Aggregate Economic Effects of Alternative Boll Weevil Management Strategies

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Abstract

This article presents an aggregate benefit-cost analysis of alternative areawide boll weevil eradication and management strategies Economic efficiency effects of the programs were measured in terms of consumer benefits, farm income, and public program costs, TECHSIM—an econometric simulation model of production and consumption of major U S agricultural crops—was used to estimate market impacts of the programs Boll weevil eradication, combined with pest management, was found to have the highest net social benefits However, this program also had the highest public (taxpayer) costs An optimum pest management alternative without eradication had the highest benefit-cost ratio, but had next to lowest net social benefits Choice of the best boll weevil program depends on budget priorities and the target group for program implementation

Keywords

Benefit-cost evaluation, pest management, pest eradication

Boll weevils infest about 7 million acres of cotton in areas extending from Virginia to central Texas Since shortly after the boll weevil first infested U S cotton in the late 1890's, the insect has ranked high, if not the highest, among insects causing economic damage to U S crops In addition to direct economic damage caused by the pest, the substantial amounts of insecticides used to control boll weevils have apparently resulted in serious environmental problems

In view of the economic and environmental problems posed by the boll weevil and in recognition of the technical and operational advances in its control, the U S Department of Agriculture (USDA) initiated comprehensive biological, environmental, and economic evaluations to assess the potential of alternative areawide boll weevil eradication[1] and management strategies This article presents results of the national economic evaluation

The economic evaluation emphasized the aggregate economic efficiency and distributional impacts of alternative areawide strategies for boll weevil control Net economic efficiency was defined in terms of consumer benefits (consumer surplus), farm income and public program costs Distributional impacts were measured in terms of consumer benefits, regional farm income, and taxpayer costs

Because any large-scale pest control program affects not only the market for the target crop but also related markets, aggregate economic evaluations of such programs are improved if they are conducted in a general equilibrium framework, otherwise, price, quantity, and surplus estimates would be biased In light of this situation, TECHSIM, a regionalized econometric simulation model for the production and consumption of major U S. field crops, was used to estimate market impacts of alternative boll weevil control programs as reflected in regional per-acre yields and production costs The version of TECHSIM utilized for this analysis did not include an explicit livestock sector, but it is otherwise essentially the same as the version reported in the first article in

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[1]Authorization for public sponsored areawide boll weevil management programs is given to the Secretary of Agriculture in the 1973 Agricultural and Consumer Protection Act, P L 93-86 (*3*) Italicized numbers in parentheses refer to items in the References at the end of this article

this issue The version used for this analysis is reported in (2)

We define alternative programs considered in the evaluation in the next section Then, we present regional insect control costs, yields, public program costs, and implementation data that are critical to an aggregate analysis We discuss the benefit-cost framework, and we present national impacts of alternative programs, followed by estimates of distributional impacts Finally, we discuss uncertainties and implications of the analysis USDA reports (*4*, *5*, *6*, *7*) provide additional details on the economic evaluation and results

Alternative Boll Weevil/Cotton Insect Management Programs

Six programs were chosen for evaluation

1. Current insect control (CIC) assumes insect control as now practiced by cotton producers with a continuation of extension education and technical assistance at current funding levels

2 Optimum pest management with continuing incentives for boll weevil management (OPM-I) uses relevant boll weevil/cotton insect management practices over all acreage where boll weevils are currently a pest problem This acreage would receive areawide diapause and/or pinhead square treatments,[2] as needed, with full reimbursement to producers for treatment costs. All areas where the areawide diapause strategy could not be implemented or where it is not needed because of an absence of boll weevils would utilize, if applicable, all relevant practices except the organized areawide diapause treatment. Additional extension personnel and support would be provided in all areas of the 11 weevil-infested States.

