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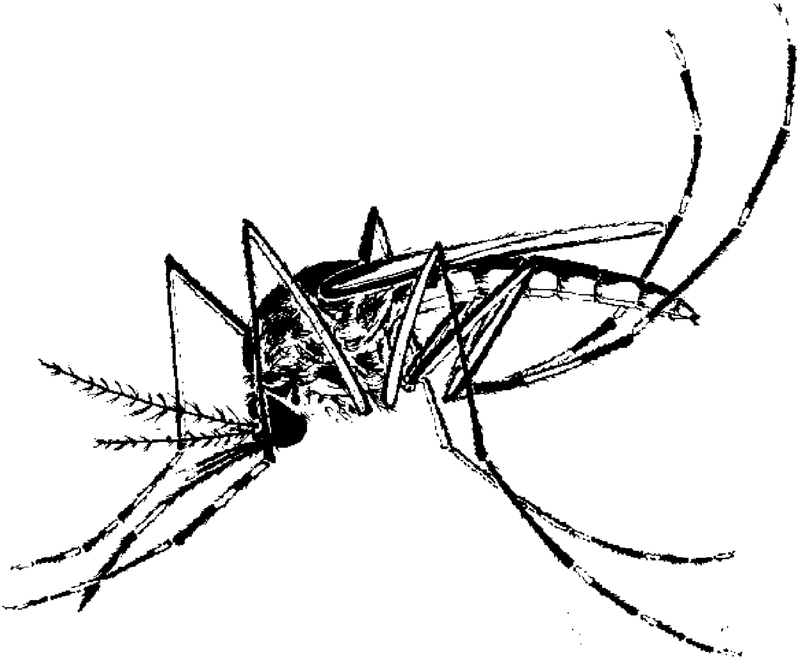
Demand For and Cost Of Coastal Salt Marsh Mosquito Abatement



North Carolina Agricultural Experiment Station

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Demand For and Cost Of Coastal Salt Marsh Mosquito Abatement

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CONTENTS

TABLES

FIGURES

APPENDICES

ABSTRACT

Data related to mosquito (mostly salt marsh *Aedes*) abatement activities for 30 East Coast districts for 1959 through 1971 were analyzed. A trend analysis was conducted on mosquito densities, temporary and permanent abatement work, total abatement expenditures and per capita abatement expenditures. A four-equation pest management model was utilized to examine the responsiveness of mosquito numbers to permanent and temporary abatement procedures and to analyze the factors affecting the demand for mosquito abatement. A regression model was employed to check for possible economies of scale in permanent and temporary abatement work. The estimated empirical results of these 2 models were then utilized to determine the relative effectiveness per dollar of permanent and temporary abatement expenditures in reducing the number of mosquitoes.

Mosquito populations (as measured by the annual mean number of female mosquitoes per light-trap night) varied widely from district to district and year to year[1]. The mean annual (May-October) collections ranged from 1.5 to 794 mosquitoes per trap night with an overall mean of 63.2. The 13-year trend (all locations averaged) was downward. The average number of acres under temporary control (treated with insecticides) was 484,600 and the number in any given year tended to change in the same direction as changes in mosquito numbers. The acreage under permanent control (ditched or diked) increased over the 13 years and the yearly average was 6,138 acres. Abatement expenditures were financed from local district taxes and state grants. Total expenditures increased during the 13 years, but a very high portion of the increases came from local funds.

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[1] Light trap collections are a standard tool for mosquito population measurements, although they yield variable results according to the species of mosquitoes involved, trap location and environmental conditions. However, these are the only type of data available for many years from all the districts included in this study, and control measures were mainly based on light trap data in these districts. In some cases, data on landing or biting rates were available. The simple correlation between these and the light trap data was +.78 which suggests that the light trap data provided a reasonable estimate of the degree of annoyance from mosquitoes.

Total and local expenditures per capita increased throughout the period, whereas the state expenditure per capita declined.

The analysis revealed that both temporary and permanent abatement procedures significantly reduced the average mosquito population during the 13-year period. A 10% increase (above the mean annual level) in acres sprayed corresponded to a 5.7% decrease in the mean number of mosquitoes per light trap night. A 10% increase in acres under permanent control resulted in a 4.4% decrease in mosquito numbers (calculated over the 10-year life of the permanent facility). Economies of scale were shown to exist in permanent abatement work but not in temporary. The estimated relationship between control measures (temporary vs permanent) and mosquito numbers, plus estimates of costs of performing units of abatement activities, indicated that, in an "average" district, temporary chemical controls reduced from 1.4 to 3.5 times as many mosquitoes per dollar of expenditure as did permanent control measures. This condition was calculated at the sample mean, i.e., for a so-called "average size" district. Very large districts which have significantly lower costs of performing permanent, but not temporary activities, have near equal returns from permanent and temporary acres controlled. Contrarily, districts with fewer people and smaller total budgets have higher costs of lowering mean level of mosquito abundance by permanent control than by chemical control in terms of direct field cost. This study only evaluated the direct dollar costs and the associated change in the number of mosquitoes and did not attempt to evaluate any of the other effects of abatement work.

The demand for abatement, as measured by local per capita expenditures, was determined to be significantly affected by income, state grants for abatement, tourism, the wage rate (a proxy for price), and population. State grants stimulated local expenditures rather than substituted for them. For the average district, it was found that a $1.00 increase in state grants caused local expenditures to increase by $.90, other things being equal. Abatement demand was found to be elastic, i.e., each 1% increase in the abatement price caused the quantity demanded to decrease by 1.7%.

The implications of these results are discussed in relation to the formation of new mosquito abatement districts or the expansion of existing programs.

Demand For and Cost Of Coastal Salt Marsh Mosquito Abatement

I. INTRODUCTION AND OBJECTIVES

Mosquito control or abatement in coastal regions has become a controversial issue in recent years because of the potential environmental problems related to the use of insecticides and alterations of marsh areas as methods of control (Water Resources Research Institute, 1970). There is concern that these activities may be destroying wildlife and fish habitat that is critical to man's welfare. In spite of these concerns, public agencies are engaging in a considerable amount of abatement activity.

This mosquito control or abatement work uses large quantities of resources each year. In 1971, $38 million were expended by 191 publicly-funded mosquito abatement districts (American Mosquito Control Association, 1972). The states of Florida and California accounted for the largest expenditures, $11 and $10 million, respectively, but other coastal areas are growing in importance. Of particular interest in this study are the salt marsh mosquito areas of the East Coast states where the principal pest species are *Aedes sollicitans* (Walker) and *Aedes taeniorhynchus* (Wiedemann).

Mosquitoes have caused sizeable economic losses to infested areas, although data on this are limited. It is well known that several human diseases may be transmitted by mosquitoes; this results in economic losses in the form of medical care costs, medicine, loss of worktime and even death. Annoyances to humans can lead to reduced labor efficiency, decreases in numbers of tourists, and depressed land values in infested areas. Livestock and poultry output may fall with increases in mosquito density. Through time, disease transmission has become less of a problem and land development and tourism are more frequently given as reasons for control.

The problem which this study investigates is the determination of economically efficient utilization of resources for mosquito control in the coastal areas. Have the control procedures been effective in reducing mosquito densities? If so, which procedures are the most effective in terms of mosquito reduction per dollar of expenditure? How much are people willing to pay for control and what are the main factors influencing the demand for control?

Mosquitoes are controlled by both private individuals and public agencies. If there are economies of scale in abatement or reduced cost in area-wide treatment because of pest mobility, then public provision of control may be preferred to private control. Private control may be advantageous in sparsely populated areas or areas in which pest densities differ greatly. Each of these and other factors need to be considered in making decisions on the formation of new control districts.

Control activities in the coastal areas can be divided into "permanent" and "temporary" measures. "Permanent" refers to ditching and impoundment operations on salt marshes to reduce the breeding areas, while "temporary" includes application of pesticides (against both the adult and the larval stages of the mosquitoes). There have been attempts to evaluate the effectiveness of ditching and impoundments (LaSalle and Knight, 1973, 1974; Dukes, et al 1974) and pesticides (Schoof, 1970) in reducing mosquito populations. Yet, no effort has been devoted to combining evaluation of costs and reduced populations to determine which control methods are economically the most efficient.

Since mosquito densities are affected by weather phenomena which occur irregularly (such as hurricanes, rainfall periods) and by permanent control measures (such as ditches) which have long lives (5-15 years), it is necessary to examine long periods of abatement activities. In addition, the demand for and cost of control is thought to vary with many economic, biological, and climatological characteristics which vary across control districts. For these reasons, this study examines data from 30 East

Coast mosquito control districts for a period of 13 years (1959-1971). Complete data were not available in this number of districts for a longer period of time.

OBJECTIVES

The overall objective of this study was to determine the costs of and demand for salt marsh mosquito abatement. The specific objectives were to:

1. Collect and summarize information on the activities of publicly-funded abatement districts to gain an understanding of the existing cost-pest density situation.
2. Specify and estimate the parameters of a model explaining abatement of salt marsh mosquitoes to determine the relative costs of temporary and permanent control activities.
3. Determine how various economic factors and mosquito abundance affect the demand for mosquito abatement.
4. Estimate the effects of the scale of operation on control costs.
5. Examine the prospects for raising local abatement revenue in other coastal areas, especially in North Carolina.

II. ORIGINS OF MOSQUITO ABATEMENT

ECONOMIC IMPORTANCE OF MOSQUITOES

The presence of excessive numbers of mosquitoes has presumably caused serious economic losses to infested communities. Retarded economic progress can occur because mosquitoes hinder agricultural production, decrease the number of tourists and vacationers to an area, present an unfavorable influence on those planning to establish or expand businesses, and delay the sale and development of real estate (White, 1957).

Historically, mosquitoes have taken a heavy toll on human and animal life as there are 13 communicable human diseases and numerous communicable animal diseases carried by the mosquito (White, 1957; James and Harwood, 1969; Horsfall, 1955, 1962). The diseases of malaria, yellow fever and encephalitis have at times reached epidemic stages in the United States. Yellow fever and malaria have been essentially eradicated, although occasional cases still occur (mainly due to importations from foreign countries). Dog heartworm is a severe problem and encephalitis continues to exhibit periodic outbreaks in horses, mules, and humans. Salt marsh *Aedes* mosquitoes are not involved in all these diseases but to varying degrees can function in the transmission of dog heartworms, encephalitis, and other diseases. Other species of mosquitoes (some associated with the marshes and others in upland habitats) in the coastal areas are involved in the epidemeology of these various diseases. Consequently, the overall program for mosquito control in a district has justification in preventing or reducing the potential for outbreaks of diseases among men and animals.

To illustrate the economic effects of a mosquito-borne disease, considerable information is available on malaria. In the early part of this century, malaria was of considerable importance. There were an estimated 1,500,000 and 2,700,000 cases of malaria in the United States in 1932 and 1934, respectively (National Resources Committee, 1938). This report estimated one death per 600 malaria cases and a minimum loss of 3.33 to 6.67 working days per malaria case. This amounted to 4,500 deaths and from 8.9 to 18.0 million sick days for the cases estimated for 1934. Additional costs were imposed by the lower efficiency of workers who returned to work and the associated cost of medical care and medicines.

One method of determining economic loss is to add dollar losses of the economic value of life, the cost of medical services and medicines, the value of lost working time, and the value of lost production due to the lower efficiency of workers. This would provide a minimum estimate of the total costs imposed by mosquitoes (Rice, 1968).

Economic costs are imposed through losses due to the nuisance aspects of mosquitoes. Not all mosquitoes are carriers of disease, but they surely influence the quality of life. A statement by the United States Public Health Service summarizes this situation (White, 1957):

"Public health has become something more than the absence of disease. Physical efficiency and comfort, on which mental equanimity depends to a substantial degree, can be seriously disturbed by the continued annoyance of pestiferous mosquitoes which may or may not have disease-transmitting potentialities."

The presence of mosquitoes also hinders agricultural operation, both the raising of livestock and the production of crops. Excessive numbers of mosquitoes may affect the efficiency of livestock operations by reducing the weight gain and feed intake of market animals or the weight and condition of breeding animals. A study in southern Louisiana showed mosquito populations caused statistically significant and economically damaging reductions in the average daily gain of feedlot steers (Steelman et al, 1972). Another study estimated that cattle producers suffered a loss of $231,250 because of mosquitoes in Cameron Parish, Louisiana, during the 1962 mosquito season (Hoffman and McDuffie, 1962). Mosquitoes may cause crop losses by interfering with the harvesting of perishable crops at the proper time. Additional workers may be needed to avoid such losses.

Areas dependent on tourist and recreation trade suffer because of mosquitoes (and other biting flies). People on pleasure trips and vacations leave hotels, beaches and camp sites if mosquitoes are numerous, and they warn others about the discomfort of such places. The loss of business affects not only the specific business enterprise but the economic well being of the entire community.

The above illustrations provide a glimpse of how mosquitoes have affected people. Attention was initially focused on the mosquito because it was a vector of disease. Once the disease aspect was brought under control, emphasis gradually turned to the nuisance aspect and secondary infections as contrasted with disease prevention per se (Herms and Gray, 1940).

MOSQUITO BIOLOGY

The mosquitoes that create problems in the coastal regions of Southeastern United States are mainly the salt marsh species, *Aedes sollicitans* (Walker) and *Aedes taeniorhynchus* (Wiedemann). These salt marsh *Aedes* mosquitoes are temporary water breeders since they lay their eggs on moist soil (not on the water surface), and the eggs require a period of drying (or conditioning) before they will successfully hatch upon subsequent flooding with water. There are other mosquitoes which are called permanent water breeders because they lay their eggs on the water surface, and their eggs hatch without any period of drying. Certain permanent water breeders (*Anopheles spp.* and *Culex spp.*) are found in standing water in portions of coastal marshes as well as in upland sites. However, the coastal control programs are designed to alleviate the problem of *Aedes sollicitans* and *Aedes taeniorhynchus*, and these species constituted the vast majority of the specimens collected in the light traps of the districts we examined.

The salt marsh *Aedes* lay their eggs on the moist soil in the marshes. This usually occurs in areas of the marsh which are slightly higher in elevation than the normal high tides so that they are only irregularly or intermittently flooded (by exceptional high tides, unusual amounts of rainfall, wind tides, etc.). Once the egg is deposited, it takes 2 to 3 days of conditioning time for it to become ready to hatch when subsequently flooded with water. The eggs may remain dry for several months and still retain their viability. When the "conditioned eggs" are flooded by heavy rains or abnormal tides, the eggs hatch into larvae. The larva develops through four stages and then becomes a pupa from which the adult mosquito emerges. This cycle may require only a few days in warm weather. If the eggs are flooded before they become conditioned, they will not hatch until once again subjected to a period of drying. Hence, the sequence of flooding (and, therefore, the sequence of rainfall as well as tide levels) is a very important factor in mosquito production. Within the first or second night after emergence, the adult usually takes off on a migratory flight that is often downwind. Salt marsh *Aedes* mosquitoes are strong fliers and fierce biters and commonly fly as much as 10 miles from their breeding site but have been known to fly much further. Once the flight is over, mosquitoes begin biting to obtain a blood meal that is necessary for their survival.

When favorable conditions occur, eggs that have accumulated for months may hatch almost simultaneously, thus causing heavy infestations of mosquitoes. Huge broods of mosquitoes can occur within 7 to 10 days

after unusually high tides or heavy rains, provided the temperature is at least 68° F.. Salt marsh mosquitoes live approximately 3 weeks, and where frosts occur, they generally die out during the winter months. The eggs that were deposited in the late fall produce the mosquitoes for the next season. The mosquito season usually begins the first week of May and ends the last of October and, therefore, data for that period are used in this study. Of course, the beginning and end depends on the temperature in any given year or locality, because the temperature greatly affects mosquito activity.

The above is a brief summary of the biology of salt marsh *Aedes* to provide a basis for understanding the relevance of the control measures to be analyzed. Further details of the biology can be obtained from the extensive literature, including: Axtell (1974a), Clements (1963), Haeger (1960), Headlee (1945), Knight and Baker (1962), Nielsen and Nielsen (1953), Provost (1958), Travis and Bradley (1943).

MOSQUITO ABATEMENT PROCEDURES

The procedures for publicly-organized abatement of mosquitoes can be separated into two categories, permanent and temporary. Permanent control activities are designed to alter the environment so as to either destroy places in which mosquitoes breed or to render them unsuitable for propagation. Temporary control measures involve the use of chemicals to kill the larvae (larviciding) and adults (adulticiding). Temporary control measures are effective only for a short period of time, and they do not alter the physical environment to the extent that permanent activities do.

