The Texas Journal of Agriculture and Natural Resource 23:50-63(2010)

The Economic Impact of Boll Weevil Eradication in Texas

Dean A. McCorkle
John R.C. Robinson
Dan Hanselka
Steven L. Klose
Texas AgriLife Extension Service, Department of Agricultural Economics, The Texas A&M University System, College Station, Texas 77843
Thomas W. Fuchs
Texas AgriLife Extension Service, Department of Entomology, The Texas A&M University System, AgriLife Research and Extension Center, San Angelo, Texas (retired)
Charles T. Allen
Texas AgriLife Extension Service, Department of Entomology, The Texas A&M University System, AgriLife Research and Extension Center, San Angelo, Texas

ABSTRACT

Substantial progress has been made in eradicating the boll weevil from the majority of the cotton producing regions in Texas. While the full economic benefits will not be realized until eradication is achieved statewide, the cumulative economic benefits to growers from 1996 to 2007 are estimated to be over $1 billion.

KEY WORDS: boll weevil, cost-benefit ratio, net present value, economic impact

INTRODUCTION

Without a doubt, the boll weevil has been the most destructive insect pest of cotton in Texas and the United States. Efforts to eradicate this insect from the U.S. Cotton Belt began in 1978 with a small, 30,000 acre pilot program conducted in North Carolina. Eradication of the boll weevil rapidly progressed across other southeastern states, as well as western cotton producing states in the 1980's. Texas joined the national boll weevil eradication (hereafter, BWE) program in the mid-1990's, along with several states in the mid-south. To the south of Texas, Mexico has also implemented a BWE program that encompasses all areas that are contiguous with the United States border.

Due to the large cotton acreages involved in Texas, the state was divided into eradication zones. Presently there are sixteen zones (see figure 1) in Texas. New Mexico has one zone in the Texas BWE program, and two zones in Texas include acreage in New Mexico. Eradication zones in Texas include all but seven counties in the state. Since these seven counties are not cotton-producing counties, all cotton acreage in the state is in the BWE program. While not complete at this time, substantial progress has been made in eradicating the boll weevil from the majority of the state's cotton producing regions. This has increased the productivity of Texas cotton, allowed the industry to be more competitive economically, and ultimately reduced insecticide exposure to humans and the environment.

OBJECTIVES: This study focused on four main objectives: 1) estimate the change in net cash flow to cotton growers in Texas as a result of BWE, 2) conduct cost-benefit analysis for each eradication zone in the state, 3) estimate the annual statewide economic benefits to growers, and 4) estimate the economic impact of BWE in 2007 in terms of economic output and employment impacts.

REVIEW OF LITERATURE

Cost-benefit analysis methods have been applied to BWE proposals and also to actual BWE programs. In general, the purpose of these studies was to determine the net economic benefits of BWE to farmers and to society. Most of these published studies measuring the economic benefit of the BWE program can be classified as either before or after-the-fact studies (*ex post*).

The before-the-fact studies tend to rely on more assumptions, and have typically been more aggregate in scope. A national study by Taylor et al., (1983) evaluated the effects of alternative BWE proposals on cotton production. Given the *a priori* nature of the study, the researchers collected expected yield and cost impacts based on expert opinion through a Delphi method. These expected changes in gross returns and variable costs were applied in a general equilibrium simulation model of the U.S. agricultural crop industry. This approach generated price and supply effects for a number of crops and allowed calculation of conventional economic surplus measures. Taylor et al. demonstrated that several eradication scenarios resulted in a higher net social value product than the status quo scenario. However, BWE scenarios had a negative net impact on producer incomes due to lower cotton prices which more than offset the positive effect of higher cotton yields and lower production costs. The Taylor et al. study highlights the importance of the supply response of lower cotton prices due to increased production from BWE, and the resulting impacts on producer benefits.

In contrast to the Taylor et al. study, Szmedra et al., (1991) used crop simulation modeling to simulate BWE scenarios in the Mississippi Delta region. Applying stochastic dominance methods to these results, the authors concluded that BWE strategies were feasible and were preferred by risk adverse farmers compared to “low IPM” or “high IPM” levels without BWE. This study suggests that BWE programs would be supported by growers in areas like Mississippi, which they have been as well as across our present study area (Texas).

Extension economists in various states have conducted a number of unpublished *a priori* studies. For example, Robinson (1995) presented a before-the-fact study of BWE in the Texas Rolling Plains. While this study included cotton price effects, the effects were so small that they were outweighed by the expected savings in boll weevil spray cost. Similarly, Robinson and Vergara (1999) used expected savings in boll weevil yield losses and on-farm sprayings, net of any increase in insecticide costs, to show that BWE in the Mississippi Delta region was still a profitable investment using the net present value criterion. While these studies were *a priori*, similar methodology used for estimating yield savings and changes in boll weevil treatment costs associated with the BWE program was used in our study.

