Chapter 26

ECONOMIC EVALUATION OF INSECT ERADICATION: THE CASE OF BOLL WEEVILS IN THE SOUTHEAST

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INTRODUCTION

The primary organizational form for agricultural pest control activities in the United States is individual farmers taking independent pest control actions on their farms. Of course, social divisions such as farms, counties, and states are not recognized by mobile pests. Crop diseases that disperse in air currents and insects that fly or hitchhike on equipment make property rights difficult to establish by individual farmers. Because of this, collective pest control through volunteer community organizations or mandatory areawide programs may be less expensive and/or more effective, than individual farm pest control. There have been a few studies directed at evaluating the economic returns from particular collective pest control efforts — abatement districts (Carlson and DeBord, 1975), volunteer community programs (Lazarus and Dixon, 1984; Rook and Carlson, 1985) and eradication programs (Johnston, 1975; Carlson, 1975; Taylor *et al.*, 1983). Successful eradication programs are common in some countries for animal diseases, but there are only a few success stories for insect pests; these primarily have dealt with eradication of newly introduced insects, such as various fruit fly species, into an area (Mangle *et al.*, 1986).

The cotton boll weevil, *Anthonomus grandis grandis* (Boheman) is a key pest of cotton in the United States. Cotton farmers expend about $200 million per year for insecticides and miticides. Damage in terms of yield reduction due to insects is estimated to be about 7-20 percent (Ridgway *et al.*, 1983). About two-thirds of the United States cotton growing area is routinely infested with boll weevils. The boll weevil is a major source of yield loss and control cost because it occurs relatively early in the season and insecticide treatments for boll weevil can disrupt natural controls of later insects such as bollworms and tobacco budworms.

The first major boll weevil eradication experiment was in Mississippi during the early 1970s, though successful weevil eradication had occurred in the 1960s in Arizona. The North Carolina-Virginia eradication trial of about 15,000 acres of cotton began in 1978. This area was chosen because it was the northeastern edge of cotton production and the boll weevil was an established major cotton pest. The trial was conducted by the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture, with financial support being shared as 25 percent federal, 25 percent state government, and 50 percent cotton growers in the trial area. This three-year trial was mandatory for all cotton grown in the original trial area (Figure 1). The trial area was divided into an eradication zone and a buffer zone. The latter area received boll weevil control to achieve non-damaging levels of weevils, but eradication was not expected in the first three years of the trial in the buffer zone. In 1983-85, the program was extended to all cotton in North and South Carolina (about 220,000 total acres). Beginning in 1987, the program was extended to all cotton in Florida, most of Georgia and counties in southeastern Alabama (Figure 1). The most recent expansion is into the remainder of Georgia and Alabama and into Northeastern Mississippi.

Eradication of an established insect species is usually an expensive investment with major uncertainties. With the current limited knowledge of pest population dynamics and migration patterns, and with weather variations, it is necessary to experiment with eradication programs. Regional programs on many operating farms can provide technical and financial information for possible extrapolation to other regions in addition to direct benefits of reduced pest populations. Collective pest control has been assisted in recent years by new technologies such as pheromone traps, sterile insect releases and computerized information systems. Also, there seems to be a need for improvements in institutions to organize decisions and resolve conflicts among farmers. Differences between areas in levels of pest attack, in effects of the program on non-target pests and in resource adjustment costs could prevent technically efficient programs from being adopted.

Economically, we can expect that eradication might be a lower cost alternative to conventional pest suppression when there are significant cost reductions from achieving and maintaining very low pest population levels. The eradication option becomes more attractive compared to annual farm-by- farm pest suppression if one or more of the following conditions occur: (a) significant cost reductions as the geographical area of pest suppression expands; (b) more uniform pest density and benefits of suppression across farms; and (c) when eradication resource are more similar to inputs used for other pests and crops. From a social perspective, an eradication program might also have environmental and health improvement effects, as well as providing principles for other pest control efforts.

This chapter presents data collection and evaluation methods for determining pesticide cost savings, cotton output changes and overall rates of return from boll weevil eradication. The North and South Carolina 1978-1987 eradication program is evaluated first, followed by presentation of results from 1986-1990 for Alabama, Florida