Permanent control procedures include impounding and ditching. Impoundments consist of dikes constructed to contain the water within an area and prevent the drying/flooding cycle that is necessary for the egg deposition and hatching. The ditching operation consists of constructing ditches throughout the marsh area to increase the rate of water runoff after unusually high tides or rainfall. The ditches are constructed in such a manner as to have them all connect to existing natural waterways or to larger ditches that empty into a major body of water. Mosquito breeding occurs when the eggs are flooded and the water is trapped in some depression and permitted to stand long enough for the larvae to develop into pupae and the adult mosquitoes to emerge. Ditching is designed to prevent the water from remaining long enough for this to occur. Ditches are permanent installations and require maintenance only every 5 to 12 years, depending on the area. Ditches are constructed differently in different locations because of differences in vegetation, soil type, and tidal action. The main variation comes in width of the ditches as different conditions require different sizes to obtain proper drainage and stable sides, and accordingly the ditches have various lengths of life.

Temporary chemical control measures involve the application of insecticides to kill the adult or the larval stage of the mosquitoes (American Mosquito Control Association, 1968). Application may be by ground-operated equipment or by aircraft. The method depends on the terrain and circumstances. A large part of the adult control is usually by truck-mounted foggers operated in the areas inhabited by people. In recent years (since 1971) the fogging machines have been rapidly replaced by ULV (ultra low volume) machines which are reported to have much lower operating costs (Fultz et al, 1972). Larval control requires treating the water where larvae are found. This involves inspections and frequently the use of hand-carried sprayers, boats, and aircraft in the coastal marsh situations. Due to the irregular occurrence of broods of salt marsh *Aedes*, larviciding requires proper timing and is often difficult to accomplish effectively.

Permanent abatement procedures are long term in nature and are not designed to instantly reduce the number of mosquitoes. Temporary outbreaks are controlled by chemical application. In practice, use of chemicals can be considered to be effective for one day in the case of adulticiding and for several days for larviciding.

Officials of the mosquito district make the decision concerning the level of abatement activity to undertake. In order to determine the extent of the mosquito problem, the districts monitor the mosquito population. The most widely used monitoring method is the New Jersey light trap. This trap is a device which contains a fan beneath a light which attracts the adult mosquito. Upon entering the light trap, the mosquito is blown into a collection jar and killed by a chemical. The traps are

emptied on a regular schedule and the mosquitoes are counted and identified. Mosquito districts operate a number of these traps during the mosquito season and use the collection size as an estimate of the intensity of the mosquito problem. The light trap is the most widely used method of monitoring, although other methods, such as landing counts and residents' complaints are used to supplement light trap counts.

ORGANIZATION AND FINANCING OF MOSQUITO DISTRICTS

Many local areas have organized to provide abatement on a public basis. The first state to pass legislation enabling the establishment of mosquito control commissions was New Jersey in 1912. Florida passed similar legislation in 1929, Virginia in 1930 and Delaware in 1933. Similar legislation was enacted in North Carolina in 1957 (North Carolina Statutes, Chapter 130, Article 24). The procedure for forming districts, the purpose and duties, the structure of the governing bodies and the corporate powers were similar for all the states.

Most of the districts included in this study are located in Florida, so Florida's enabling legislation was analyzed (Florida Statutes, 1959). Any city, town, or county, or portion thereof, or parts of two or more counties could be created into a special taxing district for the control of mosquitoes or other arthropods of public health significance. The formation of the district was accomplished by 15 percent of the resident freeholders signing a petition for the creation of the district. If upon election, the proposal received a majority of the votes cast, a second election was held for the selection of 3 commissioners to serve on the board. The commissioners were given the power to levy upon all of the real and personal taxable property within the district a special tax, not exceeding 10 mills on the dollar, as a maintenance tax to be used solely for the purposes of mosquito work. They were given all the powers of a corporate body such as the power to sue, to enter into contracts, to own real estate, to employ a field director and other trained personnel and in general to do all things necessary to provide control of mosquitoes. Districts were required to submit detailed plans of operation and budgets to the State Board of Health at least 90 days prior to the initiation of operation or each fiscal year. A public hearing was required to be held, at which time the opportunity was afforded to owners of property, or their agent, to appear before the board, examine the work plan and budget, and to show their objections to the adoption of the proposed budget. The board gives consideration to objection filed against the adoption of the budget, and, at its discretion, may amend, modify, or change the tenative work plan. A certified budget is then drawn up and submitted to the State Board for approval.

The State of Florida has made provision for state aid to the local districts. Each district submitting a certified budget is eligible to receive state funds on a dollar-for-dollar matching basis up to, but not exceeding, $15,000. These funds may be expended for any and all types of control measures approved by the State Board. In addition, every district unit is eligible to receive state funds for permanent control procedures, exclusively, up to but not exceeding 75% of the amount budgeted in local funds. The State Board prorates these funds on the amount of matchable local funds budgeted. The state and local funds budgeted can be carried over at the end of the year and rebudgeted for the following fiscal year.

The rationale for providing state aid was to have individuals living outside the district share in the cost of abatement work. Citizens visiting the abatement areas share the benefits of fewer mosquitoes just as do the local residents. Also, fewer mosquitoes promotes economic development of the area which contributes benefits to the entire state. In the case of the coastal abatement districts, the tourist-based industry is particularly important and portions of the state other than the coast would receive benefits from increased tourism.

The provision of majority rule was very important because it prevented areas from withdrawing and thereby gaining mosquito abatement from surrounding district without paying. There was one such case in Florida (Young, 1964). The Ponte Vedra community attempted to withdraw from the St. John's County Anastasia Mosquito district, but the State Attorney General ruled they could not. If Ponte Vedra was permitted to withdraw from the district, it would provide a precedent for other communities to withdraw from county abatement districts.

III. REGIONS AND DATA ANALYZED

There were 259 publicly-funded mosquito districts in the United States in 1972 (American Mosquito Control Association, 1972). These districts were located in 26 states and served an area of 135,344 square miles.

REGIONS ANALYZED

Thirty districts were selected for analysis. The selection criteria were location and length of time of operation. The districts are listed in Table 3:1.

Table 3:1 - Mosquito Abatement Districts Selected for Analysis

Regions Analyzed

Florida[a]

Brevard County
Broward County
Charlotte County
Citrus County
Collier County
Duval County
Escambia County
Franklin County
Hillsborough County
Indian River County
Lee County
Levy County

Florida (cont.)

Manatee County
Martin County
Monroe County
Nassau County
Palm Beach County
Pinellas County
St. Johns County
St. Lucie County
Santa Rosa County
Sarasota County
Volusia County
Walton County

Georgia

Chatham County

Virginia

Virginia Beach

Delaware

Entire State

New Jersey

Cape May
Monmouth
Ocean

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[a] Counties having more than one district were treated as if they were 1 unit by combining the data from the individual districts.

The selected districts are located in 5 states in Mid-Atlantic and Southeastern regions of the United States. The reasons for choosing districts within one geographic section were twofold. First, the nature of the analysis required the area to be homogeneous with respect to the type of mosquito encountered. This analysis was aimed at the salt marsh *Aedes* species, so only the coastal areas were considered. The location was further restricted to the Mid-Atlantic and Southeastern coast of the United States because the species of mosquitoes encountered were mainly *Aedes sollicitans* and *Aedes taeniorhynchus*, and environmental conditions were similar within the selected regions. Secondly, the practical difficulty of obtaining the necessary data from the districts was diminished. Very little data concerning districts' operations were available from secondary sources, and visits to the appropriate agencies were required to obtain the needed information.

The time period selected was the years 1959 through 1971. The length of the time period is important because the permanent abatement activities require a substantial period of time for completion and the resulting installations last for many years. In order to ascertain the impact of such activities, a long span of time was required. Also, the longer the time period, the greater the range in environmental conditions and in the number of mosquitoes. The 13-year time period permits the evaluation of trends and long-term effects, whereas a shorter time period would be less satisfactory for this purpose. Thirteen years was the longest data base available.

MOSQUITO NUMBERS

Light traps are a standard tool for measuring mosquito populations even though the trap efficiencies vary considerably with different mosquito species, environmental conditions and location. Light trap collections were the only type of data which were available for many years from all the districts included in this study, and control measures were mainly based on light trap data in these districts. The data used from these districts were mean number of female mosquitoes per light trap per night during May-October for each year. This included a variety of species in low numbers, but the vast majority were salt marsh *Aedes* (*A. sollicitans* and *A. taeniorhynchus*). In 2 districts, data on landing or biting rates were also available. The sample correlation between the landing rates and the light trap data was +0.78, which suggests that the light trap data provided a reasonable estimate of the degree of annoyance from mosquitoes in an area (Appendix Table 5).

The annual mean light trap counts of female mosquitoes for the 30 districts (combined) for the 1959-1971 period are presented in Figure 3:1. (Data for each district and year are tabulated in Appendix Table 2). Data on the mosquito numbers were computed on a per-light-trap-night basis during the mosquito season, May 1 through October 31. The frequency of collection and the number of traps were different in different districts so care was exercised in obtaining the common measure of the number collected "per light trap night". This was done by dividing the total number of female mosquitoes collected by the number of traps times the number of nights in the collection. This information was furnished by the mosquito abatement agencies in each area.

The trend in the number of mosquitoes during this 13-year period was definitely downward. This is apparent upon inspection of Figure 3:1. Calculation of percentage changes from different base periods indicated the reduction was substantial. The 3-year mean from 1969-1971 was 57.4% lower than the 3-year mean for 1959-1961; the 6-year mean, 1966-1971, was 44.98% lower than the 7-year mean for 1959-1965.

MOSQUITO PRODUCTION FACTORS

The factors influencing the number of mosquitoes in a district were considered to be temperature, several rainfall characteristics, and acreage of salt marsh that possessed the necessary characteristics to support mosquito breeding. Other factors undoubtedly affect mosquito population development, but the above were considered to be the major factors that were quantifiable.

The temperature variable was measured as the mean monthly average temperature for the 6-month period, May-October. This information was obtained from reports of the U. S. Weather Bureau stations in each of the areas. There was very little variation in the annual 6-month mean for the 30 districts considered as a unit. The variation occurred between locations rather than over the years. The annual 6-month mean temperature ranged from a high of 82.1° F. in Monroe County, Florida, to a low of 66.4° F. in Ocean County, New Jersey. The overall 13-year mean temperature for 30 districts was 77.0° F.. Values for each district are presented in Table 3:2.

Rainfall was considered to influence mosquito propagation by causing marsh areas to flood, thus submerging the "conditioned" egg in water and allowing development of the next generation of mosquitoes. Rainfall data were obtained from the records of U. S. Weather Bureau station in each district. The daily precipitation for the months of May through October, 1959-1971 were tabulated.

The impact of rainfall was examined in two ways; storm rainfall and sequence rainfall. The first approach was the tabulation of periods during which excessive amounts of rainfall occurred, such as those during hurricanes and tropical storms. These storms flood vast areas of high marsh that normally are not subjected to water. The hypothesis was that the greater the rainfall during such periods the greater the flooding and, consequently, the greater the mosquito production. The amount that was considered excessive was arbitrarily designated to be 2 inches per day and consecutive periods (before or after 2-inch-days) of 1 inch per day. This was called "storm rainfall". Total annual amounts of rainfall which fell in such excessive periods were tabulated for each district for each year. The means over the 13-year period for each of the districts are presented in Table 3:2 as storm rainfall.

The second approach examined the sequence of the rainfall, because a wetting and drying cycle is involved in mosquito egg development. The wetting and drying period sequence utilized was a period of rainfall days (arbitrarily designated as a day on which 1/4 inch or more of rain occurred) followed by a minimum of 2 days of no rain. The mean number of such wet and dry sequences was tabulated and summed for each district for each year. Table 3:2 gives mean annual sequences for each district over the 13-year period. The overall mean for the sample districts was 18.77 sequences with a high of 23.23 sequences in Collier County, Florida, and a low value of 15.38 sequences in Cape May, New Jersey. Total annual rainfall means are also presented in Table 3:2.

Table 3:2 - Thirteen-Year (1959-1971) Mean Values for Temperature, Rainfall and Mosquitoes for 30 Locations; May 1 through October 31.

	Temperature (°F.)	Rainfall			Mosquitoes
		Total (inches)	Storm (inches)	Sequence (number)	No./Light trap night
Brevard, Fla.	78.47	34.74	10.72	17.69	137.15
Broward, Fla.	79.99	47.44	15.08	20.38	41.70
Charlotte, Fla.	79.92	38.63	10.44	19.00	32.62
Citrus, Fla.	79.26	39.54	9.16	19.23	24.58
Collier, Fla.	79.92	46.89	14.14	23.23	158.11
Duval, Fla.	78.13	36.77	11.96	18.38	12.82
Escambia, Fla.	77.45	35.41	13.34	17.46	28.13
Franklin, Fla.	77.75	37.31	16.31	16.00	47.65
Hillsborough, Fla.	79.33	32.52	8.14	18.15	52.41
Indian River, Fla.	79.23	43.33	9.30	19.85	34.75
Lee, Fla.	80.47	42.00	11.09	20.69	249.45
Levy, Fla.	79.42	32.39	12.17	16.85	12.24
Manatee, Fla.	78.81	42.98	13.26	20.85	75.55
Martin, Fla.	79.56	40.50	9.63	20.69	99.35
Monroe, Fla.	82.14	32.34	9.35	17.54	215.28
Nassau, Fla.	77.71	32.24	10.06	19.00	13.75
Palm Beach, Fla.	78.07	44.10	11.41	22.23	52.78
Pinellas, Fla.	79.12	35.11	11.08	19.00	17.17
St. Johns, Fla.	77.28	35.59	9.01	19.23	25.43
St. Lucie, Fla.	78.79	39.44	9.98	20.69	100.23
Santa Rosa, Fla.	76.36	35.03	10.78	19.31	10.55
Sarasota, Fla.	79.32	39.87	12.52	19.23	64.61
Volusia, Fla.	78.28	34.59	8.69	17.69	30.15
Walton, Fla.	76.11	35.97	10.59	18.77	168.86
Chatham, Ga.	76.21	19.67	11.22	20.23	25.55
Va.Beach, Va.	72.65	22.31	8.51	17.38	12.37
Delaware	69.25	23.17	5.92	15.46	10.85
Cape May, N. J.	68.42	21.93	4.82	15.38	103.32
Monmouth, N. J.	66.92	34.75	5.84	16.85	10.79
Ocean, N. J.	66.48	24.98	5.77	16.54	27.88
Avg. 30 Locations	77.03	35.38	10.34	18.77	63.20

TEMPORARY CONTROL

Temporary abatement procedures involved the use of chemicals against the adult or larval stages of the mosquitoes. These chemicals were applied by aircraft, boat, and truck-mounted equipment. The data used in our analysis was the total number of acres treated each year by all methods and for all purposes in each district. No distinction was made between adulticiding and larviciding nor between the method of application. These data were once-over acreages treated. For example, 1 acre receiving chemical application on 10 different days would be counted as 10 acres treated. The data were obtained directly from the abatement districts and in some cases from the state agencies in each state. Where information on the acreages treated was not available, standard dosages were used to convert the chemical quantities to acreages. Mean acreage chemically treated for the 30 districts is shown in Figure 3:2.

PERMANENT CONTROL

The major portion of permanent abatement activity consisted of ditching operations. Ditches were constructed either to bring additional acres of salt marsh under control or to maintain the ditching system that had been installed in previous years. The data collected were in terms of the linear feet of ditch constructed and the acres of marsh in impoundments. The permanent control variable desired was one that measured the accumulated acres of salt marsh breeding area under control in each year of the 13-year time period - the "stock" of permanent work. This required a conversion factor for linear feet to acres and a depreciation factor to be applied to the existing ditching system. The linear feet per acre conversion factor used was 261 feet. This figure was selected because the Delaware ditching system had 261 feet per acre and information supplied by other district directors indicated that 250 to 270 feet was as close an approximation as could be obtained.

The depreciation factor applied was 12 years to Brevard, Broward, Charlotte, Citrus, Collier, Hillsborough, Indian River, Lee, Levy, Manatee, Martin, Monroe, Palm Beach, Pinellas, St. Johns, St. Lucie, Sarasota, and Volusia counties in Florida and Chatham County, Georgia; 8 years to

Duval, Escambia, Franklin, Nassau, and Walton counties in Florida; and 5 years to Delaware (State), Cape May, Monmouth, Ocean counties in New Jersey, and Virginia Beach County, Virginia. This expected length of life was determined from information supplied via a survey of selected district directors.

It should be pointed out that the 12-, 8-, and 5-year lives are averages of the groups; and individual district's ditches may have a slightly shorter or longer life than the average. For instance, the range around the 12-year life might be 8 to 16 years.

The permanent control stock (X_4) was computed by adding the acres ditched (D_t) and impounded (I_t) in a given year (t) to the depreciated total acres ditched from the previous years $\left(\frac{D_{t-1}}{r}\right)$ plus the acres of impoundment in previous years (I_{t-1}):

$$S_t = D_t + I_t + D_{t-1}/r + I_{t-1} = D_t + I_t + \frac{n-1}{n}\,(X_{4t-1})$$

where r = straight-line depreciation factor for a life of n years of n-1/n, n-2/n ... 1/n, n = 12, 8 or 5 years according to the area. For example, the stock at the end of 1960 for the area having a 12-year ditch life would be the acres ditched and impounded during 1960 + 11/12 of the stock of control at the end of 1959. Although there may be occasional repair of a dike of an impoundment or other maintenance, these were overall very minor expenditures and, therefore, impoundments were considered not to depreciate.