Abernathy et al., (1997), another *a priori* study conducted in the Texas High Plains, used an Agricultural Sector Model to estimate producer costs and revenues associated with boll weevil infested cotton. Based on annual yield losses, increases in insect control costs, and losses associated with acreage shifts to alternative crops from boll weevil infestation, farmer's net incomes were reduced from $189 million to $47 million (a loss of $142 million). This study provides a more in-depth analysis of the economic costs resulting from boll weevil infestations in the Texas High Plains in the absence of an eradication program, and takes into account acreage shifting from cotton to other crops.

The published *ex post* studies have been on various regions of the U.S. Carlson et al., (1982) used cost-benefit analysis to evaluate the investment efficiency of the Southeastern BWE Program in Virginia and the Carolinas. The cost of the Southeastern BWE Program included federal, state, and private (i.e. farmer) expenditures to pay for the administration, labor, and material costs of the program. Program benefits were derived by comparing nine years of post-eradication yield and cost data with baseline data. In addition to yield and cost savings, the researchers noted positive changes in land values as a beneficial effect of BWE. Carlson et al. demonstrated positive net returns and a high internal rate of return for the Southeastern BWE program. The present study also used capital budgeting, but differed in scope from Carlson et al. by focusing on farm level, per acre impacts.

Tribble et al., (1999) conducted a farm-level decision analysis about BWE adoption in Georgia. The study focused on determining the extent to which the increase in planted cotton acreage was directly associated with BWE in the region. Tribble et al. used a Cooley-Prescott adaptive regression model to estimate pre-and post-BWE cotton acreage response. The results indicated that cotton acreage had become more inelastic to own and cross-price changes. As a result of the shift in acreage response and yield increases from eradication, average net producer benefits were estimated at $88.73 per acre. While the methodology and study area used in this study differ from our study, the Tribble et al. study is included in a comparison of results to previous studies found in the Results and Discussion section.

Ahouissoussi et al., (1993) used a survey of producers during a five-year (1986-1990) period to determine the economic viability of the BWE Program in Alabama, Florida, and Georgia. The research team used a comparison of discounted program benefits with discounted costs (private and full) for assessing the net benefits of the BWE program to producers. Results of the study indicated the program increased lint yields by 100 pounds per acre and found a 19 percent internal rate of return for producers over a ten-year period. This level of yield savings is comparable to the yield savings estimates in the most recent years of our analysis.

Another regional *ex post* study of BWE, which included the Southern Rolling Plains of Texas (Johnson et al., 2001), found that in the seven years (1994-2000) it took to declare the boll weevil functionally eradicated, the costs exceeded the benefits in the first two years for a net loss to the producer before the benefits outweighed the costs (net gain) in each of the next five years. On the aggregate level for the entire zone at the end of the 7-year period, the benefits were estimated to be $1.45 for every $1.00 cost incurred by the producer. Given the similarity to our study in terms of study area and methodology, the Johnson et al., study provides interesting results for comparison purposes. It is included in a comparison of results to previous studies in the Results and Discussion section.

An *ex post* study by Carpio et. al., (2001) analyzed the economics of the cotton boll weevil control in the Texas High Plains. The study found that, at current cotton prices and insecticide costs, a typical farmer's net revenues would increase by $56 per acre annually once the boll weevil had been completely eradicated.

This present study is important in part because the Texas BWE program has been implemented statewide, e.g. all cotton-producing counties are in the BWE program. Significant progress has been made towards eradication in all zones since the program was initiated. In 2009, there were no boll weevils caught in nine of the sixteen zones and 80% of the state's cotton acreage was boll weevil-free. This study also uses input-output modeling to assess the broader economic implications, such as employment impacts and economic output, associated with boll weevil eradication in the farm and ginning sectors in Texas.

MATERIALS AND METHODS

The economic impact of the BWE Program was measured in terms of the change in net cash flow to cotton producers in 11 of the 16 boll weevil eradication zones in Texas (Figure 1). Zones 2, 13, 16, and 17 were excluded from this analysis because they just entered the program (2004 and 2005) and thus have not had enough time to realize any affects of eradication efforts. Zone 12 was excluded due to a unique situation where the primary pest was pink bollworm rather than boll weevil. Excluding this zone does not significantly affect the results due to the small number of cotton acres in this area (less than 1% of the state's cotton acres).