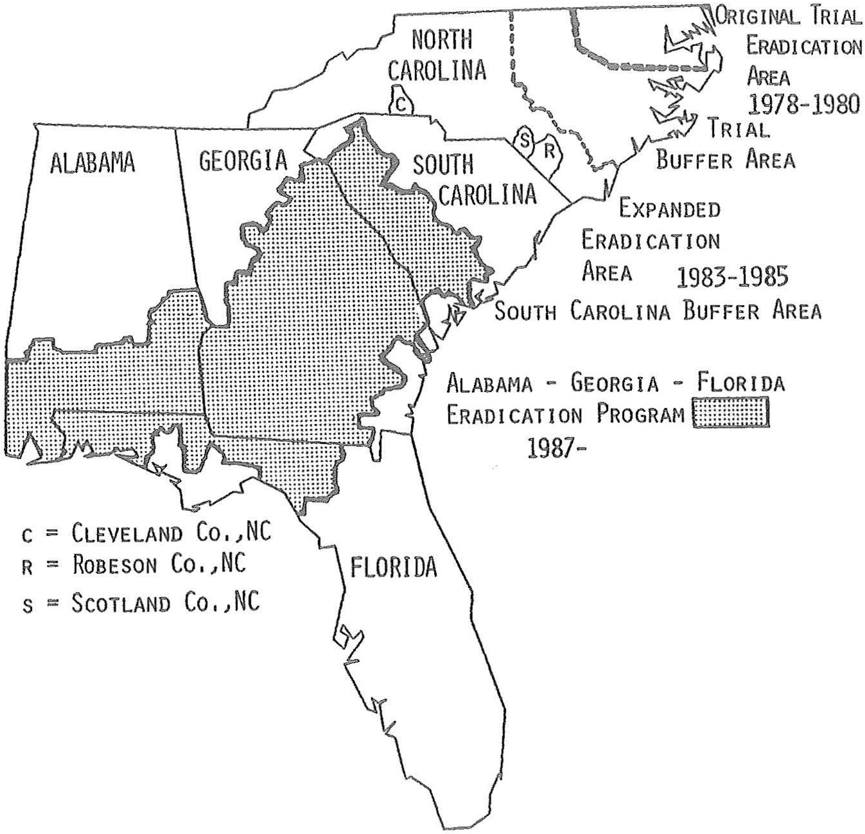

Figure 1. Southeast boll weevil eradication program areas and events.

and Georgia. Some attention is also given to measuring the environmental and informational benefits flowing from the eradication program.

EVALUATION METHODS AND DATA COLLECTION

The basic procedure used to evaluate farmer and overall returns to eradication is to estimate regional changes in: (a) pesticide use; (b) cotton yield; and (c) planted acreage. This is done by comparing regional averages before and after eradication. Before making comparisons, adjustments were made for pest level, weather, technology and changes in crop prices. In the case of pesticide use, a comparison region which did not undergo eradication is used to control for changes in new pesticide technology and pest densities. For cotton yield and planted acreage, linear regression models are developed and estimated to hold constant the effects of weather, technology and crop prices across cotton regions and time periods with and without boll weevil eradication. A more detailed description of the methodology and results is available in Carlson and

Suguiyama (1985) for the trial area, in Carlson *et al.* (1988) for North and South Carolina and Ahouissoussi *et al.* (1993) for the Alabama, Florida and Georgia area.

Changes in benefits (pesticide costs, cotton yield, planted acreage) and eradication costs are compiled by year. Average benefits and costs per acre are used to compute percent rate of return to the eradication investment since most of the costs occur early in the program while benefits are distributed over the future. Standard investment analysis is used assuming a 10 percent interest cost on all funds and contingency costs for maintenance of weevil-free areas.

Data on pesticide use were compiled by personal and telephone surveys of a random sample of cotton farmers. Large proportions of farmers (near 40 percent for the North and South Carolina program) were surveyed to insure that accurate estimates of pesticide use were obtained for all pesticides directed at weevils, bollworms, *Helicoverpa zea* (Boddie), and other pests. Official (USDA Crop Reporting Service) county figures on cotton yield and acreage were used to estimate the changes in yield and area planted. Cost data on eradication program costs and farmer assessments were made available by the APHIS program office and the farmer organization, the Southeastern Boll Weevil Eradication Foundation. Records on farmer balloting for the referenda on the program were made available by the North Carolina Department of Agriculture.

FARMER RESPONSE TO MANDATORY PEST CONTROL

The statutory authority for cooperative pest control by USDA, APHIS is the Incipient or Emergency Control of Pests Act (U.S. Code Section 148-148e) of 1937 and several other cooperative enforcement acts to prevent pest outbreaks. Each state considering mandatory boll weevil eradication has also passed enabling legislation which establishes mandatory cotton producer participation. Following the pattern in North Carolina, states have required a two-thirds approval of all voting cotton farmers prior to implementation of the program. The legislation provides a basis for collection of farmer assessments to fund part of the program, assess penalties, and enable quarantine activities to be carried out. Table 1 shows the percent affirmative votes for the various regions. In six regions the first referendum fell short of the necessary two thirds level, but the average vote has been 82 percent approval on second ballots. The votes represent farmer willingness to assess themselves fees, so they indicate the high value farmers place on the eradication program.