3 Optimum pest management with phased incentives (OPM-PI) includes the same management practices and recommended technical components as OPM-I, except that incentive payments for diapause or pinhead square treatments decrease annually over a 4-year period from full reimbursement in the first year to no reimbursement in the fifth year

4 Optimum pest management with no incentives (OPM-NI) includes the same management and technical components of the beltwide program specified for OPM-I, except that producers are not reimbursed for diapause or pinhead square treatments

5 Optimum pest management with boll weevil eradication (OPM-NI-BWE) includes eradication of the boll weevil as a major component [3] To achieve efficient implementation and to take advantage of the absence of the boll weevil, OPM-NI, including its additional extension inputs, would be in place before, during, and after eradication Eradication would begin in the Southeast and proceed west through eight separate zones, followed by the maintenance of a buffer zone between the United States and Mexico to inhibit reinfestation

6 Current insect control with boll weevil eradication (CIC-BWE) would be implemented with current levels of funding for extension education for cotton insect management before, during, and after eradication The eradication component of this program would be the same as for OPM-NI-BWE

Associated with each of the programs are unique sets of producer insect-control costs, cotton lint yields, and public program costs, all based on program components Consequently, each was expected to have a different impact on the markets for cotton and other crops and on distributional and economic efficiency

Regional Data

National economic evaluation of alternative boll weevil management options required us to estimate lint yield and per-acre insecticide use data, and to compare public expenditures for each option. Esti-

[2]Diapause control refers to late season insecticide treatment, timed to affect reproductive adult weevils prior to their overwintering The timing is such that few or no same year yield benefits result The treatment is aimed at reducing the level of next year's resident weevil population Therefore, diapause treatment is often not conducted by producers whose decisions are based on shortrun, intraseasonal considerations Pinhead square treatment is an early season control strategy which also occurs at a time that might not be chosen by a shortrun profit-maximizing producer Both strategies are relatively ineffective if not practiced over a large area

[3]One reason that boll weevil eradication has some chance of success is that the boll weevil can survive only on cotton and on a few wild host plants found exclusively in southern Texas

mation of regional yield impacts was especially difficult as little empirical evidence was available on a regional or beltwide basis. Because experiments would be too costly and time consuming to provide the yield and cost data needed for each alternative insect management strategy, we investigated the possible contributions of the following three approaches to obtain the yield and cost impacts (1) multiple regression, (2) simulation, and (3) Delphi As regression and simulation data were not available for all cotton regions, we obtained yield and insecticide cost data using a structured Delphi process for the 32 weevil-infested regions shown in figure 1

Delphi is a process by which a panel of experts is polled for information, each member of the panel is given feedback on the range and variation of initial response, and then members are polled again Delphi insecticide use and yield estimates were developed by a broad group of individuals representing cotton research, Cooperative Extension Service (CES), production, management consulting, and the chemical industry Delphi panelists were identified as experts by a representative of each respective group Because consistent data on cotton insects and their control for all weevil-infested regions are lacking and because attempts to generate these data through various analytical techniques have been unsuccessful, the subjective judgments of the expert Delphi panelists represent the best available estimates of the average subregional farm-level impacts of a change in boll weevil/cotton insect management programs In an evaluation of the Delphi results, we also found that the estimates generally fall within the range of available estimates from other partial sets of subjective or historical data (*5*)

Producers' Insect Control Costs

Strong linkages and interactions exist among boll weevil, bollworm (*Heliothis*), and other insect management practices Some chemicals and many treatments are used to control more than one insect Primary treatments against one pest often result in secondary effects on other insects. The program options including an OPM component recognize these interactions by addressing insect management in a holistic framework Insecticide use and cost estimates were also collected and expressed in terms of the total insect complex and control scenario

Figure 2 summarizes estimates of U S producer costs of insect control for alternative management programs Costs of insecticide materials and their application costs are included These estimates are based on Delphi results for longrun average levels of