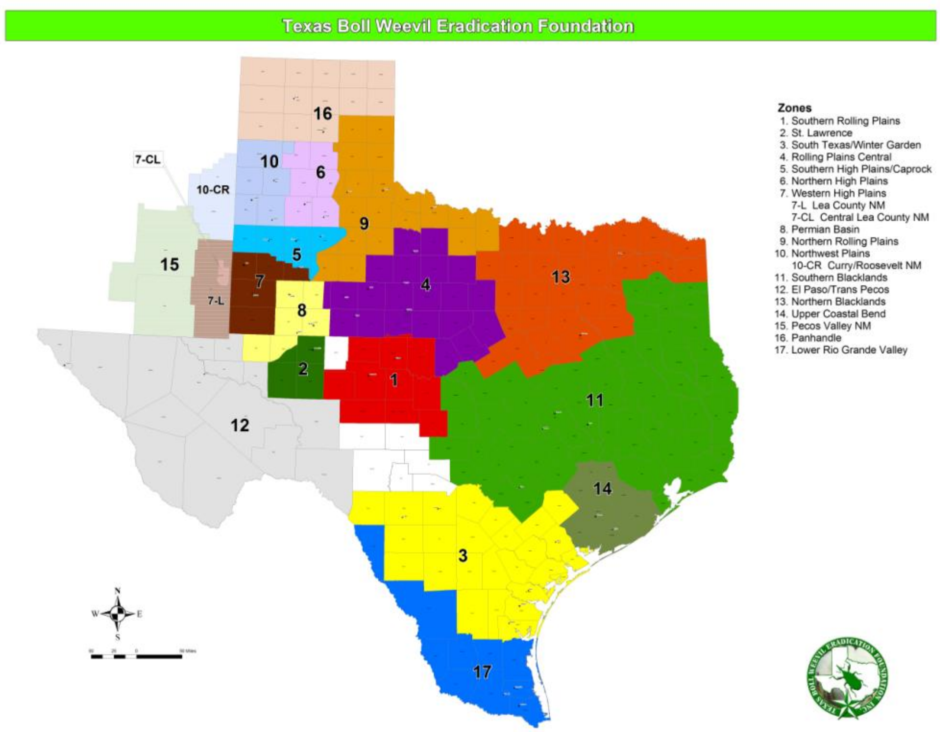

Figure 1. Texas Boll Weevil Eradication Zones.

This analysis expands on a BWE economic assessment by Robinson and Barham (2005). The analytical approach involved quantifying a multi-year average boll weevil treatment cost and yield loss for each zone prior to the start of the BWE program. This formed a baseline prior to the eradication program for each zone. To assess the economic changes relative to the baseline, for each eradication zone, the baseline was compared to post-BWE program annual boll weevil yield losses, boll weevil program assessment fees, other boll weevil treatment costs, and harvesting and ginning costs associated with the changes in production. Hereafter, the additional harvesting and ginning cost is referred to as "other cost changes."

Several data sets were used in the analysis. Secondary yield data consisted of county yield data collected by the USDA - National Agricultural Statistics Service for both irrigated and non-irrigated cotton (USDA-NASS) (Table 1). To estimate yield losses caused by boll weevils and insecticide costs for controlling boll weevils, annual yield loss and insecticide costs data from the Beltwide Cotton Conference - Cotton Pest Loss Database (2006) were used. Historical BWE program assessments were obtained from the Texas Boll Weevil Eradication Foundation (Allen, 2007).

Table 1. Post BWE Average Yields for Zones 1 through 7 (lbs. lint per acre).

	TBWEF Zones					
	1	3	4	5	6	7
1996	372	353	288			
1997	392	492	396			
1998	375	407	339			
1999	280	810	240			421
2000	178	751	250			378
2001	248	627	257	342	579	391
2002	298	641	377	455	636	493
2003	310	783	327	371	643	491
2004	515	885	506	686	757	720
2005	538	744	547	650	811	803
2006	392	880	289	464	806	681
2007	722	915	760	749	1,002	787

Table 1. Post BWE Average Annual Yields, for Zones 8 through 14 (lbs. lint per acre) and the State Average Price (*continued*).

	TBWEF Zones					
	8	9	10	11	14	State Avg. Price*
1996	378			392	523	$0.66
1997	417			498	581	$0.60
1998	460			412	353	$0.56
1999	317	310	547	612	659	$0.52
2000	294	237	520	406	543	$0.52
2001	320	310	713	504	723	$0.52
2002	351	390	844	676	783	$0.52
2003	323	354	725	620	643	$0.58
2004	452	556	817	743	701	$0.52
2005	576	612	976	724	593	$0.52
2006	474	496	965	661	829	$0.52
2007	729	733	996	813	661	$0.52

* Higher of price or loan rate.

Using the data from the Beltwide Cotton Pest Loss Database, the mean boll weevil insecticide costs per acre over multiple years prior to the eradication program (Pre-BWE) were used to form a baseline for boll weevil (exclusively) insecticide costs (Table 2). The time frame contained in the average varies and was based on the year each zone entered the BWE program, the availability of data in the Beltwide Pest Loss Database, and the number of years each zone had been infested with boll weevils. For the years after each zone entered the eradication program, annual boll weevil insecticide costs were subtracted from the baseline, resulting in the change in boll weevil insecticide costs. Similarly, pre-BWE yield loss estimates were averaged to form a baseline for yield losses attributable to boll weevils (Table 2). The post-BWE average yield loss percentages were compared to the average pre-BWE yield loss percents to obtain an average annual savings in yield loss percentage, which were multiplied by the regional cotton yields, resulting in an estimate of the average annual yield savings (Johnson et al., 2001). The yield savings was valued at the state average cotton price, except for years when the average price was below the USDA cotton marketing loan rate ($0.52/lb). In these years, the yield savings was valued at the loan rate. Cotton seed was valued at the state's average cotton seed price each year.

