BOLL WEEVIL CONTROL STRATEGIES: REGIONAL BENEFITS AND COSTS*

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Throughout the southern states and at the federal level, much attention is being focused on the appropriate strategy for controlling cotton insect pests, particularly the boll weevil. This paper presents estimated economic impacts to farmers, regions and consumers of implementing three alternative boll weevil control strategies. One strategy evaluated is a proposed boll weevil eradication program which involves integrating many controls including insecticides, reproduction-diapause control by early season stalk destruction, pheromone-baited traps, trap crops, early season control with insecticide, and massive releases of sterile boll weevils. The plan is to eradicate the boll weevil in the U.S., and then indefinitely maintain a barrier at the U.S.-Mexico border to prevent future weevil immigration to the U.S.

The other two strategies evaluated are classified as integrated pest management (IPM) programs and as such involve living with the boll weevil and managing the population rather than trying to eradicate. Technology necessary for one of the IPM strategies is currently available and could be put into practice within one year. The other IPM strategy is not presently available but, with additional entomological research, could likely be put into practice in five to ten years. For brevity, the three strategies evaluated in this study will hence forth be referred to as: (1) eradication; (2) IPM-currently available and (3) IPM-available in 5-10 years.

Economic impacts of the three strategies are analyzed at both national and regional levels. The national effects estimated are changes in consumer surplus, producer surplus, and state and federal strategy costs not passed directly on to producers. These three separate effects are aggregated to arrive at the net social benefits (excluding environmental impact) associated with a particular strategy. At the regional level, effects of each strategy on cropping patterns and land values are analyzed.

THE MODEL

Economic effects of the control strategies were estimated with an interregional activity analysis model of the production of eight crops (cotton, corn, sorghum, soybeans, wheat, barley, rye and oats) in the U.S. The objective function of the model is consumer surplus in 21 consuming regions plus producer surplus for the eight crops, less transportation costs. Maximization of this objective function subject to resource constraints gives a competitive market and spatial equilibrium solution [14]. The model includes production activities for major crops in each of 147 producing regions in the U.S.

Included in the model are demand functions for food grains, feed grains and oilmeals in each of 21 consuming regions in the U.S. Also included is a cotton lint demand function representing the total of domestic demand and net export demand.[1] These 64 demand functions were incorporated into the model in a step-wise fashion, being in very small increments. For each function, 340 steps were included. These

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[1]Cotton lint demand was assumed to be: $P = 1.05 - 0.0000001077Q$ where: P = price in cents per pound, Q = thousand pounds of lint. This demand function was subjectively specified after reviewing econometric studies of the demand for cotton. For the demand functions used for the other crops, see Taylor, *et.al.* [18].

steps were just for the relevant range of the demand curve, which was roughly between 50 and 150 percent of the equilibrium price. The method discussed by Duloy and Norton [5] was used to incorporate these demand functions into the linear framework. A substantially lower computational cost is the advantage this linear formulation has over the traditional non-linear one of a surplus objective function. Because the step size is so small, an acceptable degree of accuracy is provided with the linear formulation.

Surplus less transportation costs is maximized in the model subject to: (a) total cropland in each producing region; (b) irrigated cropland in each; (c) supply-demand balance equations; (d) convex combination constraints for each demand function; (e) barge transportation constraints where relevant and (f) upper and lower bounds on acreages of specific crops in each producing region. Readers interested in a detailed specification of the model and/or data should refer to Taylor, Van Blockland, Swanson and Frohberg [18], and Taylor and Swanson [17].

Upper and lower bounds on crop acreages were arbitrarily specified to be 150 percent and 50 percent, respectively, of the 1973 acreage of the crop. However, since flexibility restraints can be important factors in a particular solution, a sensitivity analysis was done for the cotton constraints. The change in the objective function in going from the present situation to an alternative was rather insensitive to the value of flexibility coefficients; furthermore, the ordering of alternatives in terms of net social benefits did not change.

Each boll weevil control strategy was evaluated with the interregional model by changing the per-acre cotton production cost and yield for each production activity and resolving the model.