Once an eradication program is approved, farmers can still adjust to the program. Program assessments are based on fees per acre of cotton planted. Farmers can reduce their total assessments by reducing their cotton acreage during the period in the eradication program when fees are high (first two to three years). As will be seen below, this practice has been followed somewhat, but it is limited by farmers' desire to maintain their acreage bases for the federal cotton price support program. Additionally, farmers have been able to reduce program fees slightly by obtaining fee reductions for early fall stalk destruction. Program fees in the California-Arizona boll weevil program are assessed per bale. This could give differences in farmer practices, but has not yet been evaluated.

Table 1. Voting results of boll weevil eradication referenda

State	Year	Cotton Counties	Yes Votes (percentage)
			%
North Carolina	1976	All	76
	1982	Northern trial area	91
	1982	Southern (first referendum)	68
	1983	Southern (second)	79
South Carolina	1982	All (first	64
	1983	All (second)	72
Georgia	1985	All except northwestern (first)	66
	1986	All except northwestern (second)	88
	1992	Northwest (first)	51
	1993	Northwest (second)	97
Florida	1987	All	77
Alabama	1985	Southeastern	67
	1987	Southwestern	78
	1989	Southern (confidence vote)	75
	1992	Northeastern (first)	66
	1992	Northeastern (second)	69
	1992	Central (first)	47
	1993	Central (second)	84
	1993	Northern	82
Mississippi	1993	Eastern	76

The cost-sharing arrangement in the Southeastern boll weevil program has been 70 percent farmer and 30 percent federal funding. Some input from federal and state research, extension and regulatory agencies has also occurred, but only extension costs were included. The 70 percent share paid by farmers is a major change from cost-share arrangements of other insect and animal pest control programs of APHIS. For most programs (grasshoppers, witchweed, animal diseases), farmer assessments were 0-30 percent of costs. Farmers paid 50 percent of program costs in the original 1978-1980 trial. In the expanded program in the Southeast, state appropriations are covering about one-third of the costs in Florida and about thirty-eight percent of the costs in Alabama. Farmers have paid approximately 50 percent of the costs of the Texas High Plains Boll Weevil Containment Program (Lacewell *et al.*, 1974).

PESTICIDE SAVINGS FROM ERADICATION

Three comparison areas are the original eradication area, Robeson and Scotland counties in North Carolina and all of South Carolina for the 1974 to 1987 period (Figure 1). Expenditures for bollworms and total insect control costs including scouting and eradication fees are shown in Figure 2 and Figure 3, respectively. The sharp decline in pesticides directed at boll weevils occurred in the second year of the program (1979 — original trial area, 1984 — expanded program). Bollworm insecticide use declined more gradually following eradication as farmers learned how to utilize natural enemies and take advantage of delays in the onset of in-season pests. All three regions have shown major declines in bollworm expenditures — about 68 percent in the original area, 38 percent reduction in Robeson and Scotland counties and about 33 percent on average for South Carolina.

Total farmer insect control expenditures in constant 1979 dollars for the period before and after eradication are summarized in Table 2. The largest percent reduction in costs (71 percent) was in the original trial area. The total insect control costs for the expanded program in two areas in North Carolina and three areas in South Carolina have fallen by 39 to 53 percent. All absolute reductions are statistically significant except for the two Piedmont areas of Cleveland county, North Carolina and the Piedmont area of South Carolina. These two areas have low weevil infestations, but still show savings of 46 to 53 percent. These low weevil infestation areas are of special interest because many areas in Mississippi, Arkansas and Texas have similar infestations.

Not all the reduction in insecticide use between 1978 and 1987 was due to eradication. During 1978 to 1982, there was a 12 percent decline in cotton insecticide expenditure in the Robeson - Scotland area which was not part of the eradication program. This cost saving was primarily due to introduction of the more effective pyrethroid insecticides. This cost reduction is deducted from all estimates of boll weevil eradication pesticide savings.

Pesticide savings from weevil eradication in other cotton regions may differ from those found in North and South Carolina. However the experience over the 1978-1987 period covers a wide range of conditions. Very high cost situations ($102/acre in the South Carolina buffer area), very low insect control cost situations ($15/acre in Cleveland County, North Carolina), areas with primarily bollworm treatments (South Carolina) and areas with low starting boll weevil populations (original North Carolina-Virginia trial area in 1978) occurred during the eradication experience in this period.

