# Economic Risk and the 92-Year *"Old Rotation"*



## Implications for a 250-Acre Farm

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Alabama Agricultural Experiment Station
Lowell T. Frobish, Director
Auburn University Auburn University, Alabama

# CONTENTS



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# ECONOMIC RISK AND THE 92-YEAR "OLD ROTATION"

### Implications for a 250-Acre Farm

JAMES L. NOVAK, CHARLES C. MITCHELL, JR., AND JERRY R. CREWS[1]

OVER the 92-year history of the Alabama Agricultural Experiment Station's "Old Rotation," data have been collected to analyze the effect of alternative cotton-based rotation schemes on sustainable cotton yields. In particular, these analyses have investigated the effect of winter legumes following cotton on sustainable cotton yields. Winter legumes provide a source of green manure and nitrogen for crops following cotton in the rotation. Evidence from the "Old Rotation" indicates diversification in crop rotations can be used to reduce the economic risk of a farm operation.

Conditions in agriculture call for farm decision makers to formulate and implement optimal farm plans in an increasingly risky environment. The implication of these conditions for farm plans that are sustainable over long periods is that crop rotations used should provide the minimum possible risk for an acceptable level of return. Motivated by these conditions, this study used Target-MOTAD to analyze the "Old Rotation" as sustainable crop rotation schemes that might be implemented by farm managers on a 250-acre farm. The primary purpose of this research was to determine the risk minimizing rotation scheme(s) that would optimize expected returns for this size farm operations.

The use of legume nitrogen as a substitute for nitrogen fertilizer is expected to provide positive environmental benefit. However, because of the near impossibility of measuring the benefit of this substitution on a small acreage, it was assumed to be insignificant for this analysis.

Risk efficiency in farm planning has been widely discussed in the literature. Alternative techniques, such as econometric estimation of stochastic dominance, Chance Constrained Programming,

[1]Associate Professor of Agricultural Economics and Rural Sociology, Associate Professor of Agronomy and Soils, and Associate Professor of Agricultural Economics and Rural Sociology, respectively.

simulation, Quadratic Programming, MOTAD, and extensions of MOTAD, have been used to suggest risk minimizing farm plans that have involved optimal fertilizer response (5) and contract grazing (9), changing crop mix in response to leverage and safety first (2), policy considerations (*12*), diversification (7), changing crop cultural practices (*13*), and analyzing optimal crop rotations (3).

The "Old Rotation" was designed to appeal to a wide range of cotton producers, whose preferences for taking risks would most likely differ. It was therefore decided that the method of choice for this study was Target-MOTAD. Target-MOTAD was used to develop a wide range of feasible and economically optimal rotation schemes for alternative target income and risk levels.

## DESCRIPTION OF THE STUDY

The "Old Rotation" experiment consists of 13 plots, 21.5 by 136.1 feet, which have been maintained in cotton-based rotations since 1896. In 1988, the site was listed on the National Register of Historical Places as the oldest continuous cotton study in the United States. The study has been revised several times since its inception, the latest in 1960 (*10,4,6*). Basic rotations in the study included:

Continuous Cotton:

(1) With winter legumes; no nitrogen fertilizer (R1)
(2) No winter legumes; no nitrogen fertilizer (R2)
(3) No winter legumes; 120 pounds of nitrogen per acre (R3)

Two Years, Cotton-Corn:

(4) With winter legumes; no nitrogen fertilizer (R4)
(5) With winter legumes; 120 pounds of nitrogen per acre on each crop (R5)

Three Years Cotton-Corn-Rye/Soybeans:

(6) Winter legumes after cotton; 60 pounds of nitrogen per acre on rye (R6)

The test is a non-replicated study. However, different scheduling of phosphorus and potassium fertilizer applications to crops in the rotation results in rotations with multiple replications. Timing of fertilizer application had an effect in the early days of the experiment, but is no longer significant because of a buildup of soil phosphorus and potassium levels (*4*). For this study, only crop rotation effects were considered.

This study used the past 10 years of available data from the "Old Rotation" to analyze the profitability of six alternative rotation schemes. Structural changes due to changing hybrids, machinery, pest control, etc. are minimized by using data only from this time period. Enterprise budgets were developed for each of the alternative rotations and net returns over variable costs were indexed to 1988 prices and costs.