The resulting permanent control stock variable indicates the number of acres under permanent control in each of the years. The mean number of acres under such control for the 30 districts (by years) is presented in Figure 3:3. It is apparent that substantial increases were made in the permanent installations over the 13-year period. The rate of increase was slower in the latter years, but it must be remembered that a larger and larger portion of the activity was devoted to maintenance as the acreage increased.

It is interesting, but probably misleading, to examine how the trend in numbers of mosquitoes corresponds with acres treated chemically and acres under permanent control in Figures 3:2 and 3:3. Permanent control has a pronounced upward trend, while mean number of mosquitoes has a downward trend. The acres sprayed tends to move in the same direction as the number of mosquitoes. It is tempting to conclude that most reduction in mosquito numbers is associated with permanent activities; however, this is not warranted until the effect of spraying has been accounted for in the model in Section IV.

EXPENDITURES

Information was assembled on the amount the 30 abatement districts spent on mosquito abatement during the 1959-1971 time period. The total expenditures were financed from local district taxes and from state taxes. Table 3:3 shows these mean expenditure values for the 30 districts on a total basis and on a per capita basis. This information is also presented graphically in Figures 3:4 and 3:5. (Individual district data are given in Appendix Table 2). Upon inspection of Table 3:3 and Figures 3:4 and 3:5, one observes several significant trends. First, the total amount spent by the 30 districts increased very substantially from the beginning of the period to the end of the period. These expenditure data were converted to constant dollars (1967) by the wholesale price index so it is possible to make direct purchasing power comparisons between different years.

Total expenditure for 1971 ($8.3 million) was 89% greater than total expenditure for 1959 ($4.4 million). There were 2 distinct subperiods within the 13-year period. The rate of increase in expenditure was much higher for 1968 to 1971 than for 1959 to 1968. The annual rate of increase for the 1968-1971 period was 9% while the annual rate was only 5.4% for the 1959-1968 period. The second trend was an increasing portion of total expenditures was coming from local funds. Expenditures from state funds were almost constant through the 13-year time period (see Figure 3:4).

Figure 3:5 displays the state, local and total expenditures on a per capita basis. Total and local expenditures per capita generally increased throughout the period, whereas the state expenditure per capita declined. Comparison of 3-year averages for 1959-1971 to 1969-1971 showed local per capita expenditure increased 45.8%, state per capita expenditure decreased by 26.6%, and total per capita expenditure increased by 21.4%.

There are a number of demographic and economic factors that were expected to affect expenditures for mosquito abatement. Many of these were available from secondary sources, recorded as county data. Among the economic factors thought to be of importance to local mosquito abatement expenditures are per capita annual income, tourism, wage rates of mosquito abatement workers, and state grants for mosquito abatement. All of these variables were measured in dollars which were deflated by the wholesale price index. Tourism was measured in terms of numbers of employees in lodging establishments per district.

In addition, resident population was recorded to account for the number of people among which local mosquito expenditures are shared. Each of these variables for each district and year is tabulated in Appendix Table 2. The exact specification of the relationship of the economic variables and expenditures for mosquito abatement is specified in the next section along with a model mosquito abatement equation.

Table 3:3 - Abatement Expenditures[a]: Mean Annual and Per Capita Mean Annual, 30 Districts, 1959-1971.
Source: Unpublished records of Abatement Districts.

	Mean Annual Expenditure			Mean Annual Per Capita Expenditure		
Year	Local	State	Total	Local	State	Total
1959	2,743,006	1,650,021	4,393,027	.8622	.5186	1.3808
1960	2,859,462	1,451,534	4,310,995	.8039	.4081	1.2119
1961	3,492,285	1,476,582	4,968,869	.9430	.3987	1.3417
1962	3,860,526	1,459,304	5,319,830	.9974	.3770	1.3745
1963	4,066,271	1,336,835	5,403,106	1.0148	.3336	1.3484
1964	4,304,230	1,450,575	5,754,805	1.033	.3483	1.3816
1965	4,942,513	1,417,703	6,360,216	1.1462	.3288	1.4750
1966	5,099,732	1,441,354	6,541,086	1.1447	.3235	1.4682
1967	5,236,156	1,354.325	6,590,481	1.1434	.2957	1.4391
1968	5,273,247	1,271,751	6,544,998	1.1114	.2680	1.3794
1969	6,331,774	1,438,916	7,770,690	1.2904	.2932	1.5836
1970	6,339,659	1,665,295	8,004,954	1.2683	.3332	1.6015
1971	6,506,051	1,810,048	8,316,099	1.2454	.3465	1.5918

[a] All expenditures deflated by the wholesale price index, 1967 = 100.

