Effects of the Boll Weevil Eradication Program on Alabama Cotton Farms

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Abstract: *Five-year, 0-1 mixed integer programming models of two representative Alabama farms were developed for analyzing the effects of the Boll Weevil Eradication (BWE) program on farm program participation and crop-mix decisions by Alabama cotton farmers. In previous research the BWE program was found to increase yields by approximately 100 pounds per acre in Georgia and southern Alabama where the program has been in effect for several years. In this study, these increased yields are shown to be an important factor contributing to the expanded cotton acreage in southern Alabama. For northern Alabama, gains to producers are also possible, but not to the extent realized in the southern part of the state.*

Key Words and Phrases: *Boll Weevil Eradication program, Cotton farms, Decision models.*

Ever since their arrival in the United States in the late 1800s, boll weevils have ranked as one of the major crop-damaging insect pests (Taylor *et al.*). In 1978, an experiment on 20,000 acres of North Carolina cotton land was initiated to assess the possible success of a Boll Weevil Eradication (BWE) program. The success of this program prompted its expansion to all of North Carolina, South Carolina and Virginia. In many areas of the cotton belt where boll weevil eradication has taken place, producers have been able to reduce their total pesticide costs by as much as 50 to 90 percent (USDA). Increased yields have also been attributed to the BWE program (Carlson and Suguiyama; Carlson, Sappie and Hammig). These changes in costs and yields have led to increased profits for cotton production and contributed to an increase in cotton acreage (Carlson, Sappie and Hammig).

The program may be expanded in an area by a two-thirds vote of producers. In 1987, the program moved into parts of Georgia, Florida and southern Alabama. Recently, the program has expanded into parts of northern Alabama. More producer referendums are planned in other parts of the South.

In a previous study, Ahouissoussi, Wetzstein and Duffy performed a cost-benefit analysis of the per-acre effects of the expanded program in Alabama, Florida and Georgia. They found that for this region, yield increased by 100 pounds per acre. No statistically significant decreases in insecticide costs were discovered. Nor did Ahouissoussi, Wetzstein and Duffy find any acreage expansion effects during the period of their study, which stopped in 1990. The study period thus covered only the active eradication phase of the BWE program, during which time grower assessments for the program were relatively high.[1] During this time, farmers might have been reluctant to expand cotton acreage and incur additional charges.

Since 1990, southern Alabama has been in the "containment" phase of BWE and per-acre costs of the program have fallen significantly as was anticipated at the outset of the program. Since 1990, acreage of cotton has, indeed, been expanding in the region. There has been a 25 percent increase in cotton acreage in Georgia and a 35 percent increase in Florida acreage over that time period. The most dramatic acreage increases have occurred in southwestern Alabama where acreage has nearly doubled. By contrast, in northern Alabama, where the program is not yet fully implemented, acreage has remained relatively constant.

The objective of this study is to analyze the effects, in terms of crop mix and income, of the BWE program on two representative farms, one in southern Alabama, where the program has already been fully implemented, and one in northern Alabama, where the program has not yet taken full effect. An analysis based on a whole-farm decision environment should yield additional results about the overall effects of the BWE program, not covered in the previous study (Ahouissoussi, Wetzstein and Duffy). Results for the southern Alabama farm are useful in testing whether the BWE program was the driving force for acreage expansion or whether the expansion resulted from another change, such as relative prices of crops. For northern Alabama, results are useful in predicting farm-level effects of program expansion into that area.

Methods

Results from Ahouissoussi, Wetzstein and Duffy were incorporated into whole-farm decision models to determine the effects of the BWE program on crop mix, farm program participation, and whole-farm profits. Optimal five-year farm plans were found using mixed integer programming (MIP) models. This model was previously used by Duffy, Cain and Young to analyze the effects of the 1990 Farm Bill on Alabama cotton farms. Because model mechanics are discussed in detail elsewhere (Duffy, Cain and Young;

Mims, Duffy and Young), only a brief overview will be provided here. In general, the model can be expressed as:

$$Max\ V = \sum_{t=1}^{T} \beta^{t-1} \left(\sum_{j=1}^{J} \pi_{jt} x_{jt} + \bar{\pi}_{jt} y_{jt} - F \right) \quad (1)$$

subject to a set of constraints, expressed in matrix notation as:

$$\boldsymbol{A}\,\boldsymbol{Z} \leq \boldsymbol{C} \quad (2)$$

and $J \times T$ integer variable constraints of the form:

