution at this level of risk, but they would not have been the maximum expected return. At point A the maximum expected return is less than our target expected return at $140,000. At points B, C, and D the optimal solution and the maximum expected return exceeded our target level of return of at $140,000. For additional increases in the level of risk (as returned as the allowable increase in the model), the maximum expected return increased.

A return-risk ratio measurement was calculated between each of the points to develop risk-efficient frontiers as shown in figure 4. The return-risk measurements of 17.40, 0.16, and 0.12 measures the increase in expected return for each additional dollar of risk incurred between the relevant points. Point B represents a selection where this point would contribute more than a dollar of expected return for each additional dollar of risk. For Points C and D these values represent a selection where this point would contribute less than a dollar of expected return for each additional dollar or risk. Therefore, if the farmer is particularly risk averse then point B and C would likely be selected. In addition, the operating capital required dramatically increased between points (i.e. from $240,828 for point A to $929,538 for point F).

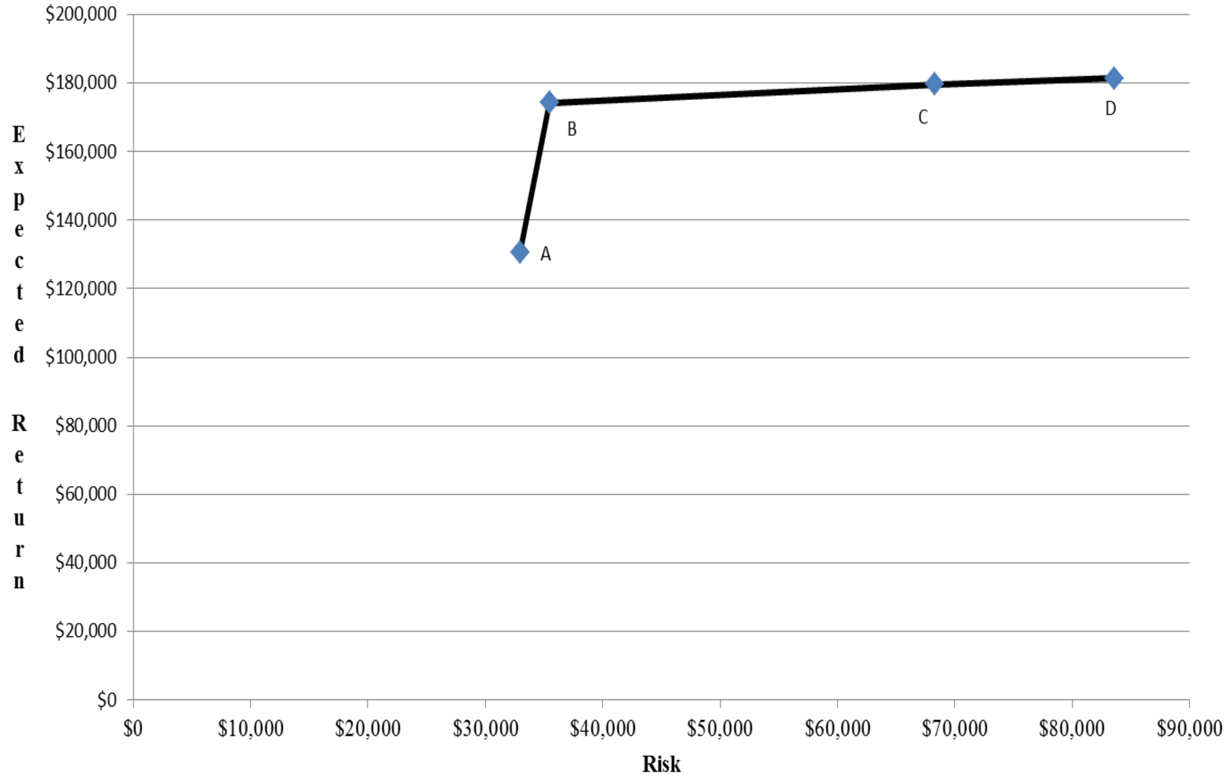
Table 12. Target MOTAD model solutions and activity levels, $140,000 target return.

Item	Point A	Point B	Point C	Point D
		Number of 160 Acre Units		
SBR-IRR				
TPC-IRR				
			2.97	4.00
TPC-RF				
TPC-RF, GP	2.00	4.00	4.00	4.00
TWSC-RF				
IRRLNDRT	4.00	4.00	1.03	
RFLNDRT	2.00			
Total[a]	8.00	8.00	8.00	8.00
	***	***	***	***
OPRLAB	452	584	764	827
HIRELAB	87	493	984	1,155
	***	***	***	***
Operating Capital ($)	$240,828	$480,680	$813,577	$929,538
Expected return ($)	$130,490	$174,205	$179,554	$181,417
Change in expected return ($)		$43,715	$5,349	$1,863
Risk ($)	$32,965	$35,477	$68,307	$83,596
Change in risk ($)		$2,512	$32,830	$15,289
Return-risk ratio[b]		$17.40	$0.16	$0.12

[a]Acreage total may not sum exactly due to rounding error. Total acreage may be calculated by multiplying the total unit above by 160 acres.

[b]Return-risk ratio is the dollar value increase in expected return for each additional dollar of risk incurred between the two relevant points. between the two relevant points.

Figure 4. Return-Efficient Frontier, $140,000 Target Return



Return-Risk Comparisons

The return risk comparison evaluates the risk-efficient frontiers using the three target levels of $100,000, $120,000, and $140,000, respectively. The risk-efficient frontiers for these three target levels is illustrated in figure 5.

We utilize the tradeoff between expected return and risk to find the most efficient portfolio choice. The alternatives of the tradeoff differ in terms of expected return and risk. Each solution provides an optimal combination for a particular value of expected return and risk level.

As evident in figure 5, an increase in the target return level, larger levels of risk are incurred but higher expected returns are achieved. The latter points on each risk-efficient frontier are less than one, which means for each additional dollar of risk the producer receives less than a dollar of expected return.

The risk-efficient frontiers for target 1, 2, and 3 are shown in descending order, which suggests a lower level of utility for each successive target level assuming the producer is risk averse. Alternatively, if the producer exhibits the risk preferring characteristic, the maximum level of utility will be obtained at the point furthest from the origin. In general, the risk-efficient frontier shifts downward and to the right for higher target levels.

The level of operating capital was recorded for each solution point of each target level of return as shown in figure 6. In general, the levels of operating capital increased as you increased the level of risk. Additionally, the levels of operating capital increased for higher levels of target return.