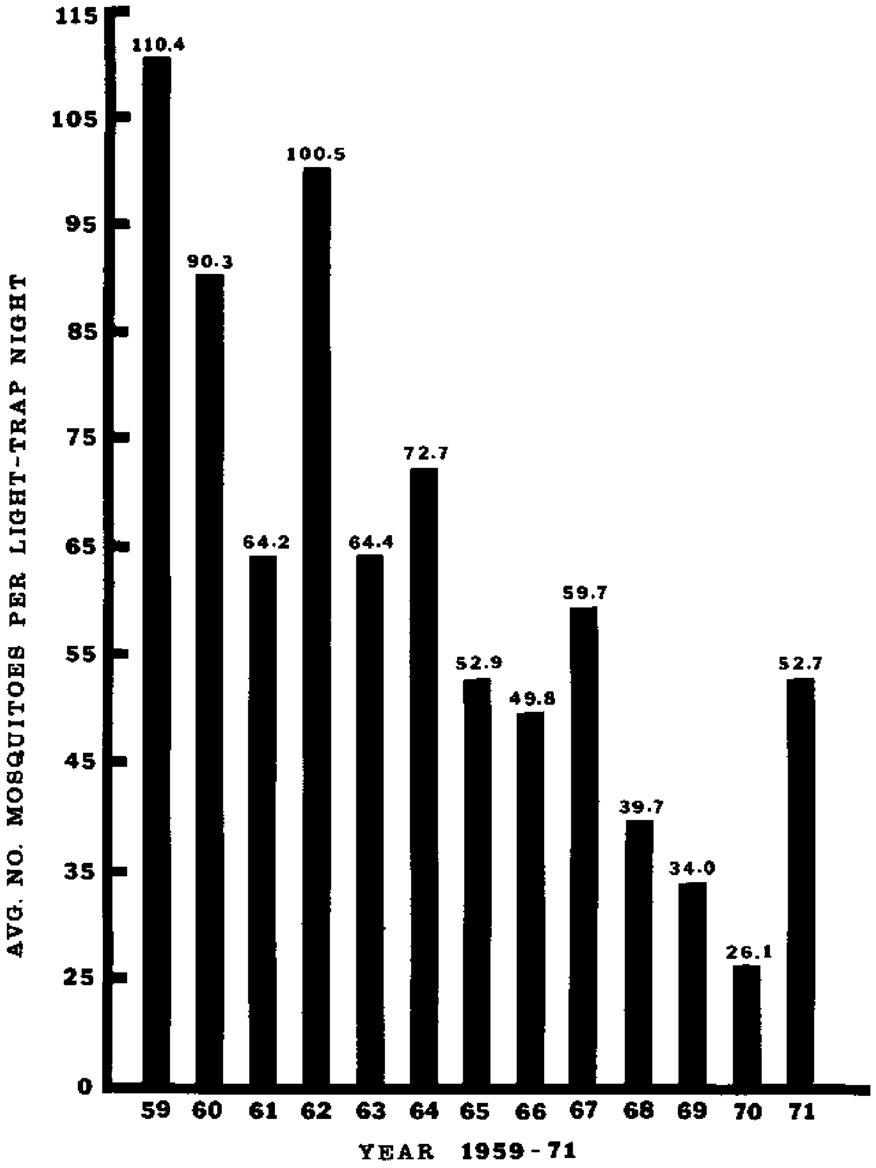

FIG. 3:1 NO. MOSQUITOES (FEMALE) PER LIGHT TRAP NIGHT, 30 DISTRICTS

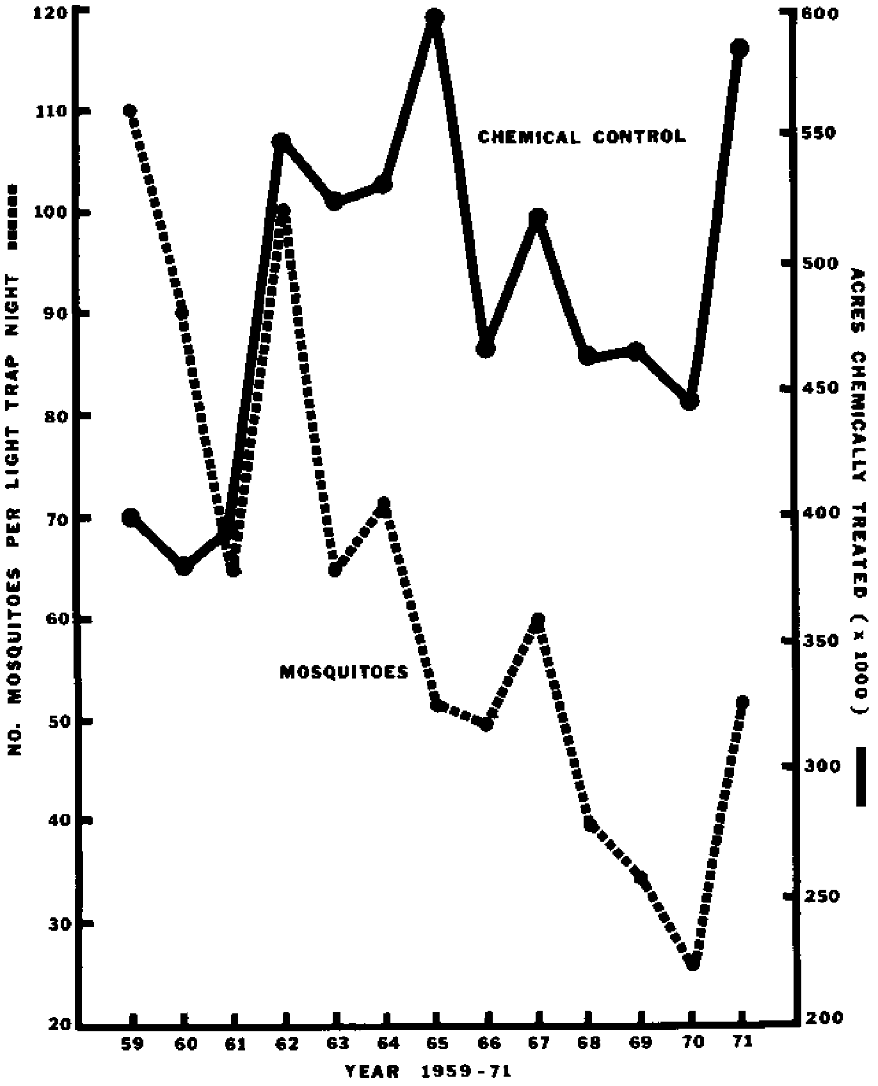

FIG. 3:2 NO. MOSQUITOES AND ACRES CHEMICAL CONTROL

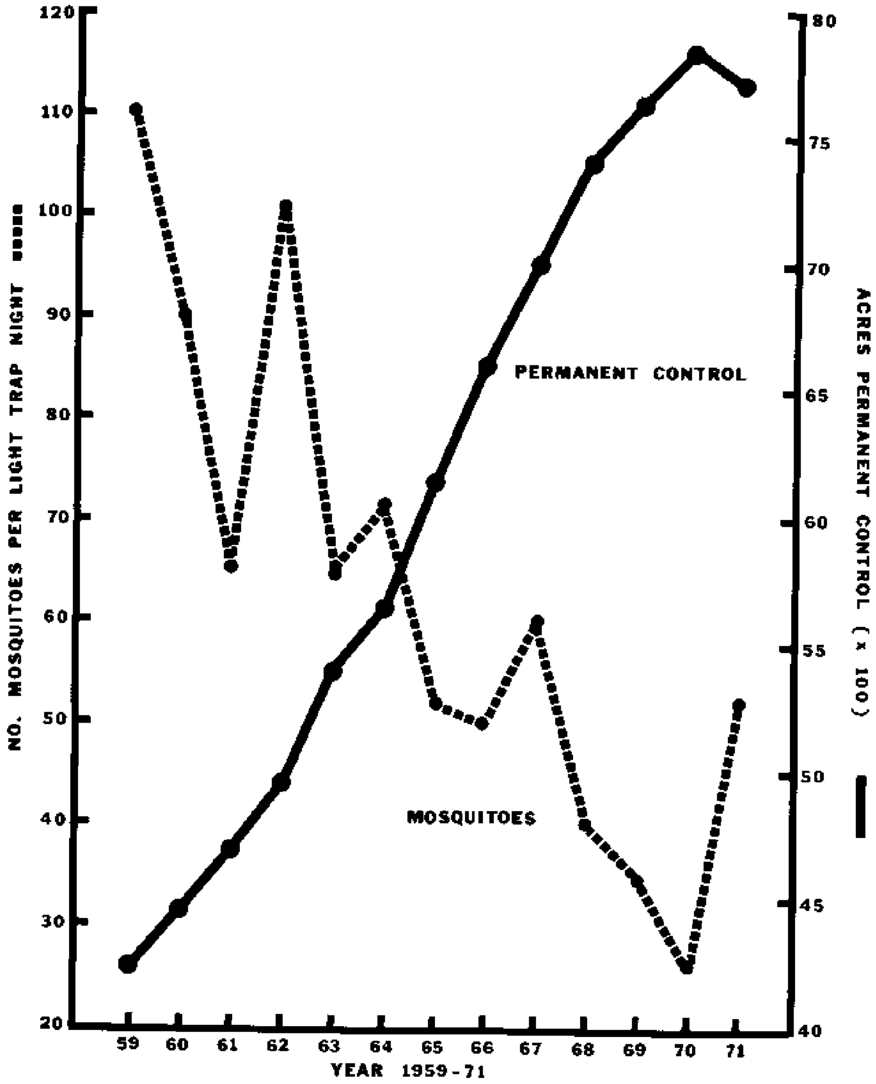

FIG. 3:3 NO. MOSQUITOES AND ACRES PERMANENT CONTROL

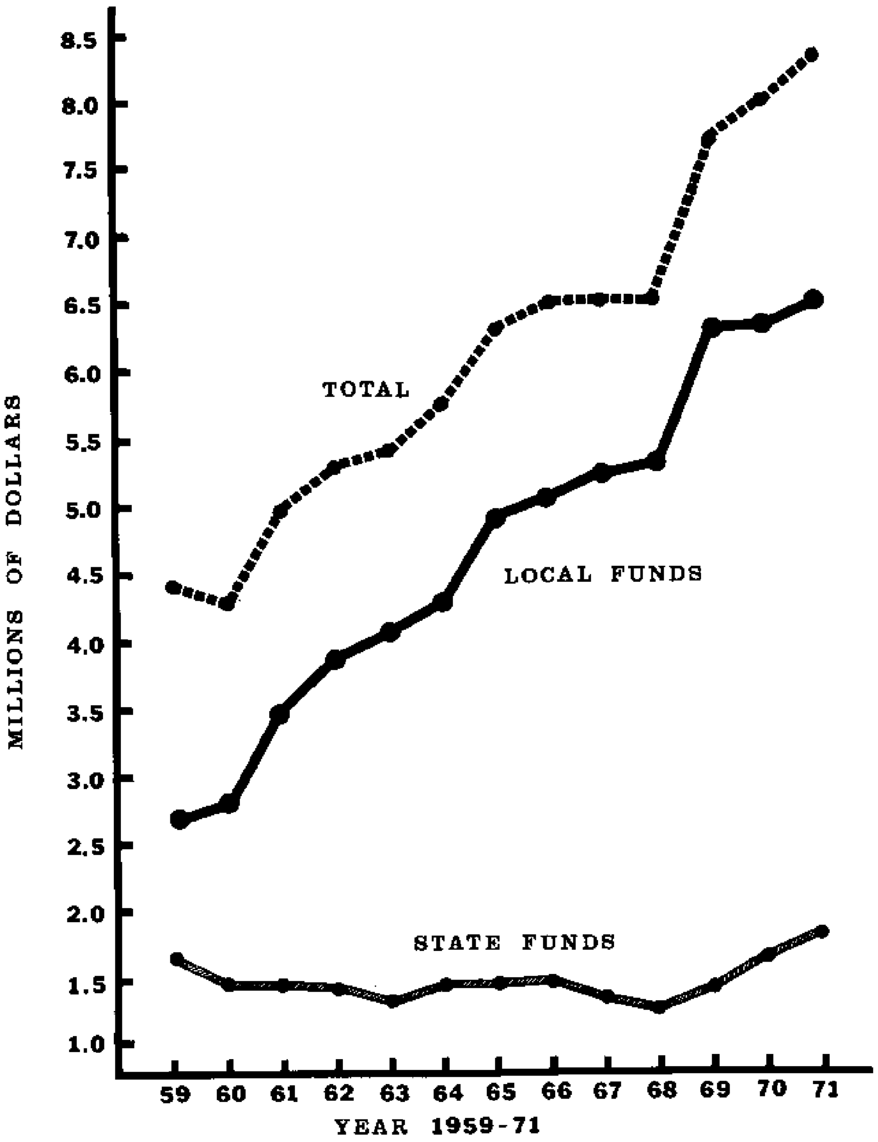

FIG. 3:4 TOTAL ABATEMENT EXPENDITURES: 30 DISTRICTS. CONSTANT 1967 DOLLARS

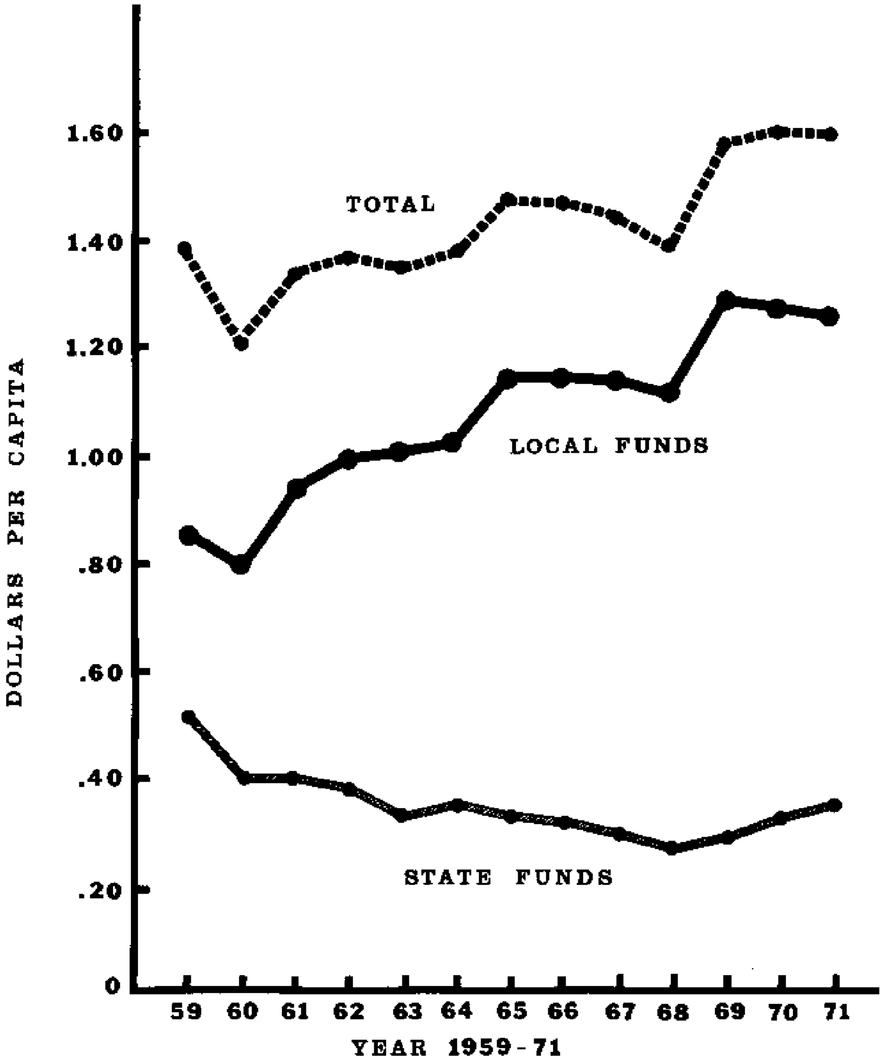

FIG. 3:5 ABATEMENT EXPENDITURES PER CAPITA: 30 DISTRICT MEANS, CONSTANT 1967 DOLLARS

IV. AN ECONOMIC MODEL OF MOSQUITO ABATEMENT

The previous 2 sections outlined several biological and economic dimensions of the mosquito abatement process. This section will attempt to specify how these dimensions are related. For ease of manipulation and measurement, the description of the mosquito biology, abatement activities, and economic behavior must be an abstraction or model. It is hoped that parameter estimates from the model can "explain" mosquito density and local per capita abatement expenditures.

Other economic models of pest management are available. Headley (1972) gave an interpretation of "economic threshold" as the pest density at which the incremental pest damage prevented (by the use of controls) is equal to the incremental control costs. Hall and Norgaard (1973) have clarified the concept of economic threshold in terms of optimal treatment level or optimal post-treatment pest density. Carlson (1970) has described a model in which both mean level and variability of infestation are included. Lee and Langham (1973) describe citrus orchard pest management in which the degree of fruit yield affects pest populations, and pest population affects citrus yields. In each case, the objective is to find the profit maximizing degree of control.

In contrast, public mosquito abatement has no crop to protect or easily identifiable profit to maximize. The analogous concept to "economic threshold" is some post-treatment, mosquito density level at which the incremental decrease in annoyance (in dollar units) is equal to the incremental increase in control costs. This "annoyance threshold" is shown at pest density N^* in Figure 4:1 which hypothetically may be equivalent to X percent abatement (reading from right to left). Higher levels of abatement would involve higher increases in costs than gains in annoyance reduction would justify.

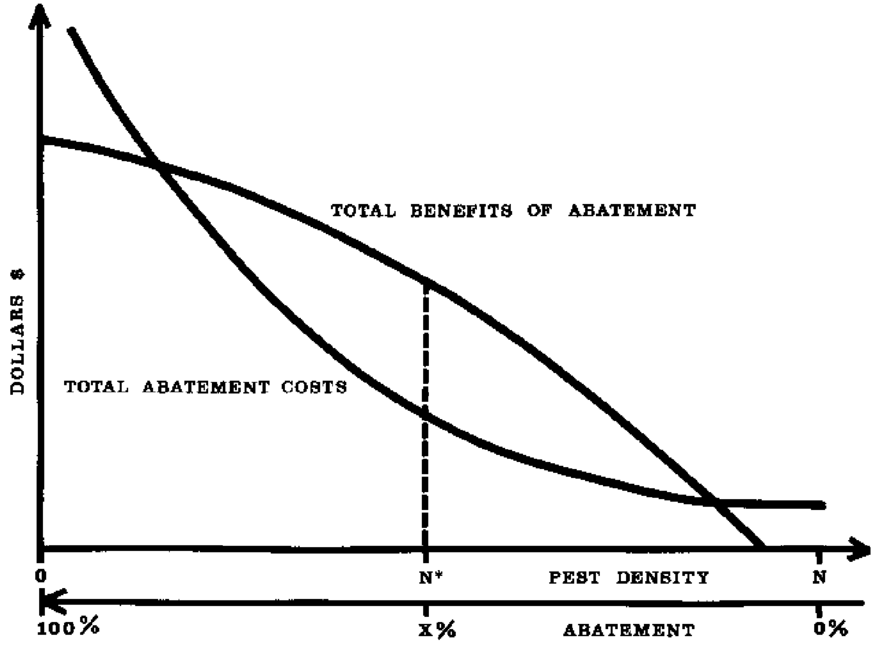

FIG. 4:1 ANNOYANCE THRESHOLD FOR MOSQUITO ABATEMENT

The abatement part of the model must include pest population growth since light trap collections reflect both control efforts (induced mortality) and the production of additional mosquitoes. The first component of the model, presented in the next subsection, will be an abatement equation describing average annual mosquito density for a control district.

The quantification of the demand for mosquito reduction will be assumed to be expressed by the expenditure of money for mosquito control. This measure is chosen rather than the number of complaints, changes in land values, or dollar value of sickness which are mosquito related. More information is available on mosquito control expenditures than on the other measures, and expenditures are commonly used in analysis of demand for public services (Borcherding and Deacon, 1972). A simultaneous equation model representing the production of abatement and abatement demand is developed in the section to follow. The model consists of 4 equations; mosquito abundance, temporary control, permanent control and demand for abatement.

MOSQUITO ABUNDANCE

The number of mosquitoes present in coastal abatement districts depends upon many environmental as well as control elements. For this study, average temperature, total storm rainfall, sequence rainfall (number of wetting and drying periods), and acres of breeding area were assumed to explain differences in mosquitoes produced. Each factor was expected to have a positive effect. Natural factors unique to particular districts such as marsh slopes, vegetation and tide levels might also be included. For simplicity, these are accounted for by allowing an intercept shift for each district by means of a district dummy variable.

Storm rainfall, temperature, and district effects are assumed to affect potential populations in a separable, additive manner. However, rainfall sequence and the proportion of breeding area not under permanent control are expected to be interrelated (LaSalle and Knight, 1973). Therefore, we examined the effect of the product of rainfall sequence and uncontrolled proportion of breeding acres on mosquito populations.

The control inputs which are expected to decrease mosquito numbers are acres treated chemically and the permanent control stock (S_t) as described in Section III. Thus, the abundance of mosquitoes as a result of the mosquito abatement process can be written as:

$$(4\text{-}1) \qquad Y_1 = f(X_1, X_2, X_3, X_4, Y_2, D_i),$$

where Y_1 = number mosquitoes per light trap night, X_1 = amount of storm rain, X_2 = sequences of wet and dry periods times proportion of breeding area not under permanent control, X_3 = mean mosquito season temperature, X_4 = stock of permanent acres under control, Y_2 = acres chemically treated and D_i = district effect variable with i = 1, 2....29.

Each of the variables in a given year, except acres treated chemically, can logically be designated as predetermined by factors other than the numbers of mosquitoes that year. However, we might expect the number of mosquitoes to effect the amount of chemical treatment, as well as vice versa.

TEMPORARY CONTROL

If district managers use light trap counts, number of complaints, or other pest density indicators to decide on chemical treatment, then we might expect acres treated to be higher in severe mosquito seasons and low when few mosquitoes are observed. The size of the district budget will also have a positive effect on acres sprayed. One important factor which might tend to reduce acres treated with insecticides is the dispersion of the human population to be protected. The higher the population density, the fewer acres which need to be chemically treated for a given level of protection.

An expression of the factors influencing acres chemically treated in a district in any year might be:

$$Y_2 = g\ (X_5,\ X_6,\ Y_1) \qquad (4\text{-}2)$$

where X_5 = budget of the abatement district, X_6 = district population density (people per square mile), and Y_1 = mosquitoes per light trap night.

There are other factors that effect acres chemically treated, but the above are thought to be most important in describing management decisions on the use of chemicals. In recent years, or in other areas, the degree of insecticide resistance and use or nonuse of ultra-low volume application methods may be of importance.

PERMANENT CONTROL

Acres of permanent control in any year affect permanent control stocks which in turn are hypothesized to affect mosquito numbers. At given prices of permanent abatement work per acre (P_{Y_3}) and chemical treatment per acre (P_{Y_2}) and a given abatement budget (X_5) we can expect the acres of permanent work (Y_3) to be determined by:

$$Y_3 \cdot P_{Y_3} = X_5 - (Y_2 \cdot P_{Y_2}) \qquad (4\text{-}3)$$

That is, permanent abatement work is somewhat of a residual claimant on the budget as expenditures for chemical treatment vary with mosquito populations.

The factors affecting permanent control decisions are assumed to be described as:

$$Y_3 = h\ (X_4,\ Y_2) \qquad (4\text{-}4)$$

Acres chemically treated (Y_2) is hypothesized to have a negative effect on acres of permanent work (Y_3), while stock of permanent acres under control (X_4) is expected to exert a positive effect.

ABATEMENT DEMAND

Decisions on the budgetary levels for many public services are difficult to analyze because both prices and quantities are difficult to specify. The model used in this study is a variation of one by Borcherding and Deacon (1972). This model assumes that all districts use majority rule voting, that capital inputs (including pesticides) are freely mobile, and that capital is available at a constant rental rate. This implies that the cost necessary to produce one more unit of abatement (marginal cost) depends on the wage rate of labor, adjusted by labor's share of total expenditure on abatement (W^B). W^B is used rather than W because it is a derived relationship from the Cobb-Douglas production function - the marginal cost of abatement is W^B (see DeBord 1974).

Quantity of abatement is the number of mosquitoes killed. It is difficult to know what number of mosquitoes would be present in the absence of controls. Local control expenditures per capita (Y_4) is assumed to be a logical proxy variable for the quantity of abatement per capita. This can be seen by referring to equation (4-3). Total local expenditures ($N \cdot Y_4$) = total budget (X_5) less total state grants ($N \cdot X_8$), where N = population. Price of work units (P_{Y_2}, P_{Y_3}) are assumed to be dependent only on wage rates (W^B), but the effect of scale economies on prices (costs) of permanent work and spraying will be examined in the next subsection.

If expenditure per capita measures quantity of mosquito abatement received per person, and price of abatement is proportional to (W^B), then the classical demand curve is a negatively sloped relationship like that shown as Z in Figure 4:2 (all other variables held constant).

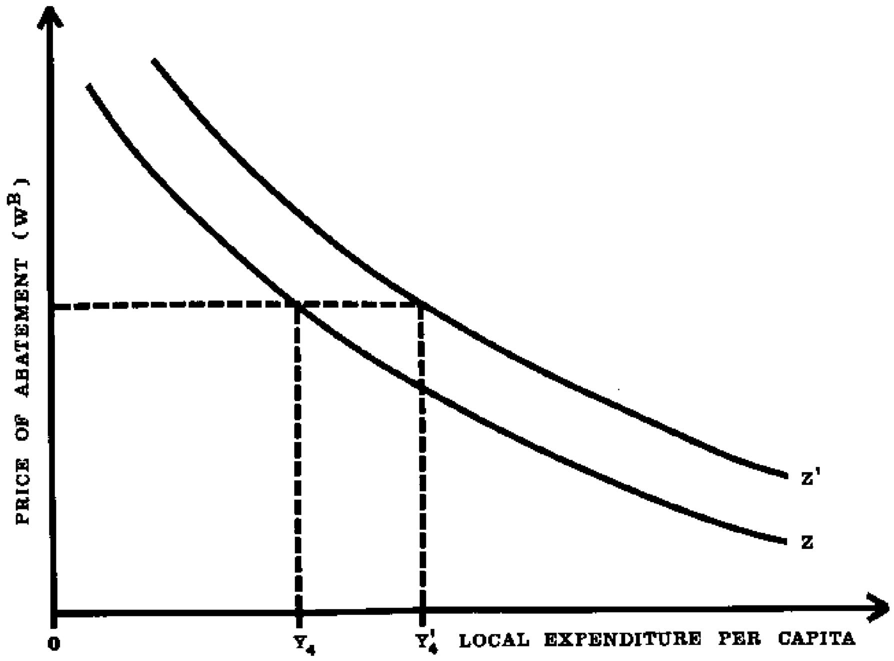

FIG. 4:2 MOSQUITO ABATEMENT DEMAND RELATIONSHIP

Many variables are expected to affect expenditures per capita other than price. If this public service is a normal good (a product for which expenditures rise as income rises) increases in per capita income (X_7) will shift the curve upward (Z to Z'). Likewise, increasing tourism (X_9) will increase the demand for mosquito protection. (The causation may also be reversed, but this complication will be ignored here). State grants (X_8) will also increase willingness to expend local funds if matching regulations are in effect on most types of expenditures. There is also the possibility that districts might substitute state funds for local funds. Evidence on each of these effects awaits estimation of the demand relationship in the next section.

The final factor affecting expenditures of abatement dollars is the number of mosquitoes. As indicated above, temporary expenditures and hence total expenditures in any one year may change when mosquito numbers (Y_1) change from normal. This is indicated in Figure 4:2 by the upward shift from Z to Z' and the resulting increase in expenditures from Y_4 to Y'_4 at a given price of abatement.

The demand equation which includes each of the above factors is:

(4-5) $$Y_4 = j\ (X_7,\ X_8,\ X_9,\ W^B,\ N,\ Y_1)$$

SIMULTANEOUS EQUATION MODEL

Based on the above explanations, the complete model used to represent the demand for and production of abatement involve the following four equations:

(4-1) $Y_1 = f\ (X_1,\ X_2,\ X_3,\ X_4,\ Y_2,\ D_i)$ (Mosquito Abundance)

(4-2) $Y_2 = g\ (X_5,\ X_6,\ Y_1)$ (Temporary Control)

(4-4) $Y_3 = h\ (X_4,\ Y_2)$ (Permanent Control)

(4-5) $Y_4 = j\ (X_7,\ X_8,\ X_9,\ W^B,\ N,\ Y_1)$ (Abatement Demand)

This is a simultaneous model because each equation has one of the other dependent variables as an independent or explanatory variable (Kmenta 1971). The quantity of abatement demanded is a function of price, income, state grants per capita, tourism, population and the number of mosquitoes. All of these variables, except mosquito numbers, are assumed to be exogenous. The number of mosquitoes in a coastal community is determined by a set of natural and control factors. All of these factors are predetermined except the acreage treated chemically. The acreage treated chemically depends on the budget, population density and the number of mosquitoes.