Table 2. Average Pre-BWE Treatment Cost (per acre) and Yield Loss Percent.

	Average Treatment Cost Pre-BWE	Boll Weevil % Yield Loss Pre-BWE	Time Frame
Zone 1	$10.26	15.45%	(1986-1993)
Zone 3	$15.94	15.00%	(1986-1995)
Zone 4	$8.74	15.52%	(1986-1995)
Zone 5	$9.93	14.87%	(1994-2000)
Zone 6	$9.93	14.87%	(1994-2000)
Zone 7	$6.76	9.28%	(1994-1998)
Zone 8	$6.04	11.21%	(1991-1998)
Zone 9	$5.40	15.97%	(1986-1998)
Zone 10	$6.76	9.28%	(1994-1998)
Zone 11	$12.43	9.39%	(1990-2000)
Zone 14	$23.61	8.08%	(1992-2001)

After comparing preliminary loss estimates using the Beltwide Cotton Pest Lost Database versus subjective grower estimates, there were some notable differences in the results. In general, the yield impacts estimated with the published Beltwide Cotton Pest Lost Database were five to ten times smaller than results obtained by interviewing growers (Robinson and Barham, 2005). Upon consultation with the entomologists who made the original Beltwide estimates, they revisited their original boll weevil yield loss estimates. This resulted in increasing the yield loss estimates in wet years. Extension Entomologists revised some of the published Beltwide boll weevil yield loss percentages, increasing them in wet years by 25% for Zones 1, 4, 8, 9, and 11, 20% in Zones 5, 6, 7, and 10, and tripling the yield loss in Zones 3 and 14 (Fuchs et al., 2006).

One of the difficulties in assessing the yield impacts attributable to BWE is the almost simultaneous introduction of improved cotton varieties, including the Bt transgenic cotton varieties. Both BWE and the adoption of improved cotton varieties have resulted in increased yields, however, the impacts of improved varieties would not have been as significant without BWE.

Annual insecticide cost savings per acre, yield loss savings per acre, BWE assessments per acre, and other cost changes (e.g. the cost of harvesting and ginning additional production) per acre were used in calculating growers annual change in net cash flow per acre resulting from BWE, net present value of the cash flows, and cost-benefit ratios. Cost-benefit analysis followed standard methodology and was conducted for the period beginning with the year the eradication program began in each zone, through 2025 (Sassone and Schaffer, 1978). Since BWE takes many years to achieve, net present value (NPV) was used to facilitate the benefit-cost analysis. NPV is useful in investment analysis when dealing with cash flows over multiple years, and involves calculating the net present value at a single point in time of all cash inflows and outflows using a discount rate. In this fashion, the NPV criterion directly accounts for the timing and magnitude of the cash flows (Barry et al., 1983). In calculating NPV, a desired rate of return is often used as the discount rate.[1] A discount rate of 5% was used in this analysis based on the premise that Texas growers were financing the program with their own equity, and 5% would be a conservative, expected rate of return had the funds been put to an alternative use. Sensitivity analysis on the cost-benefit ratios was also conducted to evaluate the effects of higher discount rates.

Boll weevil yield loss estimates have declined since the eradication program, causing production to increase relative to the pre-BWE time frame and creating downward pressure on cotton prices. Given estimates of market conditions, the estimated price impacts were -\$0.003 per pound for 1996, -\$0.002 for 1997, -\$0.003 for 1998, and -\$0.002 for 2003.[2] Applying these price adjustments to cotton production statewide resulted in the following reductions in statewide net benefits: \$6.1 million (1996), \$5.9 million (1997), \$5.6 million (1998), and \$4.1 million (2003).