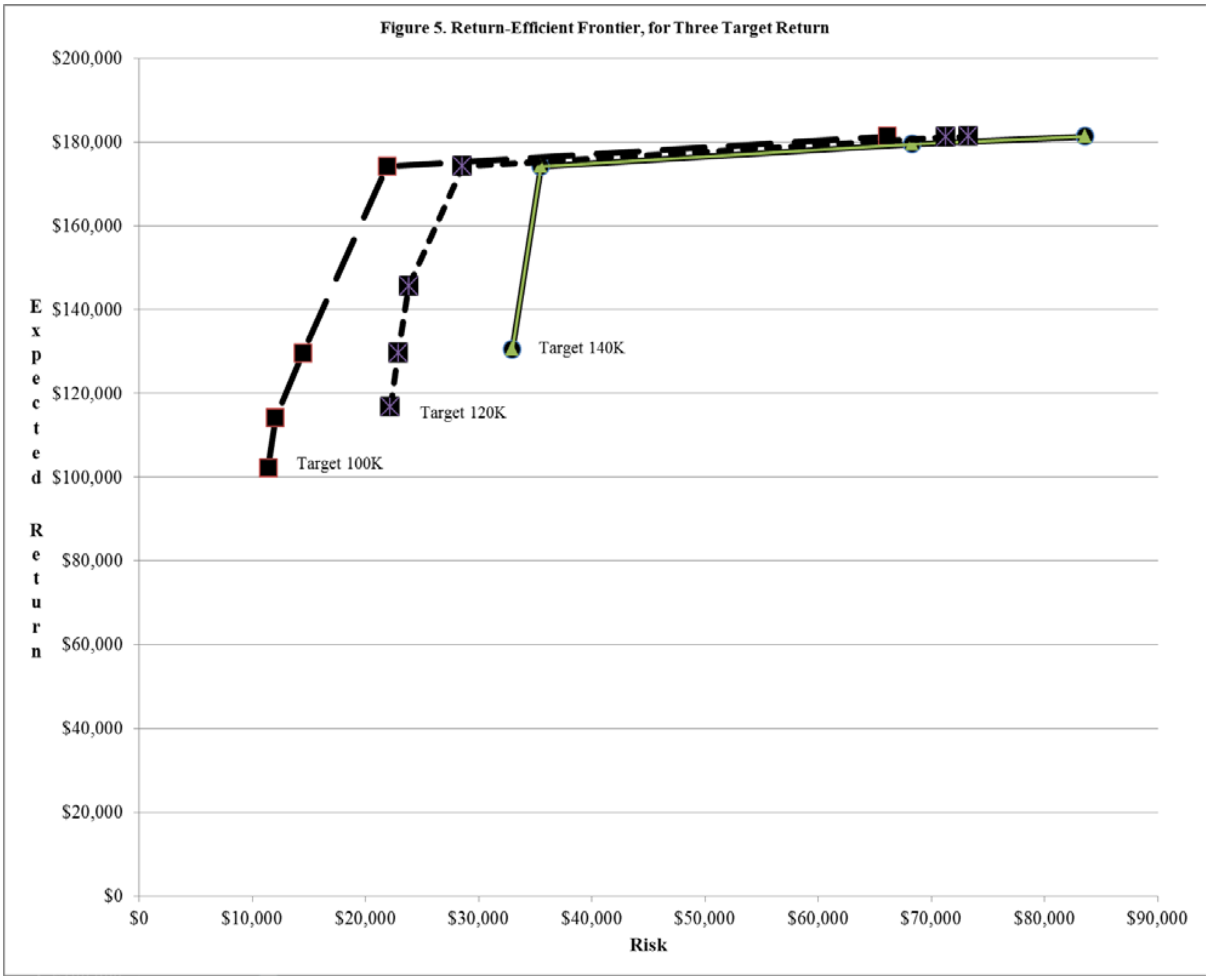
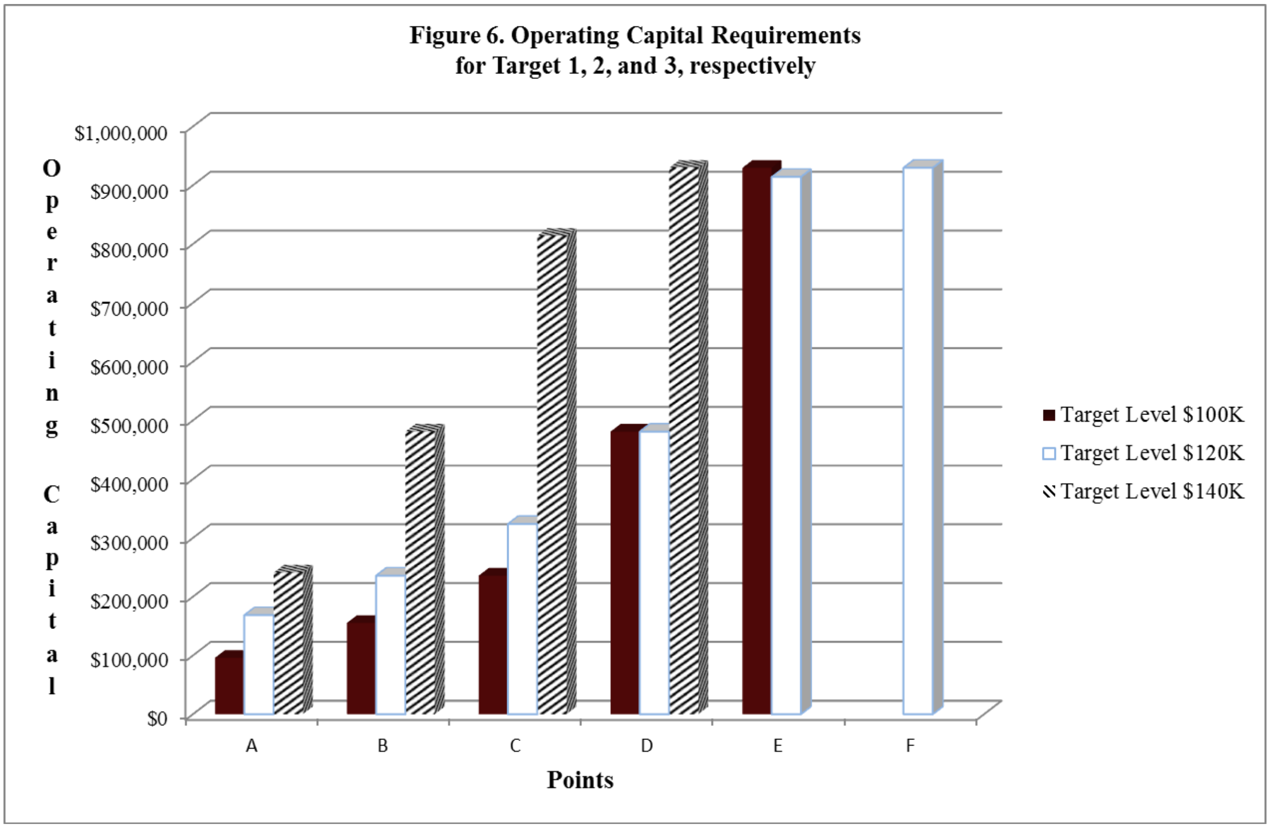


Figure 5. Return-Efficient Frontier, for Three Target Return
Expected Return
Risk
$200,000
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
$0
$10,000
$20,000
$30,000
$40,000
$50,000
$60,000
$70,000
$80,000
$90,000
Target 100K
Target 120K
Target 140K



The general results of the three target levels included the following enterprises: rain-fed land rented out, irrigated land rented out, rain-fed traditional peanut-cotton rotation with government payments, and the irrigated traditional peanut-cotton rotation. The low return, low-risk solution for rain-fed land was that rain-fed land be rented out. The low return, low to mid-risk solution for irrigated land was that irrigated land be rented out. The high return, high-risk solution for irrigated land was to use an irrigated traditional peanut-cotton rotation. The high return, mid to high-risk solution for rain-fed land was producing a rain-fed traditional peanut-cotton rotation with government payments. The best use of irrigated land in the Wiregrass was the irrigated land rented out. The best use of rain-fed land in the Wiregrass was the rain-fed traditional peanut-cotton rotation with government payments. A farmer with similar resources looking to adopt a rotation from this study would choose the rain-fed traditional peanut-cotton rotation that was receiving government payments.