Change in per-acre costs and yields associated with an adjustment from present insect control practices to the IPM alternatives was obtained from a recent study by Pimentel and Shoemaker [9]. Data were obtained from the entomologist in each state who was most familiar with boll weevil control. Both IPM alternatives have lower producer costs and/or higher yields than the present situation, so it would be to the individual cotton producer's advantage to use the integrated pest management method. For most producing regions, alternatives involve new crop varieties combined with pest management programs. Table 1 gives cost and yield changes associated with the IPM alternatives. Also given are specific strategies associated with each IPM alternative in each cotton region.

The Pimentel and Shoemaker data were supplemented by asking the same entomologists to estimate changes in per-acre costs and yields that would result if the boll weevil were eradicated. It was assumed that the boll weevil eradication program would be successful in terms of eliminating the pest. All entomologists emphasized that because of a paucity of basic entomological data, there was considerable uncertainty about the yield effects of eradication. Each entomologist was shown initial estimates given in each region and was given an opportunity to adjust initial estimates for his region. None adjusted first estimates. Yield and cost changes so obtained are shown in Table 1.

To provide a frame of reference or a benchmark, the model was solved using present boll weevil control methods. A comparison of benchmark cotton acreages with actual 1976 acreages is given in the first two columns of Table 2. This comparison can be used to get a subjective notion of the model's validity. The basic reason for large acreage discrepancy in Oklahoma and Texas is that the model showed dryland production to be more profitable than irrigated production, yet much of the cotton in these states is irrigated.

A comparison of the benchmark solution with a solution using the revised data set based on changes associated with each IPM strategy and eradication indicated expected changes in crop prices, crop production and crop acreages.

RESULTS

Estimated cotton acreage for each cotton state with the three boll weevil control alternatives is shown in Table 2. In many regions there is little to no change from the benchmark acreage. Major changes in cotton acreage included: (1) 90 percent acreage increases in Alabama with eradication; (2) 92 percent acreage increase in Arizona with the current IPM alternative, (3) 34 percent acreage increase in Arkansas for the two IPM alternatives, (4) 14 and 46 percent decrease in acreage in California with current IPM alternative and eradication, respectively, plus an eight percent acreage increase with the IPM available in 5-10 years, (5) 38 percent acreage increase in Louisiana for all but the current IPM alternative, (6) 10 percent acreage reduction in Mississippi with eradication, (7) 44 percent acreage increase in Oklahoma with eradication and a 28 percent acreage decrease for the two IPM alternatives, and (8) six percent acreage decrease in Texas for the IPM available in 5-10 years alternative and four percent acreage decrease for the other two boll weevil control alternatives.