$$Ix_{jt} + Iy_{jt} = 1 \quad (3)$$

where V represents a multi-year discounted net return function, β is a discount factor, π_{jt} represents per-acre market returns above variable costs from the jth crop in year t, x_{jt} represents acreage in crop j not in the program in year t, $\bar{\pi}_{jt}$ represents per-acre returns above variable costs from the jth crop under farm programs in year t, y_{jt} represents acreage in crop j enrolled in the program in year t and F represents total fixed costs.[2] The elements of $\boldsymbol{A}$ are technical and program coefficients; $\boldsymbol{Z}$ is a vector of all decision variables including x and y. The constant vector $\boldsymbol{C}$ represents right-hand side values for the constraints. Pairs of 0-1 integer variables, Ix and Iy, are used for the discrete choices involved in farm program participation decisions, discussed in detail below.

A five-year planning horizon was chosen for this study because it represents a time period over which the farmer can be reasonably certain the farm program (five years in length) will continue. A discount rate of 7 percent was used in this analysis (within reasonable limits, choice of a discount rate does not effect model results).

The model contains detailed replication of important provisions of the 1990 Farm Bill. Under the farm bill, base acreage in cotton is calculated as a three-year moving average (a five-year moving average is used for wheat). Cotton farmers participating in the farm program must limit cotton plantings to a portion of cotton base. In exchange, they receive a deficiency payment on a portion of base.

Eligible acres are a portion of base. First, a specified percentage of the base, set by the secretary of agriculture, must be idled if an acreage reduction program (ARP) is in effect for that year. "Triple base" provisions further limit payment acreage. Fifteen percent of a farmer's base acreage in a commodity is designated as "Normal Flex Acres" (NFA). On these acres, the farmer may plant the particular commodity for that base or a substitute crop, but will receive no deficiency payment. An additional 10 percent of acres are designated as "Optional Flex Acres" (OFA). The farmer may plant these acres in the program crop and receive a deficiency payment, or plant them in an alternative crop and forfeit the deficiency payment. ARP, NFA and OFA are "considered planted" in the commodity for the purpose of calculating future base acreage. However, farmers cannot "build base" in one program crop while participating in the farm program in another. Payments are made on "program yield," based either on farm-level historic yields through 1986 or on average county yields. Thus, program yield may or may not reflect the current situation on a particular farm. For this analysis, proven yield is set equal to actual yield.[3]

The target price for upland cotton is $0.729 per pound of lint, and the target price for wheat is $4.00. Since soybeans do not have a deficiency payment price support, there is no target price for soybeans. For this study, ARP requirements are fixed at 10 percent for upland cotton and 15 percent for wheat.[4] Expected market prices for the commodities were obtained from Alabama Cooperative Extension Service budgets: $0.62 per pound of lint for cotton, $3.15 per bushel for wheat, and $5.75 per bushel for soybeans. In the model, market prices are held constant across all five years of the planning horizon.

For each commodity in each year, a farmer must decide between program participation and nonparticipation. In the model, pairs of 0-1 integer variables were used to force the exclusivity of each participation-nonparticipation decision (Equation 3). If the integer variable for participation in the cotton program is selected, for example, transfer activities keep non-program cotton from entering the solution in that year. Similarly, if nonparticipation is selected, transfer activities exclude participation. If program cotton is selected in any given year, transfer activities divide the base acreage between acres planted in cotton, acres flexed to other crops, and any required set-aside (i.e., ARP requirements).[5]

Mechanisms for payment limitations are also included in the model, but are not enforced in this study. Legal organization is often used to avoid these limits (see Mims, Duffy and Young; Perry *et al.*).

The 50/92 program, available for cotton, and the 0/92 program, available for wheat, are not included in this analysis. Under prevailing market prices and yields, these options are not attractive to a producer unless labor or capital is constrained. If gross returns were less than variable costs or labor severely limited, this option would become attractive.

Representative Farms. Data from the Alabama Farm Analysis Association were used to develop two representative cotton farms, one for southwestern Alabama, where the BWE program is in the "containment" phase, and one for northwestern Alabama, where active eradication is now in progress. Crop enterprises for both farms are cotton, wheat and soybeans.

Based on Alabama farm analysis records for commercial-sized farms in the area, the northwestern Alabama farm is assumed to have 948 tillable acres. Fixed costs for depreciation and repairs total $53,240.00, or $56.16 per acre (fixed costs do not affect the mixed integer programming solution).

