To the Graduate Council:

I am submitting herewith a thesis written by Rebecca Leigh Collins entitled "Factors Influencing West Tennessee Farmers' Willingness to Participate In and Pay for a Boll Weevil Eradication Program." I have examined the final copy of this thesis for form and content and recommended that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

James A. Larson, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

FACTORS INFLUENCING WEST TENNESSEE FARMERS' WILLINGNESS TO PARTICIPATE IN AND PAY FOR A BOLL WEEVIL ERADICATION PROGRAM

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Rebecca Leigh Collins
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DEDICATION

This thesis is dedicated to my parents

Leon and Joyce Collins

and my future husband

David Cochran

IN MEMORY OF

My grandparents

Herman and Beatrice Collins

and

John and Katherine McBride

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Abstract

In the past, there has been little research done to determine the factors that influence farmers' decisions on participating in or paying for a boll weevil eradication program. The objectives of this study were 1) to determine and analyze factors influencing cotton farmers' willingness to participate in a boll weevil eradication program in West Tennessee and 2) to identify and analyze factors influencing cotton farmers' willingness to pay for a boll weevil eradication program.

Data reported by farmers in a 1997 mail survey were used to evaluate farmers' willingness to participate in and pay for a boll weevil eradication program. The survey was conducted to provide information for an economic study of the boll weevil eradication program (BWEP) in Tennessee. Information collected from producers who participated in the survey included the following: (1) cotton production and insect control practices for the 1994, 1995, and 1996 growing seasons; (2) personal characteristics of the principal operator including socioeconomic and demographic characteristics; (3) farm financial characteristics including taxable income; (4) sources of information used by the decision maker to make choices about the BWEP after considering the costs and benefits; and (5) decision maker attitudes about the BWEP. Because the survey was administered immediately after the February 1997 BWEP referendum for Region I, producers who were eligible to vote were asked to indicate how they voted. Producers were also asked to indicate the maximum amount, on a per acre basis, they would be willing to pay for an entire boll weevil eradication program that lasts 5 to 7 years.

A logit model was used to determine the factors that influence West Tennessee farmers' willingness to participate in a boll weevil eradication program. Producer age, boll weevil population for 1995, and eradication program education meetings were significant and positive in determining participation. Boll weevil population for 1996 was significant and negative. The negative sign may be attributed to low boll weevil populations in 1996. The importance of information from the media also had a significant, negative influence on willingness to participate. Boll weevil eradication education programs had the most significant influence on a farmer's willingness to participate in the program.

An ordinary least squares regression model was used to determine the factors that influence West Tennessee farmers' willingness to pay for the boll weevil eradication program. Producer experience growing cotton, cost of boll weevil control, and producer's attitude about damage from boll weevils and insecticide usage after the eradication program were significant explanatory variables and had a positive influence on farmers' willingness to pay for the program. Producer age was significant and negative. The most significant variable that influenced willingness to pay for the boll weevil eradication program was the age of the producer.

Despite a small sample of 26 observations used in the willingness to participate study and 79 observations used in the willingness to pay study, both contain significant information that would prove helpful to cotton farmers, the extension service, the Tennessee Boll Weevil Eradication Foundation, Inc., and other states interested in beginning a boll weevil eradication program. Cotton farmers in northwestern Tennessee that have not yet voted on the BWEP may be able to use these studies to determine their willingness to participate in or pay for the program. These studies may help the extension

service to provide helpful information to farmers on the BWEP. Also, other states may use this information to evaluate the likelihood of implementing a boll weevil eradication program in their area.

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Part 1: Introduction

Introduction

Cotton is an important cash crop in the southern United States and Tennessee. In 1997, cotton produced $209.4 million in total receipts for Tennessee farmers and was the number two ranked cash crop in the state (Tennessee Department of Agriculture). Relative to other crops, cotton is vulnerable to damage caused by pests. According to Williams, boll weevils have caused more yield damage and control costs to Tennessee cotton than any other insect. Farmers have traditionally relied on farm-level control methods to control boll weevils and other insects. These methods include chemical control, mechanical and physical control (tillage, plant material destruction, etc.), and cultural control (crop rotation, time of planting, etc.) (Flint and van den Bosch). The effectiveness of farm-level control measures may be limited because of the ability of the boll weevil to migrate among farms and overwinter in brush, grass, fence rows, etc. (Cross). Another boll weevil control measure that some Tennessee farmers are being asked to consider is the boll weevil eradication program (BWEP). In contrast to farm-level insect control, the BWEP is a cooperative-government-and-grower-sponsored area-wide cotton insect management program (U.S. Department of Agriculture).

Boll Weevil Eradication Program

In 1892, the boll weevil crossed the border from Mexico into Texas and infested the entire cotton belt by 1922 (McPherson and Langham). Since their arrival, boll weevils have caused an estimated $14 billion in control costs and yield losses to the U.S. cotton industry (U.S. Department of Agriculture, Animal and Plant Health Protection Service).

Entomologists proposed an eradication program be implemented to eliminate the boll weevil as a pest in cotton. A 3-year trial eradication program was implemented in North Carolina and Virginia in 1978 (U.S. Department of Agriculture; Brazzel; Carlson and Suguiyama). The trial eradication program resulted in decreased insecticide costs, increased cotton acreage, and a positive impact on related industries such as gins (U.S. Department of Agriculture). The program expanded into the remainder of North Carolina and all of South Carolina in 1983. Since 1985, cotton producers in Arizona, California, Mexico, Alabama, Georgia, Florida, Tennessee, Mississippi and Texas have voted to implement boll weevil eradication programs (Brazzel; U.S. Department of Agriculture).

The boll weevil eradication program (BWEP) was designed to be a cooperative program between the Animal and Plant Health Inspection Service (APHIS) and cotton growers. APHIS was responsible for supplying equipment, administrative and technical support and a portion of program funds. Seventy percent or more of the program costs were to be financed by grower assessments and/or State appropriations (U.S. Department of Agriculture). However, due to cuts in federal funding, cotton producers in future eradication areas may be responsible for equipment and up to 100 percent of the program's cost (Cunningham). The BWEP can only be implemented when 67 percent of growers in a proposed eradication area vote positively in a referendum (Cunningham). By voting in a referendum, cotton farmers are forced to make a group decision as to whether the eradication program will be implemented. Once the program is implemented, all farmers growing cotton in the designated area are required by state law to participate. BWEP personnel, rather than farmers, are responsible for insect control after the program starts.

Currently, Middle Tennessee is in the final stages of the eradication program. In February 1997, a referendum was held for the BWEP in Region I in West Tennessee. The referendum passed with 68 percent of producers voting in favor of implementation (Robinson). Those counties included in West Tennessee, Region I are: Shelby, Fayette, Hardeman, McNairy, Hardin and Tipton in their entirety, and that portion of Haywood County lying south of the Hatchie River. The BWEP for this area will begin in August 1998. The cotton producing counties north of Region I have not yet voted on the BWEP. This northwest area of Tennessee includes a majority of cotton producers, acres, and production in the state (Tennessee Department of Agriculture). Until this research, there was no information available on the factors that influence farmers' decisions about voting in a BWEP referendum or what they would be willing to pay for an eradication program in West Tennessee.

Prior Research

Carlson et al. used a linear yield model based on data from North and South Carolina to estimate an average increase in yields of 69 pounds per acre due to the eradication program. The other estimated economic benefits of the eradication program included an annual cost savings of approximately $30 per acre in insecticide costs and a $14 increase in land value due to producers switching from less valuable crops.

A regression model was used by Ahouissoussi et al. to estimate the yield effects of the BWEP for the Alabama-Florida-Georgia area. They identified a 100-pound-per-acre yield increase that could be attributed to the program. Duffy et al. used a five-year, 0-1 mixed integer programming model to analyze the effects of the BWEP on two Alabama farms. The study showed a 50-90 percent reduction in total pesticide costs, a decrease in boll weevil insecticide applications and an increase in the number of cotton acres per farm (Duffy et al.). Carlson and Suguiyama also reported the major impact of the eradication program to be a reduction in insecticide use.

Hammig et al. evaluated the BWEP in South Carolina and found, on average, program benefits exceeded costs by the fifth year, the average rate of return on investment in the program was 40 percent and an annual savings were $9 to $53 per acre. Cunningham discussed the economic benefits of the overall BWEP suggesting growers are receiving at least $12 back for every dollar they contributed to the program. Some growers have been able to recoup their costs within two years of BWEP implementation. In 1985, Carlson and Suguiyama reported an increase in beneficial insects was evident in cotton fields involved in the BWEP.

Robinson et al. used a linear logit model to determine cotton farmers' willingness to pay (WTP) for the boll weevil eradication program in the Gulf Coast area of Texas. They estimated average willingness to pay for the program to be $64.89 per acre annually for five years. Income, boll weevil control cost and indicated level of support for the program were used to predict an individual's WTP.

Kazmierczak used a qualitative choice model to measure the importance of social, economic and demographic factors on a landowner's or producer's decision to support a BWEP in Louisiana. He suggested age was negatively related to a producer's support for the eradication program and that knowledge, experience, and sources of information were significant in determining a producer's support for the BWEP. Many studies have been done to evaluate the economics of boll weevil eradication, willingness to pay for the BWEP and the factors influencing the level of participation in an eradication program after the program has been implemented. This study will evaluate farmers' willingness to participate and willingness to pay for a boll weevil eradication program before it has been implemented.