TABLE 1. PER-ACRE COSTS AND YIELDS FOR VARIOUS BOLL WEEVIL CONTROL METHODS

	Control Method									
	Present		IPM-Currently Available			IPM-Available in 5-10 Years			Eradication	
Region	Lint Yield (pounds)	Treatment Cost ($)	Change in Yield (%)	Practice	Change in cost ($)	Change in Yield (%)	Practice	Change in cost ($)	Change in Yield (%)	Change in cost ($)
Central Alabama	500	$50.33	0	(s,d)	-39.08	0	(s,d,r)	-39.08	+30	-37.78
Northern Alabama	500	26.31	0	(s,d)	-17.06	0	(s,d,r)	-17.06	+20	-19.81
Western & Central Arizona	1,100	44.38	0	(x,s,t)	-29.38	0	(x,s)	-29.38	0	0
Eastern Arizona	610	8.16	0	(s)	- 1.51	0	(s)	- 1.51	0	0
Central, E. Central & Southwest Arkansas	539	15.45	+11.3	(s,d)	- .95	11.3	(s,d)	- .95	+ 9.3	- 6.88
Northeast Arkansas	493	3.75	0	(z)	- .75	0	(z)	- .75	+ 5.1	- 2.25
San Joaquin Valley, California	861	18.90	+ 4.5	(z,t)	-16.90	+ 4.5	(z,t)	-16.90	0	0
Southern California	1,300	62.25	0	(x)	-35.25	0	(x)	-35.25	0	0
Above the fall line region, Georgia	450	57.90	0	(s,d)	-11.31	0	(s,r,d)	-26.31	0	-15.00
Below the fall line region, Georgia	450	77.90	0	(s,d)	-11.31	0	(s,r,d)	-46.31	0	-15.00
Louisiana	550	38.50	0	(s,d)	- 4.50	0	(r,d,z)	-38.50	0	-34.65
Delta region of Mississippi	650	34.11	0	(s,p,d,r)	-18.91	0	(s,p,d,r)	-18.91	+ 3.8	- 9.11
Hill region of Mississippi	475	32.60	0	(s)	- 4.60	0	(r,s,d,t)	-15.85	+ 5.3	-25.00
Missouri	500	2.49	0	(s)	+ 1.66	0	(x)	- .09	0	0
New Mexico	750	6.75	0	(s)	- 5.00	0	(x,s)	- 5.00	0	0
Eastern North Carolina	400	53.88	0	(s,d)	-31.62	0	(x,r,s,d)	-42.88	0	-24.66
Western North Carolina	400	36.50	0	(s)	- 3.00	0	(x,r,s)	-25.50	0	- 9.12
Dryland, Southwest Oklahoma	240	3.12	0	(s)	- .52	0	(s)	- .52	+14.6	- 3.12
Irrigated - Southwest Oklahoma	500	22.02	0	(t,s)	-19.87	0	(t,s)	-19.87	+15	- 6.61
Southeast Oklahoma	300	18.89	0	(s)	- .14	0	(s)	- .14	+16.7	- 6.44
Coastal Plains, South Carolina	470	57.32	0	(s,d)	- 6.82	0	(x,s)	-20,82	0	-15.00
Piedmont Region, South Carolina	470	54.75	0	(s,d)	-12.25	0	(x,s)	-21.25	0	-15.00
Northern Tennessee	600	11.76	0	(s)	-11.76	0	(r,z)	-11.76	+10	- 7.76
Southern Tennessee	600	49.32	0	(s,d)	-15.82	0	(r,s)	-43.82	+12	-40.12
Texas Blacklands	150	7.96	0	(y,s)	- 2.96	0	(r,x,s)	- 4.46	+16	- 1.84
Central Texas River Bottoms	500	15.92	0	(s)	- 6.92	0	(x,s)	-10.67	- 2.3	- 3.68
High Plains of Texas	270	1.75	0	(z)	0	0	(z)	0	0	0
Texas Lower Gulf Coast	400	7,80	0	(y,s)	- 2,80	0	(r,x,s)	- 4.30	+ 2.9	- 1.84
Texas Lower Rio Grande Valley	425	42.81	0	(s,y)	-17.81	0	(x,s,y)	-25.31	+ 5.7	- 1.06
Texas Polling Plains	196	1.33	0	(n,d)	- 1.33	0	(r,x,d)	- 1.33	+ 4.2	- 1.38
Trans Pecos region of Texas	550	39.67	0	(s,c)	-26.93	0	(s,x,c)	-30.68	0	0
Upper Gulf Coast of Texas	400	5.70	0	(y,s)	- .70	0	(r,x,s)	- 2.20	+ 2.9	- 1.61

Practice code:
s = scouting; d = diapause; r = resistant variety; z = regular; p = phermones
x = short season; t = trap crop; y = sanitation; n = no treatment; c = crop culture

Land Rent

Table 3 presents the change in annual producer surplus, which is change in the economic rent to land in each cotton producing state. This provides some insight into landowner benefits (or costs) that could be expected with the alternative boll weevil control methods.

Aggregated land rent in the 14 major cotton producing states is less for the alternative boll weevil strategies considered when compared to present insect control practices.[2] This means that a change from the present insect control situation (benchmark) to one of the alternatives evaluated would result in a landowner and hence, farmer cost or loss in the

[2] This is, of course, average rent to all land and not just to land used to produce cotton.

TABLE 2. ACTUAL AND MODEL COTTON ACREAGE BY STATE FOR ALTERNATIVE BOLL WEEVIL CONTROL METHODS

State	1975 actual acreage (only that endogenous to the model)	Control Method			
		Benchmark	IPM Currently Available	IPM-available in 5-10 years	Eradication
	- - - - - - - - - - - - (1000 acres) - - - - - - - - - - - -				
Alabama	440	261	261	261	497
Arizona	269	118	226	118	118
Arkansas	800	785	1,053	1,046	786
California	900	973	838	1,046	521
Georgia	160	150	150	150	150
Louisiana	320	416	416	576	576
Mississippi	1,175	1,029	1,029	1,029	930
Missouri	235	155	155	155	155
New Mexico	100	88	88	88	50
North Carolina	55	89	89	89	89
Oklahoma	370	1,757	1,267	1,267	2,526
South Carolina	107	163	163	163	163
Tennessee	335	237	237	237	237
Texas	4,350	8,395	8,027	7,882	8,027
Total	9,616	14,616	13,999	14,107	14,825