Figure 1

Cotton Production Regions

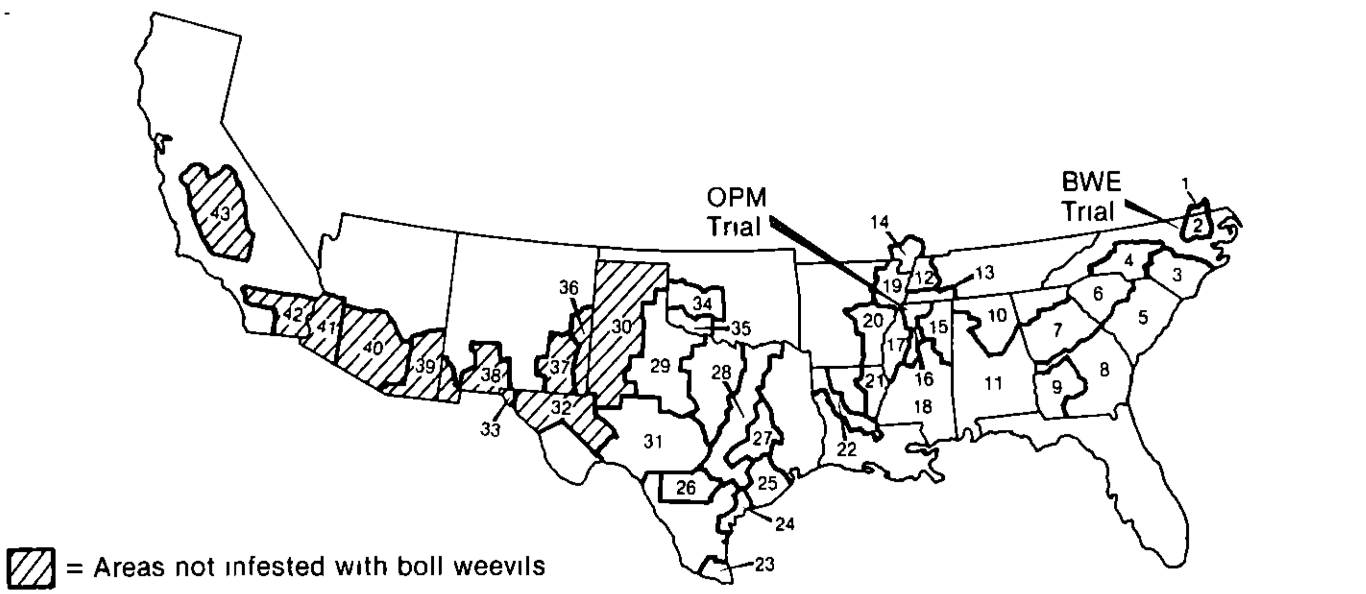
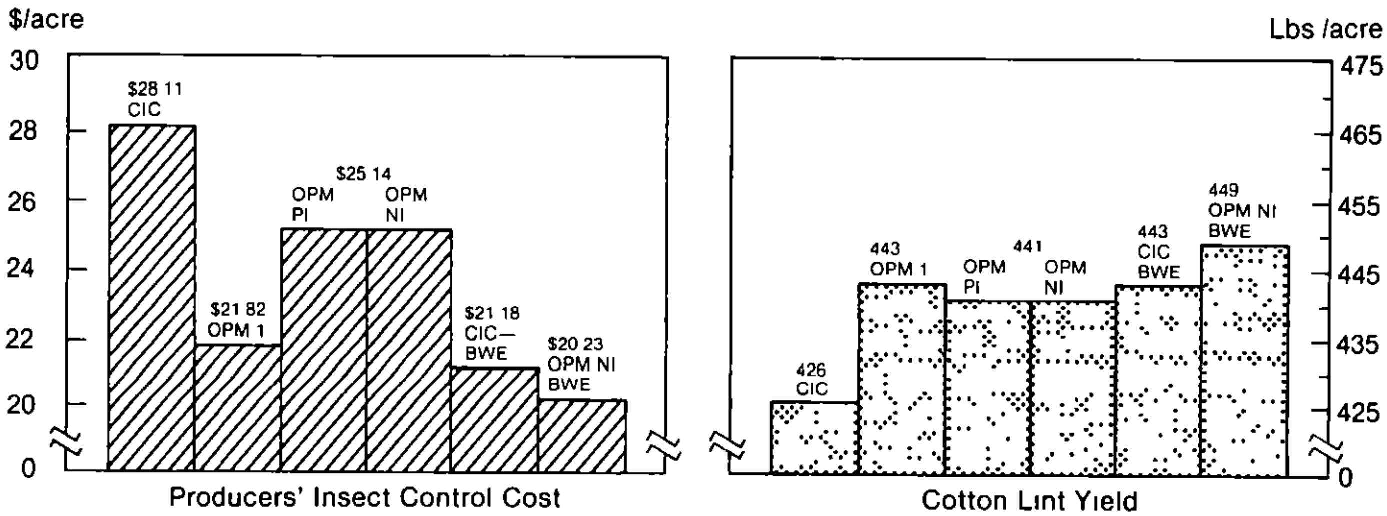