Target-MOTAD is an extension of MOTAD that is used to determine the set of feasible risk-minimizing crop rotations from the possible set of profitable "Old Rotation" alternatives (*11,8*). Target-MOTAD was chosen over other possible methods because of its practical and theoretical appeal. As demonstrated by Tauer (*11*), Target-MOTAD results are Second-degree Stochastic Dominant to solutions provided by MOTAD.

The Target-MOTAD model can be formulated as:

(1) $$\text{Maximize E (Return)} = \sum_{j=1}^{n} C_j X_j$$

subject to

(2) $$\sum_{j=1}^{n} A_{ij} X_j \leq B_i$$

(3) $$T - \sum_{j=1}^{n} C_{tj} X_j - Y_t \leq 0$$

(4) $$\sum_{t=1}^{s} P_t Y_t = K$$

(5) $$i = 1, 2, \ldots\ldots, m$$

(6) $$K = M \text{ to } 0$$

and

(7) $$X_j, Y_t, \geq 0$$

where

E(return) is the expected return from the optimal plan; $C_j$ is the expected return from activity j; $X_j$ is the level of activity j; $A_{ij}$ is the technical requirement of activity j for resource i; $B_i$ is the level of resource i; T is the target level of return; $C_{tj}$ is the return of activity j for period t; $Y_t$ is the deviation below T for time period t; $P_t$ is the probability of the state of nature occurring at time t; K is a risk constant parameterized from M to 0; m is the number of resource constraint equations; s is the number of time periods or states of nature; and M begins as an arbitrary large number. Risk is measured, in dollars, as the expected sum of the negative deviations of the optimal solution from some target income level.

The model is programmed to maximize expected returns, which are subject to achieving a satisfactory level of compliance with target income (T). A set of efficient farm plans is obtained for alternative levels of risk (K), where risk is varied from the arbitrarily large number (M) to 0. The resulting farm plans maximize expected returns for a given risk level, subject to minimized negative deviations from T. Changes are made in the value of K and optimal solutions are obtained until all realistic possible changes in basis occur and the value of expected net return cannot be improved by increasing risk.

## DESCRIPTION OF THE DATA

Objective function activities consist of net returns over variable costs from rotations 1 (R1), 3 (R3), 5 (R5), and 6 (R6). These data are shown in the table. Historic net returns used to derive the values are shown in Appendix A. Rotations 2 and 4 were not included because of negative returns.

Technical resource constraints on the system consist of land, labor, and deviations from target income. One acre of land is required to produce 1 acre of crop activity up to a maximum of 250 planted acres of land. Labor requirements are restricted to a maximum of 300 hours of labor per month. Deviation constraints relate returns per period to the target income level. The last row sums negative deviations from target income, under the assumption that deviations for each period are equally as likely to occur ($P_t$). The summed deviations are used with the parameterized value of risk to generate the optimal risk-return frontier for a given value of target income.

Rotations 1, 2, and 3 will consist of 250 planted acres of cotton in each year of the farm plan. To satisfy rotation requirements, rotations 4 and 5 will consist of 125 acres of cotton and 125 acres of corn in each year. Rotation 6 will allocate one-third of the 250 planted acres to cotton, one-third to corn, and one-third to rye-soybeans double cropped in each year. It is further assumed that the farm manager participated in the farm program at the minimal set-aside required and that these acreages satisfied the respective program base requirements

AVERAGE ANNUAL NET RETURNS ASSOCIATED WITH THE OLD ROTATION

| Rotations, 1978-88 | Net returns over variable costs/acre |
|---|---|
| 1. Continuous cotton with winter legumes (0-80-60)[1] | 55.09 |
| 2. Continuous cotton without legumes (0-80-60) | –153.98 |
| 3. Continuous cotton without legumes (120-80-60) | 21.42 |
| 4. 2 years cotton (0-80-60) - legumes - corn (0-80-60) | –.51 |
| 5. 2 years cotton (120-80-60) - legumes - corn (120-0-0) | 9.89 |
| 6. 3 years cotton (0-80-60) - legumes - corn (0-0-0) - small grain (60-0-0) - soybeans | 120.31 |

[1]Values in parenthesis are annual rates of N-$P_2O_5$-$K_2O$ per acre.

for participation in the program. Gross income used for the analysis included farm program payments.

Two hundred and fifty planted acres was selected as the land base because cotton is the primary crop of the rotation. This acreage can be adequately handled by one 2-row cotton picker. Variable costs for associated machinery operations were incorporated in the net return estimates. With the introduction of corn, rye, and soybeans into the rotations, machinery investment costs can be expected to rise. For this analysis, custom rates were used for corn, rye, and soybean harvesting. It was assumed that the other necessary machinery was owned for all of the rotation schemes.