Objectives

The objectives of this study were 1) to determine and analyze factors influencing cotton farmers' willingness to participate in a boll weevil eradication program in West Tennessee and 2) to identify and analyze factors influencing cotton farmers' willingness to pay for a boll weevil eradication program.

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Part 2: Factors Influencing Southwestern Tennessee Farmers' Willingness to Participate in the Boll Weevil Eradication Program

Introduction

Cotton is one of Tennessee's leading cash crops that produced $209.4 million in total receipts for farmers in 1997 (Tennessee Department of Agriculture). The insect pest causing the largest yield losses and control costs for producers in the state has been the boll weevil (Williams). Because of the importance of the boll weevil in cotton production, some Tennessee farmers are being asked to consider the boll weevil eradication program (BWEP) as a way to control this pest. The BWEP is a cooperative-government-and-grower-sponsored area-wide cotton insect management program designed to eliminate the boll weevil in a production area (U.S. Department of Agriculture). The program has been successfully implemented in many areas of the U.S. Cotton Belt (Brazzel; U.S. Department of Agriculture).

The BWEP can only be implemented when 67 percent of growers in a proposed eradication area vote positively in a referendum (Cunningham). Once the program is implemented, all cotton producers in the designated area are required by state law to participate. Farmers pay a yearly assessment that lasts from 5 to 7 years to fund the program. Historically, the cost of this producer-funded program has been supplemented with a 30 percent U.S. Department of Agriculture cost share and in some cases, the state implementing the program has provided some additional support. The federal cost share has been eliminated for new areas entering the program. BWEP personnel, rather than farmers, are responsible for boll weevil control after the program starts. However, farmers are still responsible for controlling other cotton insects. Producers may opt out of the program by not growing cotton. This study deals with some of the factors that influence producers' decisions to vote for the BWEP in Tennessee.

Currently, farmers in Middle Tennessee are in the final stages of the eradication program with northern Alabama. In February 1997, a producer referendum was held for the BWEP in several southwestern Tennessee counties bordering Mississippi. The referendum passed with 68 percent of producers voting to start the program in August 1998 (Robinson). Those counties included in the West Tennessee, Region I voting area are: Shelby, Fayette, Hardeman, McNairy, Hardin and Tipton in their entirety, and that portion of Haywood County lying south of the Hatchie River. The cotton producing counties north of Region I have not yet voted on the BWEP. This northwestern area of Tennessee includes a majority of cotton producers, acres, and production in the state (Tennessee Department of Agriculture).

Several studies have evaluated the farm and off-farm costs and benefits of the boll weevil eradication program (Carlson, Sappie, and Hammig; Hammig, Jordan, and Griffin; Ahouissoussi, Wetzstein, and Duffy; Duffy et al.) However, less research has been done to determine the factors that influence farmers' decisions on participating in a boll weevil eradication program. Kazmierczak used a logit model to evaluate the importance of socioeconomic and demographic factors on a landowner's or producer's decision to support a BWEP in Louisiana. He found that age, knowledge of the program, and experience were significant in determining a producer's support for the BWEP. Also, reports of previous performance of other states' programs may play a significant role in determining producers' support. Kazmierczak also suggests that a boll weevil eradication education program centered on the economic benefits associated with area-wide insect management may have a positive impact on producers' support for the BWEP.

Until this research , there was no information on the factors that influence farmers' decisions about voting for the boll weevil eradication program in West Tennessee. Because of uncertainty about the costs and benefits of boll weevil suppression, a farmer's use of information related to the eradication program along with socioeconomic and demographic characteristics of the producer may influence the decision to participate in the program. The objective of this study was to identify and evaluate the important socioeconomic, demographic, and source of information factors that influence West Tennessee farmers' willingness to participate in a boll weevil eradication program.

Theoretical Model

A random utility model was used to determine the probability that a producer will decide to participate in the boll weevil eradication program (Bell et al.). The binary-choice model specified for this analysis represents the dichotomous participate-not participate decision. Producers' participate-not participate decisions from the February 1997 West Tennessee, Region I referendum obtained from a mail survey and a logit procedure were used to fit the model. The estimated model was then used to analyze the probability of participation for an individual having modal characteristics.

The indirect utility function for the eradication program participation decision is:

$$V_i = \beta_o + \beta_1 Y + \beta_2 C + \beta_3 D + \beta_4 I + \epsilon, \tag{1}$$

where V_i is the indirect utility gained by the producer from participating (i=1) or not participating (i=0) in the BWEP; Y is current income from all sources; C is the costs of yield damage and insect control caused by the boll weevil; D is a vector of personal characteristics that influence willingness to participate including socioeconomic and demographic characteristics; I represents a vector of information sources used by the producer to determine participation; β_i are the parameters of the model, and ϵ is the random error term. The subscript for individual responses is suppressed in equation (1).

The probability that a producer will decide to participate in the BWEP is:

$$P_1 = \frac{e^{\mu^{V_1}}}{e^{\mu^{V_1}} + e^{\mu^{V_0}}}, \tag{2}$$

where P_1 is the probability a farmer will vote yes in a BWEP referendum. Equation (2) represents the binary logit model to be estimated for the analysis (Aldrich).

Survey Data

Data for this analysis were from a mail survey of Tennessee cotton producers administered in February and March of 1997 (Edens et al.). The survey was conducted to provide information for an economic study of the boll weevil eradication program in Tennessee. Information collected from producers who participated in the survey included the following: (1) cotton production and insect control practices for the 1994, 1995, and 1996 growing seasons; (2) personal characteristics of the principal operator including socioeconomic and demographic characteristics; (3) farm financial characteristics including taxable income; and (4) decision maker attitudes about the BWEP. Because the survey was administered immediately after the February 1997 BWEP referendum for

Region I, producers were asked if they voted in the referendum and, if so, how they voted. In addition, producers were asked to rate the importance of information they may have used to determine their willingness to participate in the BWEP.

Following general mail survey procedures outlined by Dillman, a cover letter explaining the survey, the questionnaire, and a postage-paid return envelope were sent to 2,327 individuals or entities identified as cotton producers (Bradley; Fraser). The first mailing of the survey instrument was on February 28, 1997. On March 7, 1997, a reminder postcard to return the questionnaire was mailed to all cotton producers. A follow up mailing with another cover letter indicating the importance of the survey and enclosing another questionnaire was sent March 21, 1997, to producers who had not responded to the first mailing or the reminder postcard. The total number of responses to the survey was 802 for an overall response rate of 34 percent. Of those respondents, 258 farmers provided data on their cotton practices. The other respondents indicated that they did not or were no longer producing cotton. The questionnaire used in the survey and the enumeration of the complete results of the survey are in Edens et al.

The number of producers who answered the Region I boll weevil eradication referendum yes-no vote question totaled 63. Of those responses, 28 individuals could not be established as living in or owning land within the referendum area based on the primary county of their farm. Three attempts were made by telephone inquiry to establish either residency or land ownership in the referendum area for these producers. Based on the telephone follow up, the 28 respondents were excluded from the analysis. Of the 35 usable observations, 23 individuals reported that they voted yes and 12 reported that they voted no in the referendum. The 66 percent yes votes in the sample closely parallels the 68 percent yes votes in the Region I referendum (Robinson).

Logit Model Estimation

Dependent Variable

The dependent variable *VOTE* was evaluated as an observed utility measure determined by the reported yes-no decision of the farmer in the BWEP referendum. A value of 1 was assigned to producers who indicated that they voted to start a BWEP in Region I. A value of 0 was assigned to farmers who said they voted against the program.

Independent Variables

Based on the theoretical model, the explanatory variables considered for the empirical logit model were demographic characteristics that describe the farm decision maker, 1996 taxable income reported by the producer, costs of boll weevil damage experienced by the producer in 1994, 1995, and 1996, and sources of information used by farmers to help decide their vote for or against the program. The independent variables used in the model are summarized in Table 1.

The demographic characteristic included in the model was the principal operator's age. The number of years of experience producing cotton was also considered, but was excluded because of high correlation with age and because fewer producers answered the experience question. In other studies involving some form of technology adoption, age was found to be negatively related to adoption (Amponsah; Turner, Epperson, and Fletcher). One reason for this relationship is older producers may tend to resist change (Turner, Epperson, and Fletcher). Older farmers may have a different planning horizon (i.e., how many years left in farming) compared with a farmer who is younger and may expect less benefits to accrue to them because of this shorter horizon when compared to the cost of the program. Due to the high level of correlation between age and experience growing cotton, age is used as a proxy for producer experience. Producer experience growing cotton would be expected to have a positive influence on willingness to participate. Farmers with more experience may be more aware of the risks of not adopting new technology (Kenkel and Norris). Because age is used as a proxy for experience growing cotton and they have opposite signs, the hypothesized sign for producer age is indeterminate.