Figure 2

Average Producer Insect Control Costs and Lint Yields by Boll Weevil/Cotton Insect Management Program, Boll Weevil-Infested States (Exclusive of Texas Subregions 30, 32 and 33)



infestation Cost levels associated with OPM and BWE programs represent full implementation of the respective programs and full adjustment by producers

Insecticide use and costs vary widely across production regions. Although CIC costs are generally highest in the Southeast, costs are also high in some areas of Texas, notably the Central River Bottoms (region 27) and Winter Garden (region 26), and in Louisiana Some areas, including Missouri, northeast Arkansas, and the Rolling Plains and Upper Concho regions of Texas, generally experience little insect pressure

Insecticide applications and producer costs per acre following implementation were generally lowest for the two eradication programs. Costs for OPM-NI-BWE were higher than those for CIC in Missouri and northeast Arkansas, where Delphi panelists indicated that current control practices for insects other than boll weevils were inadequate and would likely be corrected with added extension education.

Cotton Lint Yields

Figure 2 summarizes Delphi estimates of lint yields for the six U.S management programs CIC yields correspond closely with average 1969-78 yields provided to Delphi panelists, with some modifications as estimated by panelists Yields for other programs were estimated as changes from the CIC base

All programs increase yields Incremental yield increases are generally greater from CIC to OPM-NI than from OPM-NI to any other option. This finding reflects the panelists' belief that additional extension education and technical assistance would improve cotton insect management and boost yields Yields for OPM-PI and OPM-I either equal or slightly exceed those for OPM-NI Panelists believed that the addition of an areawide diapause program with incentives would not greatly increase yields above those associated with an increased extension education and information program. Yield increases for CIC-BWE are lower than those associated with the OPM programs in most regions in the Southeast and mid-South. The implication is that OPM programs would improve management of all cotton insects, whereas CIC-BWE impacts relate to eradication of the boll weevil only However, in most regions of eastern Texas, yields are higher for CIC-BWE than for OPM programs This may indicate that the boll weevil is more often the key pest in eastern Texas, whereas other key pests may predominate in the mid-South and Southeast

In most regions, OPM-NI-BWE average yields are higher than those for other programs, except for some regions where yields equal OPM-I. The chief rationale for higher yields, as well as for lower producer costs, for the OPM-NI-BWE program is that it combines the advantages of increased extension input and boll weevil eradication

Public Program Cost Data

Public cost is an important element in the economic evaluation of beltwide cotton insect management programs A Program Definition and Cost Facilitator Group, comprised of members of public institutions that would implement the various programs, specified guidelines and coordinated the review of Animal and Plant Health Inspection Service (APHIS) and CES estimates of public costs for the six programs (7) Program costs for implementing beltwide programs were estimated for each of 32 cotton production regions in boll weevil-infested areas (fig. 1)

Public costs include all Federal and State costs associated with each of the boll weevil/cotton insect management programs, including incentive payments to producers where applicable Incentive payments for diapause and pinhead square treatments under the OPM program were based on Delphi estimates of farmers' needs for such treatments (*5*) In this analysis, producers were assumed to pay 50 percent of eradication operational costs.[4] All research and development costs were excluded because past investments are not relevant to the choice among current alternatives Regular county extension personnel were not included in these computations because their number is unlikely to vary by the choice of insect management program However, county extension entomologists assigned specifically to cotton were included

We forecast neither changes in input price levels during the implementation period nor changes in relative price levels of different inputs We assumed technology was unchanged from existing on-the-shelf procedures during the evaluation period.

The pattern of estimated public costs for each of the beltwide programs varies considerably from initiation through full implementation (table 1) It would cost an estimated $460 million, including capital investments, during the 9 years to eradicate the boll weevil.