According to Alabama farm analysis records for 1992, a representative southwestern Alabama cotton farm has 1,692 tillable acres. Fixed costs for depreciation and repairs total $109,574.00, or $64.76 per acre. The higher per-acre costs in southern Alabama reflect a more recently purchased machinery inventory in this area of the state.[6]

Crop yields and cost of production estimates were based on 1992 budgets from the Alabama Cooperative Extension Service (ACES). For the southern Alabama farm, cotton yield (based on solid planting) was 697 pounds of lint per acre. Variable cotton production costs, excluding labor, were $335.11 in the budget. Because cottonseed sales are generally used to reduce ginning costs, the variable costs were reduced by the $27.88 in budgeted sales for cottonseed. Hence, a net variable cost of $307.23 was used in the analysis. For the southern Alabama farm, 1992 budgetary figures represent a post-eradication situation.

For the northern Alabama farm, budgeted yield was 667 pounds with budgeted variable costs of $293.61. As before, the cost of ginning was reduced by cottonseed sales ($26.68 for this farm), giving a net variable cost of $266.93 per acre. For the northern Alabama farm, 1992 budgets represent pre-eradication conditions.

For both farms, wheat yield was assumed to be 35 bu./acre, with per-acre variable costs of production of $78.36. Full-season soybeans were assumed to have a yield of 25 bu./acre, with variable production costs of $82.54/acre. Soybeans double cropped with wheat were assumed to have a yield of 23 bu., with variable production costs of $80.47. Unlike cotton production, wheat and soybean production is similar in both parts of the state.[7]

Because the model compares the post-eradication situation with pre-eradication yields, start-up costs (associated with the transition phase) are not included in the models. For the southern Alabama farm, grower assessments for start-up costs totaled $140.00 per acre from 1987 to 1991 (of this total per-acre assessment, the state of Alabama contributed $27.09). For northern Alabama, five-year assessments for start-up costs are projected to total

$75.00 per acre over the active eradication period (the state of Alabama has paid $12.60 per acre to date).

Based on farm analysis records, the initial cotton base on both farms was assumed to be half of total tillable acres. Unlike northern Alabama, where cotton has been well-established for years, many farms in southern Alabama that currently grow cotton had no cotton prior to 1990. Accordingly, a second analysis of farms with no initial base was performed for southern Alabama. Wheat base was assumed to be 38 acres on the northern Alabama farm (see Duffy, Cain and Young) and 100 acres on the southern Alabama farm. Sensitivity analysis was performed on initial wheat base. The results show the amount of initial wheat base, in general, had no effect on cotton acreage decisions.

Effects of Boll Weevil Eradication. In a recent study, Ahouissoussi, Wetzstein and Duffy used regression techniques to determine the per-acre effect of BWE on cotton yields and variable costs of production. To assess the impacts of BWE, survey information was collected from Georgia, Florida and Alabama farmers concerning cotton yields and pesticide use. Mail and telephone surveys were conducted from 1986 to 1990. The first BWE program insecticide applications took place in the fall of 1987. The 1986 and 1987 crop year survey information functioned as a benchmark against which to measure changes brought about by the program. A total of 1,919 usable survey observations were obtained over the five years of the survey project. A full statistical analysis of the data (see Ahouissoussi, Wetzstein and Duffy), accounting for weather conditions and changes in other factors affecting cotton yields, revealed that the BWE program has been responsible for a 100-pound-per-acre increase in cotton yield. This figure was similar, in percentage terms, to yield increases found by Carlson, Sappie and Hammig for the Carolinas and Virginia.

The average number of boll weevil insecticide applications fell over the study period and the average number of cotton acres per farm increased. Because of high infestations of other insect pests, particularly armyworms, no overall decrease in insecticide costs per acre was discovered during the study period.

To develop pre-eradication conditions for the southern Alabama farm, the BWE program effects must be "factored out" of the 1992 budget. In addition, variable costs of production must be reduced by the $11.65 grower assessment for 1992. Thus, pre-eradication conditions for the southern Alabama farm involve 597 pounds of lint in yield and $295.98 in variable costs.

For northern Alabama, a post-eradication situation must be estimated based on available information. Because weevil infestation levels are lower in that part of Alabama, the anticipated yield benefits will not be as high. Although the yield enhancement from BWE will not be known with certainty until sometime after 1997, for this study we assume a one-standard deviation decrease in the yield effect found for southern Alabama by Ahouissoussi, Wetzstein and Duffy. Accordingly, we assume an increase in cotton yield of 60 pounds per acre for our post-eradication situation. Current assessment in northern Alabama for the active stage of eradication is $15.00 per acre, considerably less than what was assessed in northern Alabama during the active eradication phase. Consequently, it is likely that grower-paid part of the assessment for the containment phase will also be less than the $11.65 for southern Alabama in 1992. We assume a containment phase grower cost of $7.00 per acre, sixty percent of the containment cost for southern Alabama producers.