The quantity of control demanded depends on the number of mosquitoes; the number of mosquitoes depends on the acres chemically treated; and the acres treated chemically depend on the number of mosquitoes. The estimation of the parameters for these relationships, therefore, requires the specification of a simultaneous equation model, since each of the dependent variables was hypothesized to have endogenous variables as explanatory variables. Equations (4-1) - (4-5) were estimated by converting all variables to logarithms and applying multiple regression techniques (see Section V).

ECONOMIES OF SCALE

Do large districts have advantages in cost per acre of permanent work and costs per acre treated chemically? Economic theory indicates that economies may arise from specialization and division of labor to make workers more efficient or when large-scale purchasing of inputs (quantity discounts) is possible (Ferguson and Maurice 1970).

To test for this existence of changes in cost of using chemical controls with district size, the following model will be estimated:

$$P_{Y_2} = k\ (Y_2, X_6, W^B, N) \tag{4-6}$$

If there are economies of scale, then cost per acre chemically treated (P_{Y_2}) will decrease as the number of treated acres (Y_2) increases. Other factors increasing spraying costs will be wage rates (W^B) and population of the district (N). The wage rate is the cost of labor and as it increases so will the cost per unit of work completed. The latter factor (population) reflects travel and congestion time costs. More travel and congestion will cause costs per unit of work to increase. Another factor which may reduce spraying costs is human population density (X_6), because with greater population density, there would be a tendency to undertake more adulticiding (treating residential areas) relative to larviciding (treating breeding areas). Adulticiding is less expensive per acre than larviciding.

Cost per acre of permanent control may also be affected by the scale of district operations. The following model of permanent control costs is proposed for testing:

$$P_{Y_3} = m(Y_3, W^B, N) \tag{4-7}$$

The justification for inclusion of wage rates adjusted for share of expenditures to wages (W^B) and population (N) is the same as that for chemical treatment costs, i.e. higher labor costs and congestion. Scale economies will be indicated by costs significantly decreasing in years or districts where more acres are ditched.

TEMPORARY CONTROL COMPARED TO PERMANENT CONTROL

In equilibrium, we expect a cost minimizing district to adjust the temporary (Y_2) and permanent (Y_3) abatement activities until the marginal productivity (additional mosquitoes eliminated) per dollar spent on each activity is equal. This can be expressed in the following equation:

$$\frac{MPP_{Y_2}}{P_{Y_2}} = \frac{MPP_{Y_3}}{P_{Y_3}} \tag{4-8}$$

where MPP_{Y_2} and MPP_{Y_3} = marginal adjustments in mosquito numbers from temporary and permanent control activities in the mosquito abatement equation (4-1).

P_{Y_2} and P_{Y_3} = the average prices or costs per unit of temporary and permanent control from equations (4-6) and (4-7).

In reality, this is difficult to accomplish. First, the timing of the reductions in mosquito numbers relative to the date of work completion is different. That is, for comparison to present comfort rendered, the benefits of future mosquito control from an acre ditched must be discounted to the present[1]:

$$(4\text{-}9) \qquad \frac{MMP_{Y_2}}{P_{Y_2}} = \sum_{t=0}^{n-1} MMP_{Y_3} \left(\frac{n-t}{n}\right) \Big/ (1 + r)^t \Big/ P_{Y_3}$$

where $n = 10$, $t = 0, 1, \ldots.9$, $(\frac{n-t}{n})$ = depreciation schedule, and $(1 + r)^t$ = discount formula. Also, it is difficult to assess whether permanent or temporary control is providing control since they occur simultaneously.

Furthermore, state grants may favor permanent rather than temporary control given the matching rules. Thus, we might expect managers to favor permanent rather than temporary control. Analysis of this question will follow the estimation of the general model and the economies of scale models.

V. REGRESSION ANALYSIS

All of the equations in the simultaneous equation model were estimated using the logarithmic transformation of the district data. This model permitted interaction between the number of mosquitoes (Y_1), the number of acres treated chemically (Y_2), the number of acres ditched for permanent control (Y_3) and per capita local expenditure (Y_4). The data base used were the observations from the 30 districts over the 13-year period, 1959-1971. A two-stage least-squares multiple regression procedure was used for estimation and, since serial correlation was present in equation Y_4, a first order autoregressive error model was estimated (Kmenta, 1971).

The results are presented in Table 5:1. These results are in the logarithmic form and the coefficients presented in Table 5:1 are interpreted as percentages. For example, if an independent variable has a corresponding coefficient under a particular dependent variable of -0.1, then this means that for every 1% change in the independent variable, the dependent variable will change in the opposite direction by 0.1 of 1% (or a 10% change in the independent variable will yield a 1% change in the dependent variable). If the sign is positive, then the change with the dependent variable will be in the same direction as the change in the independent variable. The coefficients which are statistically significant are indicated on the table.

---

[1] There is a direct link between Y_3 and the stock of permanent control (X_4). Increases in X_4 take place when increases in Y_3 (ditching) are greater than the maintenance. A high percentage of permanent work is ditching and the terms ditching and permanent work are used interchangeably in the analysis.

Table 5:1 - Mosquito Abatement and Abatement Demand Regression Estimates; Simultaneous Equations 1959-1971[a]; Sample Size (n) = 390.

Independent Variables[b]	Dependent Variables			
	Number Mosquitoes (Y_1)	Acres Chemical Control (Y_2)	Acres Permanent Control (Y_3)	Local Expenditure (Y_4)
Intercept	13.665 (1.25)	2.979*** (6.01)	2.133** (2.20)	-7.190*** (4.52)
No. Mosquitoes (Y_1)		0.155*** (4.27)		0.121 (0.87)
Acres Chemical Control (Y_2)	-0.570*** (3.59)		-0.244*** (2.71)	
Storm Rain (X_1)	0.033 (0.694)			
Sequence Rain (X_2)	0.107*** (3.95)			
Temperature (X_3)	-0.895 (0.359)			
Stock Permanent Control (X_4)	-0.097** (2.10)		0.791*** (25.28)	
Budget (X_5)		0.788*** (17.67)		
Population Density (X_6)		-.080*** (3.19)		
Income (X_7)				1.569* (1.86)
State Grants (X_8)				0.348** (2.08)
Tourism (X_9)				0.332** (2.22)
Wage Rate (X^B)				1.695* (1.43)
Population (N)				-0.343** (2.02)

[a] t ratios are given in parenthesis; the levels of significance are denoted by .01 = ***, .05 = **, .1 = * for a one-tailed test. Regression estimates and t ratios are from a first order autoregressive error model. t ratios were reduced approximately 3.5 fold from the original two-stage least-squares estimates.

[b] Dummy variables (D_i) were significantly different from the base district in 24 of the 29 districts; available in DeBord, 1974.

MOSQUITO ABUNDANCE

Equation (4-1), explained 70% of the variation in the number of mosquitoes and it was a statistically significant regression. All of the estimated coefficients of the explanatory variables carried the expected signs, except for the temperature variable. The empirical analysis indicated that the only natural factor significantly affecting the number of mosquitoes was the sequencing of rainfall. Storm rainfall had the expected sign but was not statistically significant.

The effect of "sequence rain" is shown by the significantly positive coefficient of X_2. Holding all of the other independent variables constant, an increase in the number of occurrences of 1/4 inch rain followed by at least 2 days without rain, causes an increase in the number of mosquitoes. Specifically, the estimated coefficient indicates that a 10% increase in the number of sequences leads to a 1% increase in the number of mosquitoes. The mean number of mosquitoes was 63.2 and the mean number of sequences was 18.77 for the 30 locations over the 1959-1971 period. A 10% increase in the number of sequences from the mean represents 1.88 more occurrences, and the resulting increase in mosquito numbers would be 0.632

The amount of "storm rain" did not exert a statistically significant effect on the mean number of mosquitoes, however, the direction of the effect was positive, as expected. These unexpected results may be due to the time period chosen for the data. The number of times hurricanes and tropical storms occur during a year are very low. The mean number of inches of storm rainfall (May 1-October 31) for the data set was 10.34 inches. It could be that districts increase the intensity of their chemical control operations after these periods and manage to keep the number of mosquitoes down. The information analyzed was on an annual basis and the timing of operations was unknown. The facts that these storms are infrequent and the data compiled was on an annual basis may lead one to conclude that this effect is lost. Data compiled on a shorter time period may indeed show it to be of significant importance.

The temperature variable was not significant and had a negative sign. The overall grouping of districts in the analysis and the use of data for only the warmer months undoubtedly obscured any positive effects of the temperature.

The factors lowering the abundance of mosquitoes were the number of acres treated chemically and the permanent control stock. These were statistically significant and the coefficients were of the expected negative sign. This means that both temporary and permanent control procedures have been effective in reducing the average mosquito density over the 13-year time period. In particular, the results of the regression indicate that a 10% increase in the acres treated with chemicals (Y_2) within a district decreases the number of mosquitoes by 5.70%, all other factors remaining constant. The mean number of acres treated chemically was 484,680 and the mean number of mosquitoes was 63.2. A 10% increase in chemical treatment represents an additional 48,468 acres and the associated reduction in the mean number of mosquitoes per light trap night would be 3.60.

The number of acres controlled by permanent abatement significantly affected the number of mosquitoes occurring in coastal environments. The negative sign of the coefficients indicates that as larger and larger acreages of salt marsh are either ditched or diked, the number of mosquitoes decreases. Specifically, a 10% increase in the stock of permanent control (X_4) leads to a 0.97% decrease in the number of mosquitoes. This 10.3 to 1 ratio of permanent control to mosquito reduction does not appear to be very effective at first glance. However, permanent control procedures last for several years depending on the area. The amount of permanent control in a year reduces the number of mosquitoes in that year and in succeeding years. This is different from spraying because chemical application is only effective for several days.

The mean number of mosquitoes per light trap night for the 13-year period was 63.2 and the mean number of acres under permanent control per district was 6,138. A 10% increase in the acres under control represents an additional 613.8 acres, and the associated decline in mean number of mosquitoes per light trap night would be 0.613 mosquitoes (63.2 x 0.97%). This reduction also occurs in succeeding years or at least a portion of the reduction occurs. Considering a 10-year life and a straight line depreciation schedule, the permanent work is 100% effective the first year, 90% effective in the second year, 80% effective in the third year, and so forth, until it becomes ineffective at the end of the tenth year. Considering an average 10-year life, the number of mosquitoes eliminated in the 10-year period, as a result of a 10% increase in ditching, was 3.37. This result is obtained by summing the depreciated reductions over the 10-year period, i.e. $3.37 = 1.0\ (0.613) + 0.9\ (0.613) + 0.8\ (0.613) + \ldots + 0.1\ (0.613)$.

TEMPORARY CONTROL

The estimated equation indicated that the number of mosquitoes present exerted a positive influence on the number of acres sprayed. This was the expected relationship because the existence of the monitoring system suggests increased spraying when buildups occur and decreased spraying when the mosquito populations are at a low level. The estimated coefficient indicates that for every 10% increase in the number of mosquitoes, an increase of 1.55% occurs in the number of acres sprayed. The mean number of mosquitoes was 63.2 and the mean acres sprayed was 484,680. A 10% increase in mosquitoes represents 6.32 mosquitoes, and the associated increase in the acres sprayed is 7,513 acres.

The relationship between acres sprayed and the real budget of the abatement district, the population density and the number of acres treated in the previous year can be interpreted in a similar fashion.

PERMANENT CONTROL

The number of acres of permanent control work performed in a given year was hypothesized to be a function of the number of acres treated chemically and the stock of permanent control. The number of permanent control acres in a year was negatively related to the number of acres treated chemically. This was expected because these abatement procedures compete with each other for the same budget dollars. Increased amounts of work done on one necessarily means that less resources are left for the other type abatement. Permanent control work is more long-term in nature than chemical usage and plans are made and money is budgeted for the entire year's work. This amount of work is completed and the money is spent unless an abnormally bad mosquito year requires the personnel to perform more temporary work. During periods of heavy infestation, permanent work may stop and equipment sit idle until the mosquito situation is brought under control. Money and labor resources may be shifted from permanent work to temporary work, and this is a second reason for expecting the negative relationship. The estimated coefficient indicated that a 10% increase in the acres treated chemically caused a 2.24% decrease in the acres of permanent work.

The amount of permanent work completed in a given year was expected to be positively related to the stock of permanent control. The stock of permanent control is an accumulation of many years of work. The expected ditch life for the 30 districts averages 9.7 years and ditches must be maintained this often on the average[1]. The larger the stock the greater the amount of work necessary just to keep the existing stock in good operating condition. In order to increase the stock, an amount of ditching greater than the maintenance is required. The estimated coefficient showed the stock was the main determinant of the amount of ditching completed within a given year. The coefficient indicated that with a 10% increase in the amount of stock, all other things being held constant, the number of acres ditched increased by 7.91%.

ABATEMENT DEMAND

The estimation procedure showed that local per capita expenditures were significantly affected by income, state grants, tourism, wage rates and population, but not by the number of mosquitoes. All of the estimated coefficients were of the expected signs.

Income was statistically significant and the estimated coefficient was + 1.569 which was elastic. This coefficient means that local per capita expenditure will increase by 15.7% when per capita income increases by 10%, all other things held constant. Income, then, is an important factor in explaining why some districts spend more on abatement than is spent by other districts.

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[1] This represents a weighted average of the expected ditch life in each district. There were 19 districts with 12-year lives, 5 districts with 8-year lives, and 6 districts with 5-year lives.

State grants per capita were positively and significantly related to the willingness of citizens to pay for abatement activities. The estimated coefficient was + 0.348 which indicates that for every 10% increase in per capita state grants, the local per capita expenditures increased by about 3.5%. The mean value of state per capita grants was $0.426 and the mean local per capita expenditure was $1.10. Thus, a dollar increase in state government grants is followed by a $.90 increase in local expenditures at the mean level of expenditures, given other factors constant. The total expenditure is the sum of local and state; therefore, a $1.00 increase in state money causes a total increase of per capita expenditure of $1.90. This indicates that state aid to local districts stimulates local expenditure rather than substituting for it. Increased state contributions cause the local districts to spend more local funds, all other things being equal. This is an important finding because states may encourage expenditures on mosquito abatement by increasing their contribution or they can curtail such activity by reducing their grants.

The state grants in all states except New Jersey and Delaware, were on a matching basis. This reflects the decision that it was felt that more mosquito abatement was socially desirable than would be provided in the absence of state grants. The reasoning relates to the distribution of benefits from abatement activities. State aid implies that individuals residing outside the abatement district receive benefits from abatement and accordingly should share in the cost, or the state agency feels it socially desirable to have a higher level of mosquito control. For one of these reasons, the state makes grants from the general revenue, thereby spreading the cost over all that contribute to the general revenue.

The tourism variable was measured as the number of employees in all lodging establishments within the abatement district. The more dependent upon the tourist and recreation industry a district was, the greater the public demand for abatement and the more willing the citizens would be to spend. This expectation was realized in the estimated empirical coefficient as it was + 0.332 and was significant at the 0.05 level.

The wage rate was employed as a price variable. It was expected to have a negative relationship with the expenditure level and the estimated results supported this expectation. The coefficient was -1.695 and it was significant. The fact that this coefficient is less than -1.0 means the demand for abatement is elastic - a 1% increase in the price (wage) results in a 1.69% decline in local per capita expenditure (proxy for the quantity of abatement).

Population size and local expenditure per capita were expected to be negatively related. This was because a larger population enabled a district to lower the expenditure per capita and still maintain the same size budget, since the expenditures could be shared among a larger number of people. The estimated coefficient was -0.343 which means that a 10% increase in the population caused the local per capita expenditure to decline 3.43%. This coefficient was statistically significant at the 0.05 level. The number of mosquitoes present in the abatement district exerted a statistically insignificant influence on the local per capita expenditure. Mosquito density variations influenced the number of acres treated with chemicals but not the total local expenditures per capita.

SINGLE EQUATION MODEL

To compare the effects of allowing for and ignoring simultaneity and to deal with the statistical problems of no independent expenditure decisions between years for a given district, the 4 equations (4-1), (4-2), (4-4), and (4-5) were estimated individually by the least-squares procedure. The results of this single equation analysis of the data from 30 districts over 13-years (390 observations) are presented in Appendix Table 8.

The single equation model and simultaneous equations model (previously presented in Table 5:1) produced very similar results in terms of total explanatory power and the correct expected signs of the coefficients. The major difference was in the magnitude of the coefficients on the temporary and permanent control variables. In the simultaneous equation model, the temporary control coefficient was 5.88 times as large as the permanent control coefficient in the mosquito abundance equation. The single equation estimation showed the reverse situation as the permanent control coefficient was 4 times the magnitude of the temporary control coefficient. In fact, the temporary control coefficient was not statistically significant, and the permanent control efficient was highly significant. The simultaneous equation model showed both variables as significant determinants of the mean number of mosquitoes.