Chapter V

Summary & Conclusions

Summary

A target MOTAD programming model was formed to examine the profitability and risk of row-crop and cow-calf enterprises. This study aimed to examine the return-risk tradeoff in order to increase the efficiency and profitability of farmers without raising the level of economic risk that farmers assume. This study hoped to help answer questions concerning the optimal enterprise mixes for different production systems for different levels of risk. The target MOTAD model used in this study compared the returns and risks related to row-crop and cow-calf production systems in the Wiregrass Region of Alabama. Returns maximized the farm income for row-crops and cattle production while reducing the risk they assumed. This model is used to help contribute to information available to producers and thereby help improve the resource allocation decisions that producers must make. Farmers with similar resources may use the results to consider alternative farming systems and to assess the return-risk tradeoffs associated with alternative enterprises. This study was designed to help farmers understand the importance of risk in farm decision making.

Row-crops and cow-calf production enterprises comprise an important group of activities throughout the southeastern United States. In this region it is common for farmers who produce row-crops to have cattle, as well. Farmers in South Alabama have large acreages that are suitable for the sod-based rotation. Many farmers in this region have practiced rotational agriculture in the past. Yield data obtained for this study from the Wiregrass Research and Experiment Station in Headland, Alabama has shown the potential benefits from the sod-based rotation in terms of higher crop yields, which generates more income than a traditional system on a per row crop acre basis. It was assumed, by adopting the Sod-Based Rotation, farmers in this region would have the potential to reduce risk considerably and increase producer incomes on a per row crop acre basis with little sacrifice in their total expected income.

The objective of this model was to maximize the expected return subject to various resource constraints given a target level of return and risk. The level of risk was measured as the level of expected absolute negative deviations below a predetermined target level of return.

The period of analysis for this study was from 2007 to 2012. A farm with 1,280 acres of land was assumed for the analysis. The target return was composed of the operator's wages, debt payment, and the opportunity cost of owned assets. The annual debt payment was based on the investment cost for land, machinery and equipment of a 1,000 acre row-crop and cow-calf operation, which was assumed to be $50,000. The level of debt was estimated using 30, 60, and 90 percent of investment costs for the respective three target return levels. This study assumed three levels of target return. It was assumed that agricultural producers usually view risk as a failure to achieve targeted returns.

Beginning with the first point (minimum level of risk) and progressing to the last point (the maximum expected return), a larger level of expected return and risk were realized for each risk-efficient frontier. Hence, individuals with strong risk averse characteristics would select the first point on any given risk-efficient frontier as seen in Tables 10, 11, and 12. The selection of successive points on the risk-efficient frontier indicates that the individual is less risk averse. The return-risk ratio measured the dollar increase in expected return for each additional dollar of risk incurred between the points.

The enterprises selected as optimal by the model included rain-fed traditional peanut-cotton rotation with government payments, irrigated land rented out, rain-fed land rented out, and the irrigated traditional peanut-cotton rotation. At the lowest levels of risk, the model rents out both irrigated and rain-fed land. As risk increases, a traditional rain-fed peanut-cotton rotation with government payments comes into the solution and replaces rain-fed land rented out. As risk increases further, the irrigated traditional peanut-cotton rotation comes into the solution and replaces irrigated land rented out.

The irrigated traditional peanut-cotton is selected by the model for producers utilizing irrigated land to achieve greater levels of profit while increasing the level of risk. The rain-fed traditional peanut-cotton rotation with government payments is selected by the model for producers utilizing rain-fed land to achieve greater levels of profit while increasing the level of risk.

It was determined from this economic analysis, the Headland sod-based rotation proved to be an economically viable system. However, the sod-based rotation produces slightly more risk and less returns than the irrigated traditional peanut-cotton rotation for producers. Part of the reason for this can be seen in Table 6. The sod-based rotation yields on average 50 more pounds of lint per acre than the irrigated peanut-cotton rotation. This yield increase is not sufficient enough to justify reducing the row crop acres planted by roughly one-half as required by the sod-based rotation system. For this study, not fully utilizing the row-crop land over the 6-year time period is not recommended. Perhaps, over a long time period, the yields of the sod-based rotation system may continue to increase which may justify the selection of a sod-based system.

The model allows producers to see the levels of risk in alternative enterprises. Farmers with similar resources and management ability can use this information to access the returns and risk for their operation. Those with higher or low levels of management should not use this information to make decisions. Alternatively, they should consult with a research or extension specialist for an analysis of their operation. Farmer comfortable running a Target MOTAD model can compute their own results. Since risk is inherent in agriculture, farmers should be concerned with the risk they assume when they make farm planning decisions. The results indicated a relationship or tradeoff between income and risk for most enterprises. By having this additional information on risk, farmers can decrease the risk they assume and maintain a target income by changing their production system, intensifying their existing enterprises, or by adding additional enterprises to their current system. It becomes clear from the model that high profits will only be achieved through exposure to more risk. Thus, farmers who strive for higher profits must tolerate more risk.

General Conclusions

This analysis documents that Target MOTAD models may be utilized to provide additional information for the decision-making of farmers. With rapid changes in technologies, inputs, and government policies farmers must consider changing their production activities in order to adapt to new risks. They must continue to allocate their resources efficiently and profitability given today's production environment. The best plan for producers in determining their optimal enterprise mix will depend on their attitude toward risk in relation to their target level of expected returns.

Based on the results of this analysis, several conclusions may be made regarding optimal production mixes, target level, and operating capital for row-crop and cow-calf enterprises in the Wiregrass region of Alabama. The optimal solutions revealed that four enterprises entered the solutions, they include rain-fed traditional peanuts and cotton with government payments, irrigated land rented out, rain-fed land rented out, and irrigated traditional peanuts and cotton. These enterprises can be used by producers to improve the levels of expected returns and lower risk.

At each target level, rain-fed traditional peanuts and cotton with government payments, irrigated traditional peanut-cotton rotation, irrigated land rented out, and rain-fed land rented out were the enterprises that entered into solution that provided the lowest level of risk and the greatest expected return. As risk was increased, the rain-fed traditional peanut-cotton rotation and the irrigated traditional peanut cotton rotation with government payments entered into the solution at each target level for the maximize level of expected return.

It is important to note from the findings of this study the rain-fed traditional peanut-cotton rotation without government payments was be the second best rotation choice. This rotation without government support provided farmers returns over variable costs that were greater than other system, except the rain-fed traditional peanut-cotton rotation with government payments. These solutions may point towards the conclusion that government assistance may not be necessary in order to get producers to plant these crops.

The sod-based rotation system was not selected as a solution for this model. It was determined to be a higher risk, lower return enterprises than the irrigated traditional peanut-cotton rotation. Of the 6 years of data utilized in this study, an outlier existed for the sod-based rotation. In 2009, the sod-based rotations cotton yielded 504 pounds of lint per acre. This outlier occurred only on this site in 2009, other yields in the Wiregrass region were normal in 2009. Over the 6 years of data collected by this study for the sod-based rotation mean cotton yield was

1201 pounds of lint per acre. This outlier in cotton yield may have contributed to the sod-based rotation not being selected by the model.

The yields on irrigated land were greater than those on rain-fed land. However, the additional input costs associated with irrigation did not provide a high enough yield and revenue in order to offset its costs. Thus, the rain-fed land is preferred in this study. In the future, should energy costs continue to rise, this also could contribute to the selection of a rain-fed production system.

Additionally, this study points out the importance of the opportunity costs associated with farming. Individuals with above average management skills would warrant higher wages (e.g. CEO of a company). These individuals would have to decide how much they are willing to forgo or how much higher to raise their wage level in this study. Additionally, the opportunity cost on assets (land, machinery and equipment) will affect the decision of whether to choose to farm or not. Rising returns in alternative investments (stocks, bonds, etc.) may influence the allocation of investments in nonfarm investments.