We did not change variable costs of pesticide use in either case, because Ahouissoussi, Wetzstein and Duffy failed to find a statistically significant decrease in pesticide costs for Georgia and southern Alabama. Problems with other insect infestations, particularly the beet armyworm, have kept pesticide costs more or less constant, in spite of the BWE program.

Results

The mixed integer programming models were used to compare the optimal crop-mix and farm-program participation decisions with and without the BWE program effects. For the southern Alabama farm with 50 percent base (Table 1), the "no eradication" optimal crop-mix involves planting cotton inside farm program limits in every year. The remainder of the acreage is planted in wheat-soybeans double-cropped.[8]

After eradication, the farm shifts heavily into cotton production. In the first two years of the planning horizon, cotton is planted outside the program to build base for future years. In years three through five, cotton is planted within program limits with the remainder of the cropland planted in wheat-soybeans. The objective function of five-year discounted returns increased from $155,970.00 to $431,653.00, a substantial gain. Because this study compares the pre-eradication conditions to post-eradication conditions, the "transition" costs of the active eradication phase are not included in the model. For a farm of this type, total assessments (state and farmer paid) for the active eradication phase would have been $140.00 per cotton acre, or $118,440.00 in total for a farm with half its acres in cotton. Thus, the benefits to this farm far outweigh the start-up costs.

In Table 2, results for a southern Alabama farm with no initial base are presented. For the pre-eradication situation, farmers would remain out of the program for one year to build base, then remain in the program every year

Table 1.

Crop Mix and Returns for South Alabama Farm, 50% Initial Cotton Base[a]

	No Eradication (Objective Function: $155,970)[b]				Eradication (Objective Function: $431,653)[b]			
Year	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]
	---------- *acres* ----------				---------- *acres* ----------			
1	846.0[d]	846.0	0	$38,043	1,692.0	0	0	$67,957
2	846.0[d]	846.0	0	38,043	1,692.0	0	0	67,957
3	846.0[d]	846.0	0	38,043	1,410.0[d]	282.0	0	126,098
4	846.0[d]	846.0	0	38,043	1,598.0[d]	94.0	0	140,667
5	846.0[d]	846.0	0	38,043	1,567.0[d]	125.0	0	138,233

[a]Farm has 1,692 acres of cropland. Cotton base is calculated as a three-year moving average of acreage planted or considered planted in cotton. Farm assumed to have 846 acres planted or considered planted in each of three years preceding this analysis.

[b]For the objective function, annual returns were discounted using a discount factor corresponding to a 7% interest rate.

[c]For ease of comparison, annual net returns were not discounted.

[d]Total acres enrolled in farm program for cotton, including acreage reduction program.

Table 2.

Crop Mix and Returns for South Alabama Farm, 0% Initial Cotton Base[a]

Year	No Eradication (Objective Function: $96,411)[b]				Eradication (Objective Function: $401,278)[b]			
	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]
	---- acres ----				---- acres ----			
1	1,692.0	0	0	-$17,234	1,692.0	0	0	$67,958
2	564.0[d]	1,128.0	0	29,348	1,692.0	0	0	67,958
3	752.0[d]	940.0	0	35,197	1,128.0[d]	546.0	0	104,177
4	1,002.7[d]	659.3	0	42,779	1,504.0[d]	188.0	0	133,380
5	772.9[d]	919.1	0	35,826	1,441.3[d]	250.7	0	128,517

[a]Farm has 1,692 acres of cropland. Cotton base is calculated as a three-year moving average of acreage planted or considered planted in cotton. Farm assumed to have no acres planted or considered planted in each of three years preceding this analysis.

[b]For the objective function, annual returns were discounted using a discount factor corresponding to a 7% interest rate.

[c]For ease of comparison, annual net returns were not discounted.

[d]Total acres enrolled in farm program for cotton, including acreage reduction program.

with the remainder of the acreage planted in double cropped wheat and soybeans. Sensitivity analysis shows that, for this farm, if cotton prices fell below 58.7 cents a pound, no cotton would be produced at all in the pre-eradication case. Similarly, if proven yield is reduced to some of the lower recorded proven yields in the state, cotton would not be produced.

For the southern Alabama farm with no initial base, the post eradication optimal farm plan involves base expansion for two years rather than one. Here, the objective function increases from $96,401.00 to $401,278.00 If a farm of this type had not have been producing cotton prior to eradication, this gain would not be reduced by the relatively high start-up costs of the program, which were borne only by farmers already in cotton production. Sensitivity analysis for this farm shows cotton continues to be produced even at low proven yields or at lower cotton prices.