The income question in the survey was structured to let respondents check one of nine categories (in $30,000 increments) that best fit their taxable income in 1996. A total of 24 out of the 35 producers in the sample answered the income question. Attempts to include this variable in the logit model failed because a global maximum was not found using the maximum likelihood procedure in SAS (SAS Institute, 1997). Given these problems, the income variable was excluded from the empirical model.

The cost of boll weevil damage includes the estimated revenue foregone from yield losses and the expenses of insect control operations targeted at the boll weevil. Farmers in the survey were asked to estimate their yield losses and insect costs for the boll weevil. A number of farmers were unwilling or unable to provide estimates of damage or costs, severely limiting the number of observations for the purpose of estimating the model. To overcome this problem, boll weevil pheremone trap count data collected by extension personnel in each county of the referendum area were used as a proxy for boll weevil damage experienced by farmers. These traps are monitored weekly by extension personnel during April, May, and June (Jones). The number of boll weevils caught in each trap indicates population moving into fields of cotton and causing damage. Higher boll weevil populations may indicate higher revenue losses from boll weevils resulting in a more positive willingness to participate in the BWEP. Thus, the expected relationship between the two is positive, i.e., higher boll weevil populations may indicate higher probability of willingness to participate. Moreover, farmers likely do not make decisions based on what happened in one year but over a longer period. For that reason, spring-time boll weevil population data for the 1994, 1995, and 1996 growing seasons were included as explanatory variables in the model.

In the survey, farmers were asked to rate the importance of the following sources of information used to make eradication program decisions: the extension service, BWEP education programs, magazine and newspaper articles, radio and television reports, crop or integrated pest management consultants, and other farmers. The ordered scale representing the importance of the information is as follows: 1=not important, 2=minor importance, 3=somewhat important, 4=important, and 5=very important. An evaluation of the responses indicated a high degree of positive correlation (0.691) between the extension service and BWEP education programs. The University of Tennessee Extension Service helped conduct education programs for the Southeast Boll Weevil Eradication Foundation, Inc. which has primary responsibility to implement the eradication program in the state. For this reason, the BWEP education program was chosen to represent education information in the model. The eradication education program was hypothesized to have a positive influence on participation. Other studies have found that producers frequently use the extension service as a source of information for decision making (Amponsah; Brown and Collins).

Due to the small number of farmers that listed radio and television reports as a source of information, magazine and newspaper articles were chosen to represent media information in the model. Turner, Epperson, and Fletcher suggested that those producers who read trade magazines were more open to the adoption of new ideas suggesting a positive influence on program participation. On the other hand, negative reports in the media about problems with the program may erode producer support for the eradication program. For example, reports of secondary insect problems allegedly caused by the BWEP led to a recall vote to terminate the program in Mississippi (Luttrell et al.). Consequently, the hypothesized relationship between newspaper and magazine articles and willingness to participate is uncertain.

A small number of respondents rated the importance of information provided by crop/integrated pest management consultants and by other farmers. Therefore, these sources of information could not be evaluated in the model.

Based on the previous discussion, the following Logistic model was estimated:

$$\begin{aligned} log\,(P_i\,/\,(1-P_i)) &= \beta_0 + \beta_1 AGE + \beta_2 BW94 + \beta_3 BW95 + \beta_4 BW96 + \\ &\quad \beta_5 PROG + \beta_6 MEDIA + \epsilon, \end{aligned} \tag{3}$$

where P_i is the probability that a farmer will participate in a boll weevil eradication program; β_i are estimated parameters; AGE represents the age of the principal operator;

BW94, *BW95*, and *BW96* are spring-time boll weevil population entering cotton fields for 1994, 1995, and 1996, respectively; *PROG* represents an ordered scale (1 to 5) of the importance of the boll weevil eradication education programs; *MEDIA* represents an ordered scales (1 to 5) of the importance of newspaper and magazine articles; and ϵ is the random error term.

Parameter Estimates

Due to missing values for one or more of the variables, 9 observations were deleted from the model estimated using the PROC LOGISTIC procedure in the SAS computer program (SAS Institute, 1997). Of the 26 observations used, 19 reported they voted yes and 7 voted no in the referendum. The percentage of yes votes for the 26 observations used in the model is 73 percent which is greater than the 66 percent yes votes with all 35 observations. However, the sample means for the independent variables included in the final model were almost identical for the 26 observations and 35 observation data sets.

The maximum likelihood estimated coefficients and the chi-square probability, change in probability, likelihood-ratio test, pseudo R-square, and prediction success statistics are presented in Table 2. Goodness-of-fit measurements indicate that the model fits the data well. The likelihood-ratio test, which measures the significance of the logit function, has a score of 30.29. The pseudo R-square of 0.40 is in the 0.20 and 0.40 range which Hensher and Johnson consider an "extremely good fit" (Aldrich and Nelson). The model correctly predicts 92.5 percent (24 out of 26) of the responses.

Logistic model parameter estimates cannot be directly used to determine the change in probability from a 1 unit change in the independent variable. To calculate changes in probability, each parameter estimate was multiplied by its sample mean for each independent variable (Table 1). Next, a density function was calculated by the following formula:

$$\frac{e^{\sum_{i=1}^{7}\beta_i \overline{X}_i}}{1+e^{\sum_{i=1}^{7}\beta_i \overline{X}_i}}, \qquad (4)$$

where base e is the numerical value of the natural logarithm function and the exponent $\Sigma\beta_i\overline{X}_i$ is the sum of the parameter estimates, β_i multiplied by the sample means $\overline{X}_i$. The change in probability for each independent variable was found by multiplying the density function by the parameter estimate. The change in probability is a function of the probability itself and when multiplied by 100 is the percentage change in the probability of the event occurring given a one unit change in the variable, ceteris paribus. For example, a 1 level increase in importance of information from *PROG* resulted in a 11.37 percent increase in the probability of the decision maker voting for the program in the 1997 referendum.

Evaluation of the model parameter estimates indicates that the *AGE*, *BW95*, *BW96*, *MEDIA*, and *PROG* variables were statistically significant at the 5 or 10 percent probability levels. The *BW94* variable was not a significant variable in explaining the yes-no votes in the referendum.

The *AGE* variable positively influences producer willingness to vote for the BWEP in the model. The positive sign on the *AGE* coefficient is the opposite of the hypothesized relationship. One possible reason is that *AGE* and farmer experience growing cotton are positively and significantly correlated with each other. Farmers with more experience may see the benefit of the eradication program more clearly based on their experience with boll weevil problems.

As expected, the *BW94* and *BW95* variables had positive signs indicating that higher boll weevil populations increased producer willingness to vote for the eradication program. However, the *BW96* variable had a negative sign rather than the hypothesized positive sign and lowered producer willingness to vote for the eradication program. The likely reasons for the boll weevil population influence in the model are as follows. As indicated by the boll weevil population statistics in Table 1, the 1995 growing season was characterized by heavy infestations of boll weevils and other insects that caused large yield losses and control costs for producers. By contrast, the 1996 growing season was characterized by low insect populations. *BW96* is significant with a negative sign. Farmers likely had much smaller yield losses and control costs in 1996, relative to their experience in 1994 and 1995. Due to the high infestation levels experience in 1995, producers likely focused most on problems of that growing season to make their decision which would make the negative sign on *BW96* somewhat spurious. Using the change in probability given in Table 2 for *BW95*, a producer who experienced the maximum boll weevil population (4,902) was 26.5 percent more likely to vote yes for the program than a farmer who experienced the minimum boll weevil populations (3,570) in the sample.

Variables estimating the impact of information on the BWEP decision have the highest significance in the model. The expected positive sign on the coefficient of the *PROG* variable indicates the importance of the education program in influencing producers' support for the program. The ordered scale representing the importance of eradication program information ranges from 1=not important to 5=very important. The change in probability indicates a 1 unit change towards increasing importance of the information. For example, a producer who rated the information with a 5 versus another farmer who rated it with a 4 would be 11.37 percent more likely to vote for the BWEP. Given the change in probability for *PROG*, a producer who stated that the eradication program information was very important was 45.48 percent more likely to vote for the program than a farmer who rated the program information as not important.

The sign on the *MEDIA* variable was negative indicating that newspaper and magazine article information about the program tended to reduce producer willingness to vote for the program. The ordered scale of *MEDIA* information importance also ranges from 1=not important to 5=very important. A one unit increase in the importance of *MEDIA* reduced the probability of voting yes in the referendum by 9 percent. Producers in the sample who rated the information as very important were 35.8 percent less likely to vote in favor of the program than individuals who rated the information as not important.

Taking all the variables together, the producer most likely to have voted yes in the referendum was an older individual with a great deal of experience growing cotton, had high boll weevil populations in 1995, rated eradication program meetings highly, and discounted the importance of negative reports in newspaper and magazines about the program. Results from the logit model also suggest that magazine and newspaper information about events related to the BWEP may have substantially impacted producer decisions in the February 1997 referendum. Negative information about the program is reflected by the inverse relationship between the *MEDIA* variable and willingness to vote for the program.

Discussion

The model results suggest that eradication program education meetings and newspaper and magazine reports were important sources of information for producers making decisions in the February 1997 Region I BWEP referendum. The BWEP education meetings were conducted by personnel from the Southeast Boll Weevil Eradication Foundation, Inc., the Tennessee Department of Agriculture, and the University of Tennessee Extension Service (Tennessee Boll Weevil Eradication Foundation, Inc.). The foundation is a non-profit corporation organized by participating states including Tennessee to carry out the program in the Southeast United States.