Expected returns were defined as net returns over variable costs. The matrix of annual returns for each rotation was analyzed using yields from the past 10 years of available rotation data. Thirty observations on the distribution of net returns over time ($C_{tj}$) were developed from these data. The structure of the Target-MOTAD model and the data used in the analysis are shown in Appendix B.

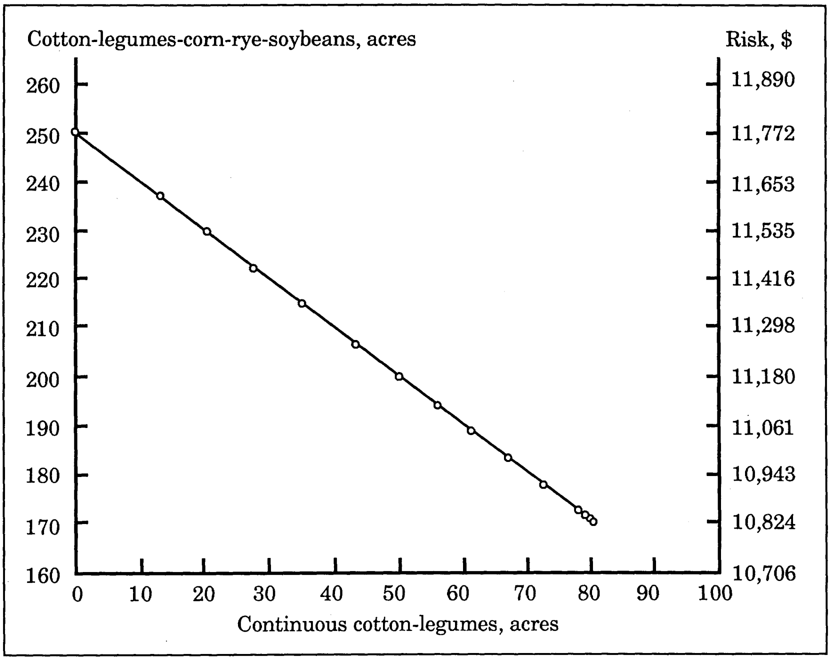
Rotations that resulted in 10-year average negative net returns were not included in the programming analysis. Therefore, rotations 2 and 4 were dropped. Crop rotations 1, 3, 5, and 6 were the only ones included in the Target-MOTAD analysis.

## RESULTS

Risk-returns for alternative target income levels are presented in Appendix Tables C through H. Results of the Target-MOTAD analysis show that risk is reduced by substituting part of the 3-year cotton, winter legume-corn, rye-soybean rotation (R6) with a continuous cotton-winter legume rotation (R1). This substitution continues to take place until the negative deviations from target income become large enough to drive the system to infeasibility. The trade off of R6 for R1 results in a lowering of net returns as risk is reduced.

At each target income level, the highest net return over variable costs results from using the 3-year R6 rotation. As target income is increased from $5,000 to $30,000, commensurately higher risk is incurred in achieving a given level of net return with a given combination of rotations R6 and R1. For an expected return of $30,077.50 and a $5,000 target income level, a $4,050.09 risk must be incurred. A $14,321.18 risk is incurred for the same expected return at a $30,000 target income.

A production possibilities curve for the rotations and a $25,000 target income is shown in the figure. This curve shows that to achieve the $25,000 target income at minimum risk, a producer should plant approximately 172 acres (69 percent) in rotation scheme R6 and 78




**Economic risk and the 92-year "Old Rotation" at Auburn University, Alabama, from 1978 to 1988.**

acres (31 percent) in rotation R1. A producer's preference for greater risk taking will result in a higher proportion of R6 being used in relation to the R1 rotation.

## SUMMARY AND CONCLUSIONS

This study compared the risk and returns from the past 10 years of Auburn University's 92-year "Old Rotation" for a 250-acre farm. Comparisons were made of sustainable, continuous cotton rotations to cotton and corn rotations, with and without nitrogen and winter legumes, and to a 3-year rotation of cotton, legumes, corn, rye, and soybeans.

Target-MOTAD specifies a set of optimal results for alternative target income and risk levels. The method does not assume a level of risk or income preference. Rather, it presents optimal results for alternative income and risk levels. The best rotation scheme for a producer will depend on attitudes towards risk versus the expected returns at the time production practices are put into action.