For the northern Alabama farm, cotton production is profitable even without the BWE program (Table 3). Under the assumptions used in this analysis, a farmer with a 50 percent initial base would seek to expand cotton base for the future by staying out of the program for two years. The same plan would be followed in the post-eradication situation. In this case, the objective value increased from $368,143.00 to $482,580.00 with eradication. Total assessment for the active eradication phase of the program is projected at $75.00 per acre or $35,550.00 in total for a farm with half its acreage in cotton. Thus, even though expected yield benefit is lower in this region, substantial gains can be achieved.

Conclusions

The BWE program resulted in yield increases of roughly 100 pounds per acre in southern Alabama (Ahouissoussi, Wetzstein and Duffy). The model of a representative farm for this region showed that these yield increases were significant enough to cause farmers to shift acreage from alternative crops into cotton. Acreage increases in the southern Alabama area, particularly for farms on which cotton was not produced before eradication, have indeed been observed in reality. For northern Alabama, where insect pressures are not as great, the BWE program will probably result in lower yield gains. Crop mix decisions did not seem as greatly affected in this region as in southern Alabama. Even so, expected gains will outweigh the producer costs of the program.

Aggregate impacts of the BWE program could potentially result in lower cotton prices, given the increased total supply. Ahouissoussi, Wetzstein and Duffy have shown, however, that the price effect is likely to be small as long as the program is limited to the southeast. Further westward expansion of

Table 3.
Crop Mix and Returns for Northwest Alabama Farm[a]

Year	No Eradication (Objective Function: $368,143)[b]				Eradication (Objective Function: $482,580)[b]			
	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]	Cotton	Wheat-Soybeans	Soybeans	Net Returns[c]
	---- acres ----				---- acres ----			
1	948.0[d]	0	0	$72,546	948.0	0	0	$101,175
2	948.0[d]	0	0	72,546	948.0	0	0	101,175
3	790.0[d]	158.0	0	97,329	790.0[d]	158.0	0	122,674
4	895.3[d]	52.7	0	107,574	895.3[d]	52.7	0	136,297
5	877.7[d]	70.4	0	105,862	877.8[d]	70.4	0	134,021

[a]Farm has 948 acres of cropland. Cotton base is calculated as a three-year moving average of acreage planted or considered planted in cotton. Farm assumed to have 474 acres planted or considered planted in each of three years preceding this analysis.
[b]For the objective function, annual returns were discounted using a discount factor corresponding to a 7% interest rate.
[c]For ease of comparison, annual net returns were not discounted.
[d]Total acres enrolled in farm program for cotton, including acreage reduction program.

the program could possibly result in sufficient increase in supply to reduce price, hence reducing the benefits of the program.

Notes

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1. Part of the producer cost in Alabama was paid by the state. In 1987, growers in southern Alabama were assessed $10.00 per acre. From 1988 to 1990, growers were assessed $35.00 per acre by the federal BWE program. In each of these three years, the state of Alabama contributed $14.00 of this $35.00 assessment. In 1991, the state paid $10.09 of the $20.00 grower assessment. In 1992, the state paid $6.35 of the $18.00 grower assessment. In 1993, the state paid $3.00 of the $10.00 assessment. For northern Alabama, grower assessments are projected at $15.00 a year for 1992 to 1996. The state has paid a total of $12.60 of these costs in 1992 and 1993.

2. Risk aversion is not considered explicitly in this study. Conclusive proof of the risk aversion of cotton farmers has not been obtained. Additionally, it has been shown (Duffy, Cain and Young) that base expanding carries little "risk" in terms of increased probability of farm failure.

3. Results of this study are sensitive to proven yields. Farms with low proven yields have less incentive to expand base because the anticipated returns from the farm program are significantly lower.

4. Within reasonable limits, ARP levels do not affect major conclusions of this analysis.

5. See Duffy, Cain and Young for the actual transfer equations used in this model, or see Perry *et al.* for a general discussion of the technique.

6. Before 1990, very little cotton was grown in this area, but acreage has been expanding rapidly (private communications with Steven G. Brown, farm analysis field man for southwest Alabama).
7. Private communications, Bob Goodman, Alabama Cooperative Extension Service.
8. Double cropping carries the risk of increased plant disease (private communications with Austin Hagan, Auburn University professor of plant pathology). As such, some farmers might wish to limit double cropping. Cotton plantings on the representative farms are assumed to be possible on the entire acreage. Rotation has not been used extensively to increase cotton yields in the study area (Mims, Duffy and Young). Accordingly, rotation effects were not included in the model.

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