Education programs were conducted in each county of the referendum area before the end of the voting period in late February of 1997. The meeting included presentations on how the program works (i.e., program start date and duration, insecticide application criteria, other insect control practices, legal responsibilities of producers, the per acre cost of the program to a producer, and the expected benefits of the program). Producers were told that the five-year program would have a maximum cost of $211.77 per acre of cotton with payments spread over seven years and ranging from $11.77 to $36.45 per acre per year. They were also told that the total cost may be less depending on boll weevil populations and availability of funding from other sources. Expected benefits were defined to include a reduction in direct control costs, a decrease in pesticide usage, and a reduction in direct yield losses caused by the boll weevil. Studies of the positive economic benefits of the program in other areas were cited in the presentation. The potential for Tennessee cotton producers having a competitive disadvantage to other producing areas that have already eradicated the boll weevil was also emphasized in the meeting. According to the model results, these education programs had a significant positive impact on the outcome of the February 1997 referendum. The model suggests that an aggressive education program may be a key factor in gaining producer support for a program in northwestern Tennessee.

Another important factor that may explain voting behavior was information about problems related to the boll weevil eradication program. Media such as *Cotton Grower* magazine and the Mississippi Agricultural and Forestry Experiment Station have printed articles focusing on problems related to the boll weevil eradication program. For example, some growers and crop consultants blame the boll weevil eradication program for causing an increase in damage from secondary pests in Alabama, Mississippi, and Texas in 1995 (Sandusky; Luttrell et al.; Williams and Layton). Intensive applications of malathion may suppress populations of beneficial insects causing populations of aphid, beet armyworms and tobacco bud worms to increase (Jones; Smith; Layton et al.).

In the spring of 1996, growers in eastern Mississippi initiated a recall vote where they voted to terminate the eradication program (Luttrell et al.). Also, growers in

Alabama saw an increase in tobacco budworms and armyworms after boll weevil eradication treatments began and a documented resistance to pyrethroids use to control the worm (Jones; Luttrell et al.; Duffy et al.).

The model also suggests that boll weevil populations experienced by farmers prior to the referendum vote can substantially impact the outcome of the referendum. Production areas north of the referendum area in northwestern Tennessee have typically experienced lower boll weevil population levels and consequently smaller levels of yield damage and control costs. For example, producers in northwestern Tennessee reported boll weevil control costs of $12.91 per acre in 1995 compared with $21.05 per acre in southwestern Tennessee (Edens et al.). Boll weevil population levels and severity of infestations along with the total cost of a program may greatly influence the willingness of producers in northwestern Tennessee to implement a program.

Summary and Conclusions

This study evaluated the yes-no responses of cotton producers voting in the February 1997 referendum to start a boll weevil eradication program in West Tennessee. The results of the analysis of producers' responses using a logit model indicated that producer age, high boll weevil populations in 1995, and eradication program education meetings had a statistically significant, positive influence on producers' willingness to participate in the boll weevil eradication program. Boll weevil population in 1996 and the importance of information from the media have a statistically significant, negative influence on willingness to participate. Producers most likely focused on the heavy 1995 boll weevil population over the light population in 1996. Farmers may have been more interested in making sure that the 1995 disaster did not happen again. Importance of information from the media and eradication education programs had the most significant impact on willingness to participate. A producer that rated the importance of media a level 5=very important compared to a level 1=not important increases the probability of participation by 35.8 percent. A producer that rated the importance of the eradication education programs a level 5=very important compared to a level 1=not important increases the probability of participation by 45.48 percent. The identification of these factors may prove to be useful information for decision making about the BWEP in northwestern Tennessee. Boll weevil population levels and severity of infestations along with the cost of the program may influence the willingness of producers in northwestern Tennessee to implement a program. In the past, farmers in northwestern Tennessee have experienced lower boll weevil populations than their southern counterparts (Edens et al.). If boll weevil populations remain low, the boll weevil eradication program may be difficult to implement in this area. On the other hand, if high levels of boll weevils are experienced before the program vote, farmers may be eager to begin the program.

Despite a small sample, this study contains significant information that would prove helpful to cotton farmers, the extension service, and other states interested in beginning a boll weevil eradication program. Cotton farmers in northwestern Tennessee that have not yet voted on the BWEP may be able to use this study to determine their willingness to participate. This study may help the extension service to provide helpful information to farmers on the BWEP. Also, other states may use this study to evaluate the likelihood of implementing a boll weevil eradication program in their area.

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Appendix

Table 1. Summary statistics of the variables used to estimate the logit model for the Boll Weevil Eradication Program producer participation analysis

Variable Name:	Description	Mean	Max	Min	Expected Sign	Stated Hypothesis
VOTE:	1 = willing to participate 0 = otherwise					
AGE:	age of the respondent	46	71	23	?	older producers tend to resist change; however, experience growing cotton and boll weevil problems may positively influence willingness to participate
BW94:	boll weevil population for 1994	539	770	134	+	high boll weevil populations are a proxy for increased revenue losses; it is expected to have a positive influence on participation
BW95:	boll weevil population for 1995	4352	4902	3570	+	high boll weevil populations are a proxy for increased revenue losses; it is expected to have a positive influence on participation
BW96:	boll weevil population for 1996	171	276	64	+	high boll weevil populations are a proxy for increased revenue losses; it is expected to have a positive influence on participation
PROG:	ranking of importance of boll weevil eradication education programs	3	5	1	+	producers rely on the advice of the extension service
MEDIA:	ranking of importance of newspaper and magazine articles read by producers	4	5	1	?	those producers reading trade magazines are more open to the adoption of new ideas

Table 2. Parameter estimates and statistical relationships of the logit model used to evaluate the yes-no votes in the February 1997 West Tennessee, Region I Boll Weevil Eradication Program referendum

Variable Name	Coefficient	Probability Chi-square	Change In Probability/Statistics
AGE	0.3011	0.0558	0.006871
BW94	0.00170	0.6970	0.000039
BW95	0.00870	0.0545	0.000199
BW96	-0.0654	0.0382	-0.00149
MEDIA	-3.9219	0.0360	-0.0895
PROG	4.9818	0.0353	0.113688
Constant	-44.4404	0.0496	-1.01416
Log-Likelihood Ratio Test			30.29
Pseudo R^2			0.40
Prediction Success:		Concordant	92.5
		Discordant	6.8

Part 3: Factors Influencing West Tennessee Farmers' Willingness to Pay for a Boll Weevil Eradication Program

Introduction

Cotton is one of Tennessee's leading cash crops that produced $209.4 million in total receipts for farmers in 1997 (Tennessee Department of Agriculture). The insect pest causing the largest yield losses and control costs for producers in the state has been the boll weevil (Williams). Because of the importance of the boll weevil in cotton production, some Tennessee farmers are being asked to consider the boll weevil eradication program (BWEP) as a way to control this pest. The BWEP is a cooperative-government-and-grower-sponsored area-wide cotton insect management program designed to eliminate the boll weevil in a production area (U.S. Department of Agriculture). The program has been successfully implemented in many areas of the U.S. Cotton Belt (Brazzel; U.S. Department of Agriculture).

The BWEP can only be implemented when 67 percent of growers in a proposed eradication area vote positively in a referendum (Cunningham). Once the program is implemented, all cotton producers in the designated area are required by state law to participate. Farmers pay a yearly assessment that lasts from 5 to 7 years to fund the program. Historically, the cost of this producer-funded program has been supplemented with a 30 percent U.S. Department of Agriculture cost share and in some cases, the state implementing the program has provided some additional support. The federal cost share has been eliminated for new areas entering the program. BWEP personnel, rather than farmers, are responsible for boll weevil control after the program starts. However, farmers are still responsible for controlling other cotton insects. Producers may opt out of the program by not growing cotton. This study deals with some of the factors that influence producers' willingness to pay for the BWEP in Tennessee.

Currently, farmers in Middle Tennessee are in the final stages of the eradication program with northern Alabama. In February 1997, a producer referendum was held for the BWEP in several southwestern Tennessee counties bordering Mississippi. The referendum passed with 68 percent of producers voting to start the program in August 1998 (Robinson). Those counties included in the West Tennessee, Region I voting area are: Shelby, Fayette, Hardeman, McNairy, Hardin and Tipton in their entirety, and that portion of Haywood County lying south of the Hatchie River. The cotton producing counties north of Region I have not yet voted on the BWEP. This northwestern area of Tennessee includes a majority of cotton producers, acres, and production in the state (Tennessee Department of Agriculture).

Several studies have evaluated the farm and off-farm costs and benefits of the boll weevil eradication program (Carlson, Sappie, and Hammig; Hammig, Jordan, and Griffin; Ahouissoussi, Wetzstein, and Duffy; Duffy et al.). However, less research has been done to determine the factors that influence farmers' willingness to pay for a boll weevil eradication program. Robinson, Ozuna, and Lacewell evaluated producer willingness to pay for the boll weevil eradication program for the Texas Gulf Coast area. They found that approximately 75 percent of individuals surveyed were supportive of the BWEP and would be willing to pay $64.89 per acre annually for five years. The largest component of the elicited willingness to pay value was the estimated $46 per acre reduction in boll weevil control expenditures. The balance of $18.63 per acre represents the risk premium a farmer would pay for the program.