The results indicate that the optimal farm plan will include a 3-year rotation of cotton, winter legumes, corn, small grains, and soybeans (R6). The highest expected return at each target income level will result from planting the entire acreage to the R6 rotation. As risks are reduced, more and more of the continuous cotton with winter legume rotation (R1) will enter the farm plan. The trade off from reducing risk is a lowering of expected returns. The best strategy to minimize risk at each target income level will include the R1 rotation in the farm plan. The risk minimizing proportion of R1 to include in the farm plan ranges from 37.5 percent at a target income of $5,000 to 32 percent at a $25,000 target income (Appendices C-H). Diversification by use of a mix of these two different sustainable rotations is shown to result in the least risky alternative farm plan for each alternative target income level.

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APPENDIX A. NET RETURNS PER PERIOD FOR ALTERNATIVE OLD ROTATION
NET RETURNS OVER VARIABLE COSTS

| Period | Continuous cotton rotations | | |
|---|---|---|---|
| | With winter legumes | No winter legumes | |
| | (0-80-60)[1] (R1)[2] | (0-80-60) (R2) | (120-80-60) (R3) |
| 1 | 96.98 | –188.18 | –.98 |
| 2 | –11.49 | –175.81 | 8.47 |
| 3 | 65.40 | –124.03 | 85.22 |
| 4 | 165.40 | –114.77 | 95.37 |
| 5 | 203.43 | –107.16 | 152.51 |
| 6 | 6.68 | –175.29 | 8.19 |
| 7 | 230.87 | –188.01 | 147.83 |
| 8 | –136.20 | –202.48 | –327.62 |
| 9 | –89.21 | –179.25 | –30.49 |
| 10 | 18.83 | –84.80 | 75.74 |
| Average | 55.09 | –153.98 | 21.42 |

| Period | 2-year cotton-legume-corn rotations | | | |
|---|---|---|---|---|
| | No nitrogen fertilizer | | With nitrogen fertilizer | |
| | (0-80-60) Cotton (R4) | (0-80-60) Corn (R4) | (120-80-60) Cotton (R5) | (120-0-0) Corn (R5) |
| 1 | 23.17 | –86.48 | 52.67 | –66.32 |
| 2 | –59.15 | –26.91 | –36.25 | –51.98 |
| 3 | 53.18 | –87.97 | 5.11 | –85.64 |
| 4 | 143.48 | –11.63 | 206.17 | –32.18 |
| 5 | 176.79 | 59.67 | 172.08 | 50.62 |
| 6 | 22.60 | –43.46 | 65.18 | –74.90 |
| 7 | 155.11 | –77.76 | 270.42 | –110.58 |
| 8 | –70.23 | –117.93 | –112.89 | –123.58 |
| 9 | –1.94 | –15.08 | 97.17 | –38.58 |
| 10 | –25.30 | –20.27 | 29.87 | –18.58 |
| Average | 41.77 | –42.78 | 74.95 | –55.17 |

| Period | 3-year cotton-legume-corn-rye-soybean rotation | | |
|---|---|---|---|
| | (0-80-60) Cotton (R6) | (0-0-0) Corn (R6) | (60-0-0) Rye-soy (R6) |
| 1 | 98.88 | –28.27 | 177.78 |
| 2 | 89.05 | –5.05 | 217.35 |
| 3 | 279.11 | –56.07 | 183.33 |
| 4 | 284.77 | –54.49 | 359.86 |
| 5 | 273.70 | 74.31 | 155.68 |
| 6 | 178.49 | –32.53 | 320.69 |
| 7 | 256.24 | –8.26 | 0 |
| 8 | –22.17 | –118.84 | 211.99 |
| 9 | 86.53 | 34.76 | 36.58 |
| 10 | 50.41 | –14.33 | 355.49 |
| Average | 157.50 | –20.88 | 224.31 |

[1]Pounds of fertilizer applied per acre.
[2]Rotation identifier.