This comparison illustrates the danger of using an inappropriate pest management model. The economic model gave theoretical reasons to reject the single equation model in that Y_2 affects Y_1, and Y_1 affects Y_2. The statistical results of the simultaneous model support this interdependent formulation of the abatement process. Therefore, the simultaneous procedure is the appropriate one to use in evaluating public mosquito abatement.

ECONOMIES OF SCALE

The average cost of performing permanent abatement work (P_{Y_3}) was hypothesized to be a function of the population (N), the wage rate (W^B), and the quantity of such work performed (Y_3). The average cost of performing temporary abatement procedures was specified as a function of the population (N), the population density (X_6), the wage rate (W^B), and the quantity of temporary work performed (Y_2).

The data used in the analysis of costs of abatement work pertains to direct field costs. One hundred and thirty-five observations were available for permanent work (24 districts in Florida for 1966-1971) and 72 observations (3 years) on temporary (adulticiding and larviciding) activities, (see Appendix Tables 3 and 4).

The results of the estimations (Table 5:2) indicate that there are economies of scale in the performance of permanent abatement work, but no significant economies in temporary work. These results are ascertained from the statistically significant negative coefficient of the acres put under permanent control (Y_3) and the nonsignificant coefficient on the acres sprayed variable (Y_2). The other explanatory variables possess the expected signs.

Table 5:2 - Average Cost of Permanent and Temporary Abatement Procedures; Empirical Estimates - Economies of Scale Regressions, Constant 1967 Dollars

Independent Variable	Average Cost Permanent Control (P_{Y_3})	Average Cost Temporary Control (P_{Y_2})
Intercept	4.118[a,b]	-4.370
Population (N)	0.200*** (4.332)	0.231*** (4.406)
Wage Rate (W^B)	0.602* (1.658)	0.493 (1.141)
Permanent Control (Y_3)	-0.439*** (-9.328)	
Temporary Control (Y_2)		-0.021 (-0.312)
Population Density (X_6)		-0.081** (-1.911)
Coeff. Mult. Det., R^2	0.408	0.351
F Value reg. F	30.056	8.925
Sample Size (n)	135	71

[a] Probability levels, .01 = ***, .05 = **, .10 = *

[b] Values in parenthesis are t values

The interesting feature of this cost analysis is the determination of how rapidly the average costs change as the quantity of each work activity changes. This is illustrated in Figure 5:1. All of the explanatory variables were assumed to be at their mean values, while the value of the acres treated by permanent procedures was altered. This provided estimates of how the average costs changed as the work level changed.

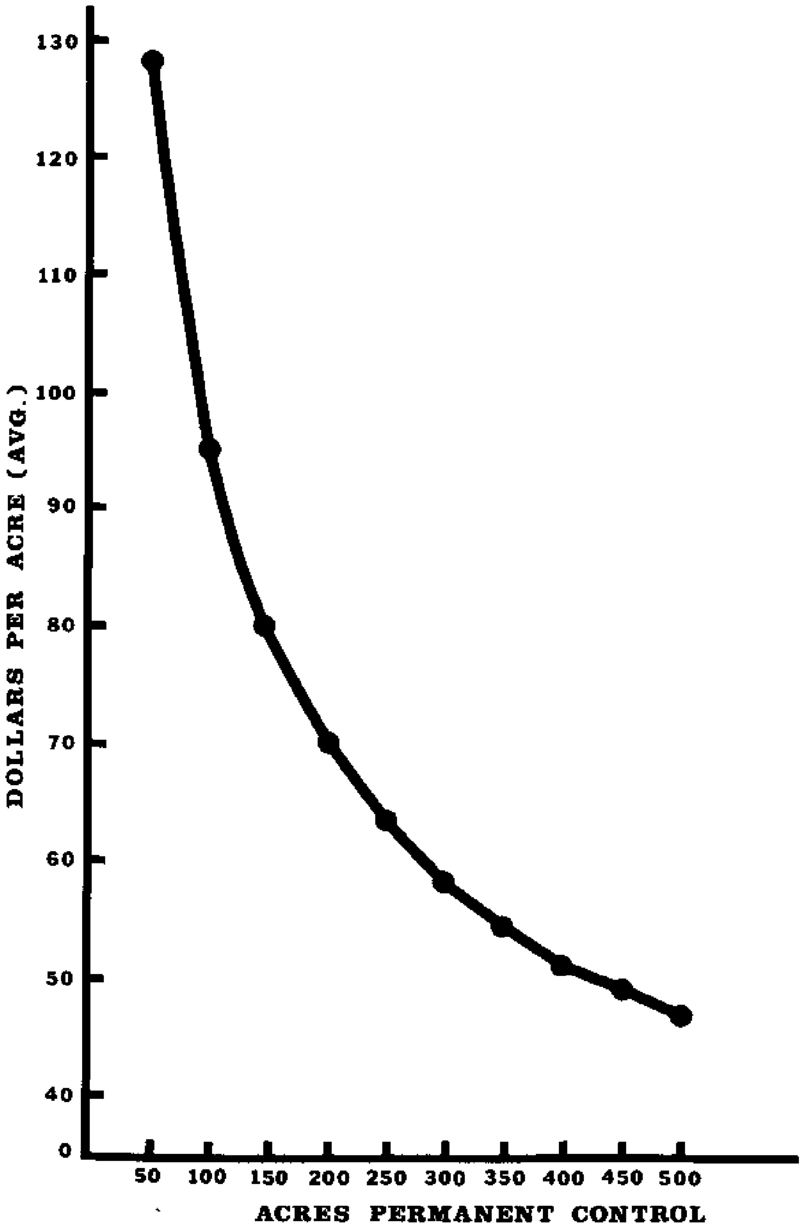

FIG. 5:1 AVERAGE COST OF PERMANENT CONTROL, CONSTANT 1967 DOLLARS

The average cost of ditching fell from a high of \$128.94 per acre when 50 acres per year were ditched to a low of \$46.91 per acre when 500 acres were ditched. The rate of decrease in cost was very rapid when acreage increased from 50 to 100 to 150, but the rate of decline became slower and slower as the scale of work per year increased to the 500 acre level.

In contrast, the spraying costs per acre was not significantly affected by the acres sprayed and this leads us to the assumption of constant costs per acre of temporary chemical control.

VI. IMPLICATIONS OF RESULTS

TEMPORARY CONTROL COMPARED TO PERMANENT CONTROL

It was determined that the responsiveness of mosquito numbers to acres chemically treated was 5.88 times the same response from the number of acres under permanent control. It was further determined that a 10% increase in the number of acres sprayed caused the mean number of mosquitoes per light trap night to fall by 3.60 (all other variables being at their means). A similar 10% increase in permanent control (all other variables constant) resulted in a total reduction of 3.37 mosquitoes (or 2.79 if one adjusts for the fact that benefits are delayed) over the total life of the ditch (10-year average).

To compare the efficiency of temporary to permanent procedures, one must discount the mosquito reductions from permanent abatement because the reductions are spread over a 10-year period (average of all districts). Discounting is based on the concept that a benefit in the future is worth less than the same benefit today, and that the value of a future benefit can be determined through the use of an interest rate. Discounting, then, must be used because future mosquito reductions have a lower value to the citizen than the same reduction in the current time period.

Comparisons were made between permanent and temporary abatement procedures. The interest rate used to discount the future benefits was 7%. A higher interest rate would lower the value of future benefits while a lower interest rate would increase the value of future benefits. The 7% rate was chosen because it was a suggested interest rate for water resources investments as outlined by the Water Resources Council (Water Resources Council, 1971). The results of the discounting procedures are presented in Table 6:1. The mosquito reductions for each year were calculated by assuming all explanatory variables to be at their means, except the quantity of acres put under permanent control and quantity of acres sprayed. The quantity of the abatement activity was increased by 10% from the mean value, and this value was entered into the abatement equation (Y_1 Table 5:1). This provided an estimate of the number of mosquitoes that would be present under such conditions. By taking the difference between the number present when the abatement activity was at its mean level and the number present when the activity was 10% above the mean level, the reduction in the number of mosquitoes per light trap night was calculated. For permanent abatement, the reduction extended over 10 years, so discounting was performed and then comparisons were made. A straight line 10-year depreciation schedule was used. The formula used to generate the measure of the mosquito reduction was $\sum_{t=0}^{n-1} \frac{n-t}{n} \cdot \left(-B_i \bar{Y}_i \,/\, (1 + 0.07)^t \right)$ where $n = 10$, $t = 0, 1, \ldots 9$; $-B_i$ = the marginal productivity of permanent abatement; $\bar{Y}_i$ = mean number of mosquitoes per trap night; $(1 + 0.07)^t$ = discount formula; $\frac{n-t}{n}$ = depreciation schedule.

These calculations show that a 10% increase in permanent work reduces mosquito numbers over the life of the facility by 4.4% (2.79 ÷ 63.2). Temporary control was 1.29 times as effective as permanent control procedures as shown in Table 6:1.

The comparison that is most appropriate, however, is one of relative physical efficiency in relation to cost of performing such activities. Economic theory provides insight into the decision process of the quantity of each control procedure to utilize. The decision principle is that a district attempting to minimize cost (within a certain budget constraint) and to maximize benefits would adjust temporary and permanent work activities until the marginal physical efficiency of temporary abatement per dollar of cost is equal to the marginal physical efficiency of permanent abatement per dollar of cost. The costs are only the direct field costs, in this situation, and do not include any indirect costs since they do not change as work completed changes.

Table 6:1 - Reduction in the Average Annual Mosquito Collection Per Light Trap Night Resulting from a 10% Increase in Permanent Control (Discounted) and Temporary Control

Year	Permanent Control (Discounted)	Temporary Control
1	.6130	3.60
2	.5156	
3	.4283	
4	.3503	
5	.2806	
6	.2186	
7	.1634	
8	.1145	
9	.0714	
10	.0333	——
Total	2.7890	3.60

Ratio: Temporary/Permanent = $\frac{3.60}{2.789}$ = 1.29

The physical efficiency comparisons were made in the previous portion of this section, and the numerical comparisons were made in Table 6:1. The comparisons involving cost will be made using the means of the logarithmic equations (geometric means rather than the arithmetic means). The results will be very similar, but it is a more direct procedure to use the means from the estimated equation. The mean acres sprayed was 311,931 and the mean acres under permanent control each year was 1,532 acres. A 10% increase for each of these activities represented an additional 31,193 acres sprayed and an additional 153.2 acres ditched. These additions would bring the total acres sprayed to 343,862 (311,931 + 31,193) and the acres ditched to 316.4. The 316.4 acres is the sum of the 163.2 acres required to maintain the stock of 1,532 acres and the 153.2 acres (1,532 x 0.10) necessary to increase the stock by 10%. The average cost of performing the additional 153.2 acres permanent work was $57.44 per acre and the cost for spraying the additional 31,193 acres was $0.104 per acre. These cost figures were determined by entering 316.46 acres into the permanent average cost equation of Table 5:2. The average cost of spraying was used since there are no scale economies involved. The cost equation permits the analysis to incorporate reductions in cost per acre of permanent work instead of simply applying the overall average costs to all changes in acreages.

By utilizing the physical reductions in mosquito numbers per unit of temporary and permanent control of Table 5:1 and the cost equation in Table 5:2, one can calculate the costs of reducing the mean number of mosquitoes per light trap night by 1.0 as: $6,354 for permanent and $1,817 for temporary abatement work[1]. This result indicates that additional expenditures on spraying are more productive than expenditures on permanent work. The cost to lower the light trap count by 1.0 is 3.50 times higher for permanent work than it is for temporary work (see Table 6:2). This comparison involves only the direct dollar costs and does not include any evaluation of environmental side effects.

The 3.5 to 1 superiority of temporary work is based on an average

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[1] Based on $57.44 per acre for permanent work and $0.104 for temporary work from equations in Table 5:2.

ditch life of 9.7 years with a range from 5 to 12 years. Three additional analyses were conducted to determine how sensitive the results are to the length of ditch life. The following lives were used: 15 years with a range from 8 to 18 years; 20 years with a range from 12 to 24 years; and 25 years with a range from 15 to 30 years. The results are presented in Table 6:2.

The length of ditch life reduces the relative advantage of temporary control over permanent control from 3.5 (life of 9.7 years) to 1.4 (life of 25 years), but temporary abatement still retains a relative advantage.

Table 6:2 - Comparisons of Average Ditch Life and the Associated Expenditures Required to Reduce Annual Mean Light Trap Counts by 1.0.

Average Ditch Life (Years)	Expenditure Required to Decrease Mean Annual Light Trap Count by 1.0		Ratio: Permanent / Temporary
	Permanent	Temporary	
9.7	$6,354	$1,817	3.50
15.0	4,608	1,892	2.44
20.0	3,903	1,969	1.98
25.0	2,863	2,037	1.41

Therefore, based on the best estimates of the effect of abatement activities on light trap counts and costs per unit of work completed from 30 districts over 13 years, it appears that expenditures for temporary activities are more productive. Our figures indicate that districts get three and one-half times as much control from temporary as permanent activities per dollar of expenditure. This calculation is performed at the data means: 311,931 acres of chemical treatment and 1,532 acres under permanent control. It can be seen in Figure 5:1 that permanent work would be much less expensive for larger districts because of economies of scale. The cost of temporary work would not decrease for larger districts, however, because there are no economies of scale to be obtained. Very large districts (900-1000 acres of ditching per year) may find temporary work as expensive as permanent work in terms of mosquitoes controlled. Contrarily, a small district must face high permanent control costs per acre as shown in Figure 5:1 and would therefore find temporary abatement much cheaper.

FORMATION OF NEW ABATEMENT DISTRICTS

One of the purposes of this study was to develop procedures for evaluating the likely demand for and costs of mosquito abatement in coastal areas which are considering initiating or increasing abatement activities. The study areas in Florida included 13 districts with populations of 10,000 - 30,000 people and high salt marsh mosquito populations, so that those districts are particularly similar to many other coastal areas, particularly those of North Carolina and South Carolina. These sparsely-populated coastal areas have special characteristics compared with the typical (mean) mosquito abatement districts (70,000 people). One of the major differences is that per capita local expenditures are much higher since there are fewer people to share the costs of a minimum control effort. Per capita expenditures from local funds may be 3 to 4 times as high as the average expenditure per capita for all 30 districts ($1.27 in 1970).

The sharing arrangements in the state of Florida encourages small districts to collect local funds in order to get state matching funds. As equation Y_4 in Table 5:1 indicated, a 10% increase in state funds leads to about a 3.5% increase in local funds. This type of matching arrangement is not available in most other states. It is not possible to accurately project the effect of no matching funds, but it is clear that this is one of the major stimulants of expenditure in sparsely populated districts in Florida. On the other hand, as Figure 3:5 indicated, state aid per capita (constant 1967 dollars) has been falling in recent years in Florida.

Per capita income, wage rates, and tourism also differ in the sparsely populated coastal areas. For example, Carteret County, North Carolina, has higher tourism (in terms of lodging workers per capita) but slightly lower per capita incomes and wage rates than the mean of the sample of districts in this analysis. Mosquito populations in coastal North Carolina seem to be slightly higher than the typical Florida district (mean of 63.2 per light trap night). For example, the 1973 light trap count for 4 locations in Carteret County was 75, (Axtell, 1974b).

Even though people are willing to expend $4 to $5 per person ($4.40 in 1970 for 13 small districts in Florida) of local tax dollars for abatement in the smaller sample districts, these low population districts have smaller total budgets ($134,000 compared with $302,000 for all districts), they perform less abatement work and control fewer mosquitoes. Less work is performed because the small districts have small budgets and high unit costs of permanent control, as indicated in Figure 5:1.

It is clearly less expensive per person to abate mosquitoes in heavily populated areas. Many other areas are willing to tax themselves if they have reasonably high mosquito populations and state support. The formation of new districts is difficult because of high costs per unit of permanent control, but this is not the case with temporary control. There appears to be no advantages of size in chemical control. Chemical control measures will have economic advantages over permanent control measures (ditching or impoundments) in sparsely populated districts based on relative costs and benefits found in similar districts of this study.

This study has not investigated the economic, demographic, and biological factors effecting the demand for state appropriations for mosquito abatement; nor have optimal sharing arrangements been investigated. Scale economies favor multiple county, permanent activities. However, earmarked appropriations tend to distort the mix of permanent and temporary abatement work. It is an open question whether the estimated over-investment in permanent control (relative to chemical control) found in the above analysis is traceable to the higher state grants for permanent work[1]. The degree of this phenomenon in other areas needs to be evaluated. Further work should probably treat adulticiding and larviciding activities separately since they likely have quite different responses. This study has also not identified the return from monitoring activities which probably vary consistently between districts.

