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ERS Staff Report
No. AGESS 810518

Appendix B

Economic Evaluation

Beltwide Boll Weevil/Cotton Insect Management Programs

ECONOMIC EVALUATION

OF

BELTWIDE BOLL WEEVIL/COTTON INSECT MANAGEMENT PROGRAMS

by

The Economic Evaluation Team

of the

USDA Interagency Working Group on Boll Weevil Programs

In Cooperation with Southern

State Departments of Agriculture,

Agricultural Experiment Stations

and

Cooperative Extension Services

FINAL REPORT

June 5, 1981

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ABSTRACT

Alternative boll weevil/cotton insect management programs were evaluated for their effects on net market benefits and for their distributive impacts on producers and consumers. The Optimum Pest Management with No Incentives and Boll Weevil Eradication (OPM-NI-BWE) program produced the highest net market benefits, as measured by the sum of producer and consumer benefits less public program costs. Consumer benefits from lower prices greatly exceeded the loss of producer incomes and public costs. The Optimum Pest Management with No Incentive (OPM-NI) program produced the highest rate of return on Federal investment. A B/C ratio of 44:1 was obtained, compared with 17:1 for OPM-NI-BWE.

Key Words: Boll weevils, Insect management, Program costs, Econometric-simulation, Net market benefits

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* This paper was produced for limited distribution to the research community outside the U.S. Department of Agriculture. *

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PREFACE

This report presents results of an economic evaluation of alternative boll weevil/cotton insect management programs. It is submitted by the Economic Evaluation Team (EET), one of three teams that evaluated the biological, economic, and environmental impacts of alternative cotton insect management programs in trial areas and beltwide. Other reports present the biological, environmental, operational and public cost components of the evaluation of alternative programs.

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CONTENTS

* Available upon request

TABLES

FIGURES

ACRONYMS

APHIS	Animal and Plant Health Inspection Service, USDA
ASCS	Agricultural Stabilization and Conservation Service, USDA
B/C	Benefit/Cost Ratio
BWE	Boll Weevil Eradication or Trial
CES	Cooperative Extension Service
CIC	Current Insect Control
CIC-BWE	Current Insect Control with Boll Weevil Eradication
ESS	Economics and Statistics Service (now ERS), USDA
MOPM	Modified Optimum Pest Management Option
NCDA	North Carolina Department of Agriculture
OBP&E	Office of Budget, Planning and Evaluation, USDA
OPM	Optimum Pest Management Option or Trial
OPM-NI-BWE	Optimum Pest Management with No Incentive and Boll Weevil Eradication
OPM-I	Optimum Pest Management with Continuing Full Incentive Payments to Producers for Diapause and/or Pinhead Square Treatments
OPM-NI	Optimum Pest Management with No Incentive Payments to Producers
OPM-PI	Optimum Pest Management with Phased Incentive Payment to Producers
OPMREEAC	Optimum Pest Management Regional Extension Education Advisory Committee
SEA-AR	Science and Education Administration-Agricultural Research (now ARS), USDA
VADAC	Virginia Department of Agriculture and Commerce

SUMMARY

The six beltwide boll weevil/cotton insect management programs analyzed were: (1) Current Insect Control (CIC); (2) Optimum Pest Management with Continuing Incentive Payments for Boll Weevil Management (OPM-I); (3) Optimum Pest Management with Phased Incentive Payments for Boll Weevil Management (OPM-PI); (4) Optimum Pest Management with No Incentive Payments for Boll Weevil Management (OPM-NI); (5) Optimum Pest Management with Boll Weevil Eradication (OPM-NI-BWE); and (6) Current Insect Control with Boll Weevil Eradication (CIC-BWE).

Economic impacts of beltwide boll weevil/cotton insect management programs on producers and consumers were estimated through the use of a national agricultural econometric-simulation model. Net market benefits associated with alternative cotton insect management programs were compared. This measure is an aggregative reflection of the net effects of changes in economic benefits and costs of alternative programs. It is generally a preferred criterion for ranking programs according to economic contributions to the nation as a whole.

Each of the program alternatives to CIC was found to strengthen the U.S. cotton industry relative to foreign cotton producers and the synthetic fiber industry. Each program would lead to long-run increases, relative to CIC, in cotton production, mill use and exports.

Compared with CIC, all programs result in lower average cotton production costs and higher average yields in weevil-infested areas. All programs would lead to long-run increases in cotton production and net incomes in areas that, historically, are heavily-infested with boll weevils.

The increase in production nationally and the resulting lower prices to mills, exporters and consumers would give significant benefits to these market participants.

The OPM-NI-BWE program was estimated to produce the highest net market benefits, based on discounted future benefits and costs. They were $3.9 billion higher than with current insect control methods. Cotton producers in the boll weevil infested areas would gain an average of 23 pounds of lint per acre in addition to reducing their insecticide costs by an average of $8 per acre, changes of about 5% and 28% respectively. Consumers would gain chiefly because the increased production would lower prices of lint and cottonseed. Also, adjustments among competing crops such as soybeans, corn and small grains would result in slightly lower prices of those crops. Federal and State government expenditures under this alternative would total about $350 million during the 12-year required to fully implement the program across the belt, assuming that producers would share 50% of eradication costs. Annual (undiscounted) net benefits following beltwide implementation of OPM-NI-BWE would total about $250 million higher than CIC. In comparison, annual benefits from OPM-NI would total about $125 million higher than CIC.

The discounted long term net benefits of other programs ranged from a gain of $3.1 billion for the OPM-I program to a gain of $2.5 billion for the OPM-PI program. As with most productivity-increasing technologies, the early adopters are able to capitalize on the gains. Those producers unable to avail themselves of the technology are at a comparative disadvantage. Consumers, including all market participants beyond the farm gate, are the ultimate beneficiaries.

Public expenditures in the long-run were highest for the OPM-I program followed by OPM-NI-BWE, CIC-BWE, OPM-PI and OPM-NI.

The OPM-I program had a greater impact on net benefits than the no-incentive (OPM-NI) program. In most production areas, the diapause component of the OPM-NI program was considered by research and extension entomologists as either ineffective or not needed in meeting the biological criteria established for that component of an OPM program. Participation rates in a diapause-based program in some areas were often not sufficient in the absence of incentives to provide for effective communitywide control of early-season weevils. In those areas, a modified OPM option consisting of Extension information and education but without areawide diapause would be delivered.

The highest benefit-cost ratio in terms of public investment was obtained for the OPM-NI program. It placed fourth among the five proposed programs based on net market benefits. A program having the highest benefit/cost (B/C) ratio is often not the one that maximizes net benefits to society. Nevertheless, the B/C ratio is a useful criterion for ranking programs when there are severe budget constraints.

Compared with CIC, the alternative insect management programs had little effect on the acreage of cotton in the United States, although a slight shift out of the Far West was indicated. The eradication programs would tend to arrest the declining acreage in those Southeast and Mid-South areas where weevil infestations are historically high, but many other factors influence acreage levels.

Total production under OPM-NI-BWE would increase because of higher yields on a slightly larger acreage. No change in quality of product was assumed. Domestic mill use and exports would rise somewhat in response to the lower price of about 2.7 cents per pound. However, the increases in quantities will not offset the price-depressing effects of higher production because of the inelastic demand for cotton. Thus, even though cotton producers in most areas heavily infested with boll weevils would be better off without the weevil, the net returns to producers nationally would be slightly less than would occur without this increased productivity.

National average prices of major competing field crops other than sorghum would decline slightly. This would occur as a result of substitution effects associated with each cotton insect management alternative as acreages were shifted among crops. These declines represent a very small proportion of the value of these crops.

The above results were based on assumptions of average conditions, including weather, insect infestation, yields, and other exogenous variables. In order to establish some possible bounds for these aggregate estimates, sensitivity analyses provided an indication of how a range of possible yields, discount rates, cost-sharing arrangements and implementation schedules would affect the distribution of net benefits. OPM-NI-BWE retained its top ranking in terms of maximum net benefits in all cases, and OPM-NI retained its top ranking in terms of the highest rate of return on Federal funding. Also assumed in this analysis were current technologies, proven production practices, and current price relationships.

Interindustry impacts of alternative programs were also explored through the use of an input-output model. The results showed the distributional effects among the major sectors of the cotton industry and other sectors of the U.S. economy. In terms of total economic activity generated, the ranking of insect management programs was identical with the ranking of net benefits obtained from the AGSIM model. In the cotton ginning, warehousing and merchandising sectors, the OPM-NI-BWE program ranked highest in generation of economic activity, followed by CIC-BWE and OPM-I.

INTRODUCTION

The Problem

The boll weevil first infested U.S. cotton during the late 1890's, when it was discovered in border areas of South Texas (1) 1/. Over the years, it has ranked high among insects causing crop losses and high control costs in the United States. Recent loss estimates indicate a somewhat diminished weevil problem (2, 3) but it remains substantial, especially when viewed in terms of interactions of boll weevil control with Heliothis control on cotton. There is widespread concern that the substantial quantities of insecticides used to control the boll weevil and other major insect pests may result in serious environmental and economic problems. This concern is embodied in the Agricultural and Consumer Protection Act of 1973, which states that "...Secretary is authorized and directed to carry out programs to destroy and eliminate cotton boll weevils in infested areas of the United States as provided herein and to carry out similar programs with respect to pink bollworms or any other major cotton insect if the Secretary determines that methods and systems have been developed to the point that success in eradication of such insects is assured" (4). This authorization has not been superceded.

In view of the economic and environmental problems posed by the boll weevil, and in recognition of the technical and operational advances in boll weevil management, a 3-year eradication trial was proposed to further test and refine the effectiveness of suppression measures. The trial would also test the logistics and detailed execution of the eradication technology on a large operational scale. Further discussions resulted in selection of a boll weevil eradication trial in North Carolina and Virginia and a concurrent pest management trial in Mississippi, the latter to evaluate an alternative Extension insect management approach (called optimum pest management) which utilized proven techniques of suppression.

The two trials--Boll Weevil Eradication (BWE) and Optimum Pest Management (OPM)--started in 1978 and continued through crop year 1980. Concurrently, biological, economic and environmental evaluations of several beltwide cotton insect management programs were carried out.

Objective and Scope

The objective of the Economic Evaluation Team was to estimate and evaluate the current and future localized and beltwide economic impacts of alternative boll weevil/cotton insect management programs.

The focus of economic evaluation was on beltwide impacts of the selected boll weevil/cotton insect management programs. Producer impacts were estimated for

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1/ Underscored numbers in parentheses refer to references listed at the end of this report.

specified regions throughout the cotton belt (figure 1) and were aggregated for analysis into larger regions (figure 2). Consumer impacts were estimated at the national level. Comparative estimates of change in net market benefits and benefit-cost ratios of each program were developed at the national level. Distributional impacts on related sectors of the cotton industry, including gins, warehouses and shippers, as well as on other industries, were evaluated for four major regions or nationally, as appropriate.

This report first describes the alternative insect management programs evaluated in this study, explains the national econometric-simulation model used and the evaluation framework, the data sources and other assumptions and procedures. National impacts of alternative programs are presented next, followed by an evaluation of the distributional and interindustry effects of those programs. Highlights of economic impacts of trial area programs are given in the final section of the text.

A brief overview of the cotton industry, including related cotton industry statistics, is found in Attachment A. Attachment B contains the methodology and additional results of the interindustry (input-output) analysis. Attachment C, a separate report, contains a detailed documentation of the econometric-simulation model. Attachments D and E, also separate reports, contain additional analyses of trial area programs.

METHODS AND PROCEDURES

Definitions of Programs

Trials

Two insect management trials were conducted during 1978-80: (1) boll weevil eradication (BWE) was tested in North Carolina and (2) the optimum pest management (OPM) approach was demonstrated in Mississippi. The components of these trials follow:

1. Boll Weevil Eradication

   The primary objective of this trial was to develop and demonstrate technological and operational capability to eradicate the boll weevil from a specified geographic area in a three-year crop program utilizing the necessary regulatory authority (5). The major components of the North Carolina trial were (1) during the first year, all chemical applications (in-season, diapause, defoliation/dessication) were performed by APHIS following State recommendations; (2) during the second year, growers were responsible for control of insects other than the boll weevil and to destroy stalks after harvest; producers were urged to follow Extension recommenda-

COTTON PRODUCTION REGIONS

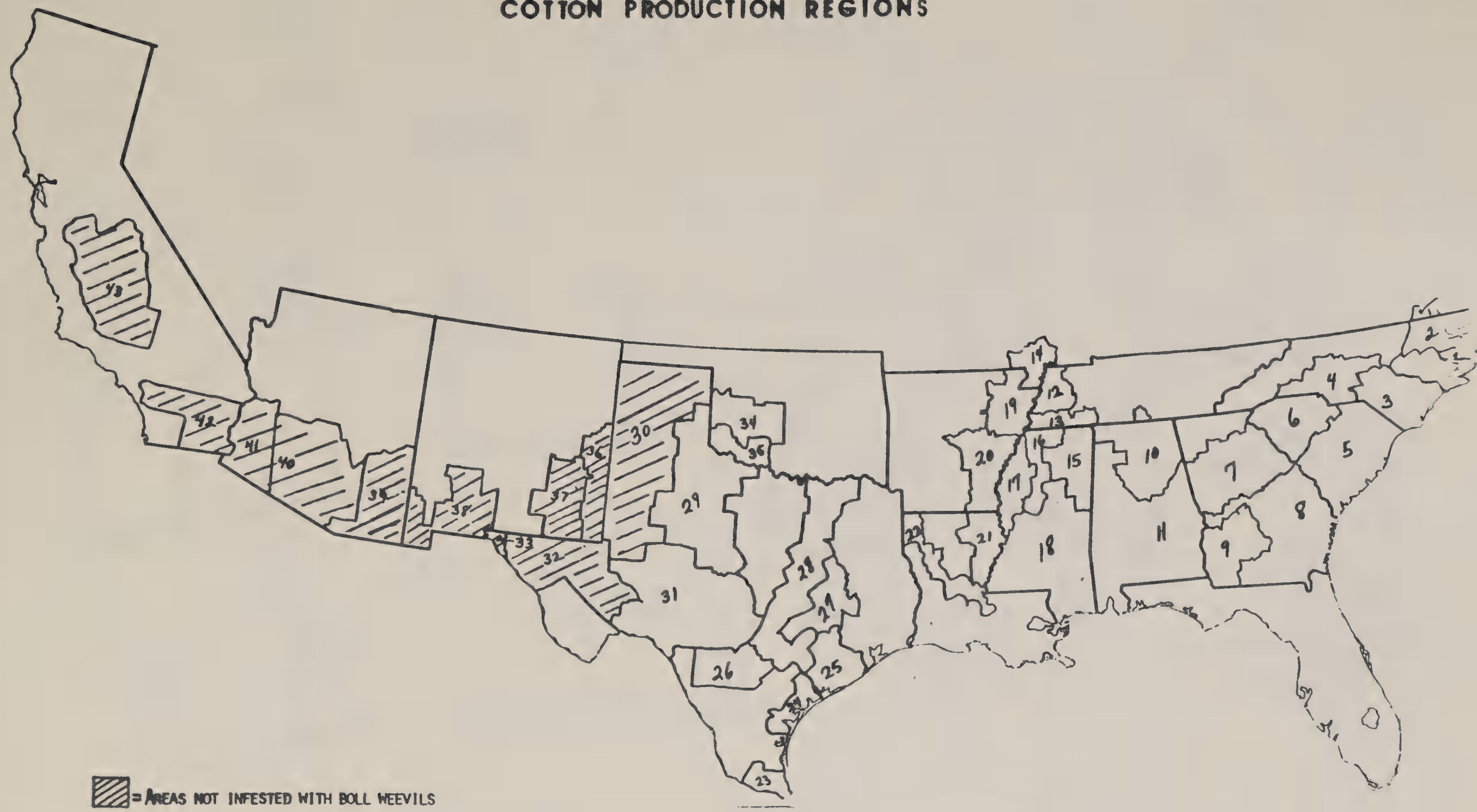

FIGURE 1

AGSIM PRODUCTION REGIONS

Figure 2

tions for cotton insects other than the boll weevil; APHIS was responsible for pin-head, in-season and diapause treatments for boll weevils, as needed, and distribution of sterile insects over the entire crop acreage; (3) during the third year, APHIS monitored and controlled incipient boll weevil infestations while growers were urged to follow CES recommendations for control of other insects.