## Appendix B. Target-MOTAD Matrix for the Old Rotation, 1978-1988

| | | R6 | R5 | R1 | R3 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 | D24 | D25 | D26 | D27 | D28 | D29 | D30 | RHS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OBJ FCN | | 120.31 | 9.89 | 55.09 | 21.42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Land . . . . | L | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 250 |
| Lab 3-1 . . . | L | .25 | .25 | .25 | .25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 4-1 . . . | L | .13 | .13 | .13 | .13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 5-1 . . . | L | .33 | .33 | .33 | .33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 6-1 . . . | L | .26 | .26 | .26 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 7-1 . . . | L | .2 | .2 | .2 | .2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 8-1 . . . | L | .06 | .06 | .06 | .06 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 10-1 . . | L | .5 | .5 | .5 | .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 11-1 . . | L | .94 | .94 | .94 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 12-1 . . | L | | | | .42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 3-2 . . . | L | .12 | .12 | .25 | .25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 4-2 . . . | L | .62 | .62 | .13 | .13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 5-2 . . . | L | .22 | .22 | .33 | .33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 6-2 . . . | L | | | .26 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 7-2 . . . | L | | | .2 | .2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 8-2 . . . | L | | | .06 | .06 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 10-2 . . | L | .75 | .25 | .5 | .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 11-2 . . | L | | .43 | .94 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 12-2 . . | L | | | | .42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 3-3 . . . | L | | .25 | .25 | .25 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 4-3 . . . | L | | .13 | .13 | .13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 5-3 . . . | L | | .33 | .33 | .33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 6-3 . . . | L | .71 | .26 | .26 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 7-3 . . . | L | .31 | .2 | .2 | .2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 8-3 . . . | L | .2 | .06 | .06 | .06 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 10-3 . . | L | .25 | .5 | .5 | .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 11-3 . . | L | | .94 | .94 | .26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Lab 12-3 . . | L | | | | .42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 300 |
| Targ 11 . . . | G | 98.88 | 52.67 | 96.98 | −.98 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 21 . . . | G | 89.05 | −36.25 | −11.49 | 8.47 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 31 . . . | G | 279.11 | 5.11 | 65.4 | 85.22 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 41 . . . | G | 284.77 | 206.17 | 165.57 | 95.37 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 51 . . . | G | 273.7 | 172.08 | 203.43 | 152.51 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 61 . . . | G | 178.49 | 65.18 | 6.68 | 8.19 | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 71 . . . | G | 256.24 | 270.42 | 230.87 | 147.83 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 81 . . . | G | −22.17 | −112.89 | −136.2 | −327.62 | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 91 . . . | G | 86.53 | 97.17 | −89.21 | −30.49 | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 101 . . . | G | 50.41 | 29.87 | 18.83 | 75.74 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 12 . . . | G | −28.27 | −66.32 | 96.98 | −.98 | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 25,000 |

Continued

APPENDIX B (CONTINUED). TARGET-MOTAD MATRIX FOR THE OLD ROTATION, 1978-1988

| | | R6 | R5 | R1 | R3 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 | D24 | D25 | D26 | D27 | D28 | D29 | D30 | RHS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Targ 22 . . . | G | -5.05 | -51.89 | -11.49 | 8.47 | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 32 . . . | G | -56.07 | -85.64 | 65.4 | 85.22 | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 25,000 |
| Targ 42 . . . | G | -54.49 | -32.18 | 165.57 | 95.37 | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | 25,000 |
| Targ 52 . . . | G | 74.31 | 50.62 | 203.43 | 152.51 | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | 25,000 |
| Targ 62 . . . | G | -32.53 | -74.9 | 6.68 | 8.19 | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | 25,000 |
| Targ 72 . . . | G | -8.26 | -110.58 | 230.87 | 147.83 | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | 25,000 |
| Targ 82 . . . | G | -118.84 | -123.58 | -136.2 | -327.62 | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | 25,000 |
| Targ 92 . . . | G | 34.76 | -38.58 | -89.21 | -30.49 | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | 25,000 |
| Targ 102. . . | G | -14.33 | -18.58 | 18.83 | 75.74 | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | 25,000 |
| Targ 13 . . . | G | 177.78 | 52.67 | 96.98 | -.98 | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | 25,000 |
| Targ 23 . . . | G | 217.35 | -36.25 | -11.49 | 8.47 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 25,000 |
| Targ 33 . . . | G | 183.33 | 5.11 | 65.4 | 85.22 | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | 25,000 |
| Targ 43 . . . | G | 359.86 | 206.17 | 165.57 | 95.37 | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 25,000 |
| Targ 53 . . . | G | 155.68 | 172.08 | 203.43 | 152.51 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | 25,000 |
| Targ 63 . . . | G | 320.69 | 65.18 | 6.68 | 8.19 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | 25,000 |
| Targ 73 . . . | G | 0 | 270.42 | 230.87 | 147.83 | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 25,000 |
| Targ 83 . . . | G | 211.99 | -112.89 | -136.2 | -327.62 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 25,000 |
| Targ 93 . . . | G | 36.58 | 97.17 | -89.21 | -30.49 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 25,000 |
| Targ 103. . . | G | 355.49 | 29.87 | 18.83 | 75.74 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 25,000 |
| TMOTAD | E | | | | | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 | 11,772 |