Currently, there is no information on the factors that influence farmers' willingness to pay for the boll weevil eradication program in West Tennessee. Because of uncertainty about the costs and benefits of boll weevil suppression, a producer's use of information and attitudes related to the eradication program along with socioeconomic and demographic characteristics of the producer may influence willingness to pay for the program. The objective of this study was to identify and evaluate the factors that influence West Tennessee farmers' willingness to pay for a boll weevil eradication program.

Analytical Framework

The contingent valuation (CV) method was used to estimate cotton producers' willingness to pay for the boll weevil eradication program (BWEP) in West Tennessee. The CV procedure, which involves the elicitation of decision makers' willingness to pay for a specific good or service, is often used to evaluate extra market goods and services (Kenkel and Norris). The CV approach is appropriate for this analysis because of producer uncertainty about the actual cost and benefits of the BWEP in Tennessee. There are several different CV formats that can be used to elicit decision maker willingness to pay: iterative (sequential) bidding, payment card, open-ended question, and dichotomous choice. Iterative (sequential) bidding is where the individual is asked to state his/her willingness to pay and then is questioned on whether he/she would be willing to pay more than the stated amount. The payment card contains a large array of willingness to pay amounts ranging from $0 to a large amount. An open-ended question gives the individual an opportunity to state his/her maximum willingness to pay without any additional questions. With dichotomous choice, the individual is given an amount and asked if he/she would be willing to pay the given amount (Mitchell and Carson). The open-ended question format was chosen to estimate producers' willingness to pay for the BWEP. The open-ended question format avoids the econometric estimation problem with data elicited using the other formats. However, the open-ended format may increase decision maker nonresponse to the willingness to pay question (Cameron and Huppert).

Producers' responses to the willingness to pay for the BWEP question from a 1997 mail survey of Tennessee cotton growers was evaluated using an ordinary least squares model. The model was then used to determine the factors that influence the amount a producer is willing to pay for the BWEP.

The model specified to evaluate the factors that influence producers' willingness to pay for the eradication program is:

$$WTPAY_i = \beta_o + \beta_1 Y + \beta_2 C + \beta_3 D + \beta_4 I + \beta_5 A + \epsilon, \quad (1)$$

where $WTPAY_i$ is the elicited willingness to pay value; Y is the decision maker's current income from all sources; C is a vector of yield damage and insect control costs caused by the boll weevil; D is a vector of personal characteristics that influence willingness to pay including socioeconomic and demographic characteristics; I is a vector of information sources used by the producer to determine willingness to pay; A is a vector of producer attitudes toward the eradication program; β_i are the parameters of the model, and ϵ is the random error term. For convenience in writing, the subscript for individual responses is suppressed in equation (1).

Survey Data

Data for this analysis are from a mail survey of Tennessee cotton producers administered in February and March of 1997 (Edens et al.). The survey was conducted to provide information for an economic study of the boll weevil eradication program in Tennessee. Information collected from producers who participated in the survey included the following: (1) cotton production and insect control practices for the 1994, 1995, and 1996 growing seasons; (2) personal characteristics of the principal operator including socioeconomic and demographic characteristics; (3) farm financial characteristics including taxable income; (4) sources of information used by the decision maker to make choices about the BWEP after considering the costs and benefits; and (5) decision maker attitudes about the BWEP.

To prepare respondents to answer the willingness to pay question, the questionnaire began by asking producers about their planted cotton acreage, harvested lint yields and lint prices received. These questions were relatively easy to answer and served to get producers involved in the survey. Growers were then asked to rank their top three cotton insect problems, what insecticides they used to control each pest, and the number of insecticide applications that were required for control. Producers were also asked to estimate their expenditures for the control of the boll weevil and for all cotton insects, their lint yield losses caused by boll weevils and all cotton insects, and their insect scouting activities and costs. Finally, producers were asked to rank the importance of information they would use to make a decision about the BWEP and their attitudes toward the program. The purpose of these questions was to make the decision maker think about the boll weevil cost and to determine a realistic total willingness to pay for the program. Producers were asked to indicate the maximum amount, on a per acre basis, they would be willing to pay for an entire boll weevil eradication program that lasts 5 to 7 years. Respondents were asked to read a short description of the boll weevil eradication program before answering the willingness to pay question.

Following general mail survey procedures outlined by Dillman, a cover letter explaining the survey, the questionnaire, and a postage-paid return envelope were sent to 2,327 individuals or entities identified as cotton producers (Bradley; Fraser). The first mailing of the survey instrument was on February 28, 1997. On March 7, 1997, a reminder postcard to return the questionnaire was mailed to all cotton producers. A follow up mailing with another cover letter indicating the importance of the survey and enclosing another questionnaire was sent March 21, 1997, to producers that had not responded to the first mailing or the reminder postcard. The total number of responses to the survey was 802 out of 2,327 for an overall response rate of 34 percent. Of those respondents, 258 farmers provided data on their cotton practices. The other respondents indicated that they did not or were no longer producing cotton. The total number of producers who answered the willingness to pay question was 161. The questionnaire used in the survey and the enumeration of the complete results of the survey are in Edens et al.

Model Estimation

Dependent Variable

The dependent variable *WTPAY* is the elicited value of willingness to pay for the boll weevil eradication program reported by farmers.

Independent Variables

Based on the theoretical model specification, the explanatory variables considered for the empirical regression model were the personal characteristics that describe the farm decision maker, the amount of taxable income reported by the producer in 1996, the costs of boll weevil damage experienced by the producer in 1994, 1995, and 1996 growing seasons, the sources of information used by farmers to decide their willingness to pay for the program, and producer attitudes toward the eradication program. The independent variables used in the model are summarized in Table 1.

The personal characteristics of the farm decision maker included in the regression model were the principal operator's age (*AGE*), number of years of formal education (*EDU*), and number of years of experience producing cotton (*EXPER*). The *AGE*, *EDU* and *EXPER* variables were treated as continuous in the regression model. Producer age is hypothesized to be inversely related with willingness to pay for the program. One reason for this relationship is older producers may tend to resist change (Turner, Epperson, and Fletcher; Goodwin et al.). Another factor that may cause a negative sign on the coefficient is the decision maker's expected planning horizon. Older farmers may have a different planning horizon (i.e., how many years left in farming) compared with a farmer who is younger (Goodwin et al.). Older producers may expect fewer benefits to accrue to them because of this shorter horizon when compared to the cost of the program. When considering new technologies, farmers will assess the expected utility derived from the eradication program. If older farmers decide that this new technology will not maximize their expected utility, their willingness to pay for the eradication program may be less than for a producer with a longer planning horizon.

Years of formal education and producer experience growing cotton are both expected to have a positive influence on willingness to pay. Producers with more schooling may be better trained to analyze the costs and benefits of the eradication program using available information. Farmers with more experience may be more aware of the risks of not adopting new technology (Kenkel and Norris). Also, education will likely encourage a positive attitude toward new ideas and a closer examination of the informational sources available on the eradication program (Goodwin et al.).

The income question in the survey was structured to let respondents check one of nine categories (in $30,000 increments) that best fits their taxable income in 1996. All respondents in the sample answered this question. The income variable in the model was structured as a 0-1 binary variable where 1 is for income of $230,000 or more and 0 is for income of $229,999 or less. In examining the distribution of responses for this variable, five respondents were in the top income category whereas the majority of producers were in the two lowest income categories. As income rises, it is expected to have a more positive influence on willingness to pay. Farmers with a larger income, or profit, have fewer financial constraints to adopting new technologies (Ervin and Ervin).

The costs of boll weevil damage were included in the regression model through two explanatory variables: (1) expenditures for boll weevil control and (2) yield losses caused by the boll weevil. Expenditures for boll weevil control were represented in the model by using the average of costs reported by farmers in the 1994,1995, and 1996 growing seasons. Larger expenditures for boll weevil control are expected to positively impact producer willingness to pay for the eradication program (Robinson, Ozuna, and Lacewell). Because activities to control boll weevils may also influence other insect pests, the marginal impact of each dollar increase in control costs on producer willingness to pay may diminish. Therefore, the log base 10 of this variable was used to impose diminishing marginal willingness to pay for the BWEP.

Boll weevil pheremone trap count data collected by extension personnel in each county in West Tennessee were used as a proxy for boll weevil yield damage experienced by farmers. These traps are monitored weekly by extension personnel during April, May, and June (Jones 1997). The total number of boll weevils caught in each trap during this period indicates the populations of boll weevils moving into fields of cotton and causing damage. Higher boll weevil populations may indicate larger revenue losses from boll weevils resulting in a greater willingness to pay for the BWEP. Thus, the expected relationship between the two is positive, i.e., higher boll weevil populations may indicate greater willingness to pay. Moreover, farmers likely do not make decisions based on insect events in any one year, but on their experience over a number of years. For that reason, a three-year average of boll weevil population data for Spring 1994, 1995, and 1996 was included as a explanatory variable in the model. Because high boll weevil populations may be associated with other insect problems, producers are expected to increase their willingness to pay at a decreasing rate as boll weevil populations increase. The log base 10 of boll weevil population data was used in the model to impose diminishing marginal willingness to pay.

