AN ECONOMIC ASSESSMENT OF THE BENEFITS OF MOSQUITO ABATEMENT IN AN ORGANIZED MOSQUITO CONTROL DISTRICT[1]

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ABSTRACT. A case study application of contingent valuation to the measurement of mosquito program benefits is presented. Annual program benefits in Jefferson County, TX are estimated to exceed costs by 1.8 times. Mean household benefits are $22.44 for owners and $18.96 for renters. Using ordinary least squares procedures these household benefits were found to be related to household socioeconomic characteristics, effectiveness of control efforts and environmental concerns.

INTRODUCTION

An environment characterized by the absence of nuisance pests is desired by many individuals. Yet, the provision of such an environment is an exercise in the provision of public goods. A public good, from the standpoint of economics, is one which, once provided, is nonrival in consumption and nonexclusive in provision. Clearly mosquito abatement satisfies these conditions reasonably well. An additional factor when dealing with mosquito abatement is quality of control. Bradford (1970) argued that quality is the dominant concern when dealing with public goods, such as mosquito abatement, for which quantity is often elusive.

Because mosquito control programs possess the characteristics of public goods, collective action by some organized group is necessary in order to provide efficient levels of abatement. Such collective action may be undertaken by public agencies, organized citizenry or through the philanthropic efforts of individuals. One form abatement provision has taken is through the auspices of an organized mosquito control district such as that existing in Jefferson County, TX. The Jefferson County Mosquito Control District (JCMCD) engages in collective efforts to cooperatively provide mosquito abatement.

In marked contrast to the costs attributed to the provision of mosquito abatement by the cooperative operation of the JCMCD program, the benefits from mosquito abatement, a public good, are not generally known. In essence, the individual is the economic agent who perceives the value of a certain "good". The "market" is a general concept referring to that place where the individual buys and sells the good or service desired at an agreed upon price. Except in a few cases, most notably public (nonexclusive and nonrival) goods, these goods and services are priced and readily transferable among individual economic agents. Mosquito abatement is one of the exceptional cases for which the ordinary market exchange function fails. Because of a lack of market transactions the economic value of mosquito abatement cannot be directly observed.

Goods and services of this type are called "nonmarket goods". Although their prices are not determined in the market place, such goods are not valueless. They have "unpriced values" for the economic agents deriving benefits from their provision (Sinden and Worrell 1979). The monetary magnitude of these "unpriced values", i.e., mosquito abatement benefits, should be a topic of interest to citizens. It is especially important information for mosquito control agencies who pursue control programs as county policy, since operation of these programs is generally supported by county tax revenues. The overall objective of this study was to measure the value of present mosquito abatement benefits relative to the costs of their provision by the JCMCD.

PREVIOUS RESEARCH. A previous, and controversial, study of salt marsh mosquito abatement programs was conducted by Carlson and DeBord (1976). In their study of 30 southeastern U.S. coastal areas, primarily in Florida, these authors concluded "at present levels of population and operation, the marginal costs of mosquito abatement are about seven times as high as the marginal benefits" (p. 150). They also examined the mix of ditching and chemical control procedures and arrived at an expected result; i.e., ditching is excessively used relative to chemical procedures. This latter conclusion is not surprising

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because ditching is a permanent control measure which is often subsidized financially by nonlocal sources, i.e., federal and state, whereas chemical control is a nonstructural measure. There is a long history of similar conclusions in economics literature for other resource situations characterized by such cost-sharing arrangements (e.g., see Griffin and Stoll (1984) for a discussion of soil conservation programs).

The primary implication of the study by Carlson and DeBord, however, was that mosquito abatement programs are carried out to an excessive degree. If marginal control benefits are in fact less than marginal control costs, then every additional unit of mosquito control is worth less to society than its cost. This study and its conclusions stepped on vested interests and was met with outrage. It was criticized by some for misuse of light trap data and also for improper interpretation of econometric results. Provost (1977), in commenting on a 1975 report by DeBord et al., stated that: "The study is a prime example of feeding a computer the wrong bits and coming up with a patent absurdity" (p. 695). Langham and Lanier (1981) questioned the mix of salt marsh and fresh-water mosquito species in the light trap data used as well as the interpretation of empirical results from simultaneous equation systems (see also response by Carlson and DeBord 1982).

