# ON ASSESSING THE BENEFITS OF PUBLIC MOSQUITO CONTROL PRACTICES[1]

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ABSTRACT. Public mosquito control can be characterized as a nonmarket good whereby the absence of price-quantity information normally used to determine demand and benefits creates a dilemma to the researcher. In response to this dilemma economists have advanced several methods to assess demand components and value of nonmarket goods. The contingent market valuation (CMV) approach is but one method. This paper outlines the relevant theory behind benefit measures, and develops and demonstrates a CMV approach that can be used to value public mosquito control.

## INTRODUCTION

Public mosquito control can be characterized as a nonmarket good, whereby it is not sold in a market as are consumer goods (clothing, termite control service, etc.) This absence of market conditions poses a dilemma to economists and public policy makers faced with assessing the value of and concerning decisions about public-nonmarket goods such as public mosquito control. Specifically the lack of numerical data (price-quantity data) normally used to determine demand and the associated value for any particular good creates a nonconventional empirical problem.

In response to this numerical dilemma, economists have advanced several techniques that have been used to assess such nonmarket goods as air and water quality improvements, a variety of recreational activities, health risk-safety, imported fire ant control and gypsy moth control.

The purpose of this paper is to outline the theory and concept of benefits, and demonstrate one approach used to assess the benefits of mosquito control.

## METHODOLOGY AND APPROACH

DEMAND AND THE CONCEPT OF BENEFITS. When considering benefits from consuming a good, economists equate the area under the associated demand curve in the absence of income effects with benefits. Points along a demand curve reflect amounts people would be willing to pay rather than forego consumption of the good in question, hence, the area under demand is a representative measure of benefits (Bohm 1976, Mishan 1976, Just et al. 1982). This is easily illustrated by way of Fig. 1.

Demand is represented by the line AB. For the price-quantity combination QoPo gross benefits are approximated by the area OACQo. At that price-quantity combination total costs are represented by the area OPoCQo. The difference between gross benefits and costs measure net benefits, area PoAC and is referred to as consumer surplus, that is, a surplus which accrues to consumers as a net economic benefit. The net benefit represents the net willingness-to-pay (WTP), the difference between what the consumer is willing to pay and the actual amount paid corresponding to the consumer's maximum net WTP. For the one price-quantity combination example, marginal WTP is equivalent to maximum WTP, but with multiple price-quantity combinations, maximum WTP is equal to the sum of marginal WTP.

CONSUMER SURPLUS AS A BENEFIT MEASURE. Although the concept of consumer surplus (CS) may appear straightforward, economists have debated over its appropriateness as a benefit measure for some time (Freeman 1979, Just et al. 1982). The crux of the issue lies with an income effect from price and income changes. A positive income effect will shift the demand curve to the left, represented by AD in Fig. 1. Total and net WTP will tend to overstate gross and net economic benefits in this case. Furthermore, ambiguous measures result depending on the order of price and/or income changes (Just et al. 1982). Recent work has focused on operational techniques to calculate exact welfare measures from demand curves (Hausman 1981, McKenzie 1983, Bergland and Randall 1984).

It must be emphasized that these techniques are based on the existence of demand curves, and hence, assume that price-quantity information are available as in the case of market goods from which demand is estimated. In the case of nonmarket goods, because price-quantity are

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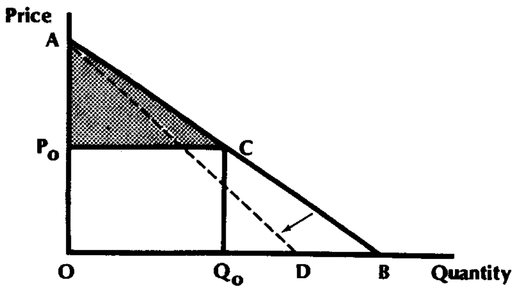

Fig. 1. Demand and consumer surplus.

not observed the researcher must first gather these data using one of the basic nonmarket approaches discussed below.

Although the commonly cited theoretical rationale for the source of discrepancy between exact welfare measures is due to income effects, other reasons have been advanced. Knetsch (1984, 1985), and Knetsch and Sinden (1984) argue that results of empirical studies provide evidence of consistent differences between exact welfare measures for goods that represent a small proportion of total expenditures (Bishop and Heberlein 1979). It is concluded that a discontinuity exists in the value function at the reference point based on experimental evidence (Knetsch 1985).

Some economists have interpreted from the empirical evidence that individuals do not behave as utility maximizers, which underlies demand theory, and hence act irrational (see Opaluch 1984 for a summary). If tastes (descriptions of what an individual likes) and values (description of the way the world ought to be) both influence consumer behavior, that is, enter into the utility function, and if tastes and values are not comparable, the relative influence of values on consumer behavior may offer an explanation of the above divergence and observed preference reversal. In fact, some researchers believe that preferences revealed through a contingent market valuation (CMV) approach, because of the hypothetical nature of the questions, are more influenced from values rather than tastes (Cummings et al. 1986). Recently, Smith and Desvousges (1986) examined disparities among welfare measures and perceived entitlements to risk. They reasoned that the difference in WTP bids to avoid increases in environmental risk and WTP bids to obtain equivalent risk levels from reductions results from traditional utility and welfare maximization whereby this process does not reflect individual's perceived entitlements to various nonmarket goods. Hence, a reformulation of perceived constraints in utility maximization is suggested to accommodate for the disparities in welfare measures.