A final aspect of pesticide use reductions is the potential for reduced environmental contamination. Comparing the period prior to eradication to the post-eradication period, there is an average reduction of 5.6 separate applications per year. For the 220,000 cotton acres in North and South Carolina, this is a reduction of about 1.2 million acre applications each year. However, to get to this reduced pesticide use situation there was a higher than average number of diapause applications required in the first two years of the program. Table 3 shows the level of in-season and diapause applications for the expansion program in North and South Carolina. During 1983 there were many more separate applications than either prior to the program or after eradication. This is an investment to obtain the less threatening environmental condition following eradication (1985 to 1987). If environmental contamination is proportional to numbers of pesticide applications, then there are additional benefits to eradication that are not

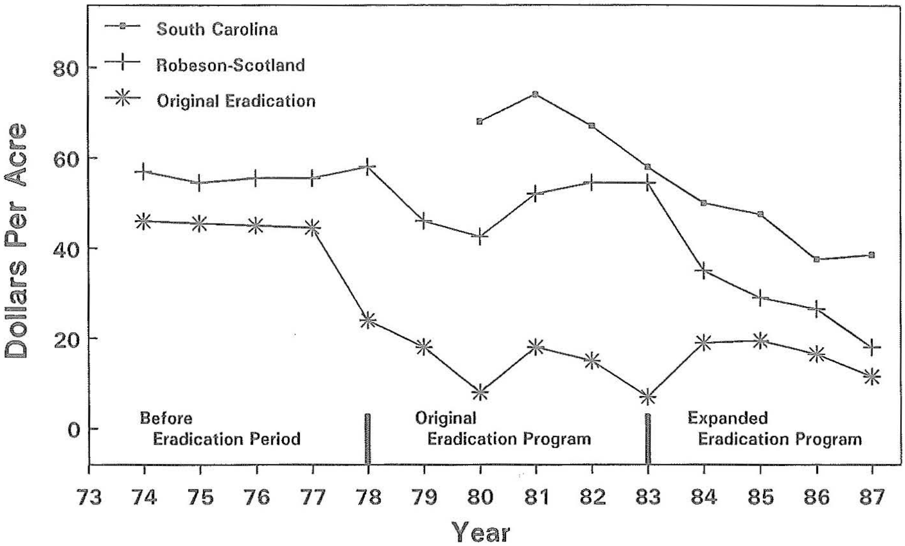

Figure 2. Bollworm control cost per acre (chemical plus application cost), adjusted to real 1979 dollars, 1974–87.

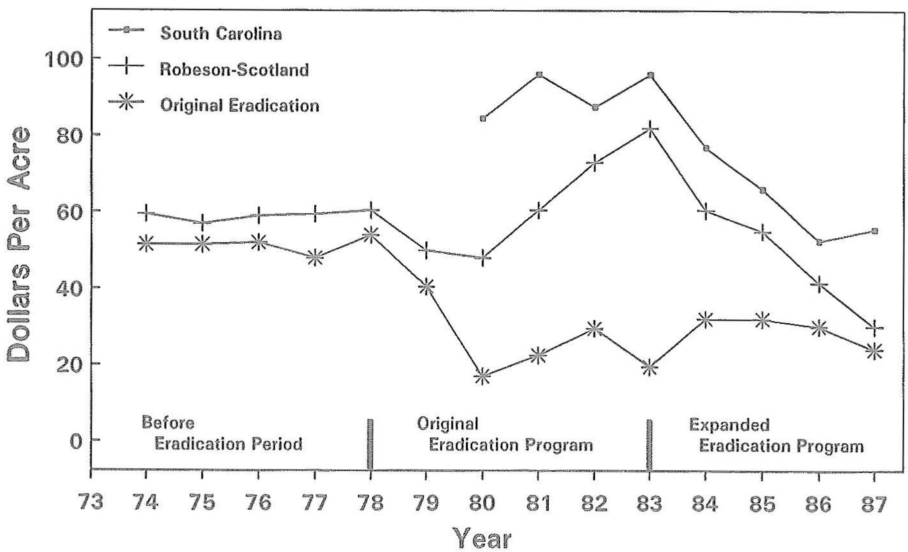

Figure 3. Total insect control cost per acre (chemicals plus application cost plus program fees and scouting), adjusted to real 1979 dollars, 1974–87.

Table 2. Changes in farmer insect control expenditures per acre associated with the boll weevil eradication (BWE) program.[1] (Source: Annual farmer surveys by North Carolina State and Clemson Universities.)