2. Optimum Pest Management

The objective of this trial was to develop and demonstrate the technological and operational capability to implement a community-wide cotton insect management program to maintain boll weevil populations below treatment levels through voluntary participation of producers (6). This option was a modification of the current Cooperative Extension Service (CES) voluntary cotton insect management program. The components of the trial in Panola County, Mississippi included (1) grandlure baited traps as survey tools; (2) producers urged to plant cotton within recommended dates; (3) recommendation and reimbursment for pin-head square application, if needed; (4) scouting of all cotton by commercial consultants, grower organizations, CES employees, or trained producers; (5) producers urged to follow CES recommendations for in-season control of boll weevil and other cotton insects; (6) full reimbursement for boll weevil diapause treatments if needed, and (7) producers urged to destroy stalks if harvested prior to frost. A system of recommendations, authorizations and verification of pin-head and diapause applications were followed before any payment was made to growers.

Incentive payments were limited to $10 per acre each year. Consultants and grower organizations were involved, with CES providing information on recommended insect control practices.

Beltwide programs

Beltwide implementation plans are of utmost importance as the focus of the evaluation was to provide decisionmakers with information for choosing a beltwide insect management program. Furthermore, the choice of beltwide programs may involve features or components not fully tested in the trial programs. Six programs, including the major components of two boll weevil management approaches tested in the trials, were chosen for evaluation of beltwide impacts (7).

The final definitions were developed and approved by SEA/CES and APHIS personnel in consultation with Optimum Pest Management Regional Extension Education Advisory Committee (OPMREEAC), the Overall Evaluation Team, and the Program Definition and Cost Facilitator Group. Briefly, the program definitions are:

1. Current Insect Control (CIC) assumes insect control as now practiced by producers with a continuation of Extension education and technical assistance at the present level of funding.

2. Optimum Pest Management with Continuing Incentives for Boll Weevil Management (OPM-I) would consist of two major insect management options--Optimum Pest Management (OPM) and Modified Optimum Pest Management (MOPM)--whichever is most applicable for a particular area. Additional Extension personnel and support would be required to implement both options.

   - OPM would utilize the boll weevil/cotton insect management practices that were tested in the Mississippi Trial with emphasis on area-wide diapause and/or pin-head square treatments, as needed, and full reimbursement to producers for the cost of these treatments.

   - MOPM would be followed in all areas where the area-wide diapause strategy could not be implemented or where it is not needed. It would utilize, if applicable, all of the practices tested in the Mississippi Trial except the organized area-wide diapause strategy but may include voluntary diapause treatments by individual producers.

3. Optimum Pest Management with Phased Incentives (OPM-PI) includes the same two management options and recommended technical components as OPM-I except that incentive payments for diapause and/or pin-head square treatments of the OPM option are phased-out by the fourth year.

4. Optimum Pest Management with No Incentives (OPM-NI) includes the same two management options and technical components of this beltwide program specified for OPM-I except that producers are not reimbursed for diapause or pin-head square treatments of the OPM option.

5. Optimum Pest Management with Boll Weevil Eradication (OPM-NI-BWE) includes eradication of the boll weevil as a major component. To insure efficient implementation and to take advantage of the absence of the boll weevil, OPM-NI would be in place prior to, during and following eradication. Beltwide eradication would utilize technology proven by the North Carolina trial and ongoing research. Eradication would begin in the Southeast and proceed west through eight separate zones, followed by the maintenance of a buffer zone between U.S. and Mexico to inhibit re-infestation.

6. Current Insect Control with Boll Weevil Eradication (CIC-BWE) would be implemented with present level of funding for Extension education for cotton insect management prior to, during, and following eradication. Beltwide eradication would be the same as OPM-NI-BWE.

The National Model

Structure of Model

Boll weevil management programs evaluated have a potential to lower insect control costs and increase yields in most of the weevil-infested cotton producing areas. These changes can affect the relative profitability of cotton and substitute enterprises, and can lead to long-run changes in national acreages of crops, consumer prices, farm income and to some degree location of crop production. Estimation of these aggregate regional and commodity impacts requires a framework for bringing together the large amounts of information on yield, production costs, incentive payments, control costs and adoption rates for a large number of production regions (figure 1) while at the same time considering the national cotton and other related markets. For this purpose, an econometric-simulation model was developed, validated and used to predict certain key economic outcomes of the various management options. 2/

The econometric-simulation model used was designed specifically to estimate the aggregate economic impacts of policies or programs that change crop yields and production costs. The model, henceforth referred to as AGSIM, includes acreage response functions for five major field crops (cotton, soybeans, corn, grain sorghum, and small grains) in each of 13 producing regions (figure 2) in the U.S. Each acreage response function depends on expected per acre net returns of that crop and any competing crops, thereby allowing acreage shifts resulting from changes in per-acre yields and production costs to be logically derived. Yield and acreage equations for all crops in a region were estimated as a block of equations using Zellner's procedure for seemingly unrelated regressions. The weighted percentage of explained variation in acreage and yield ranged from 90 percent to 95 percent in the cotton producing regions, indicating that the model fitted the observation period (1961-77) quite well. For competing crops in a given region, the symmetry condition was imposed on cross-effects. Signs of all coefficients for own net return coefficients were positive, and all signs of cross net return coefficients were negative.

The consumption side of the model is given by a set of 42 demand equations, estimated in sub-blocks using Zellner's procedure for seemingly unrelated regressions. Symmetry was imposed on cross price effects in the feed demand equations. The weighted percentage of variation explained by the regressions ranged from 69 percent to 98 percent. Coefficients of all variables had expected signs.

Cotton lint demand was modeled by three equations: one for mill demand, one for lint export demand, and one for private lint stocks. In the mill demand equation, the price of lint has a statistically significant negative sign, and

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2/ Documentation of this model is provided in Attachment C.

the price of polyester fiber has a significant positive sign. The mill demand is highly inelastic. The export demand equation has a significant coefficient for lint price, but export demand is more elastic than mill demand.

One component of the model simulates a set of prices for each crop year that simultaneously clears all markets. The model does not predict actual price in any particular year because it does not consider random variation in factors such as crop yields; rather, the model gives an equilibrium set of prices that could be expected in a year when all random variables in the system had values equal to their respective averages.

In principle, the simulation model could be formulated as a stochastic model, but repeatedly running a model with a multi-variate set of 139 stochastic terms would be prohibitively expensive. Moreover, estimated impacts averaged over stochastic simulations would not be significantly different from results obtained from the deterministic model. To summarize, while stochastic factors are highly important in forecasting models, it is not imperative to include them in long-run equilibrium models.

Several advantages of the econometric-simulation model, as well as one disadvantage can be listed. One advantage of the econometric model is that it is "positive" in the sense that it shows how producers and consumers have responded to changes in technology, relative profitability and market forces in the recent past. The model is comprehensive enough to include export demand, regional acreage and yield response. Another advantage of the model is that it implicitly accounts for many constraints such as gin capacity, managerial ability and other resource constraints which are very difficult if not impossible to include in normative activity analysis models. Finally, the model as constructed is based on an estimated adjustment time to yield and cost changes, while most linear programming studies or comparative budgets do not explicitly consider adjustment time. The main disadvantage of AGSIM is that it is not comprised of acreage and yield functions for each of the 42 cotton production regions (figure 1). It was necessary to assume that the 42 region adjustments can be accurately estimated by six cotton acreage and yield functions for AGSIM regions (figure 2). Therefore, the 42-subregion results must be viewed cautiously. Aggregate results are a weighted average of the six regional impacts.

Net Market Benefit Evaluation Framework

In the absence of external impacts, the present value of changes in consumer benefits plus changes in producer net returns less all public program costs can be a suitable measure of the national net market benefits of a program. Although objections have been raised against this approximation of social benefits, the concensus is that there is no better empirically operational measure (8, 9). It is not an all-inclusive measure of net social benefits since it excludes environmental factors, human hazards, aesthetics, potential pesticide resistance and other possible impacts that should be considered by decision-makers. These added considerations should be assessed qualitatively. Impacts on various groups of market participants and impacts on regional net farm incomes are tabulated in this report because they may be of interest for equity and political considerations 3/; nevertheless, the aggregate measure of net market benefits as defined above should be used in assessing the economic desirability of alternative boll weevil management programs.

Economic impacts of alternative management programs on producers of raw agricultural crops was defined to be the change in net returns in going from CIC to each respective management program. For this study, net returns were defined to be the difference between gross returns and variable production costs, a definition which is consistent with net return variables in the econometric model. For producers' net returns to be a valid measure of producer benefits (or costs), it is necessary that real prices of production inputs are constant over the relevant range of changes in input use that could be attributed to implementation of any of the management programs. Constant input prices appears to be a realistic assumption. 4/

In this report, the term "consumers" has a broad meaning and includes all market participants beyond the farm gate. Thus, in addition to including final consumers of processed agricultural crops, this definition includes processors of crops such as gin owners and textile mills. Market participants between the farm gate and final consumers can also be viewed as consumers in the sense that they purchase goods for processing. Final consumer benefits are defined as the difference between what consumers are willing to pay for a commodity and what they actually pay. In markets without price discrimination, (most agricultural markets), consumers pay the same price for all units of a good purchased at a particular point in time. Since consumers are willing to pay more for the first units of a good purchased than they actually pay, they are said to enjoy a benefit on these units. A decrease in market price with no change in consumer willingness to pay can be seen to increase this benefit. The area under a (income) compensated demand curve and above price is the compensating variation measure of this benefit. But since compensated demand curves are not empirically observable, we must approximate this benefit with ordinary demand functions. The amount of bias depends on the effect on real

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3/ Although the distribution of income and wealth may not be socially optimal, there are public policy instruments for redistributing income and wealth that are better than boll weevil management programs.

4/ There was explicit consideration of exceptions to this assumption in the estimation of specialized monitoring and manpower resource requirements for eradication and pest management programs.

incomes of a price change. Since price changes resulting from alternative boll weevil management programs are rather small, the bias attributed to use of ordinary demand functions rather than compensated demand functions appears to be insignificant.

In calculating the present value of all benefit and cost items, future benefits and costs were discounted with an annual interest rate of 7.125 percent. Annual benefits and costs were all estimated in constant 1979 dollars. Thus, it should be noted that the 7.125 percent interest rate is a real rate (i.e., net of inflation) and not a nominal rate. The discount rate chosen for this study is the FY-80 rate recommended by the Water Resources Council for land and water resource planning (10). The literature abounds with references to problems in selecting the correct discount rate (11). Sensitivity analyses were conducted on the discount rate and results are reported in another section of this report.

Biological Estimates

The economic evaluation of alternative insect management programs was highly dependent on valid estimates of lint yields (value of production) and insecticide use (cost of production), as well as public expenditures for each program to be compared. Beltwide yields were especially difficult to estimate as there was little empirical evidence available on a regional or beltwide basis.

Thus, the Economic Evaluation Team and the Biological Evaluation Team jointly investigated the possible contributions of three approaches to obtain yield and cost impacts. These approaches were: (1) multiple regression, (2) simulation, and (3) Delphi.

From the outset, the evaluation teams realized that the experimental method would be too costly and time consuming to provide the yield and cost data needed for each alternative insect management program. This approach would involve replicated experiments for measurement of yields and input requirements for a range of soils, weather, insect infestations and management practices. Two other estimating procedures--multiple regression and plant growth simulation models--are potentially accurate, scientific procedures that describe and quantify causative relationships (12). The regression and simulation approaches were researched at North Carolina State Univesity and Mississippi State University, respectively. The objective of both procedures was to partition the effects on yield of the major variables, including insect infestations and other damage variables.

Both multiple regression and plant simulation models were developed and were feasible for limited areas but not for developing beltwide estimates. Therefore, a modified Delphi process provided data used to estimate average lint yields, insecticide use and costs for the six alternative programs (13). These data were obtained for the 32 weevil-infested regions shown in figure 1. Aggregation of these data by AGSIM regions (figure 2) provided input to the national model. The Delphi approach was augmented by trial area results, basic research results, and other resource materials that provided guidance on technical issues. Simulation model results for selected areas were presented to panel members.

Public Cost Estimates

Public cost also is an important element in an economic evaluation of beltwide cotton insect management programs. A Program Definition and Cost Facilitator Group specified guidelines and coordinated the review of public costs of the six programs (7). Public costs of implementing beltwide programs were estimated for each of 32 cotton production regions in boll weevil-infested areas (figure 1). OPMREEAC members estimated costs of beltwide CIC and OPM programs, while APHIS developed the beltwide BWE costs.

Public costs include all Federal and State costs associated with each of the boll weevil/cotton insect management programs, including incentive payments under the OPM-I program. Incentive payments for diapause and pin-head square treatments under the OPM-I program were based on Delphi estimates of farmers needs for such treatments (13). In this analysis, producers were assumed to pay 50 percent of eradication operational costs. All research and development costs were excluded because past investments were not considered relevant to the choice among current alternatives. Regular county Extension personnel were not included in these computations because their number is not likely to vary by the choice of insect management program. However, county Extension entomologists assigned specifically to cotton were included.

All cost estimates are in constant 1979 dollars. No forecasts were made for changes in price levels during the implementation period, nor for changes in relative price levels of different inputs. Technology was assumed to be unchanged from existing on-the-shelf procedures for the evaluation period. It was felt that analysis of changes in relative prices and potential advances in technology, limitations on use, or other loss of effective technology would have been too difficult to estimate with an acceptable accuracy.

Implementation of Programs

In recognition of the likelihood that programs would not be fully implemented in the first year and that producer impacts and adjustments would not take place immediately, simplifying assumptions were made to reflect the dynamics of implementation.

Initiation of Programs

All programs are initiated in the same year. For the OPM programs (OPM-NI, OPM-PI, and OPM-I) it is assumed that 50 percent of program personnel and related resources are in place in year-1 and 100 percent in year-2. Incentive payments to producers for diapause/pinhead square treatments, if any, 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. It is assumed that in both North Carolina and in South Carolina, the OPM-NI option would be fully staffed in year 1, whereas staffing in the other States would take place over a 2 year period. Eradication would be phased across the cotton belt in eight zones, starting in year 2 in North Carolina (region 3) and ending in year 10 in the Lower Rio Grande Valley (region 23) of Texas. Eradication activities are completed in two 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 that for OPM-NI-BWE,with the exception that no additional CES personnel are funded.

Phasing of Program Impacts

Estimates of changes in cost and yield obtained from the Delphi panels provided the primary basis for evaluation of aggregate economic impacts of alternative management programs. Delphi estimates, however, reflect the impacts of full implementation of the programs. Inasmuch as it is unrealistic to assume full implementation of a program in the first year, estimates were made of the annual responses of producers' costs and yields to the adoption of given programs (table 1). These estimates were made by the respective trial program operations personnel in APHIS and CES. All changes were measured from the CIC base with the exception of OPM-NI-BWE, which relates to the change from OPM-NI to a fully implemented OPM-NI-BWE program. The sensitivity of other selected assumptions relating to implementation schedule is reported in a later section.

Program Effectiveness and Producer Participation

Additional critical assumptions relate to the effectiveness of programs and the rates of producer participation. The Biological Evaluation Team (BET) and the respective trial operations personnel concluded that the OPM and BWE trials were successful in meeting their respective performance criteria and that the technology is available for similar beltwide programs (14). The EET has assumed that the technologies and practices specified for beltwide use would be effective in terms of eradicating or suppressing the boll weevil as indicated in the respective beltwide program plans. Furthermore, we have assumed that producers would participate in the respective programs as estimated by the Delphi panels (13). Mandatory participation is specified for eradication. For OPM programs, the BET estimated the extent of farmer participation needed, by regions or areas within regions, to result in an effective program. In heavily infested areas, the percentage of acreage required to participate exceeded 90 percent. In some areas, much less acreage was required because of

Table 1 -- Time-phasing of Changes in Lint Yields and Costs During Implementation of Alternative Programs

Program	Percentage of difference from CIC by years		
	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.

historically low weevil infestation. The Delphi estimates of participation were matched against the BET estimates of required acreage (13, pp. 127-9). 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 diapause/pin-head square treatments or incentive payments. In most regions, the OPM-NI and OPM-PI programs were judged not to be effective in terms of eliminating the need for mid-season treatments for the boll weevil on at least 90 percent of the cotton acreage prior to *Heliothis* treatments. On the other hand, 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 it was also assumed that the follow-up monitoring program would detect and control incipient populations or reinfestations.