NONMARKET VALUATION METHODS. In response to the absence of price-quantity data necessary to value nonmarket goods, efforts over the past two decades have resulted in a variety of methods (see Hueth and Strong 1984 for a recent evaluation of nonmarket techniques and Cummings et al. 1986). These techniques can be separated into those that measure WTP indirectly on the basis of actions revealed in the market place (hedonic price, travel cost, and household production function approaches), while the contingent market valuation (CMV) technique measures WTP directly from consumer surveys. The CMV technique is based on the premise of a realistically designed, though hypothetical, market setting. An individual is asked to reveal his/her preference in the form of a bid (maximum amount willing to pay) contingent on the availability of the good in question. Commonly the level of the good is changed in increments and the individual is asked to reveal his corresponding bid in an iterative manner. In a demonstration project, a CMV technique was used to value public mosquito abatement (Ofiara and Allison, unpublished data).

## MOSQUITO BENEFIT MEASURE

The approach used in this paper to develop a method to value mosquito control was based on the contingent market valuation (CMV) approach. Because this approach relies on survey data and due to the nature of the CMV approach, questionnaire design forms a most crucial part of CMV applications. The plan of this section will be to present and describe the survey instrument with a primary focus on the benefit valuation questions.

Contingent market valuation allows for flexibility in the good to be valued in the proposed market. However, considerable care must be taken in developing both the good and market so that they appear realistic, credible and are easily understood by the survey respondent. It is especially important to achieve these survey objectives by introducing as little as possible (preferably none) bias or offense to the respondent (Dillman 1978, Desvousges et al. 1983, Rowe and Chestnut 1983).

BACKGROUND DATA. The first part of the questionnaire began with questions about perceptions of mosquitoes as a public health threat and/or nuisance pest; time of day mosquitoes are bothersome; perceptions of mosquitoes relative to other biting insect pests (where respondents ranked these in descending order); amount of leisure time and outdoor activities respondent spends his free time in (e.g., various sports, yard-house work, hobbies); outdoor activities that mosquitoes are bothersome to the respondent (ranked in descending order); knowledge about the mosquito control program in their area; private annual expenses on mosquito control/repellent products; socio-economic information; information about expenses for possible medical treatment resulting from mosquito bites; and opinionated questions about mosquitoes and mosquito control.

This sequence of information aided in having the survey respondent think about mosquito control and how mosquitoes affect their lives at the same time establishing a rapport with him/her. This also assisted in creating a favorable atmosphere for the main objective—benefit assessment.

BENEFIT ASSESSMENT. This portion of the questionnaire developed the hypothetical market, defined and described the good to be valued, and the valuation questions. The first part of the introduction to the valuation questions advanced the market setting and the good:

> Mosquito control in your county is provided by a mosquito control agency. This agency is delegated with providing mosquito control for the general public within its jurisdiction, in this case the county. The main objective of mosquito control is to reduce the physical amount (abundance) of mosquitoes. This is accomplished by an appropriate combination of chemical and non-chemical control tools. Benefits that arise from your county control program are related to the public health threat, and nuisance aspect of mosquitos. Many varieties of mosquitoes are carriers of disease, malaria and yellow fever are the most well known diseases. Presently, malaria and yellow fever are no longer a problem in the United States, although the potential for a problem does exist. This is a direct result of mosquito control efforts, and public health efforts. Currently, varieties of the encephalitis complex, a disease, pose threats to public health.
>
> Regarding public health aspects, benefits from control are a reduction in the incidence and mortality of mosquito borne diseases, as well as a reduction in the threat of risk to public health. In regard to the nuisance aspect of mosquitos, benefits from control are fewer mosquitoes landing on you and biting you, resulting in an overall increase in the enjoyment and satisfaction of everyday outdoor activities, as well as recreational activities. In this sense mosquito control has increased the quality of life in areas where mosquitoes are extremely abundant. To provide mosquito control for your county, first a control agency was established, and then materials and equipment were purchased. Money for mosquito control in your county comes from county residents. As a taxpayer, you pay directly for mosquito control through tax dollars each year.