Zone[2]	Average expenditure before BWE program	Average expenditure after BWE program	Percent change	Before-after change (t-values)[3]
Original North Carolina eradication area	$49.41 (1974-77)	$14.54 (1979-87)	-70.56	8.515 *
Robeson-Scotland Counties North Carolina	$55.95 (1974-82)	$33.97 (1983-87)	-39.29	2.222 *
Cleveland County North Carolina	$14.51 (1975-82)	$ 7.77 (1983-87)	-46.46	0.468
South Carolina Piedmont Area	$47.01 (1980-81)	$22.04 (1983-87)	-53.11	1.730
South Carolina Coastal Plain	$83.58 (1980-81)	$50.41 (1983-87)	-39.69	2.250 *
South Carolina buffer zone	$101.93 (1980-81)	$55.78 (1983-87)	-45.27	4.624 *

[1]Expenditures adjusted to 1979 real dollars.

[2]See Figure 1 for locations.

[3]Difference in means using pooled standard deviation, significance at 0.95 = *

Table 3. Average numbers of in-season and program diapause insecticide applications (per field) for the North Carolina and South Carolina expansion programs, 1981-87. (Source: Farmer surveys and APHIS application records.)

	Number in-season applications		Number of program diapause treatments
Year	North Carolina expansion[1]	South Carolina expansion[1]	
1981	8.97	11.10	0.00
1982	11.06	12.80	0.91
1983	8.38	11.10	12.00
1984	5.87	7.30	8.00
1985	4.66	8.90	0.10
1986	5.19	5.56	0.08
1987	4.30	4.50	0.05

[1]See Figure 1 for locations.

Table 4. Summary of savings: benefits of reduced insecticides, area expansion and yield increases for the original area and expansion area from the eradication program.

	Original eradication area	Expansion area North Carolina & South Carolina
Net reduced pesticides	$28.87[1]	$30.01[2]
Acreage expansion[3]	$13.28	$13.80
Yield effect[4]	$34.50	$34.50
Total	$76.65	$78.32

[1]1974-1977 to 1979-1987 change adjusted for the $6 cost savings (12%) achieved over the same period in other non-eradicated area from insecticide improvements. (Carlson and Suguiyama, 1985.)

[2]Insecticide savings which is a cotton area weighted average of $21.99 for North Carolina Coastal Plains, $33.17 for South Carolina Coastal Plains, and $6.74 for North Carolina Piedmont and $24.97 in the South Carolina Piedmont for an overall Piedmont savings of $18.89. (from Table 2.)

[3]92 percent acreage expansion multiplied by one-half the cost saving in insecticides.

[4]Based on yield gain of 69 pounds per acre at an assumed long run world price of $.50 per pound.

captured by the direct pesticide saving costs. The $29 to $30 per acre savings in insecticide costs (Table 4) is an underestimate of the benefits of boll weevil eradication because of the unknown value of environmental and safety gains over the life of the program.

Finally, there may be some contribution of boll weevil eradication to managing insecticide resistance of bollworms and tobacco budworms, *Heliothis virescens* (F.). Because boll weevil eradication reduces early-season use of pyrethroids, there may be less development of resistant populations. Data from 1978 to 1987 shows that in-season treatment for bollworm/tobacco budworm in North Carolina and South Carolina is delayed by an average of eight days. This delay may help reduce selection pressure, especially since 1989 when chlordimeform (Fundal®, Galecron®) use was discontinued. The value of this benefit has not yet been quantified.

COTTON YIELD AND ACREAGE EFFECTS

If farmers can reduce boll damage from other insects when boll weevils have been eradicated, yield increases are an added benefit. A model was specified and estimated using county level yield records from 10 North Carolina, 9 South Carolina and 8 Georgia counties for the 1967 to 1986 period.

The estimated linear regression model is:

$$Y_{it} = \Sigma\, \hat{a}_i W_{it} + \Sigma\, b_i L_i + 69.23\ BWE - .99\ WORM - 2.7\ WEEVIL + 2.36\ DATE + 603\ PRICE - 2.82\ ACRE, \quad R^2 = .948,$$

where:

Y_{it} = cotton yield in county i in year t;

W_{it} = nine monthly average rainfall and temperature variables, for county i and year t;

L_i = Location or county i dummy variable, one for each county;

$\hat{a}, b_i$ = estimated weather and location coefficients (not shown);

BWE = boll weevil eradication variable (= 1 when county is under eradication in a given year, 0 otherwise);

WORM = Percent worm damage from research check plot in year t;

WEEVIL = Percent weevil damage from research check plot in year t;

DATE = julian date of first insecticide treatment in research check plot in year t;

PRICE = cotton loan rate (Commodity Credit Corporation support price) in year t; and,

ACRE = acreage of cotton planted in year t.