SUMMARY AND CONCLUSIONS

This study examined the responsiveness of mosquito numbers to various types of abatement activities and the incentives to collect taxes to control mosquitoes.

The major findings of the study were: (1) mosquito abatement activities were effective in reducing the mean mosquito abundance in the study area over the 1959-1971 period; (2) economies of scale were present in permanent control (ditching and impoundments), but not in temporary control (chemicals); (3) temporary control was from 1.4 to 3.5 times as effective, per dollar of expenditure, as permanent control; (4) local abatement expenditures per capita (proxy for quantity of abatement) were significantly affected by income, state grants, tourism, the wage rate (proxy for price of abatement), and population; (5) the simultaneous nature of the abatement model was verified statistically; the number of mosquitoes affected the amount of chemical con-

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[1] Recall that the study only considered the direct abatement costs and the associated changes in mosquito numbers and no consideration was given to possible environmental problems related to either permanent or temporary control.

trol and vice versa.

The number of mosquitoes (as monitored by light trap catches) varied from year to year, but there was definite downward trend over the 1959-1971 period. The average number of acres sprayed per district per year was 484,680 and the number in any given year tended to change in the same direction as mosquito density changed. The amount of permanent acreage under control increased over the 13 years with an average of 6,138 acres per district for the period. The statistical analysis indicated that a 10% increase (above the mean) in permanent and temporary abatement work would significantly decrease mosquito numbers by 4.4% and 5.7%, respectively.

An economies of scale model indicated that the acres of permanent work completed per year significantly reduced the average cost per acre, but no such relationship was found in temporary abatement work. Considering cost and physical efficiency, temporary abatement was shown to be from 1.4 to 3.5 times as efficient as permanent abatement per dollar of expenditure, depending upon the ditch life. The analysis only considered the direct abatement effects of reduced mosquito numbers and did not attempt to account for externalities. Within these limits, it was concluded that there has been an overemphasis on permanent abatement relative to temporary abatement.

One of the objectives was to estimate to what extent per capita income, mosquito numbers, tourism, population, wage rates and state grants influenced the willingness to collect local taxes for mosquito abatement in organized districts. It was found that local expenditures per capita were significantly affected by: income, state grants, tourism, the wage rate and population.

An implication of this analysis is that sparsely populated coastal areas have much higher per capita mosquito abatement costs than heavily populated areas. As mosquito numbers, incomes, tourism and state grants rise, the ability of a district to collect abatement taxes increases. Ditching costs fall as amount of ditching completed per year rises, and chemical control costs fall as human population density rises. Thus, there are incentives to lease, rather than purchase, ditching machinery and incentives to set district boundaries to include areas with high densities of people and mosquitoes.

This report provides an overview of mosquito abatement in 30 Districts for 13 years. Similar procedures could be used to analyze the economics of mosquito abatement in a single district or in an area contemplating the formation of an abatement district. This would provide useful input to the decision-making process.

This study suggests that economic incentives exist for group action in mosquito control, although these incentives are less direct than those for individual action to control insects in crop production. The willingness to pay for mosquito abatement is quite responsive to price and income levels. Economic analysis of the demand for and cost of mosquito abatement can be accomplished by means of simultaneous regression equations following the proper formulation of conceptual models which take into consideration the mosquito biology, abatement procedures and practices, and the economic incentives of the taxpayers.

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Appendix Table 1: Individual Mosquito District Variable Descriptions and Data Transformation

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Y_1 = number of mosquitoes per light trap night

Y_2 = acres chemically treated during the year (once over)

Y_3 = acres permanent abatement work during the year; $Y_3 = X_{13} + X_{14}$

Y_4 = local expenditure per capital (dollars); $Y_4 = \frac{X_{10} - X_{11}}{N \cdot W^B \cdot X_{20}}$

P_{Y_2} = cost per acre chemically treated (dollars)

P_{Y_3} = cost per acre of permanent control activity (dollars)

X_1 = inches of storm rainfall accumulation during the mosquito season measured as 2" on any one day or a period of days having 1" per day with at least one day of 2"

X_2 = number of rainfall sequences in relation to the proportion of potential mosquito breeding acreage under permanent abatement;

$$X_2 = X_{12} \cdot \left(1 - \frac{X_{13} + X_{14}}{X_{15}}\right)$$

X_3 = average district temperature May 1-October 31 (degrees F.)

X_4 = stock of permanent abatement acres (depreciated); $X_{4_t} = X_{13_t} + X_{14_t}$

X_5 = total budget of the district (state plus local), deflated by the wholesale price index; $X_5 = (X_{17} + X_{18})/X_{20}$ (dollars)

X_6 = population density of the district; $X_6 = N/X_{19}$

X_7 = income per capital dollars (deflated)

X_8 = state grants per capita (deflated); $X_8 = X_{18}/N$

X_9 = tourism per capita; $X_9 = X_{21}/N$.

W^B = wage rate raised to the ^{B}power (B = labor's share of total expenditure)

N = population in the district

X_{10} = local expenditure on abatement activities (dollars)

X_{11} = sanitary land fill expenditures (proportion financed out of local funds);

$$X_{11} = \frac{\text{local expenditures}}{\text{local + state expenditures}} \quad \text{total sanitary land fill expenditures}$$

X_{12} = number of 1/4" rainfall days, two-day dry interval

X_{13} = acres permanent control via ditching (depreciated);

Group I: $X_{13_t} = 11/12\, X_{13_{t-1}} + Y_{3_t}$

Group II: $X_{13_t} = 4/5\, X_{13_{t-1}} + Y_{3_t}$

Group III: $X_{13_t} = 7/8\, X_{13_{t-1}} + Y_{3_t}$

when $X_{13_{t-n}} = 1958$, set $X_{13_{t-n}} = X_{16}$

X_{14} = acres permanent control via diking

X_{15} = acres of potential mosquito breeding area

X_{16} = acres under permanent control in 1959

X_{17} = local budget for mosquito abatement

X_{18} = state budget for mosquito abatement

X_{19} = square miles in the mosquito abatement district

X_{20} = wholesale price index

X_{21} = tourism proxy; the number of employees working in all lodging establishments

Locations (LOC) and Code Numbers:

1. Brevard Co., Fla.
2. Broward Co., Fla.
3. Charlotte Co., Fla.
4. Citrus Co., Fla.
5. Collier Co., Fla.
7. Duval Co., Fla.
8. Escambia Co., Fla.
10. Franklin Co., Fla.
11. Hillsborough Co., Fla.
12. Indian River Co., Fla.
13. Lee Co., Fla.
14. Levy Co., Fla.
15. Manatee Co., Fla.
16. Martin Co., Fla.
17. Monroe Co., Fla.
18. Nassau Co., Fla.
19. Palm Beach Co., Fla.
21. Pinellas Co., Fla.
22. St. Johns Co., Fla.
23. St. Lucie Co., Fla.
24. Santa Rosa Co., Fla.
25. Sarasota Co., Fla.
26. Volusia Co., Fla.
28. Walton Co., Fla.
29. Chatham Co., Ga.
31. Delaware (State)
32. Cape May Co., N. J.
33. Monmouth Co., N.J.
34. Ocean Co., N. J.
35. Virginia Beach, Va.

Appendix Table 2: Individual Mosquito District Data, Part I

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
1	59	103.9	2142452	355.762	2.44222	10.97	12.4414	79.8	10355.8
1	60	174.2	1919070	663.402	1.42370	24.26	11.2709	79.0	12203.9
1	61	70.1	2340851	530.264	1.28071	11.55	7.4626	79.0	14008.7
1	62	236.1	2896835	105.004	1.32745	12.71	10.5601	79.7	15599.8
1	63	57.1	1514039	120.364	1.30438	7.24	5.5009	78.7	17305.7
1	64	100.2	1440793	112.693	1.18629	9.18	6.6127	78.4	18330.5
1	65	74.6	2826308	177.215	1.12800	0.00	4.7303	75.8	19083.8
1	66	250.6	1602910	702.628	1.10401	25.16	6.9930	78.2	20464.2
1	67	198.0	1832527	387.770	1.06509	6.87	5.6904	77.5	21870.9
1	68	130.3	1183385	367.115	0.93681	16.36	4.7801	77.7	22829.9
1	69	56.8	734889	575.073	1.01463	7.61	4.3209	78.7	23827.3
1	70	49.6	553490	661.816	1.11468	7.41	2.3065	78.5	24677.4
1	71	281.5	1405109	617.157	0.95923	0.00	2.4774	79.1	25354.9
2	59	129.8	20848	552.670	0.17578	14.85	14.4733	81.3	752.7
2	60	63.8	139767	649.751	0.11158	20.77	8.9815	81.2	1376.7
2	61	48.9	82082	373.123	0.12469	4.07	3.5114	80.8	1717.2
2	62	49.5	167762	488.207	0.10490	9.85	0.5312	80.5	2127.0
2	63	51.0	199434	338.410	0.11393	12.42	0.0210	80.4	2357.4
2	64	46.5	220028	395.966	0.10673	20.62	0.0210	80.0	2630.7
2	65	30.8	222828	277.490	0.12376	22.59	0.0160	79.4	2712.4
2	66	24.4	120752	258.199	0.10425	20.59	0.0220	80.1	2768.0
2	67	36.3	156924	265.230	0.11490	27.28	0.0200	79.6	2826.0
2	68	10.8	199144	244.387	0.13130	21.57	0.0230	79.1	2858.3
2	69	9.5	176306	251.609	0.21180	12.67	0.0260	80.5	2895.1
2	70	8.3	172561	249.617	0.15121	8.82	0.0190	78.4	2926.9
2	71	32.5	269884	135.931	0.11777	0.00	0.0190	78.6	2842.3
3	59	20.2	424583	495.487	2.22342	36.78	23.1423	80.8	5495.5
3	60	70.6	307976	507.126	2.55543	11.75	13.3366	80.8	5544.7
3	61	58.4	259976	614.759	2.64479	4.97	15.9490	80.7	5697.4
3	62	61.0	341868	491.238	2.50567	12.65	15.0573	81.4	5713.8
3	63	34.6	425359	501.847	3.46926	19.90	14.1634	80.7	5739.5
3	64	90.5	656826	499.161	2.58304	5.48	15.9263	80.1	5760.4
3	65	13.0	640487	402.885	0.39338	7.50	16.8404	79.4	5683.2
3	66	9.2	481747	532.004	2.94019	4.49	17.7033	78.9	5741.6
3	67	24.0	425262	71.920	2.20749	7.03	13.3995	78.8	5335.1
3	68	12.3	385262	598.161	3.63517	12.92	19.5850	78.9	5488.7
3	69	10.4	467929	402.241	5.63443	5.42	19.6093	79.7	5433.5
3	70	5.9	510353	151.866	3.86119	4.70	17.0496	79.5	5132.6
3	71	13.9	744245	337.644	3.06229	2.08	17.9830	79.3	5042.5

Appendix Table 2, Part I - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
4	59	13.8	205188	136.506	4.89149	14.63	23.4881	79.7	136.5
4	60	32.9	230594	86.989	7.61300	17.46	19.3371	79.0	212.1
4	61	27.5	253479	181.854	8.02279	9.65	15.0593	79.2	376.3
4	62	48.7	370959	316.529	8.17732	0.00	17.9329	79.9	661.5
4	63	44.0	203189	45.077	7.03331	5.50	10.7786	79.3	651.4
4	64	52.8	322353	63.027	6.21466	14.66	19.7307	77.9	660.2
4	65	17.3	480050	115.479	6.74032	10.10	17.7480	78.9	720.6
4	66	2.6	646451	242.923	5.85048	5.36	16.3177	79.6	903.5
4	67	2.6	709142	242.395	6.17590	8.21	18.3198	78.7	1070.6
4	68	7.1	939639	158.184	6.54699	13.51	11.5072	79.3	1139.6
4	69	4.0	852851	180.977	6.82676	9.20	17.7871	79.9	1225.6
4	70	3.1	770524	182.379	4.77930	2.72	16.7152	79.8	1305.8
4	71	63.2	806403	192.912	4.22903	8.05	14.0908	79.2	1389.9
5	59	60.6	295273	0.000	3.31176	22.21	24.0000	81.3	0.0
5	60	91.8	366159	222.510	2.62852	22.58	20.7664	80.7	222.5
5	61	36.2	316849	245.498	3.48559	4.96	19.5505	80.2	449.5
5	62	101.0	445383	113.29	2.58144	14.49	23.3696	80.6	525.30
5	63	62.1	603686	100.88	2.63314	11.17	20.3885	80.3	582.40
5	64	80.1	714717	119.45	5.10076	17.81	44.4974	80.8	653.32
5	65	210.9	1420370	109.77	8.74659	5.40	21.2205	79.6	708.65
5	66	314.7	1021357	108.24	6.04009	21.93	23.0906	80.3	757.83
5	67	343.1	1331426	165.90	5.92547	13.44	15.3115	78.4	860.58
5	68	270.3	1224362	114.75	5.79450	19.57	24.8253	79.1	903.61
5	69	193.1	1196744	11.49	5.99914	24.31	20.1182	79.3	839.81
5	70	68.8	1364282	0.00	5.29954	2.00	18.2687	79.6	769.82
5	71	222.7	1798732	0.00	4.56180	4.00	17.3649	78.8	705.67
7	59	47.5	137067	652.89	0.08767	6.55	17.1824	79.6	8452.89
7	60	1.5	83006	447.67	0.06158	10.92	20.2362	78.4	7209.98
7	61	16.6	109576	223.75	0.09778	7.02	13.5021	75.5	5991.74
7	62	23.8	225940	198.53	0.09295	7.51	15.5856	79.3	4991.93
7	63	17.6	247079	210.10	0.10602	18.70	22.3185	77.9	4203.64
7	64	13.5	459929	470.04	0.10578	16.14	16.8501	77.6	3832.96
7	65	4.0	406110	523.09	0.11078	14.22	15.0428	78.2	3589.46
7	66	8.3	404462	480.94	0.11029	16.58	14.1619	77.1	3352.51
7	67	8.6	454741	406.74	0.12018	8.71	18.9704	77.5	3088.74
7	68	9.2	441992	310.64	0.17290	18.17	18.1192	79.3	2781.63
7	69	8.1	698517	520.18	0.68065	15.72	15.2679	79.0	2745.48
7	70	4.7	1242199	341.46	0.61033	5.64	14.3655	78.7	2537.85
7	71	3.3	1223466	459.13	0.51164	9.56	20.1287	77.6	2489.41

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
8	59	33.7	45188	64.26	0.28321	25.99	8.5743	78.5	114.26
8	60	54.0	75345	73.51	0.31989	15.20	3.1580	77.7	164.91
8	61	43.5	75152	56.34	0.23545	12.53	1.1144	75.8	188.27
8	62	67.1	79370	223.47	0.29083	2.05	0.0160	78.5	374.08
8	63	48.8	181576	66.95	0.27377	13.03	0.0110	78.1	366.22
8	64	16.9	168776	50.38	0.32304	12.64	0.0180	76.9	343.36
8	65	20.1	273601	84.69	0.44957	12.23	0.0150	76.8	359.38
8	66	14.1	219298	68.11	0.26966	3.05	0.0190	76.7	355.62
8	67	11.9	192922	89.12	0.26798	16.92	0.0190	75.1	373.61
8	68	6.2	195588	108.08	0.30374	9.65	0.0140	77.6	406.97
8	69	13.7	339443	167.19	0.27890	23.36	0.0190	77.6	492.77
8	70	14.7	383225	37.55	0.58593	22.28	0.0700	79.4	431.77
8	71	21.0	270643	27.85	0.25104	4.45	0.0190	78.2	373.27
10	59	6.0	91927	43.418	2.12230	33.56	19.9590	78.5	43.42
10	60	115.5	140461	4.008	1.57066	0.00	17.9671	77.4	38.74
10	61	65.0	96542	20.931	1.58559	6.41	12.9681	76.6	51.92
10	62	49.6	138570	36.134	2.11065	6.18	12.9523	78.8	77.67
10	63	91.3	132122	28.621	2.09307	21.52	15.9314	77.8	90.76
10	64	103.5	110934	0.000	0.98800	22.86	16.9417	77.2	72.61
10	65	29.6	93673	0.000	2.03225	28.80	16.9534	77.4	58.09
10	66	21.9	98861	0.000	1.72857	25.05	14.9671	77.1	46.47
10	67	52.5	126206	61.621	1.68628	14.09	18.9114	75.9	98.80
10	68	14.9	134061	7.644	1.55380	12.04	11.9509	78.2	86.68
10	69	21.1	115637	16.552	1.52108	20.09	18.9229	78.0	85.90
10	70	21.3	88728	0.000	1.50510	18.90	12.9578	79.2	68.72
10	71	27.2	132606	0.000	1.34409	2.53	15.9585	78.6	54.97
11	59	70.7	801166	817.935	0.37819	11.80	9.4265	81.0	8817.93
11	60	69.9	771784	420.126	0.34210	22.63	9.3710	78.4	8503.23
11	61	83.9	809990	494.372	0.41462	2.27	4.8194	79.9	8289.00
11	62	61.3	1612369	398.716	0.39910	4.06	10.0038	79.5	7996.97
11	63	30.9	1116270	257.276	0.47404	3.78	11.5667	79.2	7587.83
11	64	100.2	1381823	176.284	0.45177	7.59	9.4225	78.9	7131.79
11	65	40.6	1170767	169.111	0.50704	2.29	12.1976	78.9	6706.59
11	66	25.6	901676	240.525	0.55622	6.71	9.0110	78.9	6388.23
11	67	61.0	945934	300.824	0.54831	11.05	9.8433	78.6	6156.70
11	68	47.6	1111226	109.762	0.44538	9.12	10.2466	78.6	5753.41
11	69	24.6	1307698	47.506	0.47475	7.95	16.0178	80.3	5321.46
11	70	13.4	999694	170.605	0.41342	4.28	13.6892	79.7	5048.61
11	71	51.6	1048450	37.605	0.46344	12.30	9.9177	79.4	4665.50