Immediately following this description was information that introduced and described the good, presented along with the key visual aid[4] to help in defining the good:

> Mosquito control agencies have identified various levels of mosquito concentrations in order to assist them in their control decisions, as well as evaluate the performance of their control tools. Here are pictures that show different levels of concentrations of mosquitoes that occur throughout the mosquito season, *and* are obtainable by the mosquito control agency in your county. These pictures were taken during the daytime when most mosquitoes are *not* active feeders. GIVE RESPONDENT PHOTOGRAPHS. A general rule of thumb mosquito agencies use to represent evening or nighttime situations, when mosquitoes are *most* active, is that nighttime situations are *5 to 6 times greater* than daytime situations. That is, nighttime situations are equivalent to multiplying the number of mosquitoes in these photos by 5 or 6. In addition, similar numbers of mosquitoes that appear on the *front* of the volunteer in the pictures, also appear on the *back* of the volunteer, as well as on the rest of the body not shown.
>
> Picture A represents both an outbreak situation, *and* a situation obtainable with no control. Picture B represents high concentrations of mosquitoes that would occur with light control activities. Picture C represents moderate concentrations of mosquitoes that would occur with moderate control activities. Picture D represents light concentrations that would occur with high control activities. As the pictures show, one can easily determine the concentration of mosquitoes. Please note that a picture depicting zero mosquitoes during the mosquito season is not obtainable by *any* mosquito control agency based on the available control tools, numerous breeding sites, and the breeding cycle of mosquitoes.

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[4] A variety of visual aids and cards used in the survey to help define the good as well as questions designed for respondents that bid zero to establish reasons for zero bids are available upon request from the authors.

These relative concentration levels were developed with the assistance of the Chatham County Mosquito Control Commission (CCMCC) director, so as to correspond to light-trap data and landing rate counts associated with "light," "moderate," "high," and "outbreak" concentration levels. The photos were meant to represent a situation where an individual remaining stationary would experience the depicted level of mosquitoes over the course of a minute under daylight conditions. Although some researchers may consider these situations to be arbitrary and/or subjective, the relative concentration levels were developed as objective as current data allow, based on light-trap, landing count data and adult density index measures used by some MCDs along with expertise of CCMCC personnel knowledgeable of local residents' threshold/tolerance levels.

This was followed by a question designed to have the respondent distinguish among the concentration levels accompanied by another visual aid, the mosquito concentration ladder which anchors the photos on a 0–10 scale:

> B–1.a. Now, think about the level of mosquito concentrations in your county as a whole. HAND RESPONDENT CARD 5, "MOSQUITO CONCENTRATION LADDER." In terms of this scale from zero to ten, how would you rate the level of mosquito concentrations in your county at present time? POINT TO THE ZERO-TO-TEN SCALE AND CIRCLE NUMBER.

00 01 02 03 04 05 06 07 08 09 10 (GO TO B–1.b) UNSURE ..... 11 (GO TO B-1.d)

The respondent was then asked to consider valuing mosquito control with further description of the hypothetical market and payment mode (taxes):

> B–1.d. Now, we would like you to think about mosquito control in your county and the cost of this control. As a taxpayer, you pay directly for mosquito control in your county through tax dollars each year. The following questions are designed to measure how you value mosquito control.
>
> These questions concern the amount of money you would be willing to pay each year for various levels of mosquito control in only your county. Please keep in mind that the amounts you would pay each year would be paid in the form of higher taxes. In addition, consider the activities, both recreational and everyday activities, that you *presently* do, and that you *might* do in the future, in which mosquitoes now cause, and could cause some discomfort or nuisance to you. In other words, in the absence of mosquitoes, these present and future activities would probably be more enjoyable to you.

Tax payments were chosen because it is how most mosquito control programs are supported and, hence, adds to the realism of the overall benefit assessment. However, it should be noted that researchers question the use of taxes as a payment mode because of negative reactions sometimes elicited (Schulze et al. 1981, Mitchell and Carson 1981, Desvousges et al. 1983). As an alternative some researchers have used contributions to a fund specifically for the good in question (Walsh et al. 1984, Loehman 1984).

The next set of questions involved the valuation procedure, but, first a reference point was established to place all survey respondents at the same position. This was accomplished by having the respondent consider a situation of *no* mosquito control in their locality:

> Imagine that all current funding for mosquito control in your county were to *stop*, so that your county *no longer* had a mosquito control program. Picture A would represent this situation showing the amount of mosquitoes that would be present. One way to think of this would be that you could *expect* this level of mosquitoes to occur throughout a normal mosquito season in your county *without* a control program. In addition, Picture A represents a situation where the threat of disease transmission by mosquitoes is at its highest, as will be the nuisance aspect of mosquitoes.

This was followed by the valuation question, a direct WTP question accompanied by a payment card:

> 2–1. This payment card shows different yearly amounts people might be willing to pay for different levels of mosquito control and mosquito concentrations. HAND RESPONDENT CARD 6-A, "PAYMENT CARD," AND ALLOW RESPONDENT TIME TO LOOK AT IT.
>
> Considering that you would be faced with living in your county *without* a mosquito control program, the *high* public health threat, the *high* nuisance aspect, *and* the fact that to provide mosquito control in your county costs money; if a public body such as the county commission were to establish a mosquito control agency to provide control for your county:

What is the most it is worth to you (and your family) each year in higher taxes to *establish* a mosquito control agency in your county that could provide control, so that the situation represented by Picture B is achieved? Please pick any amount on the card, any amount in between, or any amount you think is appropriate.