EVALUATION OF BELTWIDE PROGRAMS

Public Costs

The pattern of public costs for each of the beltwide programs varies considerably from initiation through full implementation, (Table 2 and Figure 3). CIC, the baseline program, is currently costing about $2.5 million annually and it would continue at that rate.

The funding for the OPM-I program with continuing incentive payments would increase from about $6 million the first year to $36 million by the second year and remain at that level. The cost for OPM-PI would be similar to OPM-I during the first two years but would decline to $7 million by the fifth year. The OPM-NI program costs would increase to $7 million by the second year and continue at that rate. Compared with OPM-NI, about $1 million more would be needed under the OPM phased and full incentives programs during the first year to prepare producers for the areawide diapause strategy.

With the eradication programs, OPM-NI-BWE and CIC-BWE, the costs rise to $94 and $87 million, respectively, in the fifth year and decline to $8 million and $3 million by the twelfth and subsequent years depending on whether the OPM or CIC Extension support is provided. It would cost an estimated $460 million, including capital investments, during the 9 years to eradicate the boll weevil. If farmers share part of the eradication costs, public expenditures under the latter two programs would be reduced. The analysis reported in subsequent tables assumes that producers pay 50 percent of eradication costs.

The CIC and three incentive-related OPM programs would be funded through CES while the eradication programs, CIC-BWE and OPM-NI-BWE, would be jointly funded by CES and APHIS.

Table 2--Annual public costs for beltwide boll weevil/cotton insect management programs 1/

Year	CIC	OPM-I	OPM-PI	OPM-NI	OPM-NI-BWE 2/	CIC-BWE 2/
	Million dollars 3/					
1	2.5	5.6	5.5	4.7	6.2	2.5
2	"	35.8	35.6	6.9	19.1	12.1
3	"	"	28.9	"	46.2	39.2
4	"	"	22.1	"	79.5	72.5
5	"	"	6.9	"	94.3	87.3
6	"	"	"	"	74.0	67.1
7	"	"	"	"	51.0	44.1
8	"	"	"	"	74.1	67.2
9	"	"	"	"	65.4	59.3
10	"	"	"	"	21.1	16.0
11	"	"	"	"	7.7	3.3
12	"	"	"	"	7.5	3.1
13	"	"	"	"	"	"
14	"	"	"	"	"	"
15	2.5	35.8	6.9	6.9	7.5	3.1

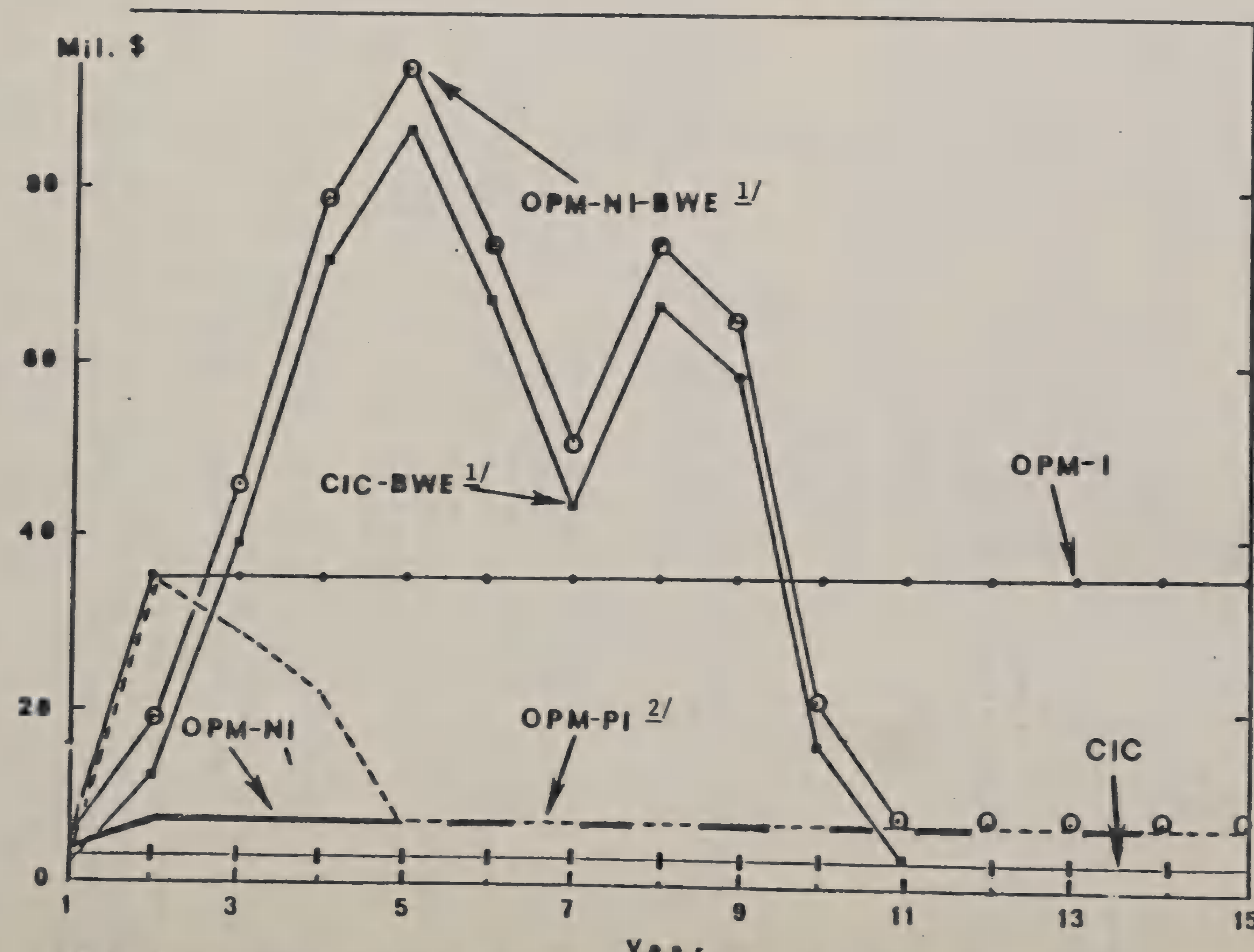
1/ The six programs are: CIC (Current Insect Control); OPM-I (Optimum Pest Management with Incentives); OPM-PI (Optimum Pest Management with Phased Incentives) OPM-NI (Optimum Pest Management with No Incentives); OPM-NI-BWE (Optimum Pest Management with No Incentives and with Boll Weevil Eradication); and CIC-BWE (Current Insect Control with Boll Weevil Eradication).

2/ 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.

3/ Assumes constant 1979 dollars and constant 1974-1978 average acreage.

Figure 3.

PUBLIC COSTS FOR BELTWIDE PROGRAMS



1/ Eradication programs would be reduced by the farmers' share of cost.

2/ OPM-PI identical to OPM-I in years 1 and 2, and identical to OPM-NI in year 5 and thereafter.

Insect Control Costs

Estimates of producer costs of insect control for alternative management programs are shown in table 3. Included are costs of insecticide materials and their application costs. These estimates are based on Delphi results (13).

Cost estimates in 1979 dollars were made for each region in weevil-infested areas, as outlined in figure 1. These costs were based on proven insect management technologies that are recommended for use in 1980. All cost estimates were based on normalized infestations, or perceived long-run average levels of infestation.

Cost levels associated with OPM and BWE programs represent those levels anticipated after full implementation of the respective programs and after full adjustment of producers to those programs.

Insecticide use and costs varied widely across production regions (Table 3). Although CIC costs were generally highest in the Southeast, high costs are also experienced in some areas of Texas, notably the Central River Bottoms (region 27) and Winter Garden (region 26), and in Louisiana. Areas that experience little insect pressure, on the average, include Missouri, Northeast Arkansas, and the Rolling Plains and Upper Concho regions of Texas.

Cost estimates in Table 3 represent the cost of controlling all cotton insects, not weevils alone. The insecticide use and costs of controlling weevils only were not isolated in this analysis. Some chemicals and some treatments are used to control more than one insect. Primary treatments often result in secondary effects. Also, the linkages and interactions between boll weevil and Heliothis management practices makes it especially difficult to isolate costs of controlling specific insects.

Almost without exception, insecticide applications and producer costs per acre following implementation were lowest for the two eradication programs. Costs for OPM-NI-BWE were higher than CIC in Missouri and Northeast Arkansas, where Delphi panelists indicated that current control practices of insects other than boll weevils were inadequate and would likely be corrected with added Extension funding.

Average impacts of alternative programs on producer insect control costs and lint yields are shown for the boll weevil-infested portion of the United States in Figure 4. These averages are based on average 1974-78 acreages and do not reflect potential acreage adjustments to the alternative programs. Acreage adjustments are covered in a later section of this report.

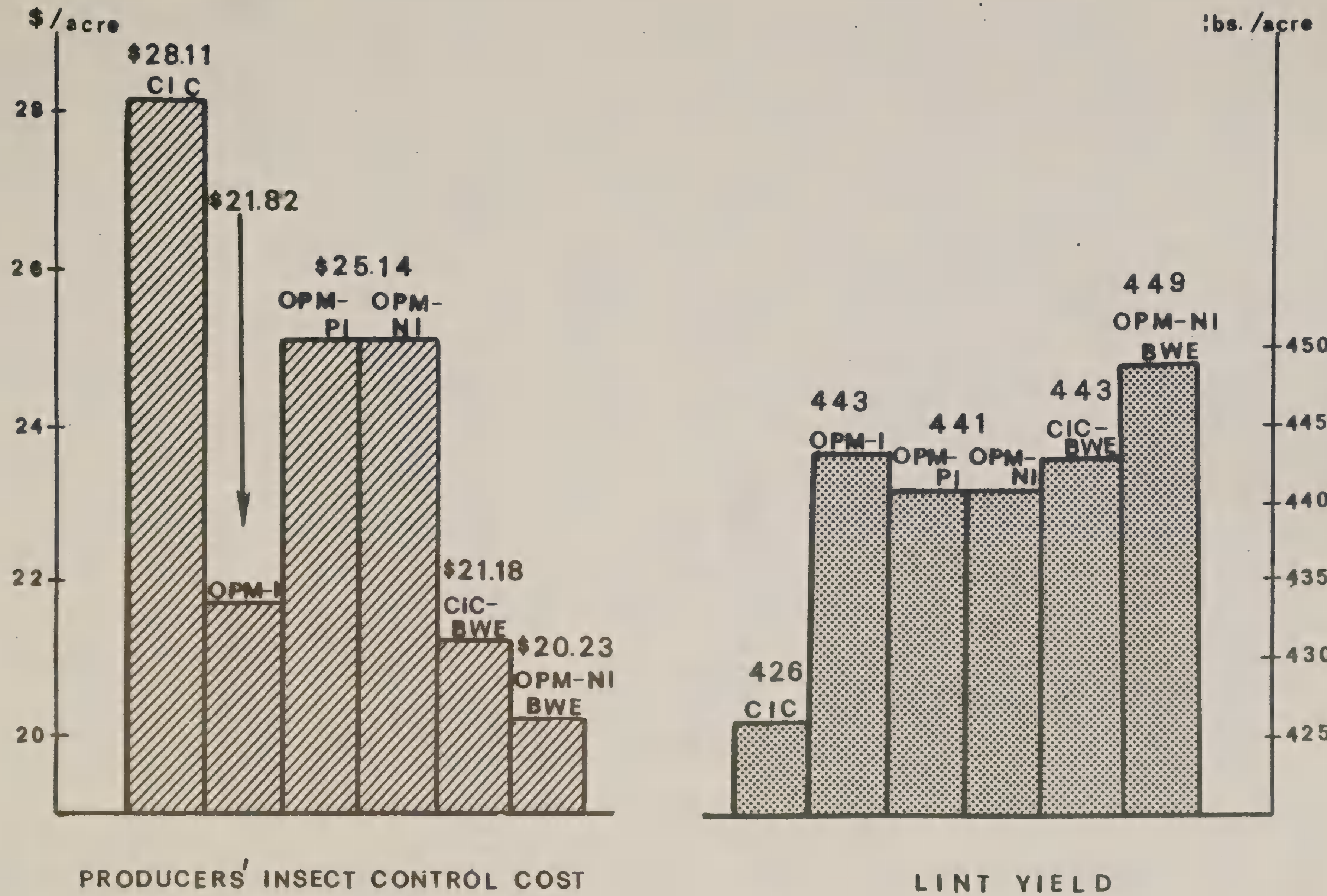
Table 3--Insect Control Costs Per Acre of Cotton by Management Program, Boll Weevil Infested Regions 1/

State and Region	CIC	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	dollars					
North Carolina						
North (2)	44.95	43.46	44.76	37.54	35.68	33.77
South (3)	52.81	49.49	49.49	49.86	46.37	49.31
Piedmont (4)	40.18	45.30	45.30	42.22	29.45	32.78
South Carolina						
Coastal Plains (5)	68.27	73.92	73.92	60.40	62.82	60.51
Piedmont (6)	40.18	45.30	45.30	42.22	29.45	32.78
Georgia						
Piedmont (7)	40.18	45.30	45.30	42.22	29.45	32.78
East 8)	86.28	79.20	79.20	78.25	64.47	66.38
Southwest (9)	92.36	88.95	88.95	77.13	79.50	74.61
Alabama						
Limestone Valley (10)	43.97	43.94	43.94	43.94	43.72	38.92
South (11)	81.18	76.25	76.25	74.68	64.83	50.27
Tennessee						
North Br. Loam (12) and South Br. Loam (13)	12.64	11.86	11.97	7.70	3.16	4.50
Missouri (14)	3.11	6.26	6.28	4.29	1.35	4.22
Mississippi						
Northeast (15)	35.97	32.58	32.58	27.44	28.56	25.05
North Central (16)	40.42	37.36	37.36	27.39	30.80	28.89
Delta (17)	44.83	42.00	42.00	38.61	42.47	42.00
South (18)	42.91	35.99	35.99	29.13	35.41	32.59
Arkansas						
Northeast (19)	3.21	5.65	5.66	4.64	2.07	3.86
Southeast (20)	24.72	21.61	21.61	19.12	15.99	18.45
Louisiana						
Northeast (21)	52.00	45.98	45.98	36.69	42.03	38.79
Red River Valley (22)	55.82	50.74	50.74	45.63	43.87	43.11
Texas						
Lower Rio Grande (23)	37.28	20.35	20.35	15.43	11.31	9.81
Lower Bend (24)	16.66	13.39	13.39	8.48	3.40	3.20
Upper Bend (25)	25.95	22.71	22.71	12.04	10.10	9.16
Winter Garden (26)	45.82	21.52	21.52	12.84	13.92	11.43
Central River Bottom (27)	61.55	40.69	40.69	29.86	16.91	14.79
Blacklands (28)	8.18	7.88	7.88	6.01	4.09	3.15
Rolling Plains (29)	3.40	0.88	0.88	0.37	0.31	0.21
Upper Concho (31)	2.93	2.40	2.40	2.40	0.99	0.97
Oklahoma						
North (34) and South (35)	22.23	20.61	20.61	20.61	16.81	14.15

1/ Producer costs of insecticide materials and application. OPM costs to producers do not include the costs of diapause and/or pin-head square treatments that are publicly funded.

SOURCE: The Delphi: Insecticide Use and Lint Yields, ESS Staff Report No. AGESS810507, 1981.

Figure 4. 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).



Lint Yields Per Acre

Delphi estimates of lint yields for the six management programs are shown in Table 4. CIC yields correspond closely with historic average 1969-78 yields provided panelists, with some modifications as estimated by panelists. Yields for other programs were estimated as changes from the CIC base.