In another study, Hansen et al. (1976) concluded that open water marsh management costs 4.5 to 50.6 less than larviciding in New Jersey. However, this latter study cannot be used to refute Carlson and DeBord's conclusions due to its failure to account for economic benefits received from use of each control method. A more recent study by Ofiara and Allison (1985) focused on cost savings from reduced ground adulticiding applications and concluded that permanent control may be preferred if given a sufficiently long time horizon. In their case study it took 27 years for the present value of net permanent control benefits to exceed that of temporary control.

Sarhan et al. (1979) empirically modelled mosquito control practices over the 1954–74 period in a California public abatement district. Their purpose was to examine economic and technical efficiency of alternative abatement methods, pesticide tolerance buildup, and to derive optimum treatment strategies. Their study of irrigated California agricultural land arrives at differing results from Carlson and DeBord's examination of southeastern coastal salt marshes. In the Sarhan et al. (1979) study the marginal cost of ditching is estimated to be $\frac{1}{10}$ the cost of using pesticides (p. 80). They question the ability (or "knock down power") of nonchemical control methods to handle critical or emergency periods such as "heavy rains and flooding in the presence of a malaria or encephalitis vector" (p. 84) and argue that continual tolerance buildup with short-term pesticide use must be accounted for as a cost of such activity when considering more longer-term strategies such as ditching. This concern is heightened by their argument that the rate of introduction has been reduced for new pesticides to replace those for which tolerance has increased.

The Carlson and DeBord study may have a different problem. Many techniques for measuring public (nonexclusive and nonrival) goods were being developed and tested at the time of their study. They chose to estimate citizen demand for mosquito abatement through use of a technique advocated by Borcherding and Deacon (1972). This approach is characterized by citizens who are assumed to vote by majority rule for a set of governmental representatives. These citizens are assumed 1) knowledgable of the costs and benefits of each governmental spending effort and 2) to vote "for candidates who offer the most efficient set of public services and taxes" (Borcherding and Deacon 1972, p. 892). Granting these and several other assumptions, public sector expenditures for various services can be examined using cross-section data to derive citizen demand curves and, thus, economic benefit measures for public services. We are concerned that these assumptions are too restrictive and, for this reason, will not lead to accurate measures of mosquito control benefits.

In our approach individual values for mosquito abatement were directly elicited rather than derived from secondary public service expenditure data as Carlson and DeBord. Our approach has also been recently recommended by Ofiara and Allison (1985) in the study cited above. It is assumed that individuals are aware of the hazards of mosquitoes (although they were reminded of nuisance and public health threats). These same individuals were assumed capable of comparing the costs and benefits of having mosquito abatement provided by the JCMCD with that of other abatement provision alternatives, e.g., individual control with self-purchased mosquito control inputs. Thus, individual residents in an area can decide which abatement approaches they prefer.

In order to estimate monetary values for nonmarket goods (e.g., mosquito abatement), nonmarket valuation methods have been developed. The theoretical concepts which underlie nonmarket valuation methods are rooted in the same economic theory used in examination of ordinary market goods (Freeman 1979). For our purposes, the nonmarket valuation method employed to value mosquito abatement benefits is the contingent valuation method (CVM). CVM utilizes individual responses to contingent circumstances posited in an artificially (hypothetical) structured market to determine values in lieu of the existence of actual markets (Sellar et al. 1985).

Contingent valuation is not void of controversy regarding its use, although it has been judged an acceptable valuation method for projects affecting water and water-related land resources (Water Resources Council 1979). Potential influences upon resulting value estimates are argued to include starting points in the bidding process, information effects, strategic behavior, free-rider behavior, and hypothetical circumstances which may lead respondents to treat the contingent market as unrealistic or result in reported behavior (expected) which differs from observed behavior (actual). Each of these has been discussed at length elsewhere (Brookshire et al. 1976, 1980; Sellar et al. 1985). The general conclusion appears to be that carefully designed contingent valuation studies can avoid or at least minimize most of these influences, some which, if they occurred, could bias resulting value estimates.

The most widely used CVM is the bidding approach. The iterative bidding approach to valuation was initiated by Davis in 1963 but did not become popular until the mid 1970's (Sellar et al. 1985). Recently, iterative and noniterative bidding approaches have been used to estimate monetary values for various nonmarket goods, e.g., aesthetic environmental improvement (Randall et al. 1974), aesthetic environmental damages (Brookshire et al. 1976), elk hunting related amenities (Brookshire et al. 1980), skiing capacity (Walsh et al. 1983), amenity benefits from agricultural land (Bergstrom et al. 1984), and preservation of whooping crane (Stoll and Johnson 1984). Using this method for valuation of mosquito abatement is a unique approach to measuring benefits in the mosquito control literature.