$__________/year.

IF ANY AMOUNT, GO TO 2–2.

IF ZERO DOLLARS, ASK: Would it be worth something to you (and your family) to *establish* a mosquito control agency in your county capable of reducing the level of mosquitoes from Picture A to a lower level? CIRCLE NUMBER.

YES............. 01 (GO TO 2–2)

NO............. 02 (GO TO 2–4)

If respondents indicated a nonzero amount they advanced to the next valuation question while respondents that bid zero were asked if they would bid a nonzero amount if a lower level of mosquito concentrations were achieved. If "yes" they advanced to the next valuation question. For those respondents not willing to pay more than zero they were asked whether they would change their outdoor activity patterns if faced with a situation of *no* control and a series of other questions to help establish a reason.

Sequential valuation questions were asked corresponding to the C and D photos:

2–2. (In addition to the amount you just told me), What is the most it is worth to you (and your family) each year in higher taxes to *establish* a mosquito control agency in your county that could provide control, so that the situation represented by Picture C is achieved?

$__________/year.

2–3. (In addition to the amount you just told me), What is the most it is worth to you (and your family) each year in higher taxes to *establish* a mosquito control agency in your county that could provide control, so that the situation represented by Picture D is achieved?

$__________/year.

APPLICATION. Time and funding limitations prevented a full scale application. The data were obtained from participation of Chatham County Mosquito Control Commission (CCMCC) and Glynn County Mosquito Control Commission (GCMCC) personnel. This application serves primarily to demonstrate the approach outlined above rather than obtaining representative benefit estimates of the general public. Two issues must be addressed concerning the relative size of the sample which involves properties of the estimators, and the representativeness of this sample involving sampling properties. Too few sample units drawn from a population may not accurately represent the population and could lead to biased estimates of the parameters in question. The point here concerns the variance about the population parameter (e.g., benefit estimates of control). Because the estimate of the variance of a population parameter is influenced by sample size, a small sample size will very likely result in a large estimated variance. In our discussion below we show that our benefit estimates are at least no more variable than benefit estimates in studies based on CMV approaches. Next we consider the representativeness of these individuals relative to the general public. Improper selection of the sample units could cause the sample to be unrepresentative of the population resulting in a sampling bias. Because one would expect these individuals to be more knowledgeable about mosquito control practices than the general public, whether or not this would result in more conservative benefit estimates is the crux of the issue. Unfortunately this cannot be formally examined with our data but is left for future endeavors. On the basis of education and income levels these individuals represent a fairly wide cross-section. Based on the overall conduct of the survey and rapport with these individuals, we believe these estimates may slightly understate benefits of mosquito control. In spite of any of the above shortcomings of these data we feel that these results merit reporting.

Estimates of annual benefits from improved levels of mosquito control on a per household and per capita (per person) basis are respectively presented in Tables 1 and 2. Concerning benefits associated with the incremental steps (marginal WTP)—outbreak to heavy, heavy to moderate, and moderate to light concentration levels—excluding influential observations,[5] incremental benefits were largest for the improvement from outbreak to heavy concentrations (or no control to light control activity). Mean estimates were $31.09/household or $9.47/person in 1984. Improvements in control associated with reducing mosquito concentrations from moderate to light levels contained the next highest benefit estimates.

Cumulative benefits associated with outbreak to moderate, outbreak to light, and heavy to

[5] Influential observations sometimes referred to as outliers can cause a problem with nonmarket good valuation studies. The techniques used to identify influential observations are based on Belsley, Kuh and Welsch (1980) and have been used before in nonmarket valuation studies (Desvousges et al. 1983, Mitchell and Carson 1984).