RESULTS and DISCUSSION

Using the acreage by zone, and the data and methods previously described, the change in total net cash flow was estimated for each zone from 1996 to 2007, and projected through 2025. An illustration of how net present value and cost-benefit ratios were calculated is shown in Table 3. A positive net present value and a cost-benefit ratio greater than one are both preferred, and are an indication of a good investment. Using the data for Zone 1, Southern Rolling Plains as an example, the table contains columns for grower assessment costs, other cost changes, boll weevil spray (treatment) cost savings, boll weevil yield savings, total costs, total benefits, and growers' net cash flow. Using the growers' net cash flow and a discount rate of 5%, the net present value for Zone 1 is estimated at \$357 per acre. Cost-benefit ratios for all eradication zones were calculated as the NPV of benefits divided by the NPV of costs for the period 1996-2025. For Zone 1, the cost-benefit ratio was estimated at 2.05 (\$699.15 divided by \$341.21); meaning there is \$2.05 in benefits for each dollar of costs incurred by growers. Price impact estimates were obtained from the Food and Agricultural Policy Research Institute at the University of Missouri (March 2007)

While the costs and benefits per acre vary by zone, some additional explanation of the costs and benefits for Zone 1 (Table 3) will be useful for understanding the costs and benefits for all zones. Future BWE assessment fees (2007-2025) for all zones were provided by the Texas Boll Weevil Eradication program. These assessment fee estimates are constant from 2007 to 2025 within each zone, but are not the same for all zones. To be on the conservative side, a 3-year average of BW yield savings for 2005-2007 was used for future years. This convention is conservative because is assumes no increase in average cotton lint yields in future years. Annual boll weevil insecticide costs were subtracted from the baseline, resulting in the change in boll weevil spray (treatment) costs, labeled "BW Spray Cost Savings" in Table 3. For each zone, the annual BW Spray Cost Savings for the initial year through 2007 was adjusted for inflation using the NASS

---

[1] The formula for calculating net present value is $\text{NPV} = \sum_{j=1}^{n} \frac{values_j}{(1+rate)^j}$ where *n* is the number of cash flows in the list of values, *j* is the time period, *rate* is the rate of discount over the length of one period, and *values* is the present value of a given period.

inflation index for agricultural chemicals (USDA:NASS, 1996-2007). For 2008 through 2025, an annual inflation rate of 2% was used for BW Spray Cost Savings and Other Cost Changes.

Table 3. Representative Farm-Level Cash Flow and Summary Investment Values From Boll Weevil Eradication and Selected Longer Season Management Practices for All Cotton in TBWEF Zone 1, Southern Rolling Plains (Nominal Dollars per Acre).

Year	Grower Assessment (a)	Other Cost Changes (b)	BW Spray Cost Savings (c)	BW Yield Savings (d)	Total Benefits (e)= (c+d)	Total Costs (f) = (a+ b)	Undiscounted Growers Net Cash Flow (g) = (e-f)
1996	$11.53	$9.12	$10.61	$35.19	$45.81	$20.65	$25.16
1997	$11.34	$10.06	$5.97	$35.55	$41.52	$21.40	$20.12
1998	$11.15	$9.85	$10.43	$32.51	$42.93	$21.00	$21.93
1999	$5.28	$7.35	$10.17	$22.50	$32.67	$12.63	$20.03
2000	$10.85	$4.68	$10.17	$14.30	$24.47	$15.53	$8.95
2001	$9.00	$6.51	$10.34	$19.93	$30.27	$15.51	$14.75
2002	$8.87	$7.83	$10.09	$23.94	$34.03	$16.70	$17.33
2003	$8.91	$8.14	$10.43	$27.64	$38.07	$17.05	$21.01
2004	$6.00	$14.32	$10.26	$41.38	$51.63	$20.32	$31.31
2005	$5.00	$15.79	$10.34	$43.23	$53.57	$20.79	$32.77
2006	$5.00	$11.81	$10.76	$31.50	$42.26	$16.81	$25.45
2007	$4.00	$21.75	$10.42	$58.01	$68.43	$25.75	$42.67
2008	$4.00	$22.19	$10.62	$44.24	$54.87	$26.19	$28.68
2009	$4.00	$22.63	$10.84	$44.24	$55.08	$26.63	$28.45
2010	$4.00	$23.09	$11.05	$44.24	$55.30	$27.09	$28.21
2011	$4.00	$23.55	$11.28	$44.24	$55.52	$27.55	$27.97
2012	$4.00	$24.02	$11.50	$44.24	$55.74	$28.02	$27.73
2013	$4.00	$24.50	$11.73	$44.24	$55.97	$28.50	$27.48
2014	$4.00	$24.99	$11.97	$44.24	$56.21	$28.99	$27.22
2015	$4.00	$25.49	$12.20	$44.24	$56.45	$29.49	$26.96
2016	$4.00	$26.00	$12.45	$44.24	$56.69	$30.00	$26.70
2017	$4.00	$26.52	$12.70	$44.24	$56.94	$30.52	$26.42
2018	$4.00	$27.05	$12.95	$44.24	$57.20	$31.05	$26.15
2019	$4.00	$27.59	$13.21	$44.24	$57.45	$31.59	$25.87
2020	$4.00	$28.14	$13.47	$44.24	$57.72	$32.14	$25.58
2021	$4.00	$28.70	$13.74	$44.24	$57.99	$32.70	$25.28
2022	$4.00	$29.28	$14.02	$44.24	$58.26	$33.28	$24.99
2023	$4.00	$29.86	$14.30	$44.24	$58.54	$33.86	$24.68
2024	$4.00	$30.46	$14.59	$44.24	$58.83	$34.46	$24.37
2025	$4.00	$31.07	$14.88	$44.24	$59.12	$35.07	$24.05
				Net Present Value	$699.15	$341.21	$357.94
						Cost-Benefit Ratio	2.05