METHODS

DESCRIPTION OF THE STUDY AREA. Jefferson County is an eastern coastal county in Texas with an area of 1,378 square miles. According to the 1980 census, the population was 250,940 people, and the number of households was 90,109; with 62,373 property owning households and 27,736 renting households. The mean annual income of property owners was $34,675 per household and that of renters was $28,829 per household.

Property owners directly support the county mosquito control program through payment of their county taxes. Renters do not contribute to the program directly, but do so indirectly by paying rent to tax paying-property owners. Every property owner-household contributed an average of $11.58 for the county mosquito control program in 1982. Approximately 3.33 cents of every tax dollar goes to county-wide mosquito control.

SURVEY APPROACH. The contingent market for valuation of mosquito abatement provided by the JCMCD was introduced by using a set of questions directed towards property owners. First, by asking multiple choice questions, the residents were led to think about the severity and/or intensity of mosquito problems around their home, then of their own attitude towards this insect pest while at the same time being asked to evaluate the effectiveness of the JCMCD program. This was followed by the contingent market in which a bidding question was asked. The bidding question was designed in the form of a payment check-list; i.e., answers were chosen from a prepared list as follows:

Question:

Suppose the Jefferson County Mosquito Control Program would be unable to continue operation because of financial reasons and that there was no alternate source of funds other than tax revenues. What is the *highest amount your household property tax could be raised* (Assume the increase goes to mosquito control) before you would recommend that the program be completely eliminated? (Circle only one number below)

1. I WOULD NOT ACCEPT ANY INCREASE.
2. $0.01 to $1.99 a year
3. $2.00 to $3.99 a year

•
•
•

26. $48.00 to 49.99 a year
27. Over $50.00, please specify;
 $________

This question asked respondents to express (or bid) their maximum household willingness to pay (WTP) in addition to their current tax contribution, in order to continue to have the mosquito abatement, presently provided by JCMCD. Before stating a bid each respondent was helped to calculate the amount of current county household taxes which supported mosquito abatement. The solicited bid in the contingent market was worded as an increment to this present tax contribution. Thus, the respondent's money bid plus current mosquito abatement tax contribution is the total value placed on JCMCD mosquito abatement.

Procedures outlined by Dillman (1978) were used to administer the willingness to pay questionnaire by mail to 1,295 taxpayers (identified by tax rolls) in the fall of 1983. Another 1,300 questionnaires were delivered to the managers of selected apartment buildings in the Jefferson County area. These managers were asked to distribute the questionnaires to pre-selected apartment residents (randomly by apartment numbers). The questionnaires given to these renting households varied slightly in order to account for their differing residential and tax paying status. In both cases, the bid represents the maximum amount of income the responding household is willing to pay to maintain the current level of mosquito abatement provided by the JCMCD (i.e., to avoid termination of the current JCMCD program). Due to incorrect addresses and nonresponses, the actual number of questionnaire responses used for the analysis presented here is 681 (478 property owners and 203 renters).[5]

ANALYSIS AND PRESENTATION OF THE SURVEY DATA. Basic statistical procedures were used to analyze the data collected. General public perceptions of mosquito problems, control programs, and their effectiveness are presented in a previous paper by the authors (John et al. 1987). Mean bid responses and confidence intervals are constructed in the present paper and then compared with mosquito control program costs.

Least squares procedures were used to examine the relationship between willingness to pay bids and socioeconomic characteristics of households. After examining several functional forms for statistical fit the following statistical model was estimated:

$$\text{BID} = \beta_0 + \beta_1\text{INCOM} + \beta_2\text{CSTSHR} + \beta_3\text{SLFCONT} + \beta_4\text{RSDNC} + \beta_5\text{CMPLNT} + \beta_6\text{FMSIZ} + \beta_7\text{EDCT} + \beta_8\text{EFCT} + \beta_9\text{ENVRNMT} + \beta_{10}\text{RENT} + \epsilon$$