APPENDIX C. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $5,000 ($20/ACRE)

| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 4,050.09 | 30,077.50 | 250.00 | .00 | 100.000 | .000 |
| 4,050.00 | 30,077.31 | 250.00 | .00 | 99.999 | .001 |
| 3,483.50 | 28,663.44 | 228.32 | 21.68 | 91.327 | 8.673 |
| 3,332.00 | 28,148.33 | 220.42 | 29.58 | 88.168 | 11.832 |
| 3,329.00 | 28,130.23 | 220.14 | 29.86 | 88.057 | 11.943 |
| 3,303.00 | 27,924.80 | 216.99 | 33.01 | 86.797 | 13.203 |
| 3,068.00 | 24,553.55 | 165.34 | 84.61 | 66.148 | 33.852 |
| 2,900.00 | 21,936.47 | 146.44 | 78.39 | 65.133 | 34.867 |
| 2,800.00 | 20,378.60 | 135.18 | 74.69 | 64.412 | 35.588 |
| 2,794.50 | 20,292.97 | 134.57 | 74.48 | 64.372 | 35.628 |
| 2,700.00 | 18,797.59 | 125.96 | 66.13 | 65.574 | 34.426 |
| 2,600.00 | 17,215.16 | 116.85 | 57.30 | 67.100 | 32.900 |
| 2,500.00 | 15,632.74 | 107.75 | 48.46 | 68.976 | 31.024 |
| 2,400.00 | 14,050.32 | 98.64 | 39.63 | 71.339 | 28.661 |
| 2,285.00 | 12,230.12 | 88.16 | 29.47 | 74.950 | 25.050 |
| 2,240.00 | 11,346.94 | 83.04 | 24.63 | 77.125 | 22.875 |
| 2,147.00 | 8,416.09 | 59.07 | 23.77 | 71.305 | 28.695 |
| 2,121.41 | 5,887.07 | 38.39 | 23.03 | 62.501 | 37.499 |

APPENDIX D. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $10,000 ($40/ACRE)

| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 5,615.04 | 30,077.50 | 250.00 | .00 | 100.000 | .000 |
| 5,615.00 | 30,077.41 | 249.99 | .00 | 99.999 | .001 |
| 4,807.00 | 27,250.59 | 206.66 | 43.34 | 82.662 | 17.338 |
| 4,723.00 | 26,777.25 | 199.40 | 50.60 | 79.759 | 20.241 |
| 4,652.00 | 25,758.66 | 183.80 | 66.18 | 73.525 | 26.475 |
| 4,600.00 | 24,935.81 | 179.06 | 61.59 | 74.408 | 25.592 |
| 4,570.30 | 24,465.83 | 176.36 | 58.96 | 74.943 | 25.057 |
| 4,535.00 | 23,778.47 | 172.40 | 55.13 | 75.771 | 24.229 |
| 4,480.00 | 22,693.88 | 166.07 | 49.25 | 77.127 | 22.873 |
| 4,450.00 | 21,752.41 | 158.37 | 48.98 | 76.378 | 23.622 |
| 4,430.00 | 21,124.76 | 153.24 | 48.80 | 75.848 | 24.152 |
| 4,400.00 | 20,183.28 | 145.54 | 48.52 | 74.997 | 25.003 |
| 4,350.00 | 18,614.16 | 132.71 | 48.06 | 73.413 | 26.587 |
| 4,320.00 | 17,672.69 | 125.01 | 47.79 | 72.345 | 27.655 |
| 4,293.00 | 16,733.35 | 117.33 | 47.51 | 71.177 | 28.823 |
| 4,280.00 | 15,448.58 | 106.82 | 47.14 | 69.384 | 30.616 |
| 4,265.00 | 13,966.15 | 94.70 | 46.70 | 66.972 | 33.028 |
| 4,255.00 | 12,977.86 | 86.62 | 46.41 | 65.111 | 34.889 |
| 4,242.82 | 11,774.13 | 76.77 | 46.06 | 62.501 | 37.499 |