[4]Other cost-share arrangements (for example, Government provision of two-thirds of total cost) were evaluated with no change in program ranking This occurred because cost-shares affected only producers' profit during the 2 years of eradication implementation

Table 1—Annual public costs for beltwide boll weevil cotton insect management programs, years 1-15

Year	CIC	OPM-I	OPM-PI	OPM-NI	OPN-NI-BWE[1]	CIC-BWE[2]
	Million dollars					
1	2.5	5 6	5 5	4 7	6 2	2 5
2	2 5	35 8	35 6	6 9	19 1	12 1
3	2.5	35 8	28 9	6 9	46 2	39.2
4	2 5	35.8	22 1	6 9	79 5	72.5
5	2 5	35 8	6 9	6 9	94 3	87 3
6	2.5	35 8	6 9	6 9	74 0	67 1
7	2 5	35.8	6 9	6 9	51.0	44 1
8	2 5	35 8	6 9	6 9	74.1	67 2
9	2 5	35 8	6 9	6 9	65 4	59 3
10	2 5	35 8	6 9	6.9	21 1	16 0
11	2 5	35 8	6 9	6 9	7 7	3 3
12	2 5	35 8	6 9	6 9	7 5	3 1
13	2.5	35 8	6 9	6 9	7 5	3 1
14	2 5	35 8	6 9	6.9	7 5	3 1
15	2.5	35.8	6 9	6.9	7 5	3 1

[1]Includes all eradication program costs as well as related OPM-NI and followup monitoring costs Public costs would be lower than these amounts if farmers share some of the eradication costs
[2]Assumes constant 1979 dollars and constant 1974-78 average cotton acreage

If farmers share part of the eradication costs, public expenditures under eradication programs would be reduced CIC and the three incentive-related OPM programs would be funded through CES, whereas the two eradication programs, CIC-BWE and OPM-NI-BWE, would be jointly funded by CES and APHIS

Schedules Assumed for Program Implementation

Recognizing that programs would probably not be fully implemented in the first year and that producer impacts and adjustments would not take place immediately, we made simplifying assumptions to reflect the dynamics of implementation

To promote comparability of results, we assumed that all programs would be initiated in the same year For the OPM programs (OPM-NI, OPM-PI, and OPM-I), we assumed that 50 percent of program personnel and related resources would be in place in year 1, and 100 percent in place in year 2 Incentive payments to producers for any diapause/pinhead square treatments would start in year 2 at the full funding level For the OPM-NI-BWE program, an OPM-NI option would be implemented in all regions in year 1, the year immediately preceding initiation of eradication in southern North Carolina In North Carolina and in South Carolina, we assumed that the OPM-NI option would be fully staffed in year 1, whereas staffing would take place over a 2-year period in the other States Eradication would be phased across the Cotton Belt in eight zones, starting in year 2 in North Carolina and ending in year 10 in the lower Rio Grande Valley of Texas Eradication activities are completed in 2 years within a given zone and are followed by continuous monitoring for incipient infestations

Eradication activities in the CIC-BWE program take place in the same sequence as those for OPM-NI-BWE, except that no additional CES personnel are funded

Estimates of changes in cost and yield obtained from the Delphi panels provided the primary basis for evaluating aggregate economic impacts of alternative management programs However, Delphi estimates reflect the impacts of full implementation of the programs Inasmuch as it is unrealistic to assume full implementation in the first year, we estimated annual responses of producers' costs and yields to the adoption of given programs (table 2). These estimates were made by the respective trial program operations in APHIS and CES All changes were measured from the CIC base except for OPM-NI-BWE, which is based on OPM-NI. We report the sensitivity of other selected assumptions relating to implementation scheduling later in this article

Additional critical assumptions relate to the effectiveness of programs and the rates of producer participation The evaluation assumes that the technologies and practices specified for use in weevil-infested regions would successfully eradicate or suppress the boll weevil as indicated in each plan We also assumed that producers would participate in the respective programs as estimated by the Delphi panels Mandatory participation is specified for eradication. For OPM programs, the Biological Evaluation Team (BET) estimated the extent of farmer participation needed, by regions or by areas within regions In heavily infested areas, the percentage of required acreage exceeded 90 percent In some areas, much less acreage was required because of historically low weevil infestation Delphi estimates of participation were matched against the BET estimates of required acreage In some areas, expected participation was less than that required, in which case the program impacts on that acreage reflected a modified OPM option (extension information and technical assistance) without organized