Table 1. Annual Benefit Estimates for Mosquito Control Improvements, 1984

| | Outbreak to Heavy | | Heavy to Moderate | | Moderate to Light | | Outbreak to Moderate | | Outbreak to Light | | Heavy to Light | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| | $/HH | | | | | | | | | | | |
| **Full Data Set:** | | | | | | | | | | | | |
| Chatham | 78.45 ± 169.64 | 22 | 66.86 ± 169.95 | 22 | 78.64 ± 169.91 | 22 | 145.32 ± 337.97 | 22 | 223.95 ± 503.81 | 22 | 145.50 ± 335.85 | 22 |
| Glynn | 23.08 ± 18.43 | 13 | 10.85 ± 9.85 | 13 | 11.31 ± 10.52 | 13 | 33.92 ± 27.12 | 13 | 45.23 ± 32.91 | 13 | 22.15 ± 18.05 | 13 |
| Both | 57.89 ± 136.49 | 35 | 46.06 ± 136.48 | 35 | 53.63 ± 137.70 | 35 | 103.94 ± 271.65 | 35 | 157.57 ± 406.00 | 35 | 99.69 ± 271.00 | 35 |
| **Data Set Without Outliers:**[a] | | | | | | | | | | | | |
| Chatham | 44.10 ± 54.26 | 21 | 31.95 ± 46.61 | 21 | 44.29 ± 55.29 | 21 | 76.05 ± 95.35 | 21 | 120.33 ± 135.95 | 21 | 76.24 ± 87.29 | 21 |
| Glynn | 23.08 ± 18.43 | 13 | 10.85 ± 9.85 | 13 | 11.31 ± 10.52 | 13 | 33.92 ± 27.12 | 13 | 45.23 ± 32.91 | 13 | 22.15 ± 18.05 | 13 |
| Both | 36.06 ± 44.89 | 34 | 23.88 ± 38.21 | 34 | 31.68 ± 46.45 | 34 | 59.94 ± 78.80 | 34 | 91.62 ± 113.88 | 34 | 55.56 ± 73.81 | 34 |
| **Data Set Without Outliers:**[b] | | | | | | | | | | | | |
| Chatham | 36.30 ± 41.90 | 20 | 23.55 ± 26.94 | 20 | 36.50 ± 43.34 | 20 | 59.85 ± 61.40 | 20 | 90.89 ± 99.10 | 19 | 56.63 ± 63.63 | 19 |
| Glynn | 23.08 ± 18.43 | 13 | 10.85 ± 9.85 | 13 | 11.31 ± 10.52 | 13 | 33.92 ± 27.12 | 13 | 45.23 ± 32.91 | 13 | 22.15 ± 18.05 | 13 |
| Both | 31.09 ± 34.83 | 33 | 18.55 ± 22.52 | 33 | 26.58 ± 36.24 | 33 | 49.64 ± 51.77 | 33 | 72.34 ± 81.49 | 32 | 42.63 ± 52.66 | 32 |
| **Outliers:** | | | | | | | | | | | | |
| Chatham | 500.00 ± 424.26 | 2 | 500.00 ± 424.26 | 2 | 500.00 ± 424.26 | 2 | 1000.00 ± 848.53 | 2 | 1066.67 ± 1159.02 | 3 | 708.33 ± 773.12 | 3 |

Note: HH refers to households.
a. Corresponds to the data set where influential observations with WTP bids in excess of $200/HH are deleted from analysis.
b. Corresponds to the data set where influential observations with WTP bids in excess of and equal to $200/HH are deleted from analysis.

light concentration levels were also estimated. Average per capita benefits corresponding to these respective levels were estimated at $16.31/person, $24.17/person, and $14.87/person in 1984.

Comparing the relative variability (SD/$\bar{X}$) of these estimates with some recent CMV studies indicates that these mosquito benefit estimates ranged from 1.1 to 1.5 ($/person) and 1.0 to 1.4 ($/HH). In a study assessing benefits of improved water quality (Desvousges et al. 1983), relative variability of user values ranged from 1.8 to 2.5 (user only) and 3.5 to 4.6 (user and nonuser combined). Loehman (1984) examined the benefits of improved air quality and ranges of the relative variability of benefit estimates range from 1.2 to 1.5, 1.1 to 1.6, 1.2 to 1.3, and 1.6 depending on the initial quality level respondents started with. It appears that our benefit estimates demonstrate a similar degree of variability compared to the above studies, although a larger sample might have produced less variable benefit estimates (the Desvousges et al. study was based on a sample of 17—user, 54—user and nonuser; the Loehman study a sample of 145, 64, 83 and 43 respondents corresponding to the above ranges).

When asked about how these respondents felt about their "bids," 43% indicated that their answers were "quite accurate," and 43% accurate in a "ball park sense." In addition, 89% of the survey respondents felt that their benefit estimates were at least a good guide in valuing

Table 2. Annual Per Capita Benefit Estimates for Mosquito Control Improvements, 1984