where household income (INCOM, in thousands of dollars), number of years residence in Jefferson County (RSDNC), number of years of formal education for respondent (EDCTN), household evaluation of the effectiveness of the JCMCD program (EFCT, a dichotomous variable where 1 indicates household could not control mosquitoes as well as JCMCD), concern for nonchemical control methods (ENVRNMT, a dichotomous variable where 1 indicates a greater willingness to contribute to support nonchemical control methods), and rental property households (RENT, a dichotomous variable with 1 indicating rental) are all expected to be positively related to the net willingness to pay bid (BID, excluding current tax contributions). The size of current household tax contributions for mosquito control (CSTSHR), expenditures for self control measures (SLFCONT), complaints to JCMCD about mosquitoes during a typical year (CMPLNT), and number of household members (FMSIZ) are all expected to be negatively related to the willingness to pay bid. The observed simple correlation was 0.20 between household annual income (INCOM) and current contributions to support mosquito abatement (CSTSHR). This correlation is low because county tax is imposed on property and not all income. Both variables were therefore used in the model without particular concern that their correlation would greatly reduce the accuracy of estimation.

RESULTS AND DISCUSSION

NET BENEFIT ESTIMATES. The number of legitimate WTP bids for the mosquito abatement provided by JCMCD was 618 or 90.7% of the 681 responses; 428 (89.5%) from property owners and 190 (93.6%) from renters. Blank bids and those who indicated protests against asking people for their willingness to pay for support of mosquito abatement were eliminated from the analysis of contingent market results. This procedure is consistent with previous literature in the contingent valuation area (Brookshire et al., 1976, 1980; Randall et al., 1974; Walsh et al., 1983). Zero bids, when protests were not indicated, were considered legitimate and included in the mean bid computation.

The mean WTP bid for mosquito abatement by property owners was estimated to be $10.86 in excess of their current mosquito abatement tax contribution. The average mosquito abatement tax contribution of property owners was $11.58/year, which is the current annual mosquito abatement cost shared by each household. Thus, by adding the mean WTP bid to the current costs shared, the mean total value (WTP) placed on mosquito abatement by each household is estimated to be $22.44 ($10.86 + $11.58) per year. The estimated mean WTP for renters was $18.90. Since renters do not directly share the current costs of the mosquito abatement provision, their mean bid was not requested as an added tax payment and represents

[5] Actual response rates were 40.5% for property owners and 13.7% for renters. The low renter response rate was expected due to the mass distribution to rental unit occupants by apartment managers. For further discussion of response rates see John et al. (1987).

Table 1. Mean willingness to pay for mosquito abatement in Jefferson County, TX during 1982.

Residence category	WTP estimates Mean	Median	95% confidence interval Lower limit	Upper limit
Property owners	\$22.44	\$16.00	\$20.88	\$24.02
Renters	\$18.90	\$13.00	\$16.37	\$21.42

the direct value of mosquito abatement i.e., no current taxes need be accounted for. Table 1 shows estimated means and confidence intervals for these estimates.

Multiplying the mean bids by the population of property owning households (62,373 in 1980), the aggregate total value of JCMCD mosquito abatement is estimated to be \$1,398,650 per year. The population of renters was 27,736 households in 1980. This leads to an estimate of \$524,210 per year for the aggregate value of JCMCD mosquito abatement for the renter population (=27,736 × \$18.96).

By adding the aggregate total value estimates of property owners and renters, the aggregate total value of JCMCD mosquito abatement in Jefferson County was estimated to be \$1,923,860. In the 1982/83 fiscal year, JCMCD spent \$1,043,636 for operation of mosquito control activities. By subtracting these operation costs from the estimated aggregate total value of mosquito abatement, the net benefits rendered to county residents by the collective JCMCD program are estimated at \$880,225 for the 1982/83 fiscal year. In other words, the total benefits county residents received from JCMCD mosquito abatement were about 1.8 times as great as costs during the 1982/83 fiscal year. Using the lower and upper limits of WTP confidence intervals (Table 1) the estimated total benefits ranged from \$1,756,386 to \$2,092,304 or from 1.7 times to 2.0 times the cost of JCMCD mosquito abatement.

It is often argued that the toxic chemicals used to control mosquitoes may cause some environmental damage, e.g., destruction of bees, useful insects, mosquito-eating fish, shrimp and vegetation in treated ditches, and damage to paint finish (John et al. 1987). To the extent these damages (external effects) do in fact occur, are quantifiable, and were unaccounted for by respondents, they should be subtracted from the estimated aggregated total benefits to obtain a more accurate net benefit estimate. The present study has not attempted to determine the magnitude of these potential JCMCD program costs. However, they may have been considered to some extent by respondents when formulating their contingent market responses (bids). A supplemental contingent market question indicated that 55% of respondents were willing to bid greater amounts for the support of nonchemical control methods.