In the survey, farmers were asked to indicate whether the following sources of information were important in making decisions about the eradication program: the extension service, BWEP education programs, magazine and newspaper articles, radio and television reports, crop or integrated pest management consultants, and other farmers. A value of 1 was assigned to producers who indicated that they used the information. A value of 0 was assigned to farmers who indicated that they did not use the information. An evaluation of the responses indicated a significant positive correlation ($\alpha = 0.0001$) between the extension service and BWEP education programs. BWEP education programs were open for anyone to attend; however, the program was specifically directed to those voting in the February 1997, West Tennessee, Region I referendum. Since the program was not offered in northwestern Tennessee, producers from this area would have to travel south to attend an eradication program meeting. The extension service variable was chosen for the model because it may better represent information used by producers in both the northwestern and southwestern production areas. The University of Tennessee extension service helped conduct education programs for the Southeast Boll Weevil Eradication Foundation, Inc. which has primary responsibility to implement the eradication program in the state. The extension service was hypothesized to have a positive influence on producers' willingness to pay for the BWEP. Other studies have found that producers frequently use the extension service as a source of information for decision making (Amponsah; Brown and Collins).

Due to the small number of farmers that listed radio and television reports as sources of information, the magazine and newspaper article variable was chosen to represent media information in the model. Turner, Epperson, and Fletcher suggested that those producers who read trade magazines were more open to the adoption of new ideas, suggesting a positive influence willingness to pay for the program. On the other hand, negative reports in the media about problems with the program may erode producer support for the eradication program. For example, reports of secondary insect problems allegedly caused by the BWEP led to a recall vote to terminate the program in Mississippi (Luttrell et al.). Consequently, the hypothesized relationship between newspaper and magazine articles and willingness to pay is uncertain.

Farmers that rely on one another for information may be considered less innovative or aggressive in seeking new information (Turner, Epperson, and Fletcher). Producer reliance on the opinions of other farmers was expected to negatively impact willingness to pay. A small number of farmers answered the crop and integrated pest management consultants question. Therefore, this source of information was not included in the regression model.

Farmers were also asked whether they expected lint yields, damage from boll weevils, damage from other insects, farm profitability, insecticide use, aerial drift, ground/surface water contamination, and operator exposure to chemicals to increase, remain the same, or decrease after the boll weevil is eradicated. Due to significant, positive multicollinearity among these variables, four were chosen to represent producer perceptions of what would happen after the boll weevil is eradicated. Those chosen were farm profitability, damage from boll weevils, damage from other insects, and insecticide use.

Because yields may increase and insect control costs may decrease, farm profitability may rise after the eradication program. Farm profitability is hypothesized to have a positive relationship with producer's willingness to pay. A value of 1 was assigned to producers who indicated an increase and a value of 0 was assigned to farmers who indicated either remains the same or decreases. Elimination of yield damage caused by boll weevils after the program is expected to increase a producer's willingness to pay. In the regression model, a 1 indicates a decrease in boll weevil damage and a 0 indicates damage either remains the same or decreases.

Prior economic studies indicate that insecticide usage should decrease after the BWEP, leading to a positive influence on willingness to pay for the program. However, there have been articles published that paint a negative image of the boll weevil eradication program and the effect it may have on damage from other insects and insecticide use (Sandusky; Jones 1995; Luttrell et al.; Smith; Layton et al.; and Williams and Layton). If producers rely on the negative articles as sources of information, they may be led to believe that insecticide use will increase after the eradication to compensate for the increase in damage from other insects. Producer perceptions about the possibility of increased damage from other insects after eradication may have a negative influence on willingness to pay. For this variable, a 1 indicates a decrease in damage from other insects and a 0 indicates damage would either remain the same or increase. Therefore, the hypothesized relationship between insecticide usage and willingness to pay is uncertain.

Based on the previous discussion, the following regression model was estimated:

$$WTPAY_i = \beta_1 + \beta_2 AGE + \beta_3 EDU + \beta_4 EXPER + \beta_5 INCOME + \beta_6 BWCOST + \beta_7 BWPOP + \beta_8 MEDIA + \beta_9 EXTEN + \beta_{10} FARMERS + \beta_{11} PROFIT + \beta_{12} DAMAGE1 + \beta_{13} DAMAGE2 + \beta_{14} INSECTIC + \epsilon, \quad (2)$$

where $WTPAY_i$ is the total amount per acre a producer is willing to pay for the BWEP; *AGE* represents the age of the principal operator; *EDU* is the amount of formal education of the farmer; *EXPER* is the number of years of experience growing cotton; *INCOME* is the 1996 taxable income of the farmer; *BWCOST* is the three-year average of boll weevil control costs for 1994, 1995, and 1996; *BWPOP* is the three-year average of spring-time boll weevil populations entering cotton fields for 1994, 1995, and 1996; *MEDIA* is the 0-1 binary variable for newspaper and magazine article information; *EXTEN* is the 0-1 binary variable for extension service information; *FARMERS* is the 0-1 binary variable for information from other farmers; *PROFIT* is the 0-1 binary variable for farm profit after the program; *DAMAGE1* is the 0-1 binary variable for damage from boll weevils after the program; *DAMAGE2* is the 0-1 binary variable for damage from other insects after the program; *INSECTIC* is the 0-1 binary variable for insecticide use after the program; and ϵ is the random error term.

Parameter Estimates

The parameters for equation (2) were estimated using the PROC REG procedure in the SAS computer program (SAS Institute, 1997). Due to missing values for the explanatory variables, a total of 79 observations were used to estimate the model. A summary of the variables used in the model and the hypothesized relationships between the dependent variables and the explanatory variables are in Table 1. The model was tested for multicollinearity problems using the PROC CORR procedure in the SAS computer program. Those variables affected by the multicollinearity have been noted in previous discussion. The model was also tested for the presence of heteroscedasticity using the Park-Glejester test where H_0: $\delta=0$ and H_a: $\delta\neq0$. No heteroscedasticity was found in the model. The ordinary least square estimated coefficients and the t-ratio, F-value, R-square, and adjusted R-square statistics are presented in Table 2. The model F-value was 4.226 with a probability of 0.0001 indicating that the model as a whole is significant in explaining producers' willingness to pay for the BWEP. The adjusted R-square statistic indicates that the model explains 34.97 percent of the total variation in the dependent variable, *WTPAY* (Pindyck and Rubinfeld).

Evaluation of the model parameter estimates indicates that the *AGE*, *EXPER*, *BWCOST*, *DAMAGE1*, and *INSECTIC* variables were statistically significant at either the 5 or 10 percent probability levels. The *EDU*, *INCOME*, *BWPOP*, *MEDIA*, *EXTEN*, *FARMERS*, *PROFIT*, and *DAMAGE2* variables were not significant at either the 5 or 10 percent probability levels in explaining a producer's willingness to pay.

The *AGE* variable had the hypothesized negative sign indicating that older producers are less willingness to pay for the BWEP. A one unit (year) increase in *AGE* results in a \$3.42 per acre decline in producer willingness to pay for the BWEP. The negative impact of decision maker age on willingness to pay is mitigated by the number of years of experience growing cotton. *EXPER* was significant at $\alpha = 0.1$ and had the expected positive sign on the coefficient. For each additional year of experience growing cotton, a producer was willing to pay an additional $2.18 per acre all other factors being equal.

EDU has a negative influence on willingness to pay, but was not statistically significant in the model. A positive sign had been hypothesized for this variable. Generally education is thought to encourage a positive attitude toward new ideas. The coefficient for *INCOME* had the expected negative sign but was not statistically significant. This income relationship is consistent with other contingent valuation studies where willingness to pay rises as income increases.

The coefficient for *BWCOST* had the expected positive sign and hypothesized relationship and was significant at $\alpha = 0.05$. The diminishing marginal willingness to pay as *BWCOST* rises relationship is shown in Figure 1. Producers in the sample estimated that they spent $12.24 per acre on average for control of boll weevils (Table 1). This expenditure level is similar to the $12.72 per acre reported by all producers in the 1997 survey (Edens et al.). At the mean $12.24 per acre expenditure level, the marginal willingness to pay for the BWEP is $15.47 per acre. Marginal willingness to pay is greater than *BWCOST* up to approximately *BWCOST* = $18 per acre and is less than *BWCOST* thereafter.

The coefficient for *BWPOP* has a positive sign as hypothesized but is not statistically significant. Nonetheless, the parameter estimate indicates decision makers willingness to pay for the program increases at a decreasing rate with larger boll weevil populations (Figure 2). The statistical significance of *BWCOST* compared with *BWPOP* may indicate that farmers place more weight on control expenditures than yield damage when determining their willingness to pay.

The coefficients for the *MEDIA* and *EXTEN* variables have positive signs but are not statistically significant. The parameter estimates for the two variables indicates that producer usage of media and extension service information increases willingness to pay. The coefficient for *FARMERS* was positive, which was opposite the negative sign hypothesized. If the decision maker depends on other farmers as a source of information, willingness to pay may increase. The model indicates that information from media reports, the extension service, or other farmers were not significant in explaining producers' willingness to pay for the BWEP.