Table 2—Time-phasing of changes in lint yields and costs during implementation of alternative programs

Program	Percentage of difference from CIC		
	Year 1	Year 2	Year 3
	Percent		
OPM-NI	25	75	100
OPM-PI and OPM-I	50	100	100
CIC-BWE[1]	0	75	100
OPM-NI-BWE[1]	25	75	100

[1]Year 1 for both eradication options refers to first year of fall diapause applications in a given region Prior to eradication in the OPM-NI BWE program, which is phased across the Cotton Belt, an OPM-NI program will be in effect During those early years, the OPM-NI percentages apply to Delphi estimates of change for that program When BWE is initiated, the adjustment from OPM-NI to OPM-NI-BWE takes place according to the 25 75 100 scale

diapause/pinhead square treatments or incentive payments In most regions, the OPM-NI and OPM-PI programs were judged not to be effective in eliminating the need for midseason treatments for the boll weevil on at least 90 percent of the cotton acreage prior to *Heliothis* treatments However, the OPM-I program was assumed to be fully effective where needed to fulfill the above performance requirements Similarly, the eradication component of CIC-BWE and OPM-NI-BWE programs was assumed to be fully effective beltwide, and the followup monitoring program was assumed to detect and control incipient populations or reinfestations

Benefit-Cost Evaluation Framework

In the absence of external impacts, the present value of changes in consumer surplus plus changes in producer surplus minus all public program costs can satisfactorily measure the national net market benefits of a program Although objections have been raised against this approximation of social benefits, we believe there is no better empirically operational measure It is not an all-inclusive measure of net social benefits, as it excludes environmental factors, human hazards, aesthetics, potential pesticide resistance, and other possible impacts that decisionmakers should consider. These added considerations, however, have not been quantified and thus could not be assessed in monetary terms

Economic impacts of alternative management programs on producers of raw agricultural crops were measured as the change in net returns for each respective management program relative to CIC For this study, we defined producer surplus as the difference between gross returns and variable production costs, a definition which is consistent with net return variables in TECHSIM supply equations For producers' net returns to be a valid measure of producer surplus, real prices of production inputs must be constant over the relevant range of changes in input use that could be attributed to implementing any of the management programs Constant input prices appear to be a realistic assumption [5]

[5] We explicitly considered exceptions to this assumption in estimating specialized monitoring and manpower resource requirements for eradication and pest management programs

In this article, the term "consumers" has a very broad meaning and includes all market participants beyond the farm gate Thus, in addition to including the final consumers of processed agricultural crops, we include processors of crops such as owners of gins and textile mills. The area under an income-compensated demand curve less associated expenditures is the compensating variation measure of consumer benefits This measure is commonly termed consumer surplus The change in consumer surplus resulting from a price change can be seen to be the area graphically bounded by the demand curve and the price axis between the two price lines; this change can be approximated by the change in price multiplied by the average of the quantities associated with the old and the new prices

Because compensated demand curves are not empirically observable, we approximated consumer surplus with ordinary demand functions. As price changes resulting from alternative boll weevil management programs are rather small, the bias attributed to using ordinary demand functions rather than compensated demand functions appears insignificant

In calculating the present value of all benefit and cost items, we discounted future benefits and costs with an annual interest rate of 7 125 percent All annual benefits and costs were estimated in constant 1979 dollars Thus, one should note that the 7 125-percent interest rate is a real rate and not a nominal rate The discount rate chosen for this study is the 1980 rate recommended by the Water Resources Council for land and water resource planning The literature abounds with references to problems in selecting the correct discount rate (for example, (*1*)) However, sensitivity analyses conducted on the discount rate show that the relative ranking of alternative programs is not sensitive to changes in the discount rate used to evaluate the options

Aggregate Evaluation Results

Evaluation results of interest to policymakers include differences among programs in public cost requirements, average producer net returns, commodity price changes, and net market benefits implied by these component measures

Compared with CIC, prices received by farmers dropped for all alternative programs (table 3) All

Table 3—Changes in commodity prices resulting from alternative boll weevil management programs and CIC base prices[1]