| | Outbreak to Heavy | | Heavy to Moderate | | Moderate to Light | | Outbreak to Moderate | | Outbreak to Light | | Heavy to Light | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| | $/person | | | | | | | | | | | |
| **Full Data Set:** | | | | | | | | | | | | |
| Chatham | 30.27 ± 83.88 | 22 | 28.35 ± 84.31 | 22 | 30.13 ± 83.77 | 22 | 58.62 ± 167.89 | 22 | 88.75 ± 251.21 | 22 | 58.48 ± 167.61 | 22 |
| Glynn | 7.43 ± 5.57 | 13 | 4.00 ± 3.58 | 13 | 4.41 ± 5.34 | 13 | 11.43 ± 8.46 | 13 | 15.84 ± 11.83 | 13 | 8.41 ± 8.18 | 13 |
| Both | 21.78 ± 66.94 | 35 | 19.31 ± 67.36 | 35 | 20.58 ± 67.11 | 35 | 41.09 ± 134.05 | 35 | 61.67 ± 200.76 | 35 | 39.89 ± 134.08 | 35 |
| **Data Set Without Outliers:**[a] | | | | | | | | | | | | |
| Chatham | 12.66 ± 15.04 | 21 | 10.65 ± 15.14 | 21 | 12.52 ± 14.23 | 21 | 23.31 ± 28.37 | 21 | 35.83 ± 39.70 | 21 | 23.17 ± 26.37 | 21 |
| Glynn | 7.43 ± 5.57 | 13 | 4.00 ± 3.58 | 13 | 4.41 ± 5.34 | 13 | 11.43 ± 8.46 | 13 | 15.84 ± 11.83 | 13 | 8.41 ± 8.18 | 13 |
| Both | 10.66 ± 12.45 | 34 | 8.11 ± 12.42 | 34 | 9.42 ± 12.21 | 34 | 18.77 ± 23.42 | 34 | 28.19 ± 33.22 | 34 | 17.53 ± 22.33 | 34 |
| **Data Set Without Outliers:**[b] | | | | | | | | | | | | |
| Chatham | 10.79 ± 12.69 | 20 | 8.69 ± 12.48 | 20 | 11.15 ± 13.10 | 20 | 19.48 ± 22.86 | 20 | 29.87 ± 35.21 | 19 | 19.30 ± 24.10 | 19 |
| Glynn | 7.43 ± 5.57 | 13 | 4.00 ± 3.58 | 13 | 4.41 ± 5.34 | 13 | 11.43 ± 8.46 | 13 | 15.84 ± 11.83 | 13 | 8.41 ± 8.18 | 13 |
| Both | 9.47 ± 10.49 | 33 | 6.84 ± 10.13 | 33 | 8.49 ± 11.12 | 33 | 16.31 ± 18.79 | 33 | 24.17 ± 28.69 | 32 | 14.87 ± 19.82 | 32 |
| **Outliers:** | | | | | | | | | | | | |
| Chatham | 225.00 ± 247.49 | 2 | 225.00 ± 247.49 | 2 | 200.00 ± 254.56 | 2 | 450.00 ± 494.97 | 2 | 461.67 ± 640.24 | 3 | 306.67 ± 427.50 | 3 |

Note: HH refers to households.
a. Corresponds to the data set where influential observations with WTP bids in excess of $200/HH are deleted from analysis.
b. Corresponds to the data set where influential observations with WTP bids in excess of and equal to $200/HH are deleted from analysis.

Table 3. Socioeconomic Characteristics, 1984

| | Education | | Income | | Age | | Household Size | | Leisure Time | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| | --- years --- | | ---- $ ---- | | ---- years -- | | ------ no. --- | | -- hrs/week --- | |
| **Full Data Set:** | | | | | | | | | | |
| Chatham | 13.3 ± 2.5 | 22 | 23,452 ± 14,285 | 21 | 42.5 ± 14.0 | 22 | 3.1 ± 1.4 | 22 | 22.4 ± 13.8 | 22 |
| Glynn | 12.5 ± 1.8 | 13 | 17,884 ± 16,261 | 13 | 32.8 ± 14.2 | 13 | 3.3 ± 1.3 | 13 | 22.0 ± 14.2 | 13 |
| Both | 13.0 ± 2.3 | 35 | 21,323 ± 15,078 | 34 | 38.9 ± 14.7 | 35 | 3.2 ± 1.3 | 35 | 22.3 ± 13.7 | 35 |
| **Data Set Without Outliers:**[a] | | | | | | | | | | |
| Chatham | 13.3 ± 2.6 | 21 | 22,999 ± 14,500 | 20 | 41.7 ± 13.7 | 21 | 3.2 ± 1.4 | 21 | 22.9 ± 13.9 | 21 |
| Glynn | 12.5 ± 1.8 | 13 | 17,884 ± 16,261 | 13 | 32.8 ± 14.2 | 13 | 3.3 ± 1.3 | 13 | 22.0 ± 14.2 | 13 |
| Both | 13.0 ± 2.3 | 34 | 20,984 ± 15,180 | 33 | 38.3 ± 14.4 | 34 | 3.2 ± 1.3 | 34 | 22.6 ± 13.8 | 34 |
| **Data Set Without Outliers:**[b] | | | | | | | | | | |
| Chatham | 13.4 ± 2.6 | 20 | 22,763 ± 14,858 | 19 | 41.7 ± 14.1 | 20 | 3.2 ± 1.4 | 20 | 22.9 ± 14.3 | 20 |
| Glynn | 12.5 ± 1.8 | 13 | 17,884 ± 16,261 | 13 | 32.8 ± 14.2 | 13 | 3.3 ± 1.3 | 13 | 22.0 ± 14.2 | 13 |
| Both | 13.0 ± 2.4 | 33 | 20,781 ± 15,377 | 32 | 38.2 ± 14.6 | 33 | 3.2 ± 1.3 | 33 | 22.5 ± 14.0 | 33 |
| **Data Set Without Outliers:**[c] | | | | | | | | | | |
| Chatham | 13.4 ± 2.6 | 20 | 22,763 ± 14,858 | 19 | 41.7 ± 14.1 | 20 | 3.1 ± 1.4 | 20 | 23.8 ± 13.7 | 20 |
| Glynn | 12.5 ± 1.8 | 13 | 17,884 ± 16,261 | 13 | 32.8 ± 14.2 | 13 | 3.3 ± 1.3 | 13 | 22.0 ± 14.2 | 13 |
| Both | 13.0 ± 2.4 | 33 | 20,781 ± 15,377 | 32 | 38.2 ± 14.6 | 33 | 3.2 ± 1.3 | 33 | 23.1 ± 13.7 | 33 |
| **Data Set Without Outliers:**[d] | | | | | | | | | | |
| Chatham | 13.4 ± 2.7 | 19 | 22,499 ± 15,243 | 18 | 41.8 ± 14.5 | 19 | 3.1 ± 1.4 | 19 | 23.7 ± 14.1 | 19 |
| Glynn | 12.5 ± 1.8 | 13 | 17,884 ± 16,261 | 13 | 32.8 ± 14.2 | 13 | 3.3 ± 1.3 | 13 | 22.0 ± 14.2 | 13 |
| Both | 13.0 ± 2.4 | 32 | 20,564 ± 15,582 | 31 | 38.1 ± 14.8 | 32 | 3.2 ± 1.3 | 32 | 23.0 ± 13.9 | 32 |
| **Outliers:** | | | | | | | | | | |
| Chatham[b] | 13.0 ± 1.4 | 2 | 29,999 ± 3,536 | 2 | 50.5 ± 14.1 | 2 | 3.0 ± 1.4 | 2 | 18.0 ± 8.5 | 2 |
| Chatham[c] | 13.0 ± 1.4 | 2 | 29,999 ± 3,536 | 2 | 50.5 ± 14.1 | 2 | 3.5 ± 2.1 | 2 | 9.0 ± 4.2 | 2 |
| Chatham[d] | 12.7 ± 1.2 | 3 | 29,166 ± 2,887 | 3 | 47.2 ± 11.5 | 3 | 3.7 ± 1.5 | 3 | 14.0 ± 9.2 | 3 |