The sign on the coefficient for *PROFIT* was negative, which was opposite of the hypothesized positive sign. One explanation for the opposite sign would be if the respondent misinterpreted the question. The question was worded so that the producer would respond according to what might happen to farm profit after the eradication program. If the respondents answered the question as to what would happen to farm profit during the program, the negative sign would be correct. Yields may increase quickly after program start. Moreover, farmers are not doing their own spraying for boll weevils, so they are not incurring this cost.

The coefficient for *DAMAGE1* has the expected positive sign and was statistically significant at the 10 percent level. Based on model results, if producers felt that damage from boll weevils would decrease after the eradication program, they are willing to pay $40.81 more per acre. The sign on the *DAMAGE2* coefficient has the hypothesized negative sign but is not statistically significant. Nonetheless, the parameter estimate indicates that producers who believe that other insect damage will increase after the end of the program may decrease their willingness to pay for the program.

The variable *INSECTIC* has a positive sign and is significant at a 10 percent level. The estimated parameter indicates that producers who believe that insecticide usage after the program will decrease are willing to pay $22.29 more per acre.

Discussion

Taking all the variables together, the producers who indicated the highest willingness to pay for the BWEP have a great deal of experience growing cotton, have experienced above average levels of boll weevil damage and control cost expenditures and insecticide usage, and have a positive perception of what boll weevil damage will be after the program. On the other hand, older farmers were found to be less willing to pay for the BWEP. Producers' use of information from media sources, the extension service, or from other farmers were not statistically significant factors in explaining willingness to pay for the program.

The predicted average willingness to pay for the BWEP using the sample means in Table 1 and the model parameter estimates in Table 2 is $58.26 per acre. To evaluate how total willingness to pay varies with each independent variable, the sample minimum and maximum values for the variable of interest were used in equation (2) while holding the other variables constant at their sample means. The results of these calculations are presented in Table 3. For example, if a farmer has the maximum number of years (40 years) of experience growing cotton (Table 1), his/her maximum willingness to pay for the

BWEP is $107.18 per acre over the life of the program. The *AGE*, *EXPER*, and *BWCOST* variables have the most significant influence on willingness to pay for the BWEP when comparing the minimum and maximum values for each variable from Table 1.

Summary and Conclusions

This study evaluated a cotton farmer's willingness to pay for the boll weevil eradication program in West Tennessee. The results of the analysis of farmer willingness to pay for the BWEP suggest that producer experience growing cotton, boll weevil control costs, damage from boll weevils, and insecticide usage have the most significant, positive influence on producers' willingness to pay for the boll weevil eradication program. Producer age has a significant, negative influence on willingness to pay. The variable with the largest impact on willingness to pay is producer age. For each 1 unit increase (year) in producer age, willingness to pay for the BWEP declines by $3.42. Boll weevil control cost was the second most influential variable. At the mean $12.24 per acre, expenditure level, the marginal willingness to pay for the BWEP is $15.47 per acre. The identification of these factors may prove useful for decision makers considering the BWEP in northwestern Tennessee. Also, those producers in northwestern Tennessee who have not voted in a BWEP referendum may find this study useful in determining their willingness to pay for the boll weevil eradication program.

Despite a small sample, this study contains significant information that would prove helpful to cotton farmers, the extension service, and other states interested in beginning a boll weevil eradication program. Cotton farmers in northwestern Tennessee that have not yet voted on the BWEP may be able to use this study to determine their willingness to pay for the program. This study may help the extension service to provide helpful information to farmers on the BWEP. Also, other states may use this study to evaluate the likelihood of implementing a boll weevil eradication program in their area.

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Appendix

Table 1. Summary statistics of the variables used to estimate the regression model for the Boll Weevil Eradication Program producer willingness to pay analysis

Variable Name:	Description	Mean	Max	Min	Expected Sign	Stated Hypothesis
WTPAY:	amount respondent is willing to pay for BWEP	58.31	180	0	NA	
AGE:	age of the respondent	42.4	71	22	-	older producers tend to resist change
EDU:	level of formal education	12.6	18	1	+	education tends to encourage a positive attitude toward new ideas
EXPER:	cotton experience	17.6	40	1	+	the more cotton experience, the more aware the producer is of boll weevil problems
INCOME:	taxable income	0.06	1	0	+	farmers with higher incomes have fewer financial constrains to adopting the eradication program
BWCOST:	average boll weevil control cost per acre	12.24	47.5	0	+	if a farmer's control costs exceed the cost of the BWEP, he may be willing to pay more for eradication
BWPOP:	average boll weevil population	757.56	2594	13.3	+	higher boll weevil populations are expected to have a positive impact on willingness to pay
MEDIA:	newspaper and magazine articles used by producers	0.89	1	0	?	those producers who read trade magazines are more open to the adoption of new ideas
EXTEN:	extension service	0.89	1	0	+	frequently used by farmers as a source of information; strong supporters of the BWEP
FARMERS:	other farmers	0.84	1	0	-	farmers who rely on other farmers for information are less likely to experiment with new technology
PROFIT:	farm profit	0.67	1	0	+	farm profit is expected to increase after the eradication

Table 1. (continued)

Variable Name: Description		Mean	Max	Min	Expected Sign	Stated Hypothesis
DAMAGE1:	boll weevil damage after the eradication	0.91	1	0	+	damage from boll weevils should decrease after the eradication having a positive impact on willingness to pay
DAMAGE2:	other insect damage after the eradication	0.32	1	0	-	damage from other insects may increase causing a negative impact on willingness to pay
INSECTIC:	insecticide use after the eradication	0.67	1	0	?	insecticide use should decrease after the eradication program; however, if other insects increase, producers may have to spray more

Table 2. Parameter estimates and statistical relationships of the regression model used to estimate willingness to pay for the February 1997 West Tennessee boll weevil eradication program

Variable Name	Coefficient	t-ratio	Prob > t/ Statistics
AGE	-3.4244	-3.561	0.0007
EDU	-0.2356	-0.157	0.8760
EXPER	2.1818	2.367	0.0209
INCOME	21.1010	0.954	0.3435
BWCOST	12.5879	2.538	0.0136
BWPOP	5.6169	1.258	0.2129
MEDIA	4.8637	0.257	0.7979
EXTEN	1.2386	0.072	0.9429
FARMERS	11.0426	0.741	0.4616
PROFIT	-8.1607	-0.618	0.5387
DAMAGE1	40.8115	1.744	0.0858
DAMAGE2	-16.5434	-1.310	0.1946
INSECTIC	22.2920	1.672	0.0994
Constant	51.4102	0.998	0.3222
F-value			4.226
Prob > F			0.0001
R-square			0.4581
Adjusted R-square			0.3497
Observations			79

Table 3. West Tennessee cotton farmers' willingness to pay (WTP) estimates for the Boll Weevil Eradication Program

Variable	Maximum[a] ($/acre)	Minimum[b] ($/acre)
AGE	-39.59	127.99
EDU	56.97	61.05
EXPER	107.18	22.16
INCOME	78.09	56.99
BWCOST	81.17	32.58
BWPOP	68.82	39.21
MEDIA	58.79	54.93
EXTEN	58.40	57.16
FARMERS	60.03	48.99
PROFIT	55.57	63.73
DAMAGE1	61.93	21.12
DAMAGE2	47.01	63.55
INSECTIC	65.62	43.33

[a] Calculated using the sample maximum value for the variable of interest in the left column while using the sample means for the other explanatory variables.

[b] Calculated using the sample minimum value for the variable of interest in the left column while using the sample means for the other explanatory variables.