This research may help the government improve its understanding of a farmer's decision making behavior and assist in the formulation of its policies which will be more effective and suitable to farmer's needs. Few would disagree that agricultural production is a risky business. Thus, greater returns will only come from improved decision-making capabilities.

Limitations of the Study and Suggestions for Further Research

This study builds on previous research of incorporating risk of the row-crop and cow-calf enterprises through the Target MOTAD model. The objectives of the model are generalized management objectives and may not necessarily reflect the real life objectives of all farms and producers. Some caution should be taken in the adoption of the enterprises presented in this study. The results may not be as applicable to other locations, as they are for the Wiregrass region of Alabama due to differing soil types, weather, and potential pests and diseases issues.

Although a conscientious effort was made to properly conduct the analysis, there are several weaknesses in the overall analysis. The model in this study was defined by a specific set of resources and constraints that vary among producers and farms.

This study was accomplished with only six years of observations. The results of this study could have been more precise had more years been available. Using data from only a small number of years may have influenced the model. This is problematic when the early years of the series influence the final solution. One way to overcome the problem would be to expand the number of observations. An assumption in the structural component of the Target MOTAD application is that negative deviations are minimized over previous years, which will minimize future negative deviations. Thus, we assume that the future distributions of price and yield will be similar to historical distributions.

This study is based on several assumptions that may vary with farm size, available resources, and weather conditions. These assumptions may vary greatly among farms. Minor changes in any of these factors may cause significant differences in the results and conclusions drawn by this analysis. Production estimates and cost can also vary among farmers with respect to the level of inputs used. Other factors that may influence the profitability of an enterprise that were not included in the study were alternative planting dates, alternative harvesting dates, various types of irrigation technologies, and different crop varieties.

A limitation of this study to the sod-based rotation is that farmers will be hesitant to change their production system until the sod-based rotation is more proven. There is additional risk for farmer's adopting a new system that affects their entire livelihood. Adopting this rotation requires time. Most likely, they already have a system that is working and provides them with an income. The risks farmers take to grow row crops has increased to over the years due to increased input costs. Growers depend on producing crops to provide an income for themselves and their families. Thus, in order for producers to adopt this new system the economic benefits must greatly outweigh the risks. The potential for success must be substantially greater for farmers to take the risk and begin sod-based farming.

Recognizing the limitations of this analysis makes the user aware of the necessary improvements that would contribute more accuracy and preciseness to the results. This analysis in its present form has several potential uses, but must be viewed giving consideration to the limitations of the analysis.

An alternative farm plan under different target income and risk levels can be projected and presented to farmers for selection according to their risk attitudes. If farmers are to adopt new farm plans in the future, then more information is needed on the risks associated with changing or adopting new enterprises. Farmer's decision making processes influence his or her attitude toward risk. The optimal farm plan for an individual depends on their income and risk preferences. The average amount of expected net return is clearly an important measure by which producers will select among alternative activities. However, producers may also have an interest in the worst possible outcome associated with each activity. Each farmer's production plan is unique, sensitive, and depends upon their decision making environment. Thus, a better understanding of a farmer's attitude toward risk could provide a greater understanding of a farmer's decision making behavior.

A study dealing with the changes in price and yield variability relating to the factors that influence profitability would be useful information to producers in the future. This additional information will allow farmers to make more profitable decisions.

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APPENDIX A

Table A1. IRRIGATED PEANUTS USING A SOD-BASED ROTATION, ALABAMA, 2011
Rotation includes bahiagrass (yr.1), bahiagrass (yr.2), peanuts (yr.3), and cotton (yr.4)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Peanut Acres	ACRE	32.00			
Peanuts	LBS	5,302.00	$0.28	$1,458.05	$46,657.60
Government Payments	ACRE	32.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	32.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,458.05	$46,657.60
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	1.00	$103.82	$103.82	$3,322.20
Burn Down Bahia	GAL	0.50	$19.98	$9.99	$319.68
Cover Crop Cost Allocation*	ACRE	1.00	$247.06	$247.06	$7,905.92
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$280.00
Peanut Seed	LBS	120.00	$0.80	$96.00	$3,072.00
Herbicides	ACRE	1.00	$54.57	$54.57	$1,746.19
Fungicides	ACRE	1.00	$95.64	$95.64	$3,060.33
Insecticides	ACRE	1.00	$0.00	$0.00	$0.00
Boron	ACRE	1.00	$3.75	$3.75	$120.00
Consultant/Scouting Fee	ACRE	1.00	$8.00	$8.00	$256.00
Irrigation	AC/IN	5.10	$6.20	$31.61	$1,011.53
Crop Insurance	ACRE	1.00	$25.00	$25.00	$800.00
Hauling	LB	5,302.00	$0.005	$26.51	$848.32
Drying & Cleaning	LB	5,302.00	$0.01	$53.02	$1,696.64
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	3.80	$11.25	$42.73	$1,367.47
Truck/Tractor/Machinery	ACRE	1.00	$105.06	$105.06	$3,362.07
Interest on Operating Capital	DOL.	455.76	$0.055	$25.07	$802.13
TOTAL VARIABLE COSTS				$936.58	$29,970.48
3. RETURNS OVER VARIABLE COSTS				$521.47	$16,687.12

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cost was shared equally between cow-calf, cotton, and peanut enterprises.

Table A2. IRRIGATED COTTON USING A SOD-BASED ROTATION, ALABAMA, 2011
Rotation includes bahiagrass (yr.1), bahiagrass (yr.2), peanuts (yr.3), and cotton (yr.4)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Cotton Acres	ACRE	32.00			
Cotton Lint	LBS	1,219	$1.15	$1,401.85	$44,859.20
Cottonseed Credit	Tons	0.76	$200.00	$152.38	$4,876.00
Government Payments	ACRE	32.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	32.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,554.23	$49,735.20
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	1.00	$103.82	$103.82	$3,322.20
Cover Crop Cost Allocation*	ACRE	1.00	$247.06	$247.06	$7,905.92
Cotton Seed	BAG	0.18	$600.00	$108.00	$3,456.00
Fertilizer - April					
Nitrogen	UNITS	25.00	$0.70	$17.50	$560.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	60.00	$0.54	$32.40	$1,036.80
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$83.20
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$280.00
Fertilizer - June					
Nitrogen	UNITS	60.00	$0.70	$42.00	$1,344.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	0.00	$0.54	$0.00	$0.00
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$83.20
Herbicides	ACRE	1.00	$46.72	$46.72	$1,495.12
Fungicides	ACRE	1.00	$0.00	$0.00	$0.00
Insecticides	ACRE	1.00	$25.71	$25.71	$822.60
Growth Regulators	ACRE	1.00	$2.97	$2.97	$95.00
Defoiliants	ACRE	1.00	$10.01	$10.01	$320.20
Boron	ACRE	1.00	$3.75	$3.75	$120.00
Consultant/Scouting Fee	ACRE	1.00	$9.00	$9.00	$288.00
Irrigation	AC-IN	5.73	$6.20	$35.52	$1,136.49
Crop Insurance	ACRE	1.00	$55.00	$55.00	$1,760.00
Aerial Application	ACRE	1.00	$0.00	$0.00	$0.00
Boll Weevil Eradication	ACRE	1.00	$2.50	$2.50	$80.00
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	2.64	$11.25	$29.67	$949.33
Truck/Tractor/Machinery	ACRE	1.00	$90.79	$90.79	$2,905.42
Interest on Operating Capital	DOL	438.18	$0.055	$24.10	$771.20
Module Builder	LB	1,219.00	$0.00	$0.00	$0.00
Ginning Cotton	LB	1,219.00	$0.095	$115.81	$3,705.76
Bale Rec./Stor./Loadout Fees	BALE	2.54	$10.50	$26.67	$853.30
TOTAL VARIABLE COSTS				$1,042.93	$33,373.74
3. RETURNS OVER VARIABLE COSTS				$511.30	$16,361.46

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.
*Cost was spread equally between cow-calf, cotton, and peanut enterprises.