mosquito control (54%—fairly good guide, 34%—a good guide).

Various socioeconomic characteristics associated with these individuals are in Table 3.[6] Inclusion of this profile information will allow comparisons with other studies and further examination of the representativeness of these individuals with the general public. Examining the data set that corresponds to the benefit estimates above (data set without outliers for outbreak to light, and heavy to light levels) the average age of these individuals was 38 years, along with an average education of 13 years. Mean income was $20,564/year per household, and the average household size was 3.2 persons. Other information of interest to us was the amount of leisure time available—average of 23 hrs/week, the number of outdoor activities these individuals participate in—mean of 6.7 activities (e.g., gardening/yardwork, cookouts/picnics, porch-patio sitting, fishing—salt and fresh water, and hiking—five most popular in which mosquitoes are bothersome in descending order of importance), and the relative level of mosquito concentrations at the time of the survey (September 1984) ranked on a 0 to 10 scale—mean 5.8 ± 2.6 which corresponds to a relative density represented by Photo C, moderate concentrations.

Various attitude-type questions were asked about mosquito control perceptions. Highlights follow. An overwhelming majority (94%) felt that mosquito control was essential in these counties. Ninety-seven percent of the respondents dismissed the suggestion that mosquito control is an unnecessary luxury, 66% would favor a tax increase to ensure mosquito control, 77% disagreed with the statement "I can live with mosquitoes," 80% indicated they would like to see an expansion of mosquito control efforts in adjacent coastal areas (presently without control), 89% agreed that knowing the value of mosquito control can help make better decisions about resource allocation, and 86% felt that this kind of research is a good idea.

## DISCUSSION

When faced with goods characterized by an absence of market conditions the researcher has little choice but to adopt alternative approaches to assist in quantifying and valuing these goods. The contingent market valuation (CMV) approach based on the willingness-to-pay concept is but one approach.

[6] Supplementary tables about socioeconomic distribution of the survey respondents, attitudes about mosquito control, and relative importance of insect biting pests are available upon request from the authors.