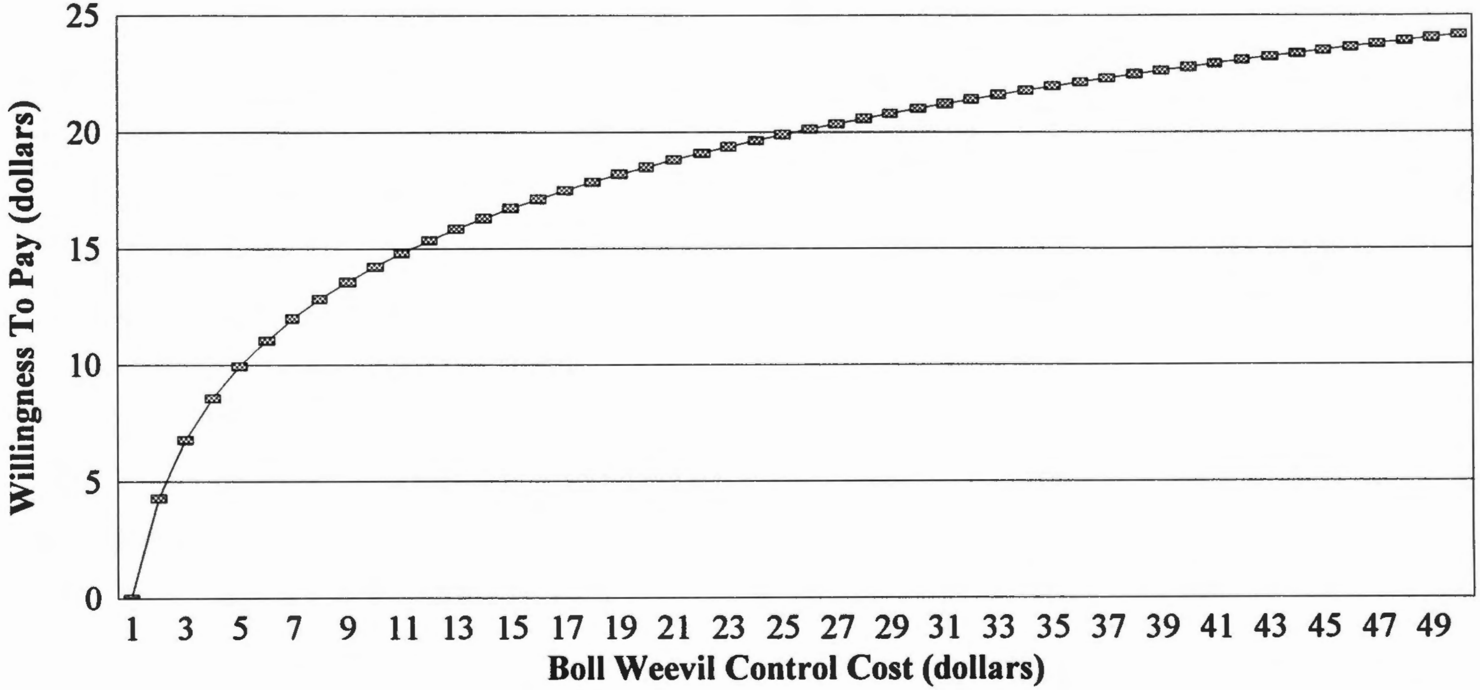

Figure 1. Marginal willingness to pay as a function of boll weevil control cost

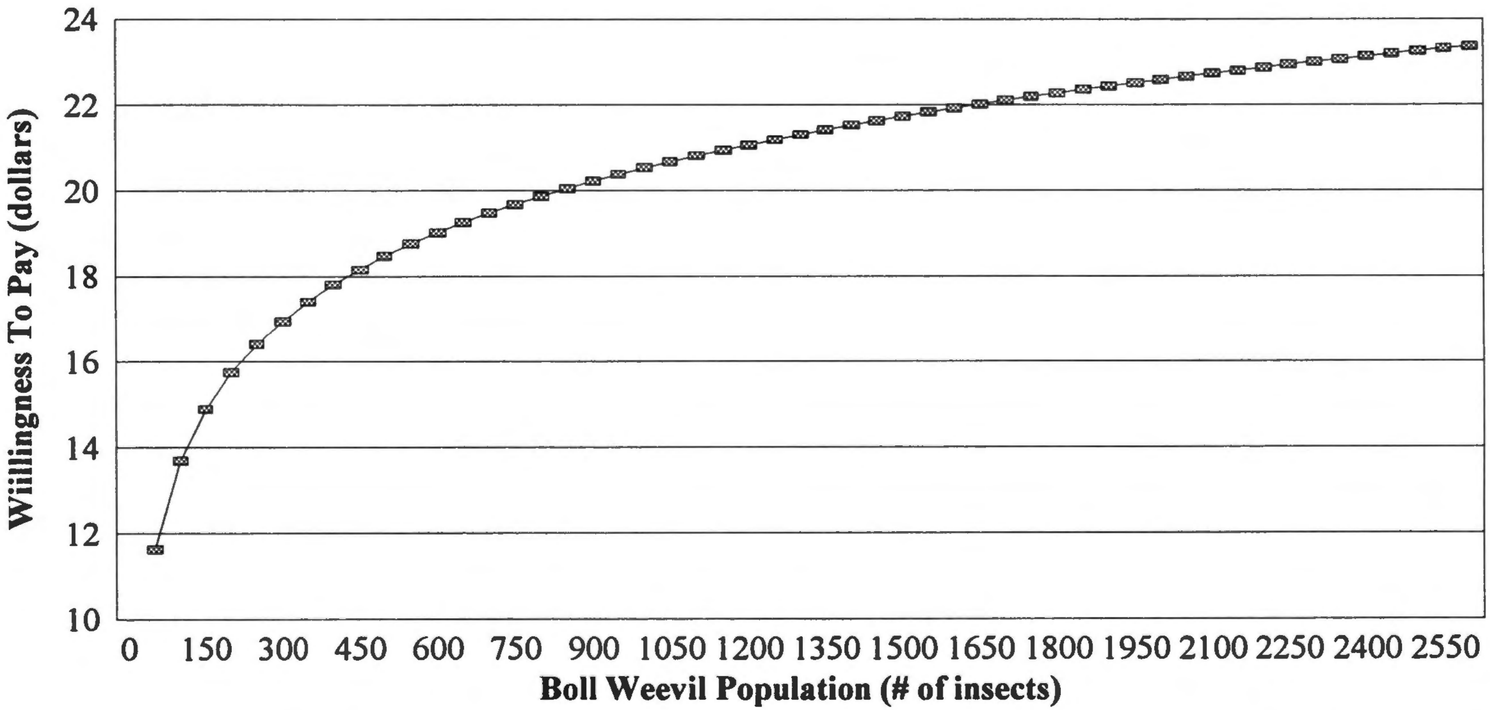

Figure 2. Marginal willingness to pay as a function of boll weevil population

Part 4: Summary

Summary

Until this study, little research had been done to determine the factors that influence farmers' decisions on participating in a boll weevil eradication program. The objective of this study was to determine and analyze factors influencing cotton farmers' willingness to participate in a boll weevil eradication program in West Tennessee.

A logit model was used to determine the factors that influence West Tennessee farmers' willingness to participate in a boll weevil eradication program. Producer age, boll weevil population for 1995, and eradication program education meetings were statistically significant and positive in determining willingness to participate. Boll weevil population for 1996 and the importance of information from the media were significant and negative. Boll weevil eradication education programs had the largest influence on a farmer's willingness to participate in the program. For each additional year a producer ages, the probability of participation increases by 0.69 percent. Boll weevil populations for 1995 and 1996 had very little influence on the probability of participation, 0.0002 and −0.002 percent, respectively. A producer that rated the importance of media a level 5=very important compared to a level 1=not important increases the probability of participation by 35.8 percent. A producer that rated the importance of the eradication education programs a level 5=very important compared to a level 1=not important increases the probability of participation by 45.48 percent.

Until this study, there has been little information on the factors that influence farmers' willingness to pay for the boll weevil eradication program. The objective of this study was to identify and analyze factors influencing cotton farmers' willingness to pay for a boll weevil eradication program.

An ordinary least squares regression model was used to determine the factors that influence a West Tennessee farmer's willingness to pay for the boll weevil eradication program. Producer experience growing cotton, cost of boll weevil control, and producer's attitude about damage from boll weevils and insecticide usage after the eradication program were significant and had a positive influence on a farmer's willingness to pay for the program. Producer age was significant and negative. The most significant variable that influenced willingness to pay for the boll weevil eradication program was the age of the producer. A 1 year increase in the age of the producer decreased willingness to pay for the boll weevil eradication program by $3.42 per acre. For each additional year of experience growing cotton, willingness to pay increased by $2.18 per acre. A 1 dollar increase in boll weevil control cost resulted in willingness to pay increasing at a decreasing rate. If producers believed damage from boll weevils and insecticide usage would decrease after the eradication program, willingness to pay increased by $40.81 and $22.29, respectively.

Currently, plans are to move forward in the expansion of the boll weevil eradication program to counties in northwestern Tennessee. The identification of these factors may prove to be useful information for extension in passing the BWEP in northwestern Tennessee. However, one limitation in using the willingness to participate study for northwestern Tennessee would be the inclusion of boll weevil population in the models. The boll weevil population data used represented only those counties that voted in the February 1997, West Tennessee, Region I BWEP referendum. Boll weevil population data may vary for the northwestern counties; therefore, causing a change in the coefficients. Producers in the northwestern counties who have not voted in a BWEP referendum may find the willingness to pay study useful in determining their willingness to pay for the boll weevil eradication program.

Despite a small sample of 26 observations used in the willingness to participate study and 79 observations used in the willingness to pay study, both contain significant information that would prove helpful to cotton farmers, the extension service, the Tennessee Boll Weevil Eradication Foundation, Inc., and other states interested in beginning a boll weevil eradication program. Cotton farmers in northwestern Tennessee that have not yet voted on the BWEP may be able to use these studies to determine their willingness to participate in or pay for the program. These studies may help the extension service to provide helpful information to farmers on the BWEP. Also, other states may use this information to evaluate the likelihood of implementing a boll weevil eradication program in their area.

Vita

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In August of 1992, she entered The University of Tennessee in Knoxville, Tennessee. In December 1996, she received a Bachelor of Science degree with a major in Agricultural Economics and a minor in Business Administration. In January 1997, she entered the Master's program in the Department of Agricultural Economics and Rural Sociology at The University of Tennessee, Knoxville. While in graduate school, she earned acceptance into Gamma Sigma Delta Honor Society. Rebecca received her Master of Science degree in Agricultural Economics in August 1998.