Table A3. COW-CALF ENTERPRISE (IRRIGATED BAHIAGRASS), SOD-BASED ROTATION, ALABAMA, 2011

Rotation includes bahiagrass (yr.1), bahiagrass (yr.2), peanuts (yr.3), and cotton (yr.4)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER UNIT	TOTAL DOLLARS
Warm Season Pasture Acres	ACRE	32.00			
Cool Season Pasture Acres	ACRE	96.00			
Brood Cows	HEAD	64.00			
1. GROSS RETURNS					
Feeder Calf Sales	LBS/COW	495.00	$1.28	$631.13	$40,392.00
Cull Cow Sales	LBS/COW	143.00	$0.65	$92.95	$5,948.80
Cull Bull Sales	LBS/COW	13.28	$0.70	$9.30	$595.00
Government Payments	HEAD	32.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$733.37	$46,935.80
2. VARIABLE COSTS					
Warm Season Pasture Establishment*	ACRE	1.00	$103.82	$103.82	$3,322.20
Warm Season Pasture Grazing	ACRE	1.00	$156.80	$156.80	$5,017.49
Cool Season Pasture Grazing**	ACRE	1.00	$247.06	$247.06	$7,905.92
Purchased Feeds	HEAD	1.00	$144.70	$144.70	$9,260.63
Animal Health	HEAD	1.00	$36.97	$36.97	$2,365.86
Labor (Wages & Fringe)	HEAD	1.00	$30.38	$30.38	$1,944.00
Marketing Expenses	HEAD	1.00	$25.34	$30.38	$1,944.00
Land Rent	ACRE	32.00	$0.00	$0.00	$0.00
Utilities	HEAD	1.00	$2.85	$2.85	$182.50
Miscellaneous	HEAD	1.00	$17.93	$17.93	$1,147.30
Truck/Tractor/Machinery	ACRE	1.00	$20.05	$20.05	$1,283.48
Interest on Operating Capital	DOL.	395.46	$0.055	$21.75	$1,392.02
TOTAL VARIABLE COSTS					$35,765.40
TOTAL VARIABLE COSTS PER BROOD COW					$558.83
TOTAL VARIABLE COSTS PER ACRE					$1,117.67
3. RETURNS OVER VARIABLE COSTS					$11,170.40
RETURNS OVER VARIABLE COSTS PER BROOD COW					$174.54
RETURNS OVER VARIABLE COSTS PER ACRE					$349.07

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Warm season pasture establishment cost is shared equally between cow-calf, cotton, and peanut enterprises.

**Cool season pasture grazing cost is shared equally between cow-calf, cotton, and peanut enterprises.

Table A4. COOL SEASON PASTURE USING A SOD-BASED ROTATION, ALABAMA, 2011

Rotation includes bahiagrass (yr.1), bahiagrass (yr.2), peanuts (yr.3), and cotton (yr.4)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
Cool Season Pasture Grazing	ACRE	96.00			
VARIABLE COSTS*					
Cover Crop					
Oats	BU	2.50	$9.00	$22.50	$2,160.00
Rye	BU	1.25	$20.00	$25.00	$2,400.00
Fertilizer (17-17-17)	CWT	3.00	$30.75	$92.25	$8,856.00
Fertilizer (Liquid N) - Dec	LBS	50.00	$0.60	$30.00	$2,880.00
Fertilizer (Liquid N) - Feb	LBS	50.00	$0.60	$30.00	$2,880.00
Irrigation	AC/IN	1.75	$6.20	$10.85	$1,041.28
Burndown Before Row Crop	GAL	0.25	$19.98	$5.00	$479.52
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	1.06	$11.25	$11.96	$1,148.55
Truck/Tractor/Machinery	ACRE	1.00	$19.53	$19.53	$1,874.78
Interest on Operating Capital	DOL.	123.54	$0.00	$0.00	$0.00
TOTAL VARIABLE COSTS				$247.08	$23,720.14

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cool season pasture cost is shared equally between cow-calf, cotton, and peanut enterprises.

Table A5. IRRIGATED PEANUTS USING A TRADITIONAL ROTATION, ALABAMA, 2011

Rotation includes peanuts (yr.1), and cotton (yr.2)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Peanut Acres	ACRE	64.00			
Peanuts	LBS	5,302.00	$0.28	$1,458.05	$93,315.20
Government Payments	ACRE	40.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	40.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,458.05	$93,315.20
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	1.00	$103.82	$103.82	$6,644.39
Burn Down Bahia	GAL	0.50	$19.98	$9.99	$639.36
Cover Crop Cost Allocation*	ACRE	1.00	$164.58	$164.58	$10,533.43
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$560.00
Peanut Seed	LBS	120.00	$0.80	$96.00	$6,144.00
Herbicides	ACRE	1.00	$54.57	$54.57	$3,492.38
Fungicides	ACRE	1.00	$95.64	$95.64	$6,120.66
Insecticides	ACRE	1.00	$0.00	$0.00	$0.00
Boron	ACRE	1.00	$3.75	$3.75	$240.00
Consultant/Scouting Fee	ACRE	1.00	$8.00	$8.00	$512.00
Irrigation	AC/IN	5.10	$6.20	$31.61	$2,023.07
Crop Insurance	ACRE	1.00	$25.00	$25.00	$1,600.00
Hauling	LB	5,302.00	$0.005	$26.51	$1,696.64
Drying & Cleaning	LB	5,302.00	$0.01	$53.02	$3,393.28
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	3.73	$11.25	$41.94	$2,683.89
Truck/Tractor/Machinery	ACRE	1.00	$102.23	$102.23	$6,542.48
Interest on Operating Capital	DOL.	412.70	$0.055	$22.70	$1,452.70
TOTAL VARIABLE COSTS				$848.10	$54,278.27
3. RETURNS OVER VARIABLE COSTS				$609.95	$39,036.93

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cost was shared equally between cow-calf, cotton, and peanut enterprises.