Yield impacts of all programs are positive. In most cases, incremental yield increases are greater from CIC to OPM-NI than from OPM-NI to any other program. This reflects the panelists' belief that additional Extension education and technical assistance would result in improved cotton insect mangement and higher yields. Yields for OPM-I are either equal to or slightly greater than for OPM-NI. Panelists believed that the addition of an area-wide diapause program with incentives would not greatly increase yields over those associated with an increased Extension education and information program. Yield increases for CIC-BWE are less than those associated with the OPM programs in most Southeast and Mid-South regions. The implication is that OPM programs would result in better management of all cotton insects whereas CIC-BWE impacts are related to eradication of the boll weevil only. However, in most East Texas regions, yields are higher for CIC-BWE than for the OPM programs. This may indicate that the boll weevil is more often the key pest in the East Texas regions, whereas other key pests may predominate in Mid-South and Southeast regions.

In most regions, OPM-NI-BWE average yields are higher than other programs, with the exception of a few regions where yields equal OPM-I. The chief rationale for higher yields, as well as lower producer costs, for the OPM-NI-BWE program is that it combined the advantageous effects of increased Extension input and boll weevil eradication.

National Model Results

Net Market Benefits

Net market benefits--a major criterion for ranking programs--were positive for all programs (Table 5). The program with the highest net benefit was OPM-NI-BWE, followed, by OPM-I, CIC-BWE, OPM-NI, and OPM-PI. Net benefits equal the sum of consumer and producer benefits less public costs. All estimates represent changes from CIC and are based on future streams of benefits and costs discounted at a 7 1/8 percent rate. Discounting permits a comparison of program impacts that occur in the future and that occur at differing rates of change over the years.

A secondary measurement for ranking programs is a benefit-cost (B/C) ratio of public investment. The B/C ratio is calculated as the sum of consumer and producer benefits divided by public costs. The B/C ratio is highest for OPM-NI,

Table 4 -- Lint Yields Per Acre by Management Program, Boll Weevil Infested Regions 1/

State and Region	CIC	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
North Carolina						
North (2)	409	429	429	429	423	433
South (3)	422	438	438	438	431	443
Piedmont (4)	340	367	367	367	358	375
South Carolina						
Coastal Plains (5)	424	449	449	449	433	454
Piedmont (6)	340	367	367	367	358	375
Georgia						
Piedmont (7)	340	367	367	367	358	375
East (8)	386	413	413	413	402	420
Southwest (9)	471	506	506	506	493	515
Alabama						
Limestone Valley (10)	436	446	446	446	440	449
South (11)	432	443	443	443	442	450
Tennessee						
North Br. Loam (12) and South Br. Loam (13)	453	456	456	456	456	459
Missouri (14)	459	464	464	464	464	467
Mississippi						
Northeast (15)	433	437	437	437	435	437
North Central (16)	526	531	531	531	532	534
Delta (17)	567	569	569	569	569	569
South (18)	524	530	530	530	528	530
Arkansas						
Northeast (19)	433	438	438	438	436	439
Southeast (20)	512	519	519	519	517	521
Louisiana						
Northeast (21)	516	525	525	525	525	527
Red River Valley (22)	534	540	540	540	540	542
Texas						
Lower Rio Grande (23)	463	488	488	494	512	519
Lower Bend (24)	434	456	456	461	465	472
Upper Bend (25)	386	403	403	407	414	420
Winter Garden (26)	526	560	560	566	577	584
Central River Bottom (27)	474	506	506	512	521	537
Blacklands (28)	239	273	273	281	289	294
Rolling Plains (29)	295	324	324	329	329	339
Upper Concho (31)	343	378	378	378	373	383
Oklahoma						
North (34) and South (35)	301	315	315	316	322	326

SOURCE: The Delphi: Insecticide Use and Lint Yields, Beltwide Boll Weevil/Cotton Insect Management Programs. ESS Staff Report No. AGESS810507, 1981.

Table 5 -- 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. Represents changes in present values of benefits and costs as compared with a baseline representing current insect control.

2/ Future benefits and costs in 1979 dollars, discounted at a 7 1/8 percent rate in perpetuity.

3/ Consumers include all market participants beyond the farm gate, including processors, mills 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 follow-up 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 less program costs paid by the government. Generally considered best criterion if there are no budget constraints.

7/ B/C ratios are calculated as the sum of consumer and producer benefits divided by public program costs. Generally considered best criterion if there are budget constraints.

followed, in order, by OPM-PI, CIC-BWE, OPM-NI-BWE and OPM-I (Table 5). The difference in B/C ratios for OPM-PI, CIC-BWE, and OPM-NI-BWE are probably insignificant.

Annual undiscounted changes in net benefits during the program implementation years are shown in Figure 5. Net benefits are low (negative for CIC-BWE) in early years because of high program costs and low but increasing program impacts. Net benefits level off by the 12th year (in this case 1993, assuming each program was initiated in 1982).

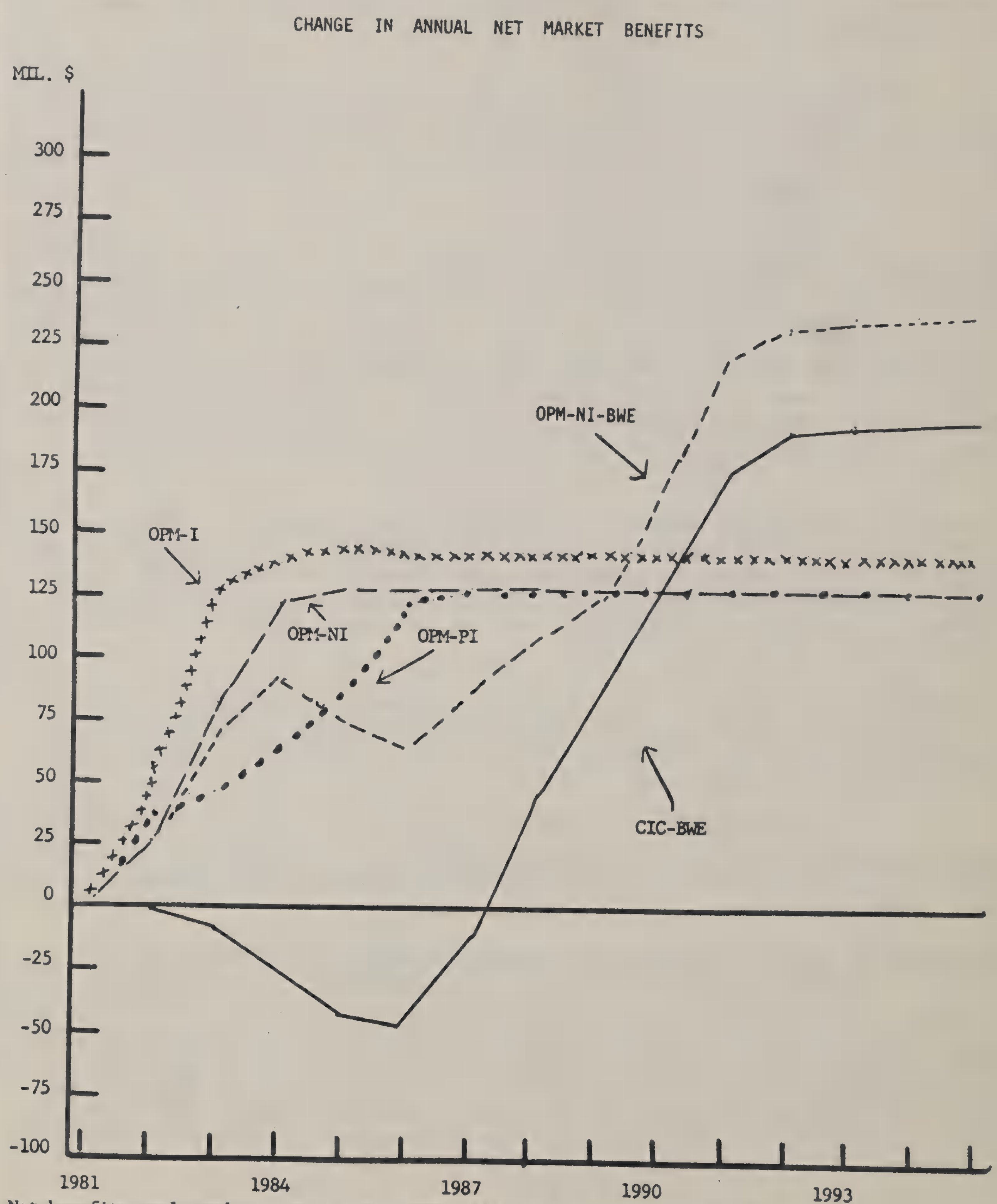
The net market benefit (proxy for net social benefit) criterion is generally accepted as the appropriate criterion to be used in cost-benefit analysis. In this evaluation, it accounts for market costs and benefits from a public point of view. Without regard to distributive impacts, the higher the net benefit the more desirable the program. The B/C ratio, however, is more appropriate for ranking programs subject to a severe capital constraint. For example, if only $7 million annually (from Table 2) were available for a pest management program, clearly the OPM-NI program would be the only specified program for selection. If adequate funding were available, the OPM-NI-BWE program would be selected under a net benefit criterion.

In interpreting the net benefits calculations, only economic or market factors are accounted for. The positive or negative impacts of alternative programs on the environment were not quantified. Further, costs of potential pesticide resistance and possible impacts of pesticide regulations were not quantified. Although all of these considerations may be important, their impacts are best considered in a qualitative manner.

The distributional impacts of alternative programs on consumers, taxpayers and producers are generally not considered, from an economic viewpoint, in the selection of a program. However, distributional impacts are shown in this report to present a more complete picture of the total impacts.

The present values of future consumer benefits are positive for all programs, ranging from a gain of $4.2 billion for CIC-BWE to $5.6 billion for OPM-NI-BWE (Table 5). Consumer benefits are derived mainly from expanded production and lower commodity prices.

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 yield and lower production costs. Many producers in the major production areas such as the Mississippi Delta, High Plains of Texas and the non-weevil infested areas of the Far West do not benefit from the proposed programs but would experience the resulting lower prices. On the other hand, producers in heavily-infested areas would benefit from these programs. Net income for soybeans, corn and small grains decreased because of



Net benefits evaluated as a change from CIC. All programs are initiated in 1982

FIGURE 5

small price decreases and small changes in the location of production. Grain sorghum returns increased slightly in response to higher prices brought about by a shift to cotton in most areas of Texas.

Crop Prices

Compared with CIC, prices received by farmers for crops other than grain sorghum declined for all alternative programs (Table 6). All prices reflect long-run equilibrium levels after full adjustment to the respective programs. Price decreases resulted chiefly from an increase in production and/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 (Figure 6). Grain sorghum prices increased slightly in response to lower sorghum production in Texas.

Unlike individual farmer adjustments or small-scale programs, the insect management programs evaluated would affect commodity prices. Since consumption of many agricultural commodities, including cotton, is not very price sensitive (in other words, the demand for these commodities is price inelastic), relatively large price changes are required to bring about small changes in consumption. A small decrease in crop losses (increase in yields) due to insects can result in measurable decreases in prices received by farmers. For example, the overall price elasticity of demand implied in this study is -.8, which means that an 8 percent increase in production would be associated with a 10 percent drop in prices received. This simply means that for products having an inelastic demand, total farm receipts are smaller with larger marketings. This is the underlying justification for farm programs that restrict total production and/or transfer some of the agricultural adjustment burden to taxpayers who ultimately benefit from progress in the farm sector. Consumers, including all market participants beyond the farm gate, are often the chief beneficiaries of major adjustments in agriculture.

Some independent estimates of cotton demand range from -.11 to -.80 for domestic mill demand, with numerous estimates near -.20 (15). More recently, Evans concluded that a 10 percent change in cotton price could change per capita mill use by 2.5 to 3.5 percent in the opposite direction (16). Recent estimates of the export demand elasticity range from -.01 to -2.0. Bredahl, Meyers, and Collins have recently estimated that, given restricted trade assumptions which may approximate the real world, a price elasticity of export demand of about -.65 might result (17). A free-trade assumption for all importing markets might result in a much more elastic export demand of about -1.9.

The demand relationships used in this evaluation are in line with recent empirical studies. These relationships are extremely complicated and depend on many factors affecting the market for cotton. However, the important point is that the price relationships indicated by historical data do not discriminate in favor of one or more of the alternative programs included in this study.

Table 6 -- 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	$/bu.	2.56	- .005	- .005	- .005	- .006	- .008
Small Grains	$/bu.	2.71	- .002	- .002	- .002	- .002	- .003
Grain Sorghum	$/bu.	2.66	.008	.008	.010	.013	.014
Cotton Lint	cts/lb	76.25	- 1.67	- 1.67	- 1.95	- 2.08	- 2.73
Cottonseed	$/T	122.46	-11.65	-11.65	-13.56	-14.40	-19.00
Soybeans	$/bu.	6.46	- .016	- .016	- .013	- .015	- .020
Cottonseed Meal	$/T	168.20	- 5.10	- 5.10	- 5.90	- 6.60	- 8.30
Cottonseed Oil	cts/lb	36.51	- 0.99	- 0.99	- 1.15	- 1.23	- 1.62
Soybean Meal	$/T	185.40	- 2.30	- 2.30	- 2.70	- 3.00	- 3.80
Soybean Oil	cts/lb	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 long-run equilibrium, after full adjustment to the particular boll weevil management program.

2/ Small grain prices are in terms of wheat equivalents.

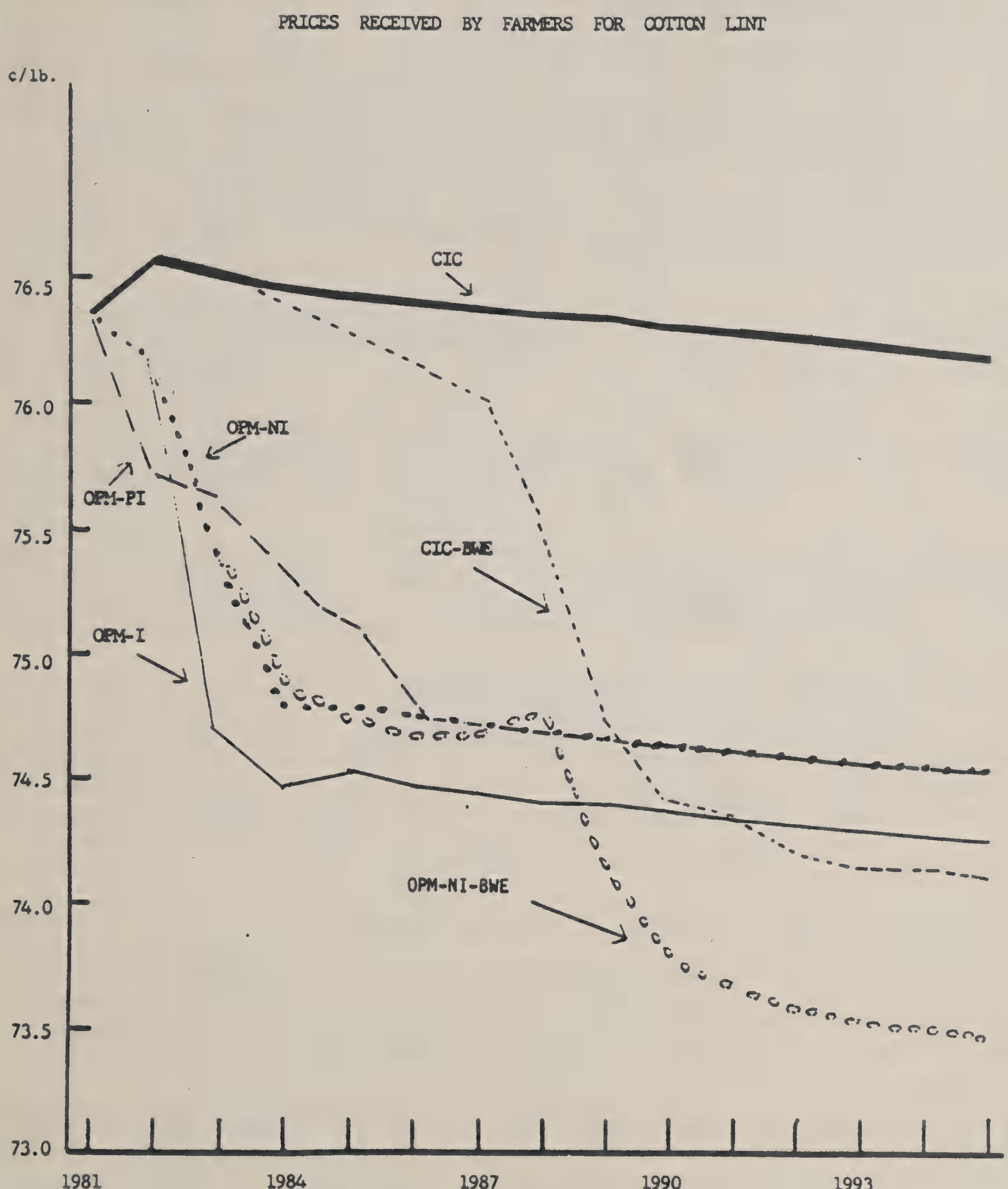


FIGURE 6

All programs are initiated in 1982.