TABLE 3. ESTIMATED ANNUAL LAND RENT CHANGES[a] BY STATE AND BOLL WEEVIL CONTROL ALTERNATIVE

State	Control Alternatives		
	IPM-Currently Available	IPM-Available in 5-10 years	Eradication
	- - - - - - - - ($1000) - - - - - - - -		
Texas	-69,989	-75,896	-93,832
Oklahoma	-10,573	-11,455	23,006
South Carolina	0	0	0
Georgia	0	0	0
Arkansas	8,374	5,689	1,482
Alabama	0	0	5,606
North Carolina	0	0	0
Tennessee	0	0	0
New Mexico	-717	-818	4,798
Arizona	-306	-299	112
California	33,590	30,716	-36,681
Mississippi	868	-753	-7,677
Louisiana	-5,197	14,926	3,684
Missouri	0	0	0
Total	-43,950	-37,890	-99,502

[a]Changes are relative to the benchmark model land results.

aggregate. Of particular significance is the $100 million annual cost associated with eradication. Discounting future returns at an eight percent rate suggests that land values in the United States would be $1.35 billion lower with boll weevil eradication. This is most dramatic, since many cotton farmers and farm organizations strongly support and, in some cases, partially fund the boll weevil eradication program.

Becoming more specific, with boll weevil eradication, results indicate that land values would drop $1269 million in Texas, $500 million in California and $104 million in Mississippi. Alternatively, land values would increase by $311 million in Oklahoma, $20 million in Arkansas, $65 million in New Mexico and $50 million in Louisiana.

The two IPM alternatives impact differently among the states relative to effect on land rent. In aggregate, however, the IPM currently available alternative would be expected to reduce farmers' returns to land by $44 million annually compared to $38 million for the IPM available in 5-10 years. This analysis raises some disturbing equity questions. Landowners in several states where the boll weevil is not a major pest would be negatively impacted by an eradication program. Further, the aggregate impact on landowners in present value terms is a wealth decrease of $1350 million; and this is for a program that is being advocated as beneficial to cotton producers. This means that although there are some farmers who derive benefits from the program, they do not receive sufficient benefits in the aggregate to be able to bring the losers back to their original position.

Social Benefits

Gross annual benefits to society were measured by the change in consumer plus producer surplus, which is the change in the objective function of the model. While there remains some controversy over such a qualification of social welfare, applications of this concept are widely made [1, 4, 6, 7, 12, 13 and 16]. Further, there are no practical or workable alternatives to this measure that have fewer shortcomings [4, 6].

The present value to society of a stream of these surplus changes into perpetuity are shown in the first column of Table 4. The second column of Table 4 gives estimates of present value costs of the IPM current alternative and the eradication program. These costs are not directly paid by producers. The cost of inducing producers to adopt the IPM current alternative is based on results of recent pilot pest

TABLE 4. PRESENT VALUE OF SOCIAL BENEFITS AND COSTS FOR THE ALTERNATIVE CONTROL METHODS[a]

Control Method	Present value of a stream of consumer plus producer surplus changes into perpetuity	Present value of non-producer program costs	Present value of social net benefits
	- - - - - - million dollars- - - - - -		
IPM-Currently Available	1,431	-176	1,255
IPM-Available in 5-10 years	1,890	N.A.[b]	N.A.
Eradication	1,985	-1,062	923

[a]All future costs and benefits were discounted at an annual rate of eight percent. All prices are for a 1973 base.

[b]Cost of developing the future alternative and of inducing producers to adopt the new technology is unknown.

management programs for cotton.[3] Because of obvious difficulties in extrapolating the effectiveness and cost of these pilot programs to all areas, the estimate shown in Table 4 should by no means be regarded as definite. The estimate of present value of the eradication program was obtained from a cost analysis by Cotton Incorporated.[4] Unfortunately, the cost of developing and inducing producers to adopt the IPM alternative that may be available in 5-10 years is not known.