The net present values for all eradication zones are presented on a per-acre basis for the 1996 – 2025 period in Table 4. The NPVs range from a low of $119 per acre in BWE Zone 11 to a high of $533 for BWE Zone 6. The reason for so much variation in the NPV's across the state is because of the differences in the level of productivity among the zones. Eradication of the boll weevil will generally lead to greater benefits in areas with higher productivity. This could include areas with ample irrigation or dry land areas that have benefitted from generous summer rains in recent years.

Table 4 also contains the cost-benefit ratios which range from a low of 1.28 in BWE zone 11 to a high of 2.14 in BWE zone 6. A cost-benefit ratio of 1.28 means that each dollar spent by growers results in estimated benefits of $1.28.

Table 4. Net Present Value and Cost-Benefit Ratio From the Texas Boll WeevilEradication Program (1996-2025).

TBWE Zones	NPV ($/Acre)[1]	Cost-Benefit Ratio
Zone 1	$357.94	2.05
Zone 3	$263.29	1.34
Zone 4	$316.56	1.91
Zone 5	$391.34	2.08
Zone 6	$533.80	2.14
Zone 7	$188.05	1.65
Zone 8	$221.02	1.78
Zone 9	$261.99	1.62
Zone 10	$296.12	1.95
Zone 11	$119.33	1.28
Zone 14	$285.25	1.68

[1.] Cost-benefit ratios are calculated as the NPV of benefits divided by the NPV of costs for the period 1996 – 2025, using a discount rate of 5%.

To evaluate the sensitivity of the cost-benefit ratios to the discount rate, additional analyses were conducted using higher discount rates of 7.5% and 10.0%. Using a discount rate of 7.5%, the cost-benefit ratios range from a low of 1.24 (Zone 11) to a high of 2.16 (Zone 6). With a discount rate of 10.0%, the cost-benefit ratios range from a low of 1.19 (Zone 11) to a high of 2.18 (Zone 6). Thus, the cost-benefit ratios are robust over this range of discount rates.

Table 5 summarizes the total land acreage enrolled in the Texas BWE program, annual total net benefits for all zones included in this study, annual net benefits per acre, and the cumulative benefits. Annual net benefits to growers are presented in 2007 (real) dollars, which is also the basis for the cumulative net benefits. Annual net benefits have increased as acreage in the eradication program has climbed from 1.4 million acres in 1996, to over 5 million acres in 2007. Annual net benefits to growers have increased from $19.4 million in 1996 to $232.2 million in 2007. The statewide cumulative net benefit (1996-2007) of the BWE program is an estimated $1.4 billion.

On a per acre basis, average annual net benefits to producers increased from $13.15 in 1996 to $46.15 in 2007 on a statewide basis. In comparison to previous studies, Carpio et al., (2001) found net benefits to Texas High Plains producers of $56 per acres after eradication was achieved. For the three eradication zones in the Texas High Plains area, our study found net benefits to producers in 2007 of $54 per acre for Zone 5, $71 per acre for Zone 6, and $30 per acre for Zone 7. These results are very comparable to the study by Carpio et al., which focused on the same study area. In a study of BWE in the South Rolling Plains area of Texas, Johnson et al., (2001) estimated a cost-benefit ratio of 1.45 for the period 1994-2000. This compares to an estimated cost-benefit ratio in our study of 2.05 for the South Rolling Plains (1996-2025). Tribble et al. found net producer benefits on average of $88.73 per acre (ranging from $54 to $116) in Georgia. Reasons for the higher benefits can be attributed to higher insecticide spray costs and yield losses associated with the boll weevil eradication in the study area.

Table 5. Statewide Summary of the Net Benefits to Cotton Producers of the Texas Boll Weevil Eradication Program.

Year	Total No. of Land Acres*	Annual Net Benefit Real Dollars (2007)	Annual Net Benefits Per Acre	Cumulative Net Benefit
1996	1,476,745	$19,419,668	$13.15	$19,419,668
1997	1,113,748	$18,422,515	$16.54	$37,842,183
1998	1,203,037	$30,952,377	$25.73	$68,794,561
1999	3,892,387	($44,641,014)	($11.47)	$24,153,546
2000	4,266,331	$81,030,115	$18.99	$105,183,661
2001	5,803,719	$133,880,149	$23.07	$239,063,811
2002	5,664,936	$152,275,230	$26.88	$391,339,041
2003	5,723,436	$173,038,040	$30.23	$564,377,081
2004	5,982,985	$222,431,130	$37.18	$786,808,211
2005	6,070,076	$219,337,363	$36.13	$1,006,145,574
2006	6,402,723	$198,785,546	$31.05	$1,204,931,120
2007	5,032,700	$232,250,380	$46.15	$1,437,181,500

*Source: Texas Boll Weevil Eradication Foundation (Allen, 2007).