Net Returns to Major Field Crops

Net returns to all major field crops combined were estimated by AGSIM regions for each cotton insect management program, assuming full adjustment to the programs (Table 7). These estimates reflect the interrelationships among competing crops and their products. Crops included are cotton, soybeans, grain sorghum, corn for grain, and small grains. Changes in annual net returns to crop producers in two AGSIM subregions--Region 7 (Texas, Oklahoma) and Region 11 (Alabama, Georgia, and South Carolina)--were positive while other cotton regions showed negative changes in net returns. All other regions showed slight decreases in net returns to these crops.

Among programs at the U.S. level, net returns to producers dropped the most for OPM-NI-BWE and the least for CIC-BWE, but the differentials among programs are relatively small.

The impacts of alternative programs on producer net returns depends on the cotton yield changes experienced, changes in cotton insect control costs, shifts in acreage and total production among crops, product price changes for the respective crops and utilization of substitute commodities.

This analysis shows a small drop in producer net returns in some regions where direct benefits (change in cotton yield and costs of production) are either small or nonexistent, and small increases in net returns in regions where program benefits (changes in yields and costs of production) are the greatest.

Aggregate Impacts on Cotton Acreage, Production, and Use

U.S. planted acreage for alternative programs differed only slightly from the CIC base of 12.7 million acres (Table 8). Production, however, differed importantly from the base, chiefly because of yield increases. Production increases ranged from 198 thousand bales, or about 2 percent, for OPM-NI to 323 thousand bales, or 3 percent for OPM-NI-BWE. Domestic fiber use and exports increased for all programs in response to lower prices.

Cotton Acreage, Production, and Net Returns by AGSIM Region

Cotton acreage in two major regions would increase after full implementation of each alternative program (Table 9). All acreage changes, however, are small in absolute and relative terms. Cotton production would increase in all regions except for California, Arizona, and New Mexico (Table 10).

Again, production would increase the most in Texas-Oklahoma (Region 7) and in the Southeast (Region 11). The resulting changes in annual net returns to cotton production are positive for regions 7 and 11 (Table 11).

Table 7 -- Long-run Change in Annual Net Returns to Major Field Crop Production by AGSIM Region 1/

AGSIM Region 2/	Change in net returns due to:				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	million dollars				
Cotton Production Regions:					
2--California	-34	-34	-39	-41	-54
4--Arizona, New Mexico	-17	-17	-20	-21	-28
7--Texas, Oklahoma	28	28	37	54	51
10--Mississippi, Arkansas, Louisiana, Boot-heel of Missouri	-25	-25	-17	-21	-34
11--Alabama, Georgia, South Carolina, Florida	2	2	5	3	13
12--North Carolina, Virginia, Tennessee	-6	-6	-5	-3	-6
Other Regions:					
1--Washington, Oregon	3/	3/	-1	-1	-1
3--Montana, Idaho, Utah, Wyoming, Nevada, Colorado	-1	-1	-1	-1	-2
5--Nebraska, Kansas	-4	-4	-3	-2	-4
6--North and South Dakota	-2	-2	-2	-2	-3
8--Minnesota, Wisconsin, Michigan	-9	-9	-8	-9	-12
9--Iowa, Illinois, Indiana, Ohio, and all crops except cotton in Missouri	-32	-32	-29	-31	-43
13--All other States in the Northeast	-2	-2	-2	-2	-3
U.S. Total	-102	-102	-84	-78	-125

1/ Crops include cotton, soybeans, grain sorghum, corn, and small grains.
2/ Location of regions is shown in Figure 2.
3/ Less than $1 million reduction.

Table 8 -- Changes in Cotton Acreage, Production, and Use for Alternative Boll Weevil Management Programs 1/

Item	CIC Base	Changes resulting from program:				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	1,000 acres					
Planted acreage	12,690	-10	-10	3	13	8
	1,000 bales					
Production	11,657	198	198	231	246	323
Domestic Fiber Use	6,667	94	94	110	117	154
Lint Exports	4,990	104	104	121	129	170

1/ All values reflect full adjustment to each program.

Table 9 -- Long-run Changes in Cotton Acreage by AGSIM Region

AGSIM Region 1/	CIC Base Acreage 2/	Change in cotton acreage by program:				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	1,000 acres					
2--California	1,179	-13	-13	-15	-16	-21
4--Arizona, New Mexico	537	-16	-16	-19	-20	-27
7--Texas, Oklahoma	6,088	27	27	34	49	46
10--Mississippi, Arkansas, Louisiana, Boot-heel of Missouri	3,434	-12	-12	-7	-10	-16
11--Alabama, Georgia, South Carolina, Florida	933	8	8	13	9	27
12--North Carolina, Virginia, Tennessee	520	-4	-4	-3	1	-2

1/ Location of AGSIM regions is shown in Figure 2.

2/ Long-run CIC base acreage estimated by AGSIM model.

Table 10 -- Long-run Changes in Cotton Production by AGSIM Region

AGSIM Region 1/	CIC base production 2/	Change in cotton production, by program:				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	1,000 bales					
2--California	2,271	-25	-25	-29	-30	-40
4--Arizona, New Mexico	1,016	-31	-31	-36	-38	-50
7--Texas, Oklahoma	4,000	189	189	223	260	305
10--Mississippi, Arkansas, Louisiana, Boot-heel of Missouri	3,276	23	23	26	26	38
11--Alabama, Georgia, South Carolina, Florida	719	39	39	43	24	64
12--North Carolina, Virginia, Tennessee	372	2	2	3	4	6

1/ Location of regions is shown in Figure 2.

2/ Long-run CIC base production estimated by AGSIM model.

Acreage drops in those regions where net returns diminish. However, the change in net returns was not large enough to impact importantly on acreage. Production, however, increased in all regions except the Far West, chiefly in response to the yield increases obtained from alternative programs. At the U.S. level, annual net return to cotton production dropped for alternatives to CIC, but the differences in net returns among programs at the national level were small.

Cotton Acreage and Net Returns by Cotton Production Region

Estimates of cotton acreage and net returns following full implementation of each program were developed for 42 cotton production regions (Tables 12 and 13) (see Figure 1 for location of regions). Changes in costs and yields for cotton production regions, in combination with price levels estimated for each alternative, were used in computing the estimates of acreage and net returns. Acreage changes in Table 12 were derived under the assumption that the acreage response elasticity for each cotton production region is equal to that of the respective AGSIM region in which it is located. Although this assumption may not be strictly valid, estimates based on AGSIM elasticities should give a fairly good indication of impacts in the cotton production regions. 5/

Among those cotton production regions having the greatest percentage increase in acreage for all alternatives are the two regions in Georgia, South Alabama, the Central River Bottoms in Texas, and the Texas Blacklands. The greatest absolute acreage increases were projected for the Texas Blacklands and the Texas Rolling Plains.

Changes in net returns per acre due to all alternatives to CIC are positive in North Carolina and Virginia, but when combined with Tennessee (AGSIM region 12, Table 11) net returns are about the same as those of CIC. Some of the highest increases in net returns from cotton production were experienced in the Southeast and East Texas regions. An increase of about $80 per acre was estimated in the Texas Central River Bottoms for the OPM-NI-BWE program, and more than $50 per acre in the Lower Rio Grande Valley and Winter Garden areas. Areas having a negative impact were chiefly those where the boll weevil is either non-existent or where infestations and damage are historically low.

5/ The results of applying the estimated percentage acreage change shown in Table 12 to the 1974-78 acreage and then summing the absolute changes may not equal the U.S. cotton acreage shown in other tables. Differences can arise because of rounding, aggregation bias, and differences between the AGSIM estimated acreage for CIC and the 1974-78 average acreage.

Table 11 -- Long-run Change in Annual Net Returns to Cotton Production by AGSIM Region

AGSIM Region 1/	Change in net returns due to:				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	million dollars				
2--California	-33	-33	-39	-41	-54
4--Arizona, New Mexico	-19	-19	-22	-23	-31
7--Texas, Oklahoma	31	31	40	57	54
10--Mississippi, Arkansas, Louisiana, Boot-heel of Missouri	-24	-24	-15	-20	-32
11--Alabama, Georgia, South Carolina, Florida	5	5	8	5	17
12--North Carolina, Virginia, Tennessee	-3	-3	-2	1	-2
U.S. Total	-43	-43	-30	-21	-48

1/ Location of regions is shown in Figure 2.

Table 12. Long-run Changes in Cotton Acreage by Production Subregion 1/

Cotton Production Subregion 2/	Cotton acreage 3/	Percentage change in cotton acreage for:				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	acres	percent				
Heavy infestation potential:						
1--Virginia-Southeast	854	1.36	1.17	2.02	1.77	2.53
2--N. Carolina-North	28,195	1.36	1.17	2.02	1.77	2.53
3--N. Carolina-South	37,600	1.08	1.08	0.83	0.66	0.96
4--N. Carolina-Piedmont	10,299	1.37	1.37	1.68	2.84	3.66
5--S. Carolina-Coastal Plains	156,474	0.78	0.78	2.97	0.48	2.99
6--S. Carolina-Piedmont	19,303	1.59	1.59	1.99	3.65	4.54
7--Georgia-Piedmont	25,286	1.93	1.93	2.33	3.65	4.88
8--Georgia-East	92,612	3.97	3.97	3.91	4.89	6.54
9--Georgia-Southwest	111,104	3.68	3.68	5.42	3.29	6.31
11--Alabama-South	183,398	0.88	0.88	0.92	2.65	5.58
15--Mississippi-Northeast	94,705	-0.05	-0.05	0.28	0.00	0.16
16--Mississippi-North Central	201,460	-0.14	-0.14	0.32	0.18	0.14
18--Mississippi-South	208,592	0.15	0.15	0.44	-0.01	0.07
20--Arkansas-Southeast	472,220	0.02	0.02	0.03	0.11	-0.08
21--Louisiana-Northeast	434,690	0.15	0.15	0.57	0.34	0.32
22--Louisiana-Red River Valley	77,565	-0.03	-0.03	0.16	0.29	0.15
23--Texas-Lower Rio Grande	278,820	2.05	2.05	2.57	3.76	3.87
24--Texas-Lower Bend	118,849	0.94	0.94	1.52	2.12	2.25
25--Texas-Upper Bend	89,639	0.32	0.32	1.52	2.63	2.35
26--Texas-Winter Garden	20,416	2.28	2.28	2.93	3.43	3.48
27--Texas-Central River Bottoms	47,801	2.53	2.53	3.43	4.64	5.23
28--Texas-Blacklands	484,460	3.69	3.69	4.87	6.23	6.50
29--Texas, Rolling Plains	1,208,381	2.48	2.48	2.91	2.95	3.51
35--Oklahoma-South Rolling Plains	212,824	1.00	1.00	0.86	1.89	2.34
Light infestation potential:						
10--Alabama-Limestone Valley	264,419	-0.19	-0.19	-0.43	-1.16	0.24
12--Tennessee-North Brown Loam	265,526	-0.84	-0.86	-0.58	0.24	-0.29

Table 12. Long-run Changes in Cotton Acreage by Production Subregion 1/ -- continued

Cotton production subregions 2/	Cotton acreage 3/	Percentage change in cotton acreage for:				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	acres	percent				
Light infestation potential (contd)						
13--Tennessee-South Brown Loam	77,444	-0.83	-0.85	-0.56	0.24	-0.28
14--Missouri-Bootheel	280,944	-0.56	-0.56	-0.52	0.33	0.36
17--Mississippi-Delta	895,960	-0.26	-0.26	-0.18	-0.38	-0.57
19--Arkansas-Northeast	458,354	-0.49	-0.49	-0.52	-0.42	-0.66
31--Texas-Upper Concho Basin	132,168	2.22	2.22	2.09	1.84	2.28
34--Oklahoma-North Rolling Plains	214,908	0.87	0.87	0.72	1.89	2.21
No infestation potential:						
30--Texas-High Plains	3,052,238	-0.75	-0.75	-0.88	-0.96	-1.25
32--Texas-Pecos Valley	38,671	-0.64	-0.64	-0.75	-0.81	-1.06
33--Texas-El Paso	17,520	-0.64	-0.64	-0.75	-0.81	-1.06
36--New Mexico-Southern Plains	31,327	-2.30	-2.30	-2.70	-2.93	-3.74
37--New Mexico-Pecos Valley	38,250	-2.27	-2.27	-2.67	-2.87	-3.74
38--New Mexico-Upper Rio Grande	50,146	-2.27	-2.27	-2.66	-2.86	-3.73
39--Arizona-Southeast	37,195	-2.27	-2.27	-2.66	-2.86	-3.73
40--Arizona-Southwest	391,780	-2.26	-2.26	-2.64	-2.83	-3.70
41--California-Imperial Valley	99,513	-0.77	-0.77	-0.90	-0.96	-1.26
42--California-San Joaquin Valley	1,131,240	-0.73	-0.73	-0.85	-0.91	-1.19

1/ Estimated changes from the 1974-78 average acreage after full adjustment to the respective programs.

2/ Location of regions is shown in Figure 1. Regions are grouped according to potential for boll weevil infestation.

3/ Average 1974-78 cotton acreage planted.