Net present value figures for alternative control methods are shown in the last column of Table 4. An eradication program, compared to what cotton producers are now doing, would yield substantial benefits to society. However, the IPM current alternative was found to have a higher (by $332 million) value to society than the eradication program.

Because public cost of the IPM alternative that may be available in the future is not known, one cannot directly compare its net social value to that of other alternatives. However, one can say that if it costs less than $636 million to develop and implement the program, it would be to society's advantage to initiate the IPM alternative available in 5-10 years compared to the current IPM alternative and eradication.

The consumer benefits accrue primarily to consumers of cotton lint; only very small price and quantity changes were found for the other products. The price of cotton lint declines by 7.3 percent under the IPM current alternative, by 8.2 percent under IPM alternative that may be available in the future, and by 11.5 percent with eradication of the boll weevil.

LIMITATIONS OF THE MODEL AND ANALYSIS

Many potential model deficiencies should be considered when evaluating validity of the results. Factors not incorporated into the model include: (1) lags in adjustments to the introduction of new boll weevil control methods; (2) heterogeneity of crop production and land base within each of the 137 producing regions; (3) transportation of commodities between producing regions within a consuming region; (4) noncost factors such as risk and uncertainty that influence farmer decision-making; (5) financial aspects of crop production and (6) lack of hard data on cost and production effects of alternative cotton pest control and production strategies.

Perhaps the model's greatest weakness is that it does not account for significant dynamic pest population factors. For example, effects of the build-up of insecticide resistance to future applications were not accounted for in the comparative static analysis.[5] Unfortunately, a dynamic spatial equilibrium model would require an immense amount of empirical data not presently available and would be prohibitively expensive to run.

CONCLUSIONS

Boll weevil control alternatives are being developed and proposed basically to benefit farmers. This analysis strongly suggests that in the aggregate, farmers in their role as landowners would not benefit from the programs. Rather, landowners would lose because land values would fall. Consumers of cotton

[3]Annual operating costs for pilot cotton pest management programs ranged from $1.30 to $5.50 per-acre per-year [11]. Based on the effectiveness of these pilot programs as reported by RvR Consultants, it was assumed that it would take three years for such a program to induce farmers to adopt currently available control methods. It would be noted that, *ceteris paribus,* both current and future alternatives would increase the profit of the individual producer so there is a strong adoption incentive. Total cost in Table 2 for the current alternative was based on the $5.50 per-acre per-year figure and, thus, may overestimate the cost of a pest management program.

[4]This cost was obtained by discounting at an 8% annual rate, the annual costs of the eradication program that were determined by Cotton Incorporated. The undiscounted cost of the program is $1428 million. These estimates include costs incurred only over the next ten years. Not included are: (a) cost of indefinitely maintaining a barrier at the U.S.-Mexico border; (b) cost of monitoring for boll weevil outbreaks in the interior U.S.; or (c) cost of treating any outbreaks.

[5]For a conceptually superior, but at present empirically unworkable model, see the dynamic stochastic model presented by Taylor [15].

however, would benefit through lower prices.

Another major implication of this study is that eradication may not be the optimum boll weevil control alternative for either society or producer. The analysis suggests that an IPM alternative requiring some additional research, but that potentially could be put into practice in five to ten years, may have the largest potential. However, likely cost of acquiring these benefits needs to be carefully considered. A boll weevil IPM control alternative, which presently exists and could be put into practice within one year, would provide social benefits of $332 million more than an eradication program. Thus, with this magnitude of difference between social benefits for IPM and eradication, very serious questions as to the economic feasibility of boll weevil eradication must be acknowledged. These results suggest that the estimates of change in yields and costs for the different boll weevil control strategies would have to be grossly inaccurate to change the basic solution and thus the recommendation of this report.

Given findings of this study as reported above, it seems appropriate to conclude by quoting a part of a 1932 Harold Callendar article that employed the Alice in Wonderland theme:

> "There are economists," said the Hatter, "who have seen what was happening and warned us. But they are only scholars who lecture and write books. The practical men who run things have no use for the academic mind. But they know the value of the boll weevil."
>
> "What is it good for?"
>
> "It eats up the cotton crops and keeps prices from falling," explained the Hatter. "Were it not for the boll weevil we should have magnificent crops, and then the South would be ruined."

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