For 2007, the IMPLAN input-output model was used to estimate the economic impact of the BWE program to both growers and cotton ginners.[2] IMPLAN is a widely used economic impact analysis model which uses economic data for each sector of the economy and can be used to estimate how a change in one sector affects economic output, employment, and value-added in other sectors of the economy that supply inputs to that sector. This analysis focused on the employment impacts, and economic output - a measure of gross sales (business activity) throughout the economy. There are numerous studies where the IMPLAN model was used in a variety of applications, including economic impact assessment of various issues relating to cotton production, farm policy, and natural resources. Flanders et al., (2006) used the IMPLAN model to evaluate the economic impact of the Georgia cotton industry on the U.S. economy. Their findings suggests the economic viability of the cotton industry is not only important for the

[2] IMPLAN Professional Ver. 2.0, Minnesota IMPLAN Group (MIG), Inc., 2006. Stillwater, MN

agricultural sector, but for all major sectors of the economy. With concern over the future supply of water available for agricultural irrigation, Yates et al., (2009) used the IMPLAN model to evaluate the economic impact of irrigated crop production relative to dry land and limited irrigation crop production in the Texas High Plains region. The study estimated that a loss of agricultural water of this magnitude – though not likely – would result in a loss of $616 million in value added and 7,300 jobs. The future availability of water for agricultural use was also the topic of a study by Howitt et al., (2009). Their results indicate an estimated 21,000 jobs would be lost due to a reduction in water supplies in the Central Valley of California.

The estimated direct impact of the BWE program at the farm-level in 2007 was $232.2 million (Table 6). Economic impact analysis at the farm-level was based on the impacts of the spending of the improved income using household expenditure patterns within the IMPLAN system. An estimated $155.4 million of the increased income was available to be spent and represents the direct impact. The remaining amount that is not spent, $76.8 million, accounts for savings, taxes and interest paid to state and federal government, and purchases of goods outside the state and goods imported from outside the U.S.

The direct impact to the ginning sector was based on the estimated cost of ginning the additional production resulting from BWE. Valco et al., (2004) estimated the average variable cost for ginning at $24.87 per bale. Using this ginning cost estimate, the cost of ginning the additional production in 2007 (1.09 million bales) was $27.3 million and represents the direct impact of ginning.

Table 6 summarizes the farm-level and ginning impacts for 2007. Economic output resulting from expenditures associated with the improved farm-level income was an estimated $266 million, which helped support an additional 2,089 jobs. For the ginning sector, economic output was estimated at $36.4 million, which helped support an additional 186 jobs. Total economic output associated with improved cotton production resulting from BWE was an estimated $302 million, which helped support over 2,275 jobs, directly and indirectly, statewide.

Table 6. Economic Impact of Boll Weevil Eradication (2007).

	Direct Impact ($ millions)	Total Economic Output ($ millions)	Employment
Impacts Farm-Level	$155.40	$266.30	2,089
Impacts to Ginning Sector*	$22.10	$36.40	186
Total Farm-Level and Ginning Sector	$177.50	$302.70	2,275

*This is the impact associated with costs incurred by cotton gins in ginning the additional production.

CONCLUSION

The goal of this study was to assess the economic benefits of BWE in Texas now that the BWE program has achieved statewide participation. Acreage involved in the Texas BWE program has grown from 1.4 million in 1995 to over 5 million today.

The growth and acceptance of BWE was a direct result of the strong public-private partnership that was formed. With the Texas BWE program now including all cotton production in the state, this study is unique in that economic benefits were assessed for the vast majority of the State's cotton production rather than the focus being limited to one or more eradication zones. It should be understood that while the study area is the entire state, the results reflect the economic benefits of BWE that have been achieved thus far. While the full economic benefits will not be realized until eradication is achieved statewide, economic benefits of over $1 billion have already been realized.

Production losses resulting from boll weevil damage have caused significant economic hardship on producers and local economies that are supported by cotton. The importance of reclaiming this lost production through BWE efforts is clear when evaluating the economic impacts associated with BWE. In 2007, BWE progress resulted in an estimated direct impact of $177.5 million which supported an additional 2,275 jobs in Texas.

Caveats to this analysis include having favorable summer moisture to realize BWE yield gains, and avoiding any serious damage associated with new pests in a post-BWE environment, e.g. Lygus or Creontiades bugs.