Table 13. Long-run Changes in Net Returns per Acre of Cotton by Production Subregions 1/

Cotton Production Subregions 2/	Change in net returns per acre for:				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	dollars				
Heavy infestation potential:					
1--Virginia-Southeast	8.86	7.56	13.54	11.73	16.82
2--N. Carolina-North	8.86	7.56	13.54	11.73	16.82
3--N. Carolina-South	7.03	7.04	5.40	4.15	6.13
4--N. Carolina-Piedmont	8.25	8.25	10.27	17.64	22.68
5--S. Carolina-Coastal Plains	4.05	4.05	16.27	2.37	16.25
6--S. Carolina-Piedmont	7.52	7.52	9.54	17.64	21.95
7--Georgia-Piedmont	9.20	9.20	11.22	17.64	23.63
8--Georgia-East	20.61	20.61	20.37	25.50	34.10
9--Georgia-Southwest	21.48	21.48	31.84	19.21	36.95
11--Alabama-South	4.64	4.65	4.94	14.59	30.96
15--Mississippi-Northeast	-1.14	-1.14	3.48	-0.34	1.62
16--Mississippi-North Central	-3.02	-3.02	5.42	2.87	1.87
18--Mississippi-South	2.27	2.28	7.61	-0.70	0.63
20--Arkansas-Southeast	-0.18	-0.18	0.06	1.53	-1.95
21--Louisiana-Northeast	2.11	2.11	9.89	5.67	5.05
22--Louisiana-Red River Valley	-1.04	-1.03	2.52	5.03	2.17
23--Texas-Lower Rio Grande	27.14	27.15	34.33	51.45	53.14
24--Texas-Lower Bend	11.84	11.84	19.17	27.11	28.87
25--Texas-Upper Bend	3.81	3.81	16.31	28.49	25.53
26--Texas-Winter Garden	37.96	37.97	49.51	58.70	59.68
27--Texas-Central River Bottoms	36.27	36.27	50.12	69.57	79.55
28--Texas-Blacklands	20.74	20.74	27.80	36.27	38.01
29--Texas, Rolling Plains	18.30	18.30	21.61	22.15	26.52
35--Oklahoma-South Rolling Plains	7.70	7.70	6.79	14.66	18.10
Light infestation potential:					
10--Alabama-Limestone Valley	-1.38	-1.37	-2.66	-6.82	0.99
12--Tennessee-North Brown Loan	-6.60	-6.70	-4.57	1.31	-2.73
13--Tennessee-South Brown Loam	-6.50	-6.60	-4.47	1.31	-2.63
14--Missouri-Bootheel	-8.48	-8.46	-7.85	4.52	4.71
17--Mississippi-Delta	-5.89	-5.89	-4.14	-8.26	-12.10
19--Arkansas-Northeast	-6.87	-6.88	-7.13	-5.86	-9.12
31--Texas-Upper Concho Basin	20.09	20.09	19.00	16.99	21.09
34--Oklahoma-North Rolling Plains	6.70	6.70	5.79	14.66	17.10
No infestation potential:					
30--Texas, High Plains	-6.20	-6.19	-7.24	-7.70	-10.13
32--Texas-Pecos Valley	-9.10	-9.09	-10.63	-11.31	-14.88
33--Texas-El Paso	-9.10	-9.09	-10.63	-11.31	-14.88

Table 13. Long-run Changes in Net Returns per Acre of Cotton by Production Subregions 1/ -- continued

Cotton Production Subregions 2/	Change in net returns per acre for:				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	dollars				
No infestation potential (Con'td)					
36--New Mexico-Southern Plains	-5.39	-5.39	-6.29	-6.70	-8.82
37--New Mexico-Pecos Valley	-9.32	-9.32	-10.89	-11.59	-15.24
38--New Mexico-Upper Rio Grande	-9.78	-9.78	-11.43	-12.16	-16.00
39--Arizona-Southeast	-10.78	-10.78	-12.59	-13.40	-17.63
40--Arizona-Southwest	-18.04	-18.03	-21.07	-22.42	-29.51
41--California-Imperial Valley	-16.85	-16.85	-19.69	-20.95	-27.57
42--California-San Joaquin Valley	-15.52	-15.51	-18.12	-19.29	-25.38

1/ Changes in per-acre net returns as compared with CIC were computed from Delphi cost and yield changes, and the estimated price change resulting from each program. Estimates for OPM-I include incentive payment where applicable. Producer share of eradication costs is assumed to be 50 percent.

2/ Location of subregions is shown in Figure 1. Regions are grouped according to potential for boll weevil infestation.

Sensitivity of Results to Underlying Assumptions

Certain key assumptions and variables in this beltwide evaluation, as in all economic models, are based on the informed judgment of individuals or groups of individuals as opposed to verifiable research results. Sensitivity analysis is a means of examining the effects of changes in the direction and magnitude of key input data used in the beltwide evaluation. The objective is to estimate the sensitivity of model results to such changes and to determine if shifts in relative rankings of alternative programs would occur.

Cost Sharing

The share of eradication program costs paid by producers was hypothesized to influence cotton acreage since it affects the net returns of growing cotton relative to other crops. Several cost-sharing arrangements between growers and government (Federal, State, or local) were tested for their comparative impacts on long-run net benefits:

1. Producer share equal to 50 percent of eradication program operational costs. This assumption was used in the beltwide evaluation reported above.

2. Producer share equal to program discounted net benefits to producers ranging from 0 to a maximum of 67 percent of total program operational costs.

3. Producer share ranging from a minimum of 33 percent of operational costs to a maximum of 67 percent of operational costs, depending on program discounted net benefits to producers.

4. Producers share no costs of eradication.

These alternative cost-share arrangements had little impact on long-term net benefits and no impact on rankings (Table 14). A producer no-share option may be a logical choice because benefits of the eradication programs accrue to all cotton consumers. An argument for full financing from the general tax base could be made on the basis of projected consumer benefits. On the other hand, some producers would benefit, especially in heavily-infested areas of the Southeast and Texas, even after accounting for potential product price reductions.

In computing net benefits, estimated changes in future costs and benefits (changes in producer costs and yields) due to the programs were discounted at 7 1/8 percent to obtain a measure of net economic benefits in terms of present values. All computations were made for an average producer in each production region, based on Delphi panel estimates of changes in yields and production costs.

Table 14 -- Sensitivity of Net Market Benefits to Alternative Cost-Sharing by Producers 1/

Item	Cost share 0-67% 2/		Cost share 33-67% 3/		No share 4/
	CIC-BWE	OPM-NI-BWE	CIC-BWE	OPM-NI-BWE	OPM-NI-BWE
	Billion dollars				
Consumer Benefits	4.16	6.44	4.17	6.45	6.43
Net Returns to Producers of Major Crops	-1.25	-2.32	-1.29	-2.35	-2.12
Non-Producer Program Costs	.27	.26	.25	.25	.40
Net Market Benefits	2.64	3.86	2.63	3.85	3.91
B/C Ratio	11:1	16:1	12:1	16:1	11:1

1/ The values in Table 5 and other tables were based on a producer share of 50 percent of eradication costs. Three alternative cost-share assumptions for eradication costs are evaluated in this table. Extension (CES) costs associated with alternative programs are assumed to be public costs.

2/ Producers' share is equal to net benefits, ranging from 0 to a maximum of 67 percent of eradication costs in each subregion.

3/ Producers' share is equal to net benefits, but ranges from a minimum of 33 percent of program costs to a maximum 67 percent.

4/ Producers do not share eradication costs.

Based on the above procedures, producers in most of the Southeast and Texas weevil-infested regions would share a full 2/3 of the discounted eradication costs under share arrangements #2 and #3 above. Producers in low-infestation regions such as the Delta of Mississippi (region 17) and Northeast Arkansas (region 19), would share little or no costs if their shares were based on a net benefit criterion. As now planned, producers in areas where boll weevils do not over-winter, and where eradication programs would not be conducted, would not share the eradication costs of adjoining areas. Such areas include Missouri Boot-heel (region 14) and North Oklahoma (region 34).

Cost-sharing for various Government programs such as those conducted by APHIS have been based on the premise that society at large benefits from pest eradication or suppression measures. Such benefits may be reflected directly through lower consumer prices or indirectly through a lower pesticide load on the environment.

The Agricultural and Consumer Protection Act of 1973 specified that cotton producers in a beltwide boll weevil eradication program would be required to pay up to one-half the cost of the program (4). The producer share of program cost in the North Carolina Boll Weevil Eradication Trial in 1978-80 was 50 percent of operating costs. Other recent programs for which the producer share was 50 percent include the fire ant program and the High Plains (TX) boll weevil suppression program.

Discount Rates

The 7 1/8 percent discount rate used in this analysis is mid-way between what some economists consider a "social" discount rate for public investment analyses of 3 to 5 percent and a "market" rate equivalent to earnings in the private sector. The rate chosen for comparison is the 10% rate specified by OMB for all projects other than those related to water and land resource planning.

Compared with a 7 1/8% rate, the 10% discount rate significantly reduces net benefits of alternative programs, but the rankings of the top two programs remain the same (Table 15). With a 10% discount rate, the OPM-NI program resulted in slightly higher net benefits than CIC-BWE.

Interindustry Impacts

The previous sections examined the market effects of the alternative cotton insect management programs. Measurements of the level of consumers' and producers' gain provide an indication of the net market benefits derived from each control program. The purpose of this section, however, is to estimate the distributional effects of these benefits throughout the major sectors of the U.S. economy.

The primary method of analysis involved a standard interindustry input-output (I-O) model (18). The latest U.S. Department of Commerce I-O model for 1972 served as the analytical basis (19). A brief summary of methodology and limitations is included in Attachment B.

Table 15—Sensitivity of Net Market Benefits to an Alternative Discount Rate of 10%

Item	Changes in present values by programs:			
	OPM-NI	OPM-I	CIC-BWE	OPM-NI-BWE
	Billion dollars			
Consumer Benefits	2.73	3.12	2.21	3.70
Net returns to Producers of Major Crops	-1.15	-.98	-.69	-1.36
Non-Producer Program Costs	.04	.31	.14	.20
Net Market Benefits	1.54	1.82	1.38	2.14
B/C Ratio	38:1	7:1	11:1	11.1

For the cotton industry, control programs are further analyzed for their impacts on the levels of regional activity in the cotton ginning and warehousing industries (Attachment B). Changes in revenue levels, salaries and wages received, and man-hours of employment are estimated. In addition, total national changes in levels of activity are estimated for the cotton merchandising industry.

The complex network of purchases and sales among the cotton sectors and all other industries in the U.S. economy was identified, and the levels of interdependence among all sectors were established. This enabled actions or changes in any one sector to be interpreted in terms of impacts on any or all of the remaining sectors.

All alternative programs show increases from CIC in total economic activity and employment (Table 16). Most of the economic activity is generated in the manufacturing sector, where the largest increases occur for industries producing apparel, broad and narrow fabrics, and other textile items. The largest declines within the manufacturing sector occur in the chemicals and chemical products industry which includes pesticides. Declines in economic activity are indicated in mining and crude petroleum and natural gas and in finance, insurance, and real estate. These declines are explained by the cotton yield increases which result in lower input expenditures per pound of lint produced, and are not wholly offset by the regional cotton acreage changes which are estimated to occur under each alternative program.

The ranking of total economic activity generated by each program is identical with the ranking of net benefits obtained from AGSIM (table 5). OPM-NI-BWE ranks highest, followed by OPM-I and CIC-BWE.

Uncertainties and Limitations of Analysis

The economic analysis relied heavily on biological relationships: (1) yield-infestation and (2) insect control inputs and costs associated with alternative cotton insect management programs. These relationships were estimated by panels of experts in a Delphi process.

The Delphi estimates were developed by a group of individuals representing cotton research, extension, production, management consulting, and the chemical industry. The Delphi panelists were identified as experts by a representative of each respective group. Because there exists a lack of consistent, beltwide data on cotton insects and their control, and attempts to generate these data through various analytical techniques were unsuccessful, the subjective judgement of the expert Delphi panels represent the best available estimates of the average subregional farm level impacts of a change in boll weevil/cotton insect management programs. The Delphi data were collected in a systematic manner that provides ex-post substantiation of the

Table 16--Changes in Economic Activity, by Cotton Insect Management Program 1/

Industry 2/	Changes from CIC in industrial output and total employment under:				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	Million Dollars 3/				
Agriculture, forestry and fisheries	39.0	39.0	46.3	48.0	65.5
Mining and crude petroleum and natural gas	-1.3	-1.3	-0.5	-2.6	-2.6
Construction	0.8	0.8	1.5	1.2	1.7
Manufacturing	233.0	233.0	282.3	272.5	369.6
Transportation, utilities, and communications	8.1	8.1	11.1	8.9	12.7
Wholesale and retail trade	9.9	9.9	12.4	12.6	16.7
Finance, insurance, and real estate	-1.7	-1.7	-0.2	--	--
Services	7.9	7.9	10.3	9.1	12.7
Total economic activity	296.0	296.0	363.4	350.4	476.2
	Million Hours				
Total Employment	16.4	16.4	19.7	19.9	26.8

1/ Annual changes from current insect control after full implementation of each program.

2/ Standard Industry Classification (SIC) codes associated with each input-output sector are published in (16), pp.4-7.

3/ The results are in 1979 dollars. The gross national product deflator was used to convert the input-output model results, which are in 1972 dollars, to 1979 values.

process' results. Additionally, in an evaluation of the Delphi results it was found that the estimates generally fall within a range of available estimates from other partial sets of subjective or historical data (13).

A degree of uncertainty must be attached to the Delphi estimates. This uncertainty arises from two sources. First, precise, scientifically determined data are not available to substantiate the scientific judgment of the Delphi panels. However, this deficiency is the reason a Delphi approach was used. Secondly, the standard deviations surrounding some Delphi average estimates, particularly those for lint yield changes in East Texas, indicate a relatively high variance of expert opinion among panel members. In recognition of this uncertainty, the economic evaluation included sensitivity analyses of the Delphi data. For example, the cotton econometric model was run using the Delphi estimates of cotton yield changes and also 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 total net social benefits, but did not alter the relative ranking of the alternative programs (Table 17).

The Delphi estimated impacts of OPM-I were made under the assumption that sufficient cotton acreage receives diapause and/or overwinter control so as to prevent any need for in-season treatment for boll weevils prior to the onset of Heliothis on at least 90 percent of cotton acreage. Similarly, Delphi estimates for both alternative boll weevil eradication programs were made under the assumption that eradication was successful and completed. The technical or operational feasibility of eradication was not considered by the Delphi experts as part of the data generation process.

Some of the uncertainty about technical success of the OPM and BWE options relative to CIC is dealt with indirectly. The discounting interest rate used is a 7.125 percent real rate. Sensitivity analysis reported earlier included results of raising the discount rate. However, discount rate changes affect only the net social benefits of the programs relative to CIC and do not account for the possibility that some BWE components, for example, might be more risky than OPM components. A risk related to biological success is the chance that major improvements might be made in CIC pest control technology such as the discovery of new pesticides or ways to improve the use of existing pest control practices.

Program components and costs were estimated by States and production regions within States, often without the benefit of substantial evidence of workability, effectiveness or producer participation. However, a rigorous review and interaction process was implemented. The risk of public program cost over-runs 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 2-3 year adoption rate used in this evaluation (Table 18). Again, a slower adoption rate resulted in slightly lower net benefits but the ranking of alternatives remained the same.

Table 17. Sensitivity of Net Market Benefits to Smaller Yield Changes 1/

Item	Change in present values by program:			
	OPM-NI	OPM-I	CIC-BWE	OPM-NI-BWE
	Billion dollars			
Consumer Benefits	2.22	2.44	2.00	3.13
Net Returns to Producers of Major Crops	-.76	-.26	-.15	-.62
Non-Producer Program Costs	.06	.44	.16	.24
Net Market Benefits	1.40	1.74	1.69	2.26
B/C Ratio	24:1	5:1	11:1	10:1

1/ Changes in yield from CIC levels, as indicated by Delphi, were reduced by 50 percent in all regions.

Table 18. Sensitivity of Net Market Benefits to Slower Implementation of OPM Programs 1/

Item	Changes in present value by program:		
	OPM-NI	OPM-I	OPM-NI-BWE
	Billion dollars		
Consumer Benefits	4.18	4.59	6.14
Net Returns to Producers of Major Crops	-1.78	-1.45	-2.19
Non-Producer Program Costs	.06	.35	.24
Net Market Benefits	2.34	2.79	3.71
B/C Ratio	40:1	9:1	16:1

1/ Assumes implementation over a 7-year period rather than 2-3 years as originally specified (see Table 5). Incentive payments would start in year-6 where applicable.

The estimation of net market benefits is controversial. The measurement of economic surplus is widely employed by economists as a useful indicator of change in benefits to society. It accounts for changes in net benefits to both producers and consumers. The estimation of true consumer benefits is difficult but the approach used is empirically workable and defensible for purposes of ranking alternative programs.

The future costs and benefits of each alternative insect management program were discounted so that "present values" of a time-stream of benefits and costs could be compared. The selection of the appropriate discount rate is somewhat arbitrary. Higher discount rates result in lower "present values" of benefits incurred in the future. A lower discount rate gives greater weight to the future than does a higher rate. Society's time preference for public investments is difficult to measure. This analysis was based on the discount rate established annually by the Water Resources Council for use in land and water resources planning. The FY-80 rate was 7 1/8 percent.

In order to simplify the analysis, we assumed that relative prices would not change over the expected life of the alternative programs. Although some shifts in price relatives are likely to occur, they will likely not seriously impact the decision criteria.

The economic analysis is based on estimates of market impacts and excludes other considerations needed for decisionmaking. Among these "incommensurables" that cannot be readily evaluated, if at all, in monetary terms are environmental factors, aesthetics, human hazards, potential pesticide resistance, future regulations of pesticides, and the like.

EVALUATION OF TRIALS

Trial evaluations emphasize the analysis of economic inpacts of the two boll weevil/cotton insect management strategies on producers in the respective trial areas as well as comparison with historic and check area data. Measurements of impacts include numbers of applications, insect control costs, scouting frequency and costs, lint yields per acre and net returns per acre. Producer participation rates and program costs are also presented. Research was undertaken to test alternative techniques--simulation and multiple regression--for estimating yields and insecticide costs associated with belt-wide programs. Most of the activity of the Economic Evaluation Team was directed to obtaining information that was used to estimate and evaluate belt-wide impacts of alternative programs.