Commodity	Unit	CIC base price	Change in price resulting from program				
			OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
Corn	Dollars/bushel	2 56	−0 005	−0 005	−0 005	−0 006	−0.008
Small grains[2]	do	2 71	− 002	−.002	− 002	−.002	− 003
Grain sorghum	do	2 66	008	008	10	.013	014
Cotton lint	Cents/pound	76.25	−1 67	−1 67	−1 95	−2 08	−2 73
Cottonseed	Dollars/ton	122 46	−11.65	−11 65	−13 56	−14 40	−19.00
Soybeans	Dollars/bushel	6 46	−.016	− 016	−.013	− 015	− 02
Cottonseed meal	Dollars/ton	168 20	−5 10	−5 10	−5.90	−6 60	−8 30
Cottonseed oil	Cents/pound	36 51	− 99	− 99	−1 15	−1 23	−1.62
Soybean meal	Dollars/ton	185 40	−2 30	−2 30	−2 70	−3 00	−3.80
Soybean oil	Cents/pound	28 57	− 06	− 06	− 01	− 01	− 02

[1] All prices and price changes are averages of estimated values for 1993-95 in 1979 constant dollars All values reflect longrun equilibrium, after full adjustment to the particular boll weevil management program

[2] Small grain prices are in terms of wheat equivalents

prices reflect longrun equilibrium levels after full adjustment to the respective programs. Price decreases resulted chiefly from increases in production or substitution effects among products The equilibrium base price for cotton lint was 76 25 cents per pound. Price decreases ranged from 1 7 cents per pound for OPM-NI to 2 7 cents per pound for OPM-NI-BWE (table 3).

Net market benefits—a major criterion for ranking alternative programs—were positive for all programs (table 4) The program with the highest net benefit was OPM-NI-BWE, followed in order by OPM-I, CIC-BWE, OPM-NI, and OPM-PI Net benefits equal the sum of consumer and producer benefits minus public costs. All estimates represent changes from CIC and are based on future streams of benefits and costs discounted at the 7 125-percent rate

The benefit-cost (B/C) ratio is an alternative measurement for ranking alternative programs that is relevant with a budget constraint The B/C ratio is calculated as the present value sum of consumer and producer benefits divided by the present value of public costs The B/C ratio is highest for OPM-NI, followed in order by OPM-PI, CIC-BWE, OPM-NI-BWE, and OPM-I (table 4) The differences in the B/C ratios for OPM-PI, CIC-BWE, and OPM-NI-BWE are probably insignificant

Net income to cotton producers as a group was negative for all programs The aggregate impact of lower cotton lint and cottonseed prices exceeded the positive effect of increased yields and lower production costs Many producers in the major production areas such as the Mississippi Delta, the High Plains of Texas, and the nonweevil-infested areas of the Far West do not directly benefit from the programs included in this evaluation, but they do experience the resulting lower prices However, producers in heavily infested areas do benefit from these programs Net income for soybeans, corn, and small grains decreased because of small price decreases and minor changes in the location of production. Grain sorghum returns increased slightly in response to higher prices caused by a shift to cotton in most areas of Texas.

Uncertainties and Implications of the Analysis

The economic analysis reported here relies heavily on biological relationships (1) yield-infestation and (2) insect control inputs and costs associated with alternative programs for cotton insect management We estimated these relationships through the interaction of experts in a Delphi process.

A degree of uncertainty in the Delphi estimates arises from two sources. First, precise, scientifically determined data are not available to substantiate the scientific judgment of the Delphi panelists However, this deficiency is the reason a Delphi approach was used. Second, the standard deviations surrounding some Delphi average estimates, particularly those for lint yield changes in eastern Texas, indicate a relatively

Table 4—Present values of benefits and costs for alternative boll weevil management programs[1]

Group or item	Changes in present values[2]				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	Billion dollars				
Consumer benefits[3]	4 58	4 50	5 16	4 17	6.46
Net income to cotton producers	− 85	− 84	− 60	− 42	− 96
Net income to other producers[4]	−1 10	−1 09	−1 04	− 84	−1 37
Program costs paid by the Government[5]	06	12	44	.16	.24
Net market benefits[6]	2 57	2.45	3.07	2 75	3 89
B/C ratio[7]	44 1	21 1	8 1	18 1	17 1