Table 6A. IRRIGATED COTTON USING A TRADITIONAL ROTATION, ALABAMA, 2011
Rotation includes peanuts (yr.1), and cotton (yr.2)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Cotton Acres	ACRE	64.00			
Cotton Lint	LBS	1,219	$1.15	$1,401.85	$89,718.40
Cottonseed Credit	Tons	0.76	$200.00	$152.38	$9,752.00
Government Payments	ACRE	40.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	40.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,554.23	$99,470.40
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	1.00	$51.91	$51.91	$3,322.20
Cover Crop Cost Allocation*	ACRE	1.00	$164.58	$164.58	$10,533.43
Cotton Seed	BAG	0.18	$600.00	$108.00	$6,912.00
Fertilizer - April					
Nitrogen	UNITS	25.00	$0.70	$17.50	$1,120.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	60.00	$0.54	$32.40	$2,073.60
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$166.40
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$560.00
Fertilizer - June					
Nitrogen	UNITS	60.00	$0.70	$42.00	$2,688.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	0.00	$0.54	$0.00	$0.00
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$166.40
Herbicides	ACRE	1.00	$47.14	$47.14	$3,017.04
Fungicides	ACRE	1.00	$0.00	$0.00	$0.00
Insecticides	ACRE	1.00	$25.71	$25.71	$1,645.20
Growth Regulators	ACRE	1.00	$2.97	$2.97	$190.00
Defoiliants	ACRE	1.00	$10.01	$10.01	$640.40
Boron	ACRE	1.00	$3.75	$3.75	$240.00
Consultant/Scouting Fee	ACRE	1.00	$9.00	$9.00	$576.00
Irrigation	AC-IN	5.73	$6.20	$35.52	$2,272.97
Crop Insurance	ACRE	1.00	$55.00	$55.00	$3,520.00
Aerial Application	ACRE	1.00	$0.00	$0.00	$0.00
Boll Weevil Eradication	ACRE	1.00	$2.50	$2.50	$160.00
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	2.64	$11.25	$29.67	$1,898.66
Truck/Tractor/Machinery	ACRE	1.00	$90.79	$90.79	$5,810.85
Interest on Operating Capital	DOL	371.20	$0.055	$20.42	$1,306.61
Module Builder	LB	1,219.00	$0.00	$0.00	$0.00
Ginning Cotton	LB	1,219.00	$0.095	$115.81	$7,411.52
Bale Rec./Stor./Loadout Fees	BALE	2.54	$10.50	$26.67	$1,706.60
TOTAL VARIABLE COSTS				$905.28	$57,937.88
3. RETURNS OVER VARIABLE COSTS				$648.95	$41,532.52

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cost was spread equally between cow-calf, cotton, and peanut enterprises.

Table A7. RAINFED PEANUTS USING A TRADITIONAL ROTATION, ALABAMA, 2011

Rotation includes peanuts (yr.1) and cotton (yr.2)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Peanut Acres	ACRE	80.00			
Peanuts	LBS	5,302.00	$0.28	$1,458.05	$116,644.00
Government Payments	ACRE	40.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	40.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,458.05	$116,644.00
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	0.00	$103.82	$0.00	$0.00
Burn Down Bahia	GAL	0.50	$19.98	$9.99	$799.20
Cover Crop Cost Allocation*	ACRE	1.00	$153.74	$153.74	$12,299.05
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$700.00
Peanut Seed	LBS	120.00	$0.80	$96.00	$7,680.00
Herbicides	ACRE	1.00	$54.57	$54.57	$4,365.47
Fungicides	ACRE	1.00	$95.64	$95.64	$7,650.83
Insecticides	ACRE	1.00	$0.00	$0.00	$0.00
Boron	ACRE	1.00	$3.75	$3.75	$300.00
Consultant/Scouting Fee	ACRE	1.00	$8.00	$8.00	$640.00
Irrigation	AC/IN	0	6.20	0	0
Crop Insurance	ACRE	1.00	$25.00	$25.00	$2,000.00
Hauling	LB	5,302.00	$0.005	$26.51	$2,120.80
Drying & Cleaning	LB	5,302.00	$0.01	$53.02	$4,241.60
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	3.73	$11.25	$41.94	$3,354.86
Truck/Tractor/Machinery	ACRE	1.00	$102.23	$102.23	$8,178.10
Interest on Operating Capital	DOL.	339.56	$0.055	$18.68	$1,494.07
TOTAL VARIABLE COSTS				$697.80	$55,823.97
3. RETURNS OVER VARIABLE COSTS				$760.25	$60,820.03

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cost was shared equally between cow-calf, cotton, and peanut enterprises.

Table A8. RAINFED COTTON USING A TRADITIONAL ROTATION, ALABAMA, 2011.
Rotation includes peanuts (yr.1) and cotton (yr.2)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
1. GROSS RETURNS					
Cotton Acres	ACRE	80.00			
Cotton Lint	LBS	1,219	$1.15	$1,401.85	$112,148.00
Cottonseed Credit	Tons	0.76	$200.00	$152.38	$12,190.00
Government Payments	ACRE	40.00	$0.00	$0.00	$0.00
Crop Insurance	ACRE	40.00	$0.00	$0.00	$0.00
TOTAL GROSS RETURNS				$1,554.23	$124,338.00
2. VARIABLE COSTS					
Bahiagrass Establishment Cost Allocation*	ACRE	0.00	$41.53	$0.00	$0.00
Cover Crop Cost Allocation*	ACRE	1.00	$153.74	$153.74	$12,299.05
Cotton Seed	BAG	0.18	$600.00	$108.00	$8,640.00
Fertilizer - April					
Nitrogen	UNITS	25.00	$0.70	$17.50	$1,400.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	60.00	$0.54	$32.40	$2,592.00
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$208.00
Lime (Prorated)	TONS	0.25	$35.00	$8.75	$700.00
Fertilizer - June					
Nitrogen	UNITS	60.00	$0.70	$42.00	$3,360.00
Phosphate	UNITS	0.00	$0.52	$0.00	$0.00
Potash	UNITS	0.00	$0.54	$0.00	$0.00
Ammonium Sulfate	UNITS	10.00	$0.26	$2.60	$208.00
Herbicides	ACRE	1.00	$47.14	$47.14	$3,771.30
Fungicides	ACRE	1.00	$0.00	$0.00	$0.00
Insecticides	ACRE	1.00	$25.71	$25.71	$2,056.50
Growth Regulators	ACRE	1.00	$2.97	$2.97	$237.50
Defoiliants	ACRE	1.00	$10.01	$10.01	$800.50
Boron	ACRE	1.00	$3.75	$3.75	$300.00
Consultant/Scouting Fee	ACRE	1.00	$9.00	$9.00	$720.00
Irrigation	AC-IN	0.00	6.20	$0.00	$0.00
Crop Insurance	ACRE	1.00	$55.00	$55.00	$4,400.00
Aerial Application	ACRE	1.00	$0.00	$0.00	$0.00
Boll Weevil Eradication	ACRE	1.00	$2.50	$2.50	$200.00
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	2.64	$11.25	$29.67	$2,373.33
Truck/Tractor/Machinery	ACRE	1.00	$90.79	$90.79	$7,263.56
Interest on Operating Capital	DOL	322.06	$0.055	$17.71	$1,417.07
Module Builder	LB	1,219.00	$0.00	$0.00	$0.00
Ginning Cotton	LB	1,219.00	$0.095	$115.81	$9,264.40
Bale Rec./Stor./Loadout Fees	BALE	2.54	$10.50	$26.67	$2,133.25
TOTAL VARIABLE COSTS				$804.31	$64,344.46
3. RETURNS OVER VARIABLE COSTS				$749.92	$59,993.54

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.

*Cost was spread equally between cow-calf, cotton, and peanut enterprises.

Table A9. RAINFED COOL SEASON PASTURE USING A TRADITIONAL ROTATION, ALABAMA, 2011.
Rotation includes peanuts (yr.1) and cotton (yr.2)

Item	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	TOTAL DOLLARS
Cool Season Pasture Grazing	ACRE	160.00			
VARIABLE COSTS*					
Cover Crop					
Oats	BU	0.00	$9.00	$0.00	$0.00
Rye	BU	1.25	$20.00	$25.00	$4,000.00
Fertilizer (17-17-17)	CWT	3.00	$30.75	$92.25	$14,760.00
Fertilizer (Liquid N) - Dec	LBS	0.00	$0.60	$0.00	$0.00
Fertilizer (Liquid N) - Feb	LBS	0.00	$0.60	$0.00	$0.00
Irrigation	AC/IN	0.00	6.20	$0.00	$0.00
Burndown Before Row Crop	GAL	0.25	19.98	$5.00	$799.20
Land Rent	ACRE	1.00	$0.00	$0.00	$0.00
Labor (Wages & Fringe)	HOUR	1.06	$11.25	$11.96	$1,914.26
Truck/Tractor/Machinery	ACRE	1.00	$19.53	$19.53	$3,124.64
Interest on Operating Capital	DOL.	76.87	$0.00	$0.00	$0.00
TOTAL VARIABLE COSTS				$153.74	$24,598.10

NOTE: The above variable costs are estimates. Actual costs and quantities will vary from farm to farm.
*Cool season pasture cost is shared equally between cow-calf, cotton, and peanut enterprises.