Table 3, continued

| | Outdoor Activities | | Race[e] | | Mosquito Concentration Rating[f] | | Length of Residence | |
|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| | - - - no. - - | | | | | | - - - - years - - | |
| **Full Data Set:** | | | | | | | | |
| Chatham | 6.1 ± 3.3 | 22 | 0.59 ± 0.50 | 22 | 6.2 ± 3.0 | 21 | 14.2 ± 10.9 | 12 |
| Glynn | 7.7 ± 2.7 | 13 | 0.69 ± 0.48 | 13 | 5.5 ± 1.8 | 13 | 7.2 ± 4.1 | 5 |
| Both | 6.7 ± 3.1 | 35 | 0.63 ± 0.49 | 35 | 5.9 ± 2.6 | 34 | 12.1 ± 9.8 | 17 |
| **Data Set Without Outliers:[a]** | | | | | | | | |
| Chatham | 6.0 ± 3.4 | 21 | 0.57 ± 0.51 | 21 | 6.2 ± 3.0 | 20 | 14.2 ± 10.9 | 12 |
| Glynn | 7.7 ± 2.7 | 13 | 0.69 ± 0.48 | 13 | 5.5 ± 1.8 | 13 | 7.2 ± 4.1 | 5 |
| Both | 6.7 ± 3.2 | 34 | 0.62 ± 0.49 | 34 | 5.9 ± 2.6 | 33 | 12.1 ± 9.8 | 17 |
| **Data Set Without Outliers:[b]** | | | | | | | | |
| Chatham | 6.1 ± 3.5 | 20 | 0.60 ± 0.50 | 20 | 6.0 ± 3.0 | 19 | 14.2 ± 10.9 | 12 |
| Glynn | 7.7 ± 2.7 | 13 | 0.69 ± 0.48 | 13 | 5.5 ± 1.8 | 13 | 7.2 ± 4.1 | 5 |
| Both | 6.7 ± 3.2 | 33 | 0.64 ± 0.49 | 33 | 5.8 ± 2.6 | 32 | 12.1 ± 9.8 | 17 |
| **Data Set Without Outliers:[c]** | | | | | | | | |
| Chatham | 5.9 ± 3.4 | 20 | 0.55 ± 0.51 | 20 | 6.2 ± 3.1 | 19 | 14.2 ± 10.9 | 12 |
| Glynn | 7.7 ± 2.7 | 13 | 0.69 ± 0.48 | 13 | 5.5 ± 1.8 | 13 | 7.2 ± 4.1 | 5 |
| Both | 6.6 ± 3.2 | 33 | 0.61 ± 0.50 | 33 | 5.9 ± 2.6 | 32 | 12.1 ± 9.8 | 17 |
| **Data Set Without Outliers:[d]** | | | | | | | | |
| Chatham | 5.9 ± 3.5 | 19 | 0.58 ± 0.51 | 19 | 6.0 ± 3.1 | 18 | 14.2 ± 10.9 | 12 |
| Glynn | 7.7 ± 2.7 | 13 | 0.69 ± 0.48 | 13 | 5.5 ± 1.8 | 13 | 7.2 ± 4.1 | 5 |
| Both | 6.7 ± 3.2 | 32 | 0.63 ± 0.49 | 32 | 5.8 ± 2.6 | 31 | 12.1 ± 9.8 | 17 |
| **Outliers:** | | | | | | | | |
| Chatham[b] | 6.0 ± 1.4 | 2 | 0.50 ± 0.71 | 2 | 8.5 ± 0.7 | 2 | - | - |
| Chatham[c] | 8.0 ± 1.4 | 2 | 1.00 ± 0.00 | 2 | 7.0 ± 1.4 | 2 | - | - |
| Chatham[d] | 7.0 ± 2.0 | 3 | 0.67 ± 0.58 | 3 | 7.7 ± 1.5 | 3 | - | - |

a. Corresponds to the data set where influential observations with WTP bids in excess of $200/HH are deleted from analysis.
b. Corresponds to the data set where influential observations with WTP bids in excess and equal to $200/HH associated with improvements from outbreak to heavy (photo B) and heavy to moderate (photo C) levels as well as total bid for outbreak to moderate (photos B + C) levels are deleted from analysis. Outliers are simply the observations deleted.
c. Corresponds to the data set where influential observations with WTP bids in excess and equal to $200/HH associated with moderate to light levels only, are deleted from analysis. Outliers are simply the observations deleted.
d. Corresponds to the data set where influential observations with WTP bids in excess and equal to $200/HH associated with outbreak to light (photos B + D) and heavy to light (photos C + D) levels are deleted from analysis. Outliers are simply the observations deleted.
e. 1 if white, 0 if nonwhite.
f. 0 = lowest, 10 = highest.

This paper develops a CMV approach that can be used to value public mosquito control. The preliminary study demonstrates how this approach can be used to assess and interpret a value of benefits from mosquito control. Compared to other CMV studies our benefit estimates demonstrate a similar degree of variability. With slight adaptations a similar procedure could be applied in different areas; however, we recommend that researchers not familiar with nonmarket good benefit techniques seek professional assistance from economists knowledgeable about these techniques.

The CMV approach is composed of four critical interrelated elements, the hypothetical market, the good to be valued, the payment mode, and the valuation questions. Much care must be taken in advancing both the good and market setting in the questionnaire design so that they appear realistic and credible, and are easily understood by the survey respondent. The valuation questions must not only be unambiguous but also must appear credible to the respondent. All of these elements are intertwined and of equal importance in questionnaire design. Carelessness in any of these parts would not only cast doubt on the survey application, but, add to the skepticism associated with the CMV approach and results. As with any study based on survey data the study is only as good as its data and this begins with the design of the survey instrument along with the sampling method.

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