The model includes rainfall variables for each of April through October, and temperature variables for September and October, location variables to reflect soil quality and other factors, bollworm and boll weevil infestation variables, date of first insecticide treatment, county acreage figures to reflect falling land quality as more cotton is planted, a cotton price variable and finally a variable to designate if the county is under eradication or not. That is, the BWE variable takes on a value of one in years 1979 and thereafter for the original eradication counties, and for 1984 and years following for the remaining North and South Carolina counties. The Georgia counties are a non-eradication check area during the 1967 to 1986 period.

The estimated model shows a 69.2 pound lint gain when a county is under eradication and all other factors in the model are held constant. All variables in the model are statistically significant at the 0.95 or higher level except for May rainfall. The overall model explains about 95 percent of the year-to-year and county-to-county yield variation. A sensitivity analysis (Carlson *et al.*, 1988) of this shows that the yield gain from eradication is about one-third smaller when Georgia counties are used as a non-eradication check area compared with analysis of only North and South Carolina counties. This difference probably reflects the fact that improved cotton production technology has increased yield potential separate from the effects of eradication in the past five to ten years.

The price of cotton at the farm level over the past ten years (1975 to 1984) is $0.60 per pound in the Southeast. However, part of the price level is due to the cotton price support program. To reflect scarcity values of cotton, international prices are used, which for the staple length produced in the Southeast is about $0.50 per pound on average for the past 10 years. Therefore, the yield enhancement (69.2 pounds) due to eradication of the boll weevil has a value of about $34.50 per acre.

Because the boll weevil is eradicated from an entire region and not just the current cotton area, there is the potential for returns to a new area which is switched from other crops to cotton production. The amount of crop switching is estimated by a nine-variable, nonlinear regression model (see Carlson *et al.*, 1988 for details). The model specifies county cotton acreage as a function of two boll weevil eradication variables, four crop price variables, a weather variable, time trend and an index variable for the 1983 payment in kind (PIK) program. The model explains 75 percent of the year (1965 to 1986) and county to county (same 27 counties as the yield model) variation in cotton acreage. An estimated 92-percent increase in cotton acreage has occurred in North and South Carolina since the eradication program was completed, holding all other variables in the model constant.

The value of the increase in cotton acreage is estimated to be one-half of the increase in cotton area multiplied by the gain from insecticide savings (Carlson and Suguiyama, 1985). This value is approximately $14 per acre. This is an approximate estimate of the extra net return a farmer would expect as marginal land is switched from some crop like soybean to cotton.

The overall net benefits per acre from eradication for pesticide savings, yield enhancement and new cotton land are shown in Table 4. The pesticide savings are slightly higher in the expansion area of South Carolina and North Carolina compared to the original eradication area. The overall benefits are about $78 per acre. To determine the rate of return from eradication, program costs, expenditures to suppress reinfestations and timing of costs and benefits need consideration.

PROGRAM COSTS

One of the major uncertainties about boll weevil eradication is the likelihood of reinfestation of eradicated areas and the cost of cleanup for these reinfestations. Table 5 shows the cleanup activities for cotton in the original eradication area for the 1981 through 1987 period. The cotton area in column one includes that in the buffer area as well. The reinfestation rate has been from 0 to 22 percent, with very low reinfestation rates since 1983.

Through use of pheromone traps, it has been possible to detect reinfested fields prior to a widespread outbreak from the point sources of reinfestation. Costs of treating fields, adding traps, checking traps and travel expenses are $5 to $50 per treated acre. However, the costs per program acre are very small, especially as the area in the program increases. The likelihood of reinfestation clearly has declined since the distance to the source of large weevil populations was increased by about 300 miles beginning in 1984. The average cost over this seven year period for clean-up activities is about $.94 per program acre (average of final column in Table 5).

The boll weevil eradication program costs and net returns for labor, insecticides, traps and overhead expenditures are shown in Table 6 for the first three years and the average year following the first three years. Both farmer and total program costs are shown. Actual expenditures in 1978, the first year of the trial program, included costs to manage bollworms as well as boll weevils. This part of the costs ($51 per acre) has been deducted since it was not part of the program after the first year, and it would have been required in the absence of the program. The program cost was about $120 per acre for the first three years of the original program. The expansion program was altered and was slightly less expensive. The use of diflubenzuron (Dimilin®) and the release of sterile male insects was not included in the expanded program. Also, the expanded program did not begin until August of the first year with more emphasis on diapause treatments. The third phase of eradication—that is underway in Georgia, Alabama and Florida—is following a similar program and cost structure as the expanded program in South Carolina and southern North Carolina.

The final cost component is the contingency or maintenance fee in the fourth and following years. This figure is currently at $6 per acre in the original eradication area and is at $8 in the expanded program area. Cleanup costs so far have been closer to $1 per acre as shown in Table 5. For the rate-of-return calculations discussed in the following section, it is assumed that this cost is the actual cost up through 1988 and $6, thereafter.