REFERENCES

Abernathy, J., P. Adkisson, C. Anderson, D. Ethridge, T. Fuchs, L. Jones, R. Lacewell, J. Lesser, B. McCarl, B. Robinson, D. Rummel, E. Segarra, J. Smith, G. Cronholm, T. Doederlein, J. Hunter, D. Palmer, and M. Scott. 1997. "Assessment of the economic impact of the boll weevil in the Texas high plains." Special Report 97-1.

Ahouissoussi, N.B.C., M. Wetzstein, and P. Duffy. 1993. "Economic returns to the boll weevil eradication program." Journal of Agricultural and Applied Economics 25 (2):46-55.

Allen, C. 2007. Interview by author. College Station, TX, February, 7.

Barry, Peter J., J. A. Hopkin, and C.B. Baker. 1983. *Financial Management in Agriculture*. The Interstate Printers and Publishers, Inc., Danville, Ill.

Carlson, G.A., G. Sappie, and M. Hammig. 1982. "Economic returns to boll weevil eradication." USDA-ERS. Agriculture Economic Report No. 621. Washington, D.C.

Carpio, C., O. Ramirez, and S. Armstrong. 2001. "Economics of the cotton boll weevil control in the Texas high plains." Reprinted from the Proceedings of the Beltwide Cotton Conference, Volume 1:256-262(2001), National Cotton Council, Memphis, TN.

Cotton Pest Loss Database. 2006. *Proceedings of the Beltwide Cotton Conference*. National Cotton Council.

Flanders, A., N. B. Smith, and J. C. McKissick. 2006. "Input-Output analysis with public policy objectives: A case study of the Georgia cotton industry". Journal of Agribusiness 24 (2): 221-234.

Fuchs, T., C. G. Sansone, J. F. Lesser, and R. Parker. 2006. Interview by author. College Station, TX, March 8.

Howitt, R., J. Medillin-Azuara, and D. MacEwan. 2009. "Measuring the employment impact of water reductions." Department of Agricultural and Resource

Economics and Center for Watershed Sciences, University of California, Davis. Departmental Publication. Available: http://swap.ucdavis.edu/swapfiles/reportspapers/MeasuringEmploymentImpacts-092909.pdf

Johnson, J.L., C.G. Sansone, T.W. Fuchs and R.R. Minzenmayer. 2001. "Grower-level benefit cost analysis of boll weevil eradication in the southern rolling plains of Texas." *Proceedings of the Beltwide Cotton Conferences*. National Cotton Council. Memphis, TN. Volume 1:227-230.

Robinson, J.R.C. 1995. "Economic impacts of boll weevil eradication." Unpublished Analysis Presented at Texas/Oklahoma Boll Weevil Eradication Workshop, January 3, 1995, San Antonio, Texas.

Robinson, J.R.C. and D.F. Barham. 2005. "Economic evaluation of boll weevil eradication in Texas." A Final Report to Cotton Incorporated Agreement 04-593.

Robinson, J.R.C. and O. Vergara. 1999. "Structural changes to consider in valuing boll weevil eradication programs." *Proceedings of the Beltwide Cotton Conferences*. National Cotton Council (1999):321-324.

Sassone, P.G. and W.A. Schaffer. 1978. "Cost-benefit analysis: A handbook." Academics Press, Inc.: San Diego, California. pp. 182.

Szmedra, P.I., R.W. McClendon, and M.E. Wetzstein. 1991. "Economic risk efficiency of boll weevil eradication." Southern Journal of Agricultural Economics 23: 237- 244.

Taylor, C.R., G.A. Carlson, and K. Reichelderfer. "An aggregate economic evaluation of alternative boll weevil management strategies." Agricultural Economic Research 35(1983):604-9.

Tribble, C.A., C. McIntosh, and M. Wetzstein. 1999. "Georgia cotton acreage response to the boll weevil eradication program." Journal of Agricultural and Applied Economics 31 (3): 499-506.

USDA: National Agricultural Statistics Service (NASS), Texas Field Office. 1996-2007. "Texas Agricultural Statistics." Reports for 1996-2007.

USDA: National Agricultural Statistics Service (NASS), Texas Field Office. 2006. "Texas County Cotton Yield Data." http://www.nass.usda.gov/QuickStats/PullData_US_CNTY.jsp

Valco, T.D., B. Collins., D. Findley., K. Green., L. Todd., R. Isom., and H. Willcutt. 2004. "Cost of Ginning Cotton – Survey Results." USDA: Agricultural Research Service (ARS) Publication.

Yates, J., J. Smith, J. Pate, J. A. Weinheimer, R. Dudensing, and J. W. Johnson. 2009. "Regional economic impact of irrigated versus dryland agriculture in the Texas high plains." Report from the Texas AgriLife Extension Service, Texas AgriLife Research, The Texas A&M University System, and Texas Tech University. http://www.aaec.ttu.edu/acc/Published%20Papers/Proceedings/2010%20Beltwide/Irrigated_Versus_Dryland_FullPaper.pdf