The chief purpose of the trials in North Carolina and Mississippi was to test the operational and technical feasibility of implementing two boll weevil/cotton insect management approaches on a large area. From an economic perspective, trial results provided only partial indications of potential beltwide impacts.

This section contains a summary of economic measurements of trials. Economic impacts are presented in more detail for North Carolina and Mississippi in Attachments D and E, respectively.

Highlights of Boll Weevil Eradication Trial in North Carolina

The economic evaluation of the Boll Weevil Eradication Trial (BWET) in North Carolina centered on measurement of changes in insecticide use for cotton production, cotton yields, and public expenditures relative to current insect control (CIC). The evaluation was based on data for a four-year base period prior to initiation of the BWET program, 1974-1977, and the three years of trial implementation, 1978-1980. The data were collected from personal and telephone interviews of about 200 randomly selected farmers, supplemented by data from other sources. Producer impacts in two cotton growing regions were evaluated--the eradication zone (EZ) and a control zone (CZ) comprised of three other major North Carolina cotton counties. Comparisons were possible over time and between two areas, one with eradication and one without it.

There were major reductions in total insect control expenditures per acre following reduction of boll weevils in the first year of the BWET program. Actual eradication zone expenditure by producers for insect control for 1974-1977 averaged $50.81, while the expenditure in 1979 and 1980 averaged only $32.61 (Attachment D, Tables 2 and 9). This is a 36 percent reduction. However, there was also a general downward trend (20 percent) in cotton insect control expenditures in the control zone during the same years. A further substantial reduction in producer cost would likely take place when the producer share of APHIS program costs is phased out. The producer cost share in 1980 was $15.29 per acre. The Delphi panel estimated that with eradication the eradication zone should experience a 26 percent reduction in insecticide use. Accounting for the general downward trend in insecticide use, the actual experience of the eradication zone was very similar to what the Delphi panel estimated would happen with eradication.

The Delphi panel estimated about a 14-24 pound lint yield increase from eradication of the weevil in northern North Carolina, depending on the concurrent extension program in place. The actual experience adjusted for weather is difficult to measure. Table 19 shows actual yields for the BWET program years. The only yield statistically different from long-run trend yields is the 1978 yield in the eradication zone. This yield of 611 pounds per acre is 114 pounds above the 1974-1977 average yield of farmers growing cotton in 1978 or 1979. For the same year the CZ yields were 16 pounds less than the base period. A statistical model of cotton yields revealed that when other factors were held constant, each day of delay of insecticide treatment would raise yields by

Table 19 -- Economic Impact on Producers of the Eradication Trial Program During Implementation Years

Item	Unit	Eradication Zone			Control Zone		
		1978	1979	1980	1978	1979	1980
Number of producers	No.	179	183	259	115	110	119
Cotton acreage	Ac.	12,030	14,085	24,174	23,540	22,200	26,252
No. of applications per acre	No.	10.10	2.43	1.13	9.38	6.78	6.82
Active ingredients per acre	Lbs.	12.13	0.40	0.18	10.38	3.63	2.93
Insecticide cost per acre	$	---	13.98	6.60	43.30	35.20	32.14
Application cost per acre	$	---	3.65	1.70	11.73	8.48	8.53
Scouting cost per acre (private)	$	---	0.25	0.28	2.50	3.00	3.25
Producer share of APHIS cost [a]	$	46.61	23.47	15.29	---	---	---
Producer insect control cost per acre [b]	$	46.61	41.35	23.87	57.53	46.68	43.92
Public insect control cost per acre	$	47.64	25.68	16.76	0.91	1.32	1.02
Lint yield per acre	Lbs.	611	371	359	464	510	418
Returns above producer insect control costs [c]	$	356.65	198.69	292.05	248.71	283.29	323.92

[a] In 1978, the BWE program costs included control of the boll weevil and other insects, plus other program activities. This expenditure was evenly shared by all producers in the BWE trial area. A charge of $46.61 per acre was assessed to each producer in 1978.

[b] Includes producer share of APHIS program costs in eradication zone.

[c] Cotton prices are 66 cents, 64.7 cents, and 88 cents, 1979, and 1980, respectively.

about 1.6 percent. This means that only about 2 to 3 days of delay are needed to obtain the yield gains estimated by the Delphi panel. More research is needed to establish the biological evidence for believing that absence of weevil treatments will lead to enough additional predators to delay bollworm treatments given the mass migrations of bollworms experienced in northern North Carolina.

Acreage reductions in cotton occurred as a result of eradication implementation and the projected producer shares of eradication costs of $50.50, $24.00 and $20.00 per acre in 1978, 1979 and 1980, respectively. Actual producer shares were somewhat lower than those projected (Table 19). The three-year average effect was a 1.5 percent reduction in acreage for each additional dollar charged, based on a model of profit maximization estimated for the 1956-1980 period. This relatively large acreage adjustment is consistent with the acreage adjustments for the North Carolina region in the national econometric model, AGSIM.

Highlights of Optimum Pest Management Trial in Mississippi

A partial analysis of the economic impacts on producers of the Optimum Pest Management Trial in Mississippi is presented. Actual impacts on producers during the trial years include lint yield, costs and insecticide use information for Panola County, the trial county, compared with Pontotoc County, which served as a check area representing current insect control (CIC).

All information for this analysis was based on annual surveys of a sample of producers. The sample, consisting of about 30 producers in Panola County and 13 producers in Pontotoc County, represented about 30 percent of the producers and 45 percent of the cotton acreage in both counties. Cotton acreage increased over the three-year trial period chiefly in response to favorable cotton prices relative to soybeans, an important competitive crop (Table 20). Although not strictly comparable with Panola County from a control standpoint, Pontotoc County was selected as the most appropriate of nearby counties to represent current insect control. Panola county producers have, historically, applied more insecticides, scouted a higher proportion of cotton acreage and experienced higher yields than Pontotoc County.

The strategy of OPM was to utilize naturally occurring beneficial insect populations to their fullest potential, thereby reducing the level of chemical control required. An integral part of OPM is scouting of individual fields by qualified individuals on a regular basis as recommended by entomologists. Insecticide application decisions can then be made on a field basis. Another integral part of OPM consisted of several applications of organophosphates in the early fall which are targeted at boll weevil populations beginning to diapause.

Table 20 -- Economic Impact on Producers of the OPM Trial During Implementation Years

Item	Unit	Panola County Trial Area			Pontotoc County Check Area		
		1978	1979	1980	1978	1979	1980
No. of producers (sample)	No.	26	33	33	12	13	13
Cotton acres	Ac.	30,400	31,343	37,669	3,150	4,041	8,095
No. applications per acre 1/	No.	7.29	6.92	6.86	1.00	1.15	1.69
Active ingredients per acre	Lbs.	3.37	2.94	2.90	0.58	1.36	1.26
Insecticide cost per acre	Dols.	20.31	19.26	19.71	5.08	3.23	5.46
Application cost per acre application	Dols.	1.25	1.60	2.00	1.25	1.60	2.00
Scouting cost per acre scouted	Dols.	2.00	2.50	4.00	4.00	2/	2/
Total insect control cost per acre	Dols.	27.79	31.53	37.00	8.62	5.01	8.58
Producer cost of insect control per acre	Dols.	20.47	19.36	20.93	8.62	5.01	8.58
Public cost of insect control per acre	Dols.	7.32	12.17	16.07	---	---	---
Lint yields per acre (sample)	Lbs.	562	593	479	514	586	356
Returns above producer insect control costs	Dols.	357.04	403.54	383.08	337.47	412.81	291.73

1/ Includes diapause applications: 3.9 in 1978, 3.5 in 1979, and 3.8 in 1980.

2/ No commercial scouting.

The average number of insecticide applications, including diapause applications, in Panola County during the trial years ranged rather narrowly from 7.3 applications in 1978 to 6.9 applications in 1980 (Table 20). The long-term expected number of applications with current practices and "normal" infestations is about 9.5 in Panola County. The Delphi indicated about 8.4 applications for the production region in which Panola is located. The number of diapause applications during the trial period averaged 3.9 in 1978, 3.5 in 1979, and 3.8 in 1980.

Boll weevil infestations were below average during all three trial years in most of the weevil-infested areas of the Cotton Belt. Panola and Pontotoc Counties were no exception. However, boll weevil populations were comparatively heavy in Pontotoc County in late 1979 and in 1980. The diapause applications in Panola County were effective in preventing a substantial buildup of weevils in that county in 1980, with no apparent effect on the population of beneficial insects (13). No in-season applications for control of the boll weevil were required in Panola County.

Total insect control cost per acre increased during the trial years in Panola County, chiefly in response to higher application costs and higher scouting costs. Insecticide cost per acre, including diapause materials, remained about the same during the trial period. The public cost of the OPM trial increased from $7.32 per acre in 1978 to $16.07 per acre in 1980. This included trial management and operations personnel as well as the cost of diapause treatments. Producer costs remained at about the same level over the three years, ranging narrowly from $19 to $21 per acre. In comparison, producer costs in Pontotoc County ranged from $5 per acre in 1979 to about $8.60 per acre in 1978 and 1980. The Delphi estimated that producer insect control costs, following full implementation and adjustment of OPM in the regions where these counties are located, would be substantially lower than current insect costs (13). CIC costs in the N. Central (Panola County) region averaged about $40 per acre while costs in the Northeast (Pontotoc County) region averaged $36 per acre. Following OPM, producer costs would drop by about $13 per acre and $9 per acre, respectively.

Lint yields during the trial period, as in other years, were extremely variable. The lowest yield in both counties was experienced in 1980, when drought affected most producing areas from Texas east. Average yields in Panola County ranged from 479 pounds per acre in 1980 to 593 pounds in 1979, compared with a 1968-77 average of 515 pounds per acre. Program impacts were very difficult to assess, as weather impacts were undoubtedly of greater importance than insect populations or insect control factors. A computer simulation model was used to estimate lint yields associated with selected alternative cotton insect management strategies for four production regions in Mississippi (14). This model indicated an expected increase in yield of 22 pounds per acre for a fully implemented OPM program in the North Central region in which Panola County is located. On the other hand, the Delphi panel of experts estimated that average yields would increase only five pounds per acre with an OPM program (13).

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ATTACHMENTS

Attachment	Title
A	The Cotton Industry in Brief
B	Interindustry Analysis
C*	Description of Econometric-Simulation Model
D*	Economic Evaluation of Boll Weevil Eradication Trial Program in North Carolina
E*	Economic Evaluation of Alternative Cotton Insect Management Strategies in Mississippi

* Available upon request

THE COTTON INDUSTRY IN BRIEF

Importance of Cotton

The United States ranks as one of the world's largest cotton producers, exporters and consumers (Table 1A). About one-fifth of the world's cotton was produced in the United States in the past three years. U.S. exports account for about one-third of world cotton trade and constitute an important source of foreign exchange. In 1979-80, 9.2 million bales were exported, the highest level since 1926-27. In 1980-81, exports dropped back to 5.7 million bales. During the past decade U.S. cotton exports have averaged about 5 million bales a year, or about 40 percent of annual U.S. production. In the near future, exports are expected to total about 6 million bales annually.

Cotton consumption by U.S. textile mills declined sharply during the decade 1965-75. However, mill use appears to have stabilized at about 6 - 6 1/2 million bales. Declines in mill consumption resulted from rapid expansion in use of synthetic fibers. Cotton's share of the expanding textile market dropped from 53 percent in 1965 to 25 percent in 1978. Since 1978, cotton's share has stabilized as demand for natural fibers and high cotton content in products remains strong.

End uses of cotton can be grouped into three categories: apparel, household, and industrial. The largest market for cotton products is apparel, where cotton's market share is about 35 percent. Cotton accounts for about 45 percent of fibers used in men's apparel, 21 percent of women's apparel, and 38 percent of children's clothing. In the household market, cotton's market share is about 20 percent. Cotton also has about 20 percent of the industrial textile market.

Cotton production, marketing and manufacturing affects the lives of many people. The 54,000 producers distributed across the Cotton Belt received an estimated $5.1 billion from the sale of lint and seed during 1979-80 (Table 2A). Ginning, warehousing and marketing also provide significant sources of revenue and employment in local areas. Moreover, many producers and retailers of pesticides, fertilizer, and machinery and equipment are involved. Since cotton is a major raw material for the textile and apparel industries, spinners, weavers, finishers and manufacturers of apparel, household and industrial products have a stake in cotton's future. The estimated retail value of cotton apparel products alone totals over $30 billion a year.

Cotton Acreage and Production

During the past decade, U.S. cotton production has averaged more than 12 million bales a year, fluctuating from a high of nearly 15 million in 1979 to a low of 8.3 million in 1975. Both acreage and yields have been major determinants of variation in annual production. While Government programs and prices of cotton and competing crops have influenced acreage, weather has been

Table 1A -- Cotton Production, Consumption, and Exports in Selected Countries, 1978, 1979 and 1980 1/

Country	Production			Consumption			Exports		
	1978/79	1979/80	1980/81	1978/79	1979/80	1980/81	1978/79	1979/80	1980/81
	Million Bales								
United States	10.9	14.6	11.1	6.4	6.5	5.9	6.2	9.2	5.7
USSR	12.3	13.1	14.3	9.0	9.1	9.3	3.7	3.7	4.4
China	10.0	10.1	12.1	12.6	13.8	14.7	0.1	---	---
Other 2/	26.8	27.9	27.7	34.9	36.3	35.9	9.8	10.1	10.1
World Total	60.0	65.7	65.2	62.9	65.7	65.8	19.8	23.0	20.1

1/ Season beginning August 1.

2/ World Total minus U.S., USSR, China.

Source: Foreign Agricculture Circular, FC 5-81, FAS, USDA, February 1981.

Table 2A -- Selected Cotton Industry Statistics, 1979/80

Item	Units	Region				United States
		Southeast	South Central	Southwest	West	
Cotton production	Mil. bales	0.6	3.1	6.1	4.9	14.7
Value of production 1/	Bil. dol.	.2	1.1	1.9	1.9	5.1
Active gins	Number	278	786	877	391	2,332
Estimated ginning revenue 2/	Mil. dol.	19.7	102.1	268.8	187.5	578.1
Estimated employment 3/	Number	2,595	8,125	8,374	3,943	23,037
Cotton warehouses	Number	195	109	94	25	423
Estimated warehouse revenue 4/	Mil. dol.	4.3	40.5	76.2	60.5	181.5
Estimated employment 5/	Number	1,436	2,706	2,080	607	6,829
Cotton merchants 6/	Number	226	264	236	81	807
Textile mills 7/	Number					7,110
Apparel manufacturers 7/	Number					26,428
Cottonseed oil mills 7/	Number					98

1/ Farm value of lint and seed.
2/ Average ginning charge times number of bales ginned.
3/ Both full time and seasonal employment.
4/ Average warehouse charges for receiving, shipping, compression and 3 months storage.
5/ Both full time and seasonal employment.
6/ Includes shippers, mill buyers, brokers, gin-buyers and other buyers of cotton including branch offices.
7/ Data from 1977 Census of Manufacturers, Bureau of Census. Regional breakdown not available.

the chief determinant of year-to-year variability in yields. Average yields, for example, varied from 420 pounds per harvested acre in 1978 to 547 pounds per acre one year later, then dropped to 411 pounds per acre in 1980. The most recent 5-year centered average yield is 473 pounds.

U.S. cotton production has continued to shift westward. In 1980, the West accounted for about 40 percent of U.S. output, up from only 18 percent during 1970/71 (Table 3A). In contrast, the Southeast share has continued to decline to around 4 percent of the total. The Southwest and West accounted for 75 percent of cotton production in the last two seasons--the largest share ever for these regions. This regional shift in production is due chiefly to lower average production costs in the West and Southwest, as well as higher opportunity costs of producing cotton in the eastern Belt. The elimination of direct payments made on the basis of acreage allotments also has encouraged the trend westward.