OVERALL NET RETURN TO ERADICATION

The yield and pesticide savings benefits of eradication begin the first year following eradication in the original area. The acreage expansion effects begin the fourth year. In the expanded program, because eradication began in August of the first year, acreage benefits occur in the third year of the program. The net return per acre, considering all

Table 5. Extra costs of clean-up activities in original eradication zone, 1981-87. (Source: Compiled from APHIS records.)

Year	Total acres	Treated acres	Percent area reinfested	Average number of treatments	Total additional cost[1] ($)	Cost per treated acre ($)	Cost per program acre ($)
1981	50095	0	0.00	0	0	0.00	0.00
1982[2]	46003	10144	22.05	6	263,744	26.00	5.73
1983[2]	42435	8563	20.18	2	102,756	12.00	2.42
1984	72747	35	0.05	13	1,767	50.50	0.02
1985	64140	92	0.14	3	1,426	15.50	0.02
1986	56675	0	0.00	0	0	0.00	0.00
1987	61900	15	0.02	0	75	5.00	0.0012

[1]Average variable cost of $3.50 per acre per treatment for pesticides and application, plus an estimated average fixed cost of $5.00 per acre for added traps and pheromone, personnel and travel expenses.

[2]General reinfestation of the original eradication zone occurring as a result of increased acreage in the original buffer area and a period of uncertainty about the expansion of the program.

costs (farmer and federal), are shown (Table 6) for the first three and the typical year after the fourth year for both the original trial area and the expanded program.

The final summary number given in Table 6 is the computed rate of return to the eradication investment in North and South Carolina. This is the rate of interest that will make the present value of all program costs just equal the present value of program benefits. The return is 86 percent for the trial program and 97 percent for the expanded program. To put these figures in perspective, returns on savings accounts or bonds are 2.5 and 7 percent, respectively. For individual cotton farmers who only had to pay 50 to 70 percent of the costs the returns are even higher.

Table 6. Total eradication program and farmer costs and returns.

	Year 1	Year 2	Year 3	Years after program[1]
Original North Carolina/Virginia trial eradication area				
Farmer costs	$21.00	$23.00	$15.00	$ 9.43
Total costs	$42.00	$47.00	$31.00	$ 9.43
Net return	- $42.00	$16.37	$32.37	$66.65
Rate of return = 86%				
North Carolina/South Carolina expansion area				
Farmer costs	$25.47	$25.23	$17.70	$ 9.26
Total costs	$46.96	$31.52	$30.58	$10.99
Net return	- $46.96	$32.99	$47.73	$70.31
Rate of return = 97%				

[1]Average of program and farmer fees for fourth and following years: 1982-1986 for trial area, 1986-1988 for North Carolina/South Carolina expansion area ($/ac).

EVALUATION RESULTS FOR ALABAMA, FLORIDA, AND GEORGIA

An application of the above evaluation methods is the determination of costs and benefits for the Alabama-Florida-Georgia area (Ahouissoussi *et al.*, 1993). Regressions for determining Alabama-Florida-Georgia BWE program affects on producers' yield, insecticide use, and cotton acreage are similar in form to the regressions employed for the North and South Carolina program. Results from these equations covering the pre-eradication period 1986 and 1987 and the eradication period 1988 through 1990 indicate that the BWE program resulted in yield increases of approximately 100 pounds per acre over what they would have been in the absence of the program.

No significant relation was determined between BWE and either insecticide cost or cotton acreage per farm. One explanation for no significance between BWE and insecticide cost was the relatively large increase in other insect pests, particularly beet armyworm, which developed in 1988 through 1990. Unfortunately, not since 1977 was there such a widespread outbreak of beet armyworm. This resulted in a significant increase in insecticide use offsetting any possible gains from decreased costs from BWE.

In terms of planted cotton acreage, since 1989 there is a steady upward tend (Figure 4, USDA). BWE probably explains a portion of this trend along with other factors including low prices for competing crops such as soybeans.