APPENDIX E. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $15,000 ($60/ACRE)

| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 7,486.96 | 30,077.50 | 250.000 | .000 | 100.000 | .000 |
| 7,485.00 | 30,070.31 | 249.890 | .110 | 99.956 | .044 |
| 7,450.00 | 29,941.34 | 247.912 | 2.088 | 99.165 | .835 |
| 7,400.00 | 29,757.10 | 245.087 | 4.913 | 98.035 | 1.965 |
| 7,350.00 | 29,572.86 | 242.263 | 7.738 | 96.905 | 3.095 |
| 7,300.00 | 29,388.61 | 239.438 | 10.562 | 95.775 | 4.225 |
| 7,200.00 | 29,020.13 | 233.788 | 16.212 | 93.515 | 6.485 |
| 7,100.00 | 28,651.64 | 228.138 | 21.862 | 91.255 | 8.745 |
| 7,000.00 | 28,283.15 | 222.488 | 27.512 | 88.995 | 11.005 |
| 6,900.00 | 27,914.67 | 216.838 | 33.162 | 86.735 | 13.265 |
| 6,818.00 | 27,610.99 | 212.182 | 37.818 | 84.873 | 15.127 |
| 6,700.00 | 26,991.71 | 202.687 | 47.314 | 81.075 | 18.925 |
| 6,600.00 | 26,466.89 | 194.640 | 55.360 | 77.856 | 22.144 |
| 6,479.00 | 25,821.56 | 184.745 | 65.255 | 73.898 | 26.102 |
| 6,444.00 | 25,379.26 | 178.278 | 71.350 | 71.417 | 28.583 |
| 6,420.00 | 23,172.86 | 160.234 | 70.704 | 69.384 | 30.616 |
| 6,390.00 | 20,208.01 | 135.988 | 69.837 | 66.070 | 33.930 |
| 6,375.00 | 18,725.58 | 123.865 | 69.403 | 64.090 | 35.910 |
| 6,364.22 | 17,660.21 | 115.152 | 69.092 | 62.500 | 37.500 |

APPENDIX F. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $20,000 ($80/ACRE)

| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 9,479.64 | 30,077.50 | 250.000 | .000 | 100.000 | .000 |
| 9,475.00 | 30,063.52 | 249.786 | .214 | 99.914 | .086 |
| 9,375.00 | 29,761.20 | 245.150 | 4.850 | 98.060 | 1.940 |
| 9,275.00 | 29,454.74 | 240.451 | 9.549 | 96.181 | 3.819 |
| 9,250.00 | 29,353.38 | 238.897 | 11.103 | 95.559 | 4.441 |
| 9,100.00 | 28,552.17 | 226.613 | 23.388 | 90.645 | 9.355 |
| 9,000.00 | 27,859.15 | 215.987 | 34.013 | 86.395 | 13.605 |
| 8,900.00 | 27,166.13 | 205.361 | 44.639 | 82.144 | 17.856 |
| 8,800.00 | 26,473.11 | 194.735 | 55.265 | 77.894 | 22.106 |
| 8,750.00 | 26,126.60 | 189.422 | 60.578 | 75.769 | 24.231 |
| 8,700.00 | 25,780.09 | 184.109 | 65.891 | 73.644 | 26.356 |
| 8,600.00 | 25,087.07 | 173.483 | 76.517 | 69.393 | 30.607 |
| 8,550.00 | 24,740.56 | 168.170 | 81.830 | 67.268 | 32.732 |
| 8,500.00 | 24,300.64 | 161.425 | 88.575 | 64.570 | 35.430 |
| 8,491.00 | 24,064.43 | 157.803 | 92.197 | 63.121 | 36.879 |
| 8,490.00 | 23,979.16 | 157.071 | 92.248 | 63.000 | 37.000 |
| 8,486.00 | 23,583.85 | 153.838 | 92.133 | 62.543 | 37.457 |
| 8,485.65 | 23,549.26 | 153.555 | 92.123 | 62.503 | 37.497 |

APPENDIX G. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $25,000 ($100/ACRE)