Table A10. Wheat for Grain, Alabama 2011-2012

ESTIMATED ANNUAL COSTS PER ACRE:
FOLLOWING RECOMMENDED MANAGEMENT PRACTICES

ITEM	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. GROSS RECEIPTS				
WHEAT	BU.	69.00	$7.50	$517.50
2. VARIABLE COSTS				
SEED (CERTIFIED)	BU.	2.00	$20.00	$40.00
FERTILIZER				
NITROGEN	LBS.	100.00	$0.71	$71.00
PHOSPHATE	LBS.	60.00	0.52	$31.20
POTASH	LBS.	60.00	0.54	$32.40
Cost of Cover Crop	ACRE	1.00	146.62	$146.62
CROP INS. (Wheat)	ACRE	1.00	$0.00	$0.00
LIME (PRORATED)	TONS	0.33	35.00	$11.55
HERBICIDES	ACRE	1.00	15.00	$15.00
INSECTICIDES	ACRE	1.00	$12.00	$12.00
FUNGICIDES	ACRE	0.50	$16.00	$8.00
NEMATICIDES	ACRE	1.00	$0.00	$0.00
IRRIGATION	AC-IN	0.00	$9.00	$0.00
AERIAL APPLICATION	APPL	0.00	$9.00	$0.00
DRYING	BU.	69.00	0.00	$0.00
HAULING	BU.	69.00	0.30	$20.70
LABOR (WAGES & FRINGE)	HOUR	1.58	8.25	13.068
LAND RENT	ACRE	1.00	20.00	$20.00
TRACTOR/MACHINERY	ACRE	1.00	20.23	20.23
INTEREST ON OP. CAP.	DOL.	194.00	0.07	13.58
TOTAL VARIABLE COSTS				455.348
3. INCOME ABOVE VARIABLE COSTS				62.15

Table A11. Soybeans, Alabama 2011

ESTIMATED ANNUAL COSTS PER ACRE:
FOLLOWING RECOMMENDED MANAGEMENT PRACTICES

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. GROSS RECEIPTS				
Soybeans	BU.	37.00	$11.43	422.91
2. VARIABLE COSTS				
Seed & Inoculant	BAG	1.00	50.00	
Fertilizer				
Phosphate	UNITS	40.00	0.49	19.60
Potash	UNITS	40.00	0.49	19.60
Lime (Prorated)	TONS	0.33	35.00	11.55
Herbicides	ACRE	1.00	30.00	30.00
Insecticides	ACRE	1.00	8.00	8.00
Fungicides	ACRE	1.00	14.00	14.00
Nematicide	ACRE	1.00	0.00	0.00
Consultant/Scouting Fee	ACRE	0.00	6.00	0.00
Irrigation	AC/IN	0.00	12.00	0.00
Drying	BU.	40.00	0.25	10.00
Hauling	BU.	40.00	0.00	0.00
Crop Insurance	ACRE	1.00	10.00	10.00
Aerial Application	ACRE	0.00	9.00	0.00
Land Rent	ACRE	0.00	40.00	0.00
Labor (Wages & Fringe)	HOUR	1.00	11.25	11.25
Tractor/Machinery	ACRE	1.00	17.00	17.00
Interest on Operating Capital	DOL.		0.0700	20.09
TOTAL VARIABLE COST				171.09
(Approximate Range per Acre : $125 to $300)				
3. INCOME ABOVE VARIABLE COSTS				251.82

Table A12. Corn, South Alabama 2011

ESTIMATED ANNUAL COSTS PER ACRE:

FOLLOWING RECOMMENDED MANAGEMENT PRACTICES

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. Gross Receipts				
Corn	BU.	110	5.53	$608.30
2. Variable Costs				
Seed	1000K	28	2.75	$77.00
Seed Treatment	ACRE	0	0.00	$0.00
Tech Fee	ACRE	1	0.00	$0.00
Fertilizer				
Nitrogen*	UNITS	160	0.60	$96.00
Phosphate	UNITS	60	0.49	$29.40
Potash	UNITS	60	0.49	29.40
Micronutrients	ACRE	1	8.00	8.00
Lime (Prorated)	TONS	0	35.00	11.55
Herbicides	ACRE	1	30.00	$30.00
Insecticides	ACRE	1	7.00	7.00
Fungicides	ACRE	1	0.00	0.00
Nematicide	ACRE	1	0.00	$0.00
Consultant/Scouting Fee	ACRE	0	5.00	$0.00
Irrigation	AC/IN	0	12.00	$0.00
Drying	BU.	120	0.25	$30.00
Hauling	BU.	120	0.25	$30.00
Crop Insurance	ACRE	1	20.00	20.00
Aerial Application	ACRE	0	9.00	0.00
Land Rent	ACRE	0	40.00	0.00
Labor (Wages & Fringe)	HOUR	1.6	11.25	18.00
Tractor/Machinery	ACRE	1	19.00	19.00
Interest on Operating Capital	DOL.		0.07	14.19
Total Variable Costs				419.54
(Approximate Range per Acre : $300 to $650)				
3. Income Above Variable Costs				188.76275

Table A13. Irrigation Budget, Wiregrass Region of Alabama

CENTER PIVOT COST ANALYSIS (ELECTRIC) 128 Acres TOTAL	Initial Cost	Years Useful Life	Yearly Depreciation
A. Basic System - Investment Cost 64 Acres ROW CROP		Updated	8/17/2011
1. System Electric Drive - System Options: NO End Gun or Booster Pump - Running Lights - Automatic End Gun System Pivot Pipe Length = 1312 feet @ $50.00 per foot	$65,600	20	$3,280
2. Freight, Installation	$12,000	20	$600
3. Power Unit and Pump - ELECTRIC Centrifugal Pump @ 79.28 %Efficiency 640 GPM @ 131 ' TDH= 26.7 MINIMUM CONTINUOUS HORSEPOWER Above TDH includes 50 feet elevation lift from water source to field	$0	20	$0
4. Generator for Pivot - N/A KW + 2800 ft safety wire @ $5.00 per foot =	$14,000	20	$700
5. PVC Pipe (installed), 10 2800 feet, 8 Inch I.D. @ $8.91 per foot =	$24,948	20	$1,247
6. Pipe Valves, Fittings, Concrete	$5,000	20	$250
7. Miscellaneous Soil Moisuring Monitoring Equipment)-	$3,890	--	--
TOTAL INITIAL COST	$125,438		$6,077
TOTAL INITIAL COST PER ACRE	$980		$47
B. Annual Ownership Cost (With 5 % SALVAGE VALUE)			Yearly Totals
1. Yearly Depreciation			$6,077
2. Interest on Average Investment 9 %			0
3. Insurance on Average Investment 0.7 %			0
TOTAL ANNUAL OWNERSHIP COST			$6,077
TOTAL ANNUAL OWNERSHIP COST PER ACRE			$47.48
C. Annual Operating Cost Per Acre-Inch of Water - (Applied at 85% Application Efficiency)			
1. Electricity $0.10 per KWH * 2412 KWH to apply 1 NET Acre-Inch of Water			$3.77
15% of fuel/power cost)			$0.57
3. Repairs - Power Unit (0.06% of power unit initial cost) (electric - .06%, diesel - .17%)			$0.00
4. Repairs - Irrigation Unit (0.16% of irrigation system initial cost)			$1.64
5. Labor - ($8.00 per hour)			$0.10
TOTAL OPERATING COST PER ACRE-INCH			$6.07
COTTON ANNUAL OPERATING COST APPLYING 5.73 " of WATER on 32 ACRES			$1,113.02
PEANUTS ANNUAL OPERATING COST APPLYING 5.10 " of WATER on 32 ACRES			$990.64
BAHIA HAY ANNUAL OPERATING COST APPLYING 7.33 " of WATER on 32 ACRES			$1,423.81
BAHIA GRAZING ANNUAL OPERATING COST APPLYING 6.25 " of WATER on 32 ACRES			$1,214.02
WINTER GRAZING ANNUAL OPERATING COST APPLYING 1.75 " of WATER on 96 ACRES			$1,019.78
D. Annual Total Costs for Owning and Operating the above Irrigation System as Described			
TOTAL ANNUAL COST (OWNERSHIP + OPERATING) PER SYSTEM			$11,838.27
(ROW CROP + BAHIA HAY/GRAZING) TOTAL ANNUAL COST PER IRRIGATED ACRE			$92.49