Unfortunately, funding limitations precluded data collection for subsequent years past 1990. With subsequent years data, empirical estimates for insecticide cost savings and acreage response could be derived. In cases characteristic of such funding limitations which precludes data collection essential for evaluation alternative methods are simulation or programming models (Szmedra *et al., 1991*, Duffy *et al.,* 1994). For example, a mixed integer programming model developed by Duffy *et al.,* 1994 sup-

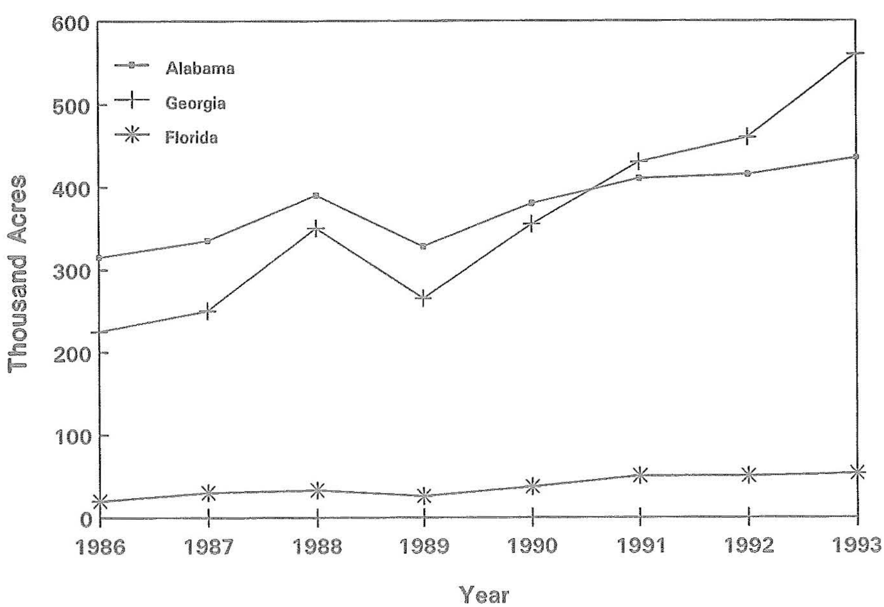

Figure 4. Cotton acreage in the Southeast.

ports the view that BWE is a major factor associated with increased cotton acreage. Their result, for southern Alabama, indicates optimal crop-mix would involve no cotton at all without the yield increase attributed to eradication. By contrast, when the 100 pound yield increase is included in the total yield, cotton is planted extensively.

The five years of data, 1986 through 1990, used for the Alabama-Florida-Georgia BWE evaluation are sufficient for assessing the short-term program impacts. Results indicate a 19 percent rate of return from farmers' investment in the BWE program. Such a return is comparable with a mean of 17 percent which private companies commonly consider as favorable for investment projects. However, this result is significantly less than the 86 and 97 percent rate of return, found in earlier years in North and South Carolina when full farmer and government costs were considered (Table 6).

CURRENT ISSUES

A major concern is how well eradication will work in other areas of the Cotton Belt where the boll weevil is not as major of a pest. Primary research for Northern Alabama, where boll weevil damage is significantly lower compared with the southern region of the state, indicates that the BWE program for farmers who are already producing cotton may not prove as lucrative as for Southern Alabama producers (Duffy *et al.,* 1994). Currently, research on this subject is continuing by agricultural economists in Georgia and Alabama. For other cotton growing regions, the program is expanding into the Mid-South (Mississippi, Louisiana, Arkansas, and Tennessee). The BWE program in the Southwest is almost completed. The only remaining area is 60 miles into Mexico consisting of 3,000 cotton acres. Once this acreage enters the program in 1994 a natural buffer will exist between the Southwestern United States/Northern Mexico and the rest of Mexico. As the BWE program continues to expand there may be some concern that cotton prices might decline with the resulting increased production. However, research based on published elasticities, indicates that the effect of a 100 pound increase in yield for the entire Southeast would be less than a penny a pound, a negligible effect (Ahouissoussi *et al.,* 1993).

SUMMARY

Experimentation with boll weevil eradication in North and South Carolina has led to improvements in organizational and technical features of the program over the 1978 to 1993 period. Eradication of the boll weevil reduces insecticide use in two ways. First, in-season sprays are no longer targeted at the boll weevil, and secondly, greater survival of predators and parasites results in higher mortality of bollworms, tobacco budworms and other pests with reduced need for controlling them with insecticides. The estimated pesticide use reduction from eradication is 40-70 percent (about $30 per acre). Eradication has also encouraged cotton acreage expansion (about 92 percent worth $14 per acre) and increased lint yield by about 15 percent, (69 pounds per acre in North and South Carolina, 100 pounds in the Southeast). Considering the total additional cost of the program (farmer and public expenditures) and total benefits, the rate of return on the eradication investment is estimated to be 97 percent. There are also environmental benefits of the program associated with reduced insecticide use (approximately 5.6 fewer insecticide applications per acre per year). Expansion efforts in Georgia, Alabama, and Florida have been enhanced by knowledge gained in the Carolinas. Eradication efforts in the Southeast will provide information for farmer votes and program plans in the Mid-South region. The decision to undertake an eradication program must weigh the tangible and intangible benefits and costs as indicated in this chapter.