Cotton's primary competitors include soybeans and corn in the Southeast and Delta, grain sorghum in the Southwest, and barley and wheat in the Far West. Competition from soybeans has resulted in significant fluctuation in cotton acrage in the Delta in recent years.

Cost of Production

Costs of producing upland cotton in four major regions of the U.S. are based on FEDS (Firm Enterprise Data System) budgets for the 1979 crop year (Table 4A) (20). These cost estimates are updated annually and comprise the official data used for updating target prices for major field crops. Costs per acre and per pound of lint varied substantially in 1979, as in other years. Costs per pound of lint were relatively low in the Southwest and West, which is consistent with results in most recent years. A notable exception was 1978, when poor weather and high insect populations affected the California crop. The relatively low costs in Texas and California, in combination with a comparative economic advantage of cotton production, help to explain the shift of cotton acreage from the Southeast and some areas of the Delta States.

The "chemicals" cost category (Table 4A) includes insecticides, fungicides, herbicides, and defoliants and desiccants. In 1979, insecticide costs per acre planted and their relative importance were as follows:

	Dollars	Percent of variable costs
Southeast	65.50	25
Delta	37.19	16
Southern Plains	4.18	3
Southwest	55.05	12
United States	21.27	10

Table 3A -- Cotton acreage harvested and production by regions, selected years 1965-80.

	West 2/	Southwest 3/	Delta 4/	Southeast 5/	Total
			1,000 acres		
1965/66	1,241	6,120	3,974	2,280	13,615
1970/71	1,079	5,346	3,355	1,375	11,155
1975/76	1,271	4,219	2,616	690	8,796
1976/77	1,562	4,843	3,611	898	10,914
1977/78	2,086	6,992	3,388	808	13,275
1978/79	2,151	6,813	2,862	574	12,400
1979/80	2,395	7,411	2,412	613	12,831
1980/81	2,268	7,221	2,835	664	12,989
			1,000 bales		
	2,707	5,030	5,051	2,150	14,938
1965/66	1,796	3,402	3,819	1,175	10,192
1970/71					
	2,640	2,563	2,491	607	8,302
1975/76	3,444	3,489	2,874	773	10,580
1976/77	4,100	5,936	3,827	527	14,389
1977/78	3,177	4,174	2,939	566	10,856
1978/79	4,868	6,061	3,061	639	14,629
1979/80	4,674	3,521	2,433	496	11,124
1980/81					
			Percent of Production		
1965/66	18.1	33.7	33.8	14.4	100.0
1970/71	17.6	33.4	37.5	11.5	100.0
1975/76	31.8	30.9	30.0	7.3	100.0
1976/77	32.6	32.9	27.2	7.3	100.0
1977/78	28.5	41.2	26.6	3.7	100.0
1978/79	29.3	38.4	27.1	5.2	100.0
1979/80	33.3	41.4	20.9	4.4	100.0
1980/81	42.0	31.6	21.9	4.5	100.0

1/ Year beginning August 1. 1980/81 preliminary.
2/ California, Arizona, New Mexico and Nevada.
3/ Texas and Oklahoma.
4/ Missouri, Arkansas, Tennessee, Mississippi, Louisiana, Illinois and Kentucky.
5/ Virginia, North Carolina, South Carolina, Georgia, Florida and Alabama.

Source: Cotton and Wool Situation, CWS-26, ESS, USDA, February 1981.

Table 4A -- Cotton Production Costs per Planted Acre and Per Pound of Lint by Cost Item, Specified Regions, 1979

Cost Item	Southeast	Delta	Southern Plains	Southwest	United States
COSTS PER ACRE					
Variable	$ 259.66	$ 228.18	$ 130.93	$ 444.87	$ 205.67
Seed	6.12	5.47	6.51	6.09	6.23
Fertilizer	30.02	22.33	8.11	24.95	14.44
Lime	3.75	1.01	---	---	.35
Chemicals 1/	87.87	60.43	10.88	81.43	34.92
Custom operations 2/	12.54	9.25	4.01	25.63	8.87
All labor	25.70	31.12	29.52	75.61	37.15
Fuel & lubrication	17.71	18.73	20.09	67.36	27.43
Repairs	35.73	35.22	15.96	48.20	25.64
Ginning	33.37	39.11	32.03	79.34	41.10
Purchased irrigation water	---	---	.08	23.54	3.88
Interest	6.85	5.51	3.74	12.72	5.66
Machinery ownership	100.28	91.48	51.39	129.83	73.72
Replacement	56.42	51.99	30.11	75.74	42.74
Interest	35.10	31.78	17.54	44.69	25.36
Taxes & insurance	8.76	7.71	3.74	9.40	5.62
General farm overhead	9.54	9.38	7.72	15.04	9.30
Management 3/	36.95	32.90	19.00	58.97	28.87
Total, excluding land	406.43	361.94	209.04	648.71	317.56
Land allocation:					
Composite with--					
Current value 4/	56.75	71.54	42.03	154.41	66.41
Average acquisition value 5/	34.91	49.39	27.93	99.75	43.88
COSTS PER POUND OF LINT					
Variable	.530	.400	.375	.443	.410
Machinery ownership	.205	.160	.147	.129	.147
Farm overhead	.019	.016	.022	.015	.019
Management	.075	.058	.054	.059	.057
Total, excluding land	.829	.635	.599	.646	.633
Land allocation:					
Composite with--					
Current value	.116	.126	.120	.154	.132
Average acquisition value	.071	.087	.080	.099	.087
Value of cottonseed	.085	.104	.098	.097	.099

Table 4A -- Cotton Production Costs per Planted Acre and per Pound of Lint by Cost Item, Specified Regions, 1979 (Continued)

Cost Item	Southeast	Delta	Southern Plains	Southwest	United States
TOTAL PER POUND COST OF PRODUCTION					
With land at current value 6/	$ .860	$ .657	$ .621	$ .703	$ .666
With land at acquisition value 7/	.815	.618	.581	.648	.621
Yield per acre (pounds)	490	570	349	1004	502
Percent of U.S. production	4.3	20.9	42.2	32.5	100.0

1/ Includes herbicides, insecticides, fungicides and harvest-aid chemicals not otherwise included under custom operations.

2/ Includes custom application of crop chemicals, the cost of chemicals in some cases, and custom harvesting and hauling.

3/ Based on 10 percent of above costs.

4/ Based on prevailing tenure arrangements in 1979, reflecting actual combinations of cash rent, net share rent, and owner-operator land allocations, land values, land tax rates, and cash rents.

5/ Same as footnote 4, except average value of cropland during the last 35 years is used for owner-operator land instead of current land value.

6/ Total cost with land allocation based on a composite of prevailing tenure arrangements and current land values (see footnote 4 above).

7/ Total cost with land allocation based on a composite of prevailing tenure arrangements and acquisition values (see footnote 5 above).

NOTE: Blanks indicate not applicable.

INTERINDUSTRY ANALYSIS

Method of Analysis

The primary method involved use of a standard interindustry or input-output (I-O) model (18). The latest U.S. Department of Commerce I-O model for 1972 served as the analytical basis (19).

The 496 sectors contained in the Department of Commerce model were aggregated to 83 sectors. Using USDA cost of production data and published data on regional cotton ginning and warehousing costs, the cotton production, ginning, and warehousing sectors were dissaggregated on a regional basis from the broad groupings of the Commerce tables. Because of their national scope of operations, cotton merchants and shippers were disaggregated only at the national level, using published cost studies. The final tables consist of 96 industries showing a detailed cotton industry within the total U.S. economic system. These tables show the total expansion of output by industry as a result of the delivery of $1 of commodity output to final users such as households, governments, and exports. The increased industrial output reflects the direct purchase of inputs used to produce the commodity, as well as the indirect economic activity generated as the input-supplying industries make additional purchases.

Linkage of the Cotton I-O and AGSIM Models

The information required to implement AGSIM and its resulting equilibrium solutions comprise the input for the I-O analysis. The difference between AGSIM equilibrium solutions for each fully implemented insect management program and the CIC baseline was determined for (1) regional cotton production costs disaggregated along I-O sectors, (2) regional cotton yields, and (3) domestic cotton mill consumption and exports. These differences, in terms of percentage changes, were applied to the I-O model to examine national changes in economic activity.

The regional cost and yield changes were used to alter the I-O model's production coefficients (input requirements per $1 of output). Final demands for industrial sectors producing textile products were increased by an amount that would result in a change in intermediate demand for raw cotton equal to the change in mill consumption estimated by AGSIM. Raw cotton for domestic use was assumed to be distributed to end uses as apparel, 52.4%; household furnishings, 33.3%; and industrial use, 14.3%. Manmade fiber mill consumption was assumed to be unchanged. Cotton export changes were introduced as final demand changes for raw cotton. As a percent of CIC baseline production levels, production changes for other crops were small and thus were not considered. The results of the I-O analysis, then, measure economic activity based on the net effects of changes in cotton production coefficients and final demand for cotton and cotton textiles.

For the cotton ginning, warehousing, and merchandising sectors, supplemental data on salaries and wages paid, and man-hours required per $1 of output were developed. These data were then applied to the new output level which was determined by the changes in cotton production levels estimated for each insect management program. Results, therefore, provide new levels of wages and salaries and employment for cotton gins, warehouses, and for the merchandising industry.

Impacts on Cotton Marketing Sectors

The estimated impacts of the alternative insect control programs on the cotton ginning, warehousing, and merchandising sectors of the cotton industry are summarized in Tables 1B through 3B. Beltwide, the largest positive impacts result from the OPM-BWE program. However, the CIC-BWE program would be ranked next, ahead of OPM-I, reflecting the somewhat lower level of production under OPM-I.

The cotton ginning industry, in total, would receive significantly larger overall benefits from each alternative to CIC. Estimated increases in national ginning revenue would range from $12 million for OPM-NI to over $19 million from OPM-BWE (Table 1B). Changes in salaries and wages paid and man-hours of employment also show strong increases. For the cotton warehousing and merchandising sectors, estimated net increases in revenue from program alternatives range from about $2 to $4 million in each sector (Tables 2B and 3B).

Alternative program benefits vary among regions. When the AGSIM regions are aggregated into the four standard production regions, negative changes in all activities are shown for the West. These declines reflect the reduced production levels expected under each program. Cotton ginning, warehousing, and merchandising activities increase moderately in the Southeast and South Central regions, while significant increases would occur in the Southwest (Texas and Oklahoma).

Assumptions and Limitations

The use of the I-O framework requires assumptions about the nature of production and consumption. These assumptions do not seriously affect interpretation of results if analysis is restricted to the year for which the table was constructed (1972). The use of the direct and total requirements for periods beyond the base year assumes that the structure of the economy does not change, ruling out the substitution of one input for another as a result of intertemporal changes in technology and/or relative prices. Also, for any level of production, an industry's mix of inputs is assumed to remain constant, so that a doubling of inputs will double output. This includes constant employment requirements per dollar of output.

The assumption of an increase in final demand for textile items in order to provide a market for the additional cotton production under each control option ignores (1) substitution of cotton for manmade fiber, implying all new textile items are 100% cotton, and (2) the means by which final demand increases are effected (e.g., the way households reduce expenditures on nontextile items to offset their increased expenditures on textiles).

Table 1B -- Changes in Cotton Ginning Activity by Regions 1/

Region and Activity 2/	Units	Insect Management Program				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-BWE
Southeast:						
Revenue 3/	mil. dol.	1.65	1.65	1.85	1.05	2.71
Salaries & Wages 4/	" "	.57	.57	.64	.36	.94
Employment 5/	1,000 man-hrs	105.44	105.44	118.51	67.22	173.23
South Central:						
Revenue 3/	mil. dol.	1.09	1.09	1.22	1.26	1.85
Salaries & Wages 4/	" "	.33	.33	.37	.38	.56
Employment 5/	1,000 man-hrs	62.24	62.24	69.44	71.80	105.53
Southwest:						
Revenue 3/	mil. dol.	11.91	11.91	13.99	16.29	18.94
Salaries & Wages 4/	" "	5.06	5.06	5.95	6.92	8.05
Employment 5/	1,000 man-hrs	535.85	535.85	629.88	733.12	852.47
West:						
Revenue 3/	mil. dol.	-2.63	-2.63	-3.04	-3.17	-4.16
Salaries & Wages 4/	" "	-.73	-.73	-.84	-.88	-1.15
Employment 5/	1,000 man-hrs	-110.30	-110.30	-127.55	-133.20	-174.75
U.S. Total:						
Revenue 3/	mil. dol.	12.02	12.02	14.02	15.43	19.34
Salaries & Wages 4/	" "	5.23	5.23	6.12	6.78	8.40
Employment 5/	1,000 man-hrs	593.23	593.23	690.28	738.94	956.48

1/ These data reflect the additional (+ or -) cotton ginning activity associated with expected changes in production levels under each insect control option. All values are in 1979 dollars.

2/ Regional groupings based on the following AGSIM regions: Southeast--AGSIM regions 11 and 12 (except Tennessee); South Central--AGSIM region 10 (plus Tennessee); Southwest--AGSIM region 7; and West--AGSIM regions 2 and 4.

3/ Changes in revenue reflect estimated gross ginning receipts.

4/ Changes in salaries and wages paid only, and not net income to business.

5/ Changes in employment reflect changes in man-hours required and not necessarily new employees.

Table 2B -- Changes in Cotton Warehousing Activity, by Regions 1/

Region and Activity 2/	Units	Insect Management Program				
		OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-BWE
Southeast:						
Revenue 3/	mil. dol.	0.28	0.28	0.32	0.18	0.47
Salaries & Wages 4/	" "	.17	.17	.19	.11	.29
Employment 5/	1,000 man-hrs	35.30	35.30	39.82	22.62	58.83
South Central:						
Revenue 3/	mil. dol.	.33	.33	.37	.38	.56
Salaries & Wages 4/	" "	.13	.13	.14	.15	.22
Employment 5/	1,000 man-hrs	21.33	21.33	23.88	24.74	36.68
Southwest:						
Revenue 3/	mil. dol.	2.36	2.36	2.79	3.25	3.81
Salaries & Wages 4/	" "	1.07	1.07	1.26	1.48	1.73
Employment 5/	1,000 man-hrs	130.98	130.98	154.54	180.18	211.36
West:						
Revenue 3/	mil. dol.	-.69	-.69	-.80	-.84	-1.11
Salaries & Wages 4/	" "	-.29	-.29	-.34	-.36	-.47
Employment 5/	1,000 man-hrs	-32.31	-32.31	-37.50	-39.24	-51.93
U.S. Total:						
Revenue 3/	mil. dol.	2.28	2.28	2.68	2.97	3.73
Salaries & Wages 4/	" "	1.08	1.08	1.25	1.38	1.77
Employment 5/	1,000 man-hrs	155.30	155.30	180.74	188.30	254.94

1/ These data reflect the additional (+ or -) cotton warehousing activity associated with expected changes in production levels under each insect control option. All values are in 1979 dollars.

2/ Regional groupings based on the following AGSIM regions: Southeast--AGSIM regions 11 and 12 (except Tennessee); South Central--AGSIM region 10 (plus Tennessee); Southwest--AGSIM region 7; and West--AGSIM regions 2 and 4.

3/ Changes in revenue reflect estimated gross warehouse receipts.

4/ Changes in salaries and wages paid only, and not net income to business.

5/ Changes in employment reflect changes in man-hours required and not necessarily new employees.

Table 3B -- Changes in U.S. Cotton Merchandising Activities, by Cotton Insect Management Program 1/

Insect Management Program	Estimated Change in Merchandising:		
	Revenue 2/	Salaries & Wages 3/	Employment 4/
	Mil. Dol.		1,000 man-hrs
OPM-NI	2.2	.46	123.20
OPM-PI	2.2	.46	123.20
OPM-I	2.6	.54	143.36
CIC-BWE	2.7	.57	152.88
OPM-BWE	3.6	.75	200.48

1/ These data reflect the additional cotton merchandising activity associated with expected changes from CIC production levels under each cotton insect management program. All values are in 1979 dollars.

2/ Changes in revenue reflect gross merchandising receipts.

3/ Changes in salaries and wages paid only, and not net income to business.

4/ Changes in employment reflect changes in man-hours required and not necessarily new employees.

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