EFFECTS OF SOCIOECONOMIC PARAMETERS ON WILLINGNESS TO PAY. The following model was estimated statistically as previously described (*t*- values in parentheses):

$$
\begin{aligned}
\text{BID} = &-9.15 + 0.14\ \text{INCOM} + 0.98\ \text{CSTSHR} + 0.06\ \text{SLFCONT} \\
&(-1.65)^{*} \quad (3.49)^{***} \quad (45.67)^{***} \quad (1.86)^{**} \\
&+ 0.005\ \text{RSDNC} - 0.49\ \text{CMPLNT} - 0.16\ \text{FMSIZ} \\
&\quad (0.92) \quad (-0.64) \quad (-0.22) \\
&+ 0.68\ \text{EDCTN} + 4.36\ \text{EFCT} + 9.51\ \text{ENVRNMT} - 2.33\ \text{RENT} \\
&\quad (2.16)^{**} \quad (1.58)^{*} \quad (4.46)^{***} \quad (-1.02)
\end{aligned}
$$

*** significant at 0.01 level F = 252.95
** significant at 0.05 level N = 336
* significant at 0.10 level $R^2 = 0.89$

The model was significant at the 0.001 level as indicated by the F value of 252.95 and R-square of 0.89. The variables which were significantly related with BID are: level of income (in thousands), current household mosquito abatement tax contributions, money spent for individually purchased self control measures, years of formal education, whether the household believed it could control mosquitoes better than the JCMCD program, and willingness to financially support nonchemical control measures. A \$1,000 increase in income is estimated to result in a \$0.14 increase in willingness to pay (BID). An increase of one dollar in current costs shared results in a \$0.98 increase in WTP for mosquito abatement.

Further, in Jefferson County one additional dollar spent for individually purchased self mosquito control measures resulted in a \$.06 increase in WTP, while one additional year of education added \$.68 to WTP. The respondents who evaluated the JCMCD program as effective would be willing to pay over \$4.00 more than would those who thought they could control mosquitoes better than the JCMCD. About 85%

of the residents who live in the county recognized the effectiveness of the JCMCD program. Residents willing to support nonchemical methods were concerned with the quality of environment regarding the uses of toxic chemicals and were willing to pay $9.51 more than other respondents.

The kind of household (renter or owner, and payment vehicle) used in collecting WTP did not contribute to variation in the WTP estimate. In general, all significant coefficients had the expected signs, except CSTSHR (current tax contribution). Possibly this variable actually indicated a difference in household preferences for mosquito abatement held by households having greater property wealth, more than it indicated current economic sacrifices (which are rather minimal) for mosquito abatement.

CONCLUSION

This study estimated household willingness to pay for mosquito abatement, a public (nonrival and nonexclusive) good. The estimated total benefits associated with JCMCD mosquito abatement programs were 1.8 times as great as the annual costs of operating the program.

The direct measures of WTP elicited from respondents for mosquito abatement were related to attitudes regarding mosquitoes. The mail survey approach to contingent valuation allowed for widespread citizen involvement in expressing opinions and, therefore, the results should be more politically acceptable. However, one's perception of value for a good is influenced by socioeconomic status in the community. Since attitudes of respondents towards mosquito abatement depend upon socioeconomic characteristics, knowledge of mosquito problems and geographical conditions of mosquito biology (John et al. 1987), the results revealed here are strictly applicable only to Jefferson County and must be generalized with caution.

The contingent valuation method (CVM) was used to estimate value for the nonmarket good, mosquito abatement, using a noniterative, payment checklist. This study is one of the first published applications of this method in the area of insect pest control. For this reason the results and the usefulness of this nonmarket valuation method for mosquito abatement may be questioned by some people concerned with mosquito control. Nonmarket valuation methods have a relatively short history and may still require improvement in the manner of their application. This is especially true for measurement of incremental mosquito control program changes. However, CVM has a strong base in economic theory, and has been used in numerous empirical studies. This valuation information should be viewed as one of many inputs to decision making with respect to mosquito control programs. Rarely are decisions based solely on comparison of benefits and costs; other factors will likely play a critical role in final decisions.

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