Table A14.

Linear Programming Model

	SBR - Irrigated	Traditional P/C Irrigated	Traditional P/C Rainfed	Traditional P/C Rainfed GP	Traditional W, S, C Rainfed	Irrigated Land Rented out	Rainfed Land Rented out	HL- Jan	HL- Feb	HL- Mar	HL- Apr
OBJ	$15,413.40	$17,220.28	$22,834.17	$31,600.29	$1,804.62	$13,429.43	$7,259.21	-12	-12	-12	-12
Land- Irrigated	128	128	0	0	0	128.00	0				
Land- Rainfed	32	32	160	160	160	32.00	160				
OPERCAP	$99,123.39	$112,216.15	$120,168.42	$120,168.42	$88,756.43	0	0				
Labor- Jan	20.15	0	0	0	0.00	0	0	-1			
Labor- Feb	32.15	0	0	0	0.00	0	0		-1		
Labor- Mar	21.11	0	0	0	0.00	0	0			-1	
Labor- Apr	30.07	8.33	8.48	8.48	8.33	0	0				-1
Labor- May	57.43	66.83	81.6	81.6	66.83	0	0				
Labor- Jun	29.59	13.39	14.8	14.8	13.39	0	0				
Labor- Jul	38.07	17.87	20.4	20.4	17.87	0	0				
Labor- Aug	28.63	9.55	10	10	9.55	0	0				
Labor- Sept	26.71	11.47	12.4	12.4	11.47	0	0				
Labor- Oct	77.43	98.83	121.6	121.6	98.83	0	0				
Labor- Nov	20.15	0	0	0	0.00	0	0				
Labor- Dec	32.15	0	0	0	0.00	0	0				
HL Hired- Jan								1			
HL Hired- Feb									1		
HL Hired- Mar										1	
HL Hired- Apr											1
HL Hired- May											
HL Hired- Jun											
HL Hired- Jul											
HL Hired- Aug											
HL Hired- Sep											
HL Hired- Oct											
HL Hired- Nov											
HL Hired- Dec											
T01	-9247.08	-19347.88	-17440.20	5459.44	-15678.38	12235.10	6729.31				
T02	-1711.49	-10382.27	5357.33	39613.84	39613.84	11945.38	6432.13				
T03	-19502.24	-21624.26	1173.40	-13436.92	-6669.71	12971.09	7095.95				
T04	19426.18	13096.97	11760.20	21477.63	-10833.79	13183.85	7212.34				
T05	54175.88	89721.77	74563.58	89977.18	20207.82	14400.00	7920.00				
T06	49339.14	51857.33	61590.72	46510.58	23080.97	15841.18	8165.56				
Lambda											
LEVEL	0.00	0.00	0.00	2.00	0.00	4.00	2.00	0	0	0	0

Table A15.
Linear Programming Model

HL- May	HL- Jun	HL- Jul	HL- Aug	HL- Sept	HL- Oct	HL- Nov	HL- Dec	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	TYPE	RHS	USED	SLACK
-12	-12	-12	-12	-12	-12	-12	-12							MAX		130,489.50	
														LE	512.00	512.00	0.00
														LE	768.00	768.00	0.00
														GE	0.00	240,828.24	-240,828.24
														LE	160.00	0.00	160.00
														LE	160.00	0.00	160.00
														LE	160.00	0.00	160.00
														LE	160.00	16.99	143.01
-1														LE	160.00	160.00	0.00
	-1													LE	160.00	29.66	130.34
		-1												LE	160.00	40.88	119.12
			-1											LE	160.00	20.04	139.96
				-1										LE	160.00	24.85	135.15
					-1									LE	160.00	160.00	0.00
						-1								LE	160.00	0.00	160.00
							-1							LE	160.00	0.00	160.00
														GE	0.00	0.00	0.00
														GE	0.00	0.00	0.00
														GE	0.00	0.00	0.00
														GE	0.00	0.00	0.00
1														GE	0.00	3.53	-3.53
	1													GE	0.00	0.00	0.00
		1												GE	0.00	0.00	0.00
			1											GE	0.00	0.00	0.00
				1										GE	0.00	0.00	0.00
					1									GE	0.00	83.70	-83.70
						1								GE	0.00	0.00	0.00
							1							GE	0.00	0.00	0.00
								1						GE	140,000.00	140,000.00	0.00
									1					GE	140,000.00	140,009.13	9.13
										1				GE	140,000.00	140,000.00	0.00
											1			GE	140,000.00	140,000.00	0.00
												1		GE	140,000.00	253,729.90	113,729.90
													1	GE	140,000.00	172,873.78	
								0.167	0.167	0.167	0.167	0.167	0.167	E	32,965.00	32,965.00	0.00
3.53368	0	0	0	0	83.6972	0	0	66687.3	0	100882	29826.3	0	0				
															Target		
															140,000		

Table A16. Consumer Price Index - All Urban Consumers
Original Data Value

Base Period: 2011=100
Years: 2007 to 2012

Year	Jan	Feb	Mar	Apr	May	Jun
2007	202.416	203.499	205.352	206.686	207.949	208.352
2008	211.080	211.693	213.528	214.823	216.632	218.815
2009	211.143	212.193	212.709	213.240	213.856	215.693
2010	216.687	216.741	217.631	218.009	218.178	217.965
2011	220.223	221.309	223.467	224.906	225.964	225.722
2012	226.665	227.663	229.392	230.085	229.815	229.478

Table A17. Consumer Price Index - All Urban Consumers
Original Data Value

Jul	Aug	Sep	Oct	Nov	Dec	Annual	2011 Adjustment
208.299	207.917	208.490	208.936	210.177	210.036	207.342	0.922
219.964	219.086	218.783	216.573	212.425	210.228	215.303	0.957
215.351	215.834	215.969	216.177	216.330	215.949	214.537	0.954
218.011	218.312	218.439	218.711	218.803	219.179	218.056	0.969
225.922	226.545	226.889	226.421	226.230	225.672	224.939	1.000
229.104	230.379	231.407	231.317	230.221	229.601	229.594	1.021