[1]Net benefits and B/C ratios are based on unrounded data Figures in this table represent changes in present values of benefits and costs as compared with a baseline that represents current insect control

[2]Future benefits and costs are in 1979 dollars, discounted at a 7 125-percent rate into perpetuity

[3]Consumers include all market participants beyond the farm gate, including processors, millers, and final consumers

[4]Includes producers of soybeans, corn for grain, grain sorghum, and small grains

[5]Producers were assumed to pay 50 percent of eradication program costs, exclusive of capital costs and followup monitoring Producer shares of program costs are reflected in returns to cotton production

[6]Net market benefits equal the sum of above consumer and producer benefits minus program costs paid by the Government This is generally considered the best criterion if there are no budget constraints

[7]B/C ratios were calculated as the sum of the present value of consumer and producer benefits divided by the present value of public program costs This is generally considered the best criterion if there are budget constraints

high variance of expert opinion among panelists Therefore, the economic evaluation included sensitivity analyses of the Delphi data We ran TECHSIM by using the Delphi estimates of cotton yield changes and also by using yield changes equal to 50 percent of those estimated by the Delphi panel Comparison of results of these runs showed that reduced yields resulted in lower net social benefits (as would be expected), but they did not alter the relative ranking of the alternative programs (*4*)

The Delphi estimated impacts of OPM-I were made under the assumption that sufficient cotton acreage receives diapause or overwinter control so as to prevent the need for in-season treatment for boll weevils prior to the onset of *Heliothis* on at least 90 percent of the cotton acreage Similarly, Delphi estimates for both alternative programs for boll weevil eradication were made under the assumption that eradication was successful in the strict sense of reducing the population to zero The Delphi experts did not address the technical or operational feasibility of eradication as part of the data generation process, but its feasibility would necessarily be part of the program selection process

Program components and costs were estimated, even though there was little empirical evidence on workability, effectiveness, or producer participation However, a rigorous review and interaction process was implemented To a limited degree, the risk of public program cost overruns would be provided for by small contingency funds in the program budgets There was little research or other information on the rate of adoption or producer participation in voluntary extension programs Sensitivity analysis provided an estimate of the effects of a 7-year adoption rate for OPM-related programs as compared with the 2- to 3-year adoption rate used in this evaluation (*4*). Again, the ranking of alternatives remained the same, although a slower rate of adoption resulted in slightly lower net benefits

In addition to the uncertainties mentioned above, it is not known that eradication *per se* is technically feasible regardless of expenditures Unfortunately, the nature of the boll weevil problem implies that there is no scientific way to assess the probability of eradication short of a complete eradication effort for the United States, then, the probability of success is 0 or 1 Consequently, there is no scientific or objective way to assign probabilities to estimates of economic effects that appear in this article

Major Conclusions

All the alternative programs increase consumer benefits at the expense of farm income, moreover, consumers could compensate producers for their losses and still be better off In an *ex ante* sense, many producers have difficulty perceiving how they would be worse off without the boll weevil, similarly, consumers may have difficulty perceiving benefits attributable to boll weevil management programs In an *ex post facto* sense, changes in consumer benefits and farm income resulting from a boll weevil program would be concealed by many other factors that influence prices and farm income Thus, there would be considerable political danger in selling consumers on the idea that they could compensate producers and be better off For these reasons, compensation appears quite unlikely

If boll weevil control has a high enough budget priority for any of the programs to be financially feasible and if the decision is to be made without regard to whom the benefits and costs accrue, then OPM-NI-BWE is the preferred program, as it has the highest net social benefits On the other hand, if boll weevil control is a low priority budget item, the preferred program is not clear unless it is compared with many other possible investments of public funds With budget constraints, greater importance should be given to the B/C ratio than to net social benefits Using a B/C ratio criterion indicates that OPM-NI is the preferred program even though it has the next to the lowest net social benefits

From the long-range perspective of agricultural producers, CIC is the preferred program option because aggregate farm income is highest under current boll weevil management methods Although producers in heavily infested regions would gain from any of the programs evaluated, the gainers cannot compensate the losers and still be better off

Given the results of this study, the choice of the "best" boll weevil management program depends on the target group for program implementation

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