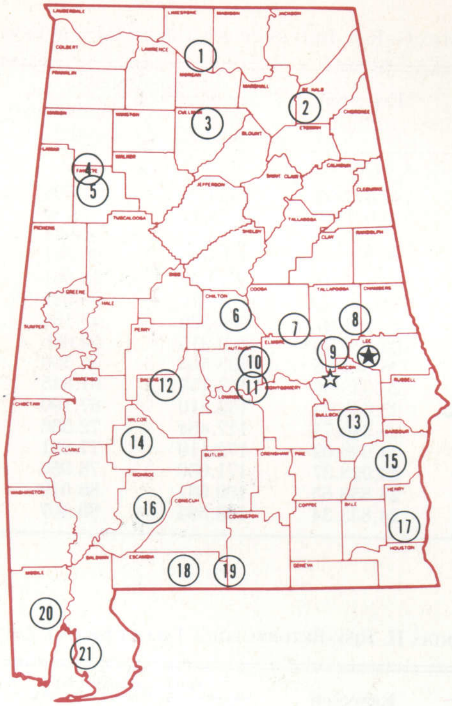
| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 11,771.18 | 30,077.50 | 250.000 | .000 | 100.000 | .000 |
| 11,770.00 | 30,071.71 | 249.911 | .089 | 99.964 | .036 |
| 11,600.00 | 29,233.51 | 237.059 | 12.941 | 94.824 | 5.176 |
| 11,500.00 | 28.740.45 | 229.499 | 20.501 | 91.800 | 8.200 |
| 11,400.00 | 28,247.38 | 221.939 | 28.061 | 88.776 | 11.224 |
| 11,300.00 | 27,754.33 | 214.379 | 35.621 | 85.752 | 14.248 |
| 11,200.00 | 27,261.27 | 206.820 | 43.181 | 82.728 | 17.272 |
| 11,110.00 | 26,810.92 | 199.915 | 50.086 | 79.966 | 20.034 |
| 11,050.00 | 26,392.58 | 193.500 | 56.500 | 77.400 | 22.600 |
| 11,000.00 | 26,043.96 | 188.155 | 61.845 | 75.262 | 24.738 |
| 10,950.00 | 25,695.34 | 182.810 | 67.190 | 73.124 | 26.876 |
| 10,900.00 | 25,346.71 | 177.464 | 72.536 | 70.986 | 29.014 |
| 10,850.00 | 24,998.09 | 172.119 | 77.881 | 68.848 | 31.152 |
| 10,840.00 | 24,928.37 | 171.050 | 78.950 | 68.420 | 31.580 |
| 10,830.00 | 24,858.65 | 169.981 | 80.019 | 67.992 | 32.008 |
| 10,826.37 | 24,833.34 | 169.593 | 80.407 | 67.837 | 32.163 |

APPENDIX H. RISK-RETURNS FOR A TARGET INCOME LEVEL OF $30,000 ($120/ACRE)

| Risk | Expected return | Acres planted to | | Percent of acreage in | |
|---|---|---|---|---|---|
| | | 3-year rotation | Continuous cotton | 3-year rotation | Continuous cotton |
| *Dol.* | *Dol.* | *Acres* | *Acres* | *Pct.* | *Pct.* |
| 14,321.18 | 30,077.50 | 250.000 | .000 | 100.000 | .000 |
| 14,320.00 | 30,071.71 | 249.911 | .089 | 99.964 | .036 |
| 14,250.00 | 29,726.57 | 244.619 | 5.381 | 97.848 | 2.152 |
| 14,100.00 | 28,986.98 | 233.279 | 16.721 | 93.312 | 6.688 |
| 14,000.00 | 28,493.92 | 225.719 | 24.281 | 90.288 | 9.712 |
| 13,900.00 | 28,000.86 | 218.159 | 31.841 | 87.264 | 12.736 |
| 13,800.00 | 27,507.79 | 210.600 | 39.401 | 84.240 | 15.760 |
| 13,700.00 | 27,014.74 | 203.040 | 46.961 | 81.216 | 18.784 |
| 13,600.00 | 26,521.68 | 195.480 | 54.520 | 78.192 | 21.808 |
| 13,500.00 | 26,028.62 | 187.920 | 62.080 | 75.168 | 24.832 |
| 13,445.00 | 25,710.98 | 183.050 | 66.951 | 73.220 | 26.780 |
| 13,425.00 | 25,242.10 | 175.860 | 74.140 | 70.344 | 29.656 |
| 13,400.00 | 24,655.99 | 166.874 | 83.127 | 66.749 | 33.251 |
| 13,394.50 | 24,526.72 | 164.896 | 85.104 | 65.959 | 34.041 |

# Alabama's Agricultural Experiment Station System
# AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



## Research Unit Identification

- ★ Main Agricultural Experiment Station, Auburn.
- ☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Substation, Spring Hill.
21. Gulf Coast Substation, Fairhope.