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
12	59	93.0	398158	322.567	6.83611	11.84	15.7710	80.1	1242.57
12	60	57.6	458183	41.226	6.21642	7.30	13.0335	78.6	1679.91
12	61	33.4	398844	95.693	8.54823	3.80	12.6547	79.1	2404.53
12	62	50.0	471221	385.322	8.19946	6.19	11.1675	79.8	3371.14
12	63	36.3	313230	327.881	5.54335	16.83	8.6150	79.6	3754.01
12	64	50.0	392377	178.115	6.31526	7.14	8.2010	78.8	4516.04
12	65	31.1	493857	109.330	7.75686	12.30	6.8856	79.4	4946.53
12	66	25.6	402651	50.364	6.88435	24.58	5.5504	77.9	5096.69
12	67	23.5	303886	195.375	3.62521	0.00	4.5062	79.3	5291.50
12	68	10.8	349597	74.203	2.61437	9.57	5.1025	79.6	5266.42
12	69	12.2	243709	32.969	2.54026	0.00	6.6594	79.6	5202.18
12	70	10.9	294267	35.517	3.20363	7.17	5.7060	78.7	5145.85
12	71	17.4	430347	26.571	2.75310	14.21	6.1680	79.5	5085.27
13	59	367.7	1331592	506.153	4.91638	13.60	16.6746	80.7	1646.15
13	60	371.9	1397822	738.184	4.18881	11.13	21.4251	79.9	2247.16
13	61	238.6	1117949	952.820	5.29411	13.88	23.1592	80.9	3012.71
13	62	411.7	2504825	942.989	4.51229	12.77	22.0092	81.4	3704.64
13	63	254.3	1650136	833.088	5.63034	3.41	19.9673	80.9	4229.01
13	64	364.9	2157984	570.011	4.51524	2.78	15.1727	80.2	4446.61
13	65	260.7	2438816	656.180	5.71456	11.08	18.8995	79.7	4732.23
13	66	193.8	1414978	604.851	5.41014	4.49	21.6781	80.7	4942.73
13	67	248.9	1890409	527.743	6.01782	8.66	18.8236	80.5	5058.58
13	68	95.2	715429	466.625	5.60037	22.77	18.8131	80.3	5103.66
13	69	81.9	917867	465.345	6.13742	25.23	25.3851	80.7	5143.70
13	70	120.7	726560	386.992	5.11536	9.85	15.0508	80.2	5102.05
13	71	232.6	1608506	475.383	5.66369	4.58	18.8018	80.0	5152.26
14	59	12.9	72000	39.755	0.79277	21.18	18.9956	78.8	39.75
14	60	13.3	49309	63.690	0.85352	16.05	19.9884	79.9	100.13
14	61	14.2	54788	13.989	0.89759	7.51	15.9902	79.8	105.78
14	62	12.0	105455	49.230	0.87523	5.19	18.9839	80.6	146.19
14	63	7.8	88243	38.065	1.12471	3.40	18.9811	79.7	172.07
14	64	16.3	129358	17.912	1.09621	20.60	13.9858	78.8	175.65
14	65	36.4	123491	43.218	1.08649	12.91	12.9846	79.3	204.23
14	66	12.1	170716	26.709	1.12830	6.74	14.9814	80.0	213.92
14	67	10.3	129940	37.678	1.00325	9.79	15.9784	77.2	233.77
14	68	4.7	97067	31.356	1.13783	11.54	17.9744	78.9	245.64
14	69	4.4	121213	24.080	1.12679	11.22	16.9755	78.9	249.25
14	70	7.4	122958	36.904	0.85083	12.87	11.9816	80.6	265.39
14	71	7.3	129746	16.494	0.85926	19.25	20.9684	80.0	259.77

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
15	59	106.8	447225	522.406	0.64812	13.74	19.4651	79.3	671.41
15	60	115.3	298764	501.149	0.96068	26.45	20.2042	78.7	1116.61
15	61	162.2	408001	445.153	0.72429	7.65	20.1627	78.7	1468.71
15	62	135.8	386668	265.326	0.91839	4.47	16.4911	79.0	1611.64
15	63	29.3	410425	285.268	0.91689	8.71	15.3543	78.9	1762.61
15	64	34.5	495274	296.839	0.95073	3.75	12.6687	78.1	1912.56
15	65	78.7	511032	286.475	0.75932	8.47	14.7812	77.4	2039.66
15	66	61.2	477529	251.092	1.45416	7.71	16.1517	78.5	2120.78
15	67	109.9	415226	291.207	1.02702	14.68	15.8900	77.8	2235.25
15	68	51.6	421383	98.973	1.03563	18.70	17.6219	78.9	2147.95
15	69	26.0	227242	165.238	0.91026	28.84	19.1917	80.7	2134.20
15	70	41.9	198585	59.625	1.05330	13.43	15.6108	80.0	2015.97
15	71	29.0	151681	45.272	0.93175	15.77	15.0841	78.5	1893.25
16	59	243.9	118642	242.375	1.24267	12.44	18.1655	80.4	742.38
16	60	174.7	61624	39.540	0.99929	17.75	18.1614	79.9	1157.05
16	61	57.7	9212	106.284	1.48077	11.41	10.1023	79.8	2027.33
16	62	154.0	97551	69.100	1.08321	6.71	9.7779	80.3	2669.57
16	63	71.7	70157	110.728	1.14420	15.26	9.9680	79.7	3008.00
16	64	97.4	135322	135.460	1.12724	13.02	11.0214	79.6	3075.29
16	65	88.8	78934	163.050	1.24862	0.00	6.3694	79.3	3164.57
16	66	83.7	79806	80.881	1.00263	13.37	7.8825	79.2	3218.24
16	67	47.6	203311	88.149	1.18362	5.08	7.1956	79.4	3521.20
16	68	69.0	153843	51.149	1.94393	10.13	8.6418	79.3	3519.58
16	69	34.0	138231	27.471	2.88164	5.50	7.7621	80.0	3643.84
16	70	64.6	226540	175.096	2.62896	6.99	5.7532	78.7	3917.87
16	71	104.5	310740	66.245	2.32336	7.47	5.7351	78.7	4066.21
17	59	794.0	386619	0.000	1.77045	7.54	16.0000	79.0	0.00
17	60	552.2	278643	0.000	1.89245	13.59	19.0000	82.4	0.00
17	61	375.4	638838	209.992	2.29726	3.30	13.9160	82.6	209.99
17	62	478.3	589189	0.000	2.42701	3.37	13.9230	82.5	192.49
17	63	264.1	579832	0.000	4.13988	16.09	13.9294	82.5	176.45
17	64	95.2	991837	0.000	4.23408	0.00	11.9445	82.4	161.75
17	65	32.3	1281276	0.000	5.09420	0.00	14.9365	83.2	148.27
17	66	32.3	1194350	608.831	5.13160	12.68	22.5106	81.7	744.74
17	67	56.1	1326953	513.506	5.42027	2.25	17.3848	82.7	1196.19
17	68	12.8	1393290	186.333	6.02325	12.03	25.0470	82.0	1282.84
17	69	10.2	1456662	96.582	6.44374	25.86	19.2728	82.8	1272.52
17	70	28.8	1261068	123.579	6.02252	15.53	15.4103	81.8	1290.05
17	71	67.0	1544817	210.63	7.45892	9.25	20.1641	82.3	1393.18

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
18	59	30.6	149770	123.64	3.74746	8.99	13.7148	79.1	1523.64
18	60	14.8	203200	151.23	3.38584	13.48	18.8620	77.3	1370.14
18	61	8.7	118933	0.00	3.55331	2.82	13.2597	77.0	1096.11
18	62	11.4	178230	192.54	3.24575	10.48	16.6580	78.5	1069.43
18	63	9.0	145406	201.36	3.57347	10.56	16.6972	79.1	1056.91
18	64	22.6	180413	69.31	3.37387	16.77	17.1411	77.1	914.84
18	65	15.5	56194	70.59	3.50954	3.44	17.4923	76.5	802.46
18	66	10.2	77479	195.55	3.62583	5.42	15.6445	76.5	837.52
18	67	5.2	69043	131.45	4.03664	11.26	15.7459	75.8	801.47
18	68	7.9	101043	98.87	5.10389	25.84	14.1499	77.5	740.04
18	69	17.1	85625	158.95	3.64260	14.22	21.1838	78.5	750.98
18	70	16.2	89164	96.87	3.23367	7.56	12.4739	79.1	697.66
18	71	9.6	83976	162.04	3.48566	0.00	16.8620	78.2	720.17
19	59	82.3	233164	263.28	0.47959	20.15	7.8060	78.4	1463.28
19	60	76.8	178764	370.64	0.44156	15.37	6.8802	77.2	1711.98
19	61	59.8	131588	447.07	0.42175	4.65	2.8771	77.4	2016.38
19	62	186.2	80827	376.85	0.47060	15.88	1.4567	78.7	2225.20
19	63	40.0	81321	270.43	0.45423	17.24	0.7484	78.2	2310.19
19	64	40.8	87521	260.54	0.47755	5.09	0.1906	76.5	2378.22
19	65	48.7	93722	254.00	0.57142	12.77	0.0220	77.4	2434.04
19	66	29.0	168776	357.26	0.43586	15.69	0.0240	79.0	2588.46
19	67	42.8	123346	288.92	0.50313	3.23	0.0230	77.8	2661.67
19	68	30.1	184594	452.34	0.30637	16.39	0.0230	78.3	2892.21
19	69	14.2	137776	444.79	0.38492	8.36	0.0260	79.1	3095.98
19	70	8.2	84143	196.51	0.31847	6.12	0.0250	78.6	3034.50
19	71	27.3	103176	105.34	0.38384	7.42	0.0230	78.3	2886.97
21	59	50.9	664005	1674.73	0.52899	18.87	5.8601	79.5	4674.73
21	60	38.0	909578	1979.79	0.35702	13.35	0.0205	78.6	6264.96
21	61	35.4	1050234	779.00	0.44276	8.25	0.0190	78.7	6521.88
21	62	33.6	1880636	944.96	0.68159	23.30	0.0210	79.2	6923.36
21	63	7.8	4145468	856.46	0.48700	6.50	0.0150	79.2	7202.87
21	64	18.8	1605144	787.66	0.38312	12.35	0.0170	78.5	7390.30
21	65	8.9	1235834	674.95	0.38558	6.44	0.0700	78.7	7449.39
21	66	3.9	825409	493.54	0.45063	6.44	0.0180	79.2	7322.15
21	67	6.2	665576	573.84	0.44010	10.80	0.0150	78.6	7285.81
21	68	7.1	882465	716.08	0.42284	12.74	0.0190	79.2	7394.74
21	69	4.4	1074519	717.69	0.44691	6.43	0.0240	80.0	7496.20
21	70	3.3	968591	515.79	0.47087	3.02	0.0230	79.6	7387.30
21	71	4.9	1077970	525.42	0.49524	15.49	0.0170	79.5	7297.12

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
22	59	40.2	231612	212.25	1.28152	4.60	20.9459	78.7	224.25
22	60	52.8	104436	52.52	1.10682	3.85	19.9594	77.3	231.91
22	61	31.7	143142	57.15	1.90402	10.75	14.2222	77.1	242.68
22	62	41.7	371444	124.30	2.73528	12.99	17.2651	78.3	318.44
22	63	25.2	337407	188.31	2.56944	19.63	14.1480	77.5	443.06
22	64	30.5	363541	34.81	2.45144	23.65	17.1017	76.6	389.26
22	65	20.8	172025	87.42	2.86577	0.00	18.9774	76.8	398.83
22	66	20.7	177649	144.88	2.72840	10.15	16.9294	77.1	463.94
22	67	29.4	259589	242.58	2.45626	6.18	19.3476	76.3	613.73
22	68	8.4	266037	139.89	2.64635	13.12	18.3824	76.1	630.88
22	69	11.0	280680	198.08	2.89247	8.24	20.9277	78.3	702.78
22	70	7.8	160728	177.50	3.23188	0.00	16.2929	77.1	739.73
22	71	10.4	212898	269.93	3.55190	3.97	18.6800	77.4	861.72
23	59	213.7	404946	0.00	2.39557	23.95	14.0000	79.5	2000.00
23	60	105.6	316800	0.00	2.04450	12.43	11.0880	78.7	2832.00
23	61	55.3	396551	0.00	2.08976	8.38	7.2590	78.7	3438.00
23	62	257.5	670402	17.05	2.39710	7.38	6.8638	78.8	4284.05
23	63	112.8	539238	51.05	2.31085	14.00	4.8542	78.6	4733.68
23	64	97.6	557626	106.65	2.17370	14.13	1.1628	77.9	5667.77
23	65	111.9	498474	172.85	2.37014	0.00	0.0150	77.8	6037.65
23	66	37.4	408637	168.77	2.32254	11.51	0.0200	79.1	6179.20
23	67	46.6	512689	83.49	2.34801	2.26	0.0210	78.6	6223.67
23	68	121.2	464341	33.49	1.73911	6.77	0.0710	78.4	6214.43
23	69	41.5	476365	5.94	1.80659	13.39	0.0240	79.7	6178.42
23	70	28.5	497214	101.26	1.75260	12.29	0.0180	79.4	6240.73
23	71	73.4	882863	0.00	1.62608	3.31	0.0730	79.1	6196.59
24	59	15.4	147733	0.00	0.26819	14.78	21.0000	78.6	0.00
24	60	7.1	60606	0.00	0.37856	18.00	25.0000	76.2	0.00
24	61	17.1	150609	0.00	0.34126	12.87	24.0000	74.5	0.00
24	62	13.4	153898	0.00	0.34749	6.00	13.0000	77.6	0.00
24	63	13.2	157188	0.00	0.46863	9.02	14.0000	76.9	0.00
24	64	13.2	141722	0.00	0.83729	6.95	18.0000	75.8	0.00
24	65	20.3	146085	39.47	0.79085	7.07	18.2501	75.7	39.47
24	66	10.7	114425	47.32	1.05770	0.00	17.5011	75.0	78.89
24	67	11.2	222546	30.27	1.05073	14.84	19.0390	74.3	93.38
24	68	4.5	258910	13.52	0.98182	0.00	16.4119	75.7	88.23
24	69	6.4	304049	9.65	1.04992	15.27	20.2349	77.0	80.23
24	70	2.6	352971	13.60	1.13323	29.16	15.6776	78.7	77.79
24	71	2.1	389092	17.18	1.06696	6.13	18.4117	76.7	79.41

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
25	59	62.8	192207	835.91	0.70520	21.16	5.5294	80.4	2835.91
25	60	107.8	252141	792.47	0.59292	29.27	3.0397	78.4	3392.06
25	61	79.7	217186	863.34	0.97473	3.71	0.1364	78.9	3972.73
25	62	94.2	350546	840.11	0.74511	18.74	0.0170	80.1	4481.78
25	63	49.3	240291	1200.27	0.59127	7.69	0.0200	79.5	5308.57
25	64	46.9	315152	1168.08	1.03290	5.81	0.0210	79.1	6034.27
25	65	43.6	385698	1073.31	1.10183	15.57	0.0160	79.6	6604.73
25	66	23.8	420365	819.75	0.82841	5.68	0.0210	79.3	6874.09
25	67	59.8	487136	682.57	0.41575	17.76	0.0170	78.2	6983.82
25	68	35.6	428365	719.12	0.50120	13.35	0.0210	78.7	7120.95
25	69	33.3	371638	614.89	0.70014	4.18	0.0250	80.1	7142.42
25	70	51.2	374789	571.28	0.39558	7.56	0.0160	79.7	7118.50
25	71	151.9	492365	171.74	0.50094	12.31	0.0170	79.2	6697.03
26	59	71.1	311719	568.87	1.33072	8.24	14.8966	80.2	1068.87
26	60	23.2	253182	772.60	1.22732	9.39	17.7388	77.4	1752.40
26	61	34.7	278964	856.59	1.51028	5.09	12.6165	77.9	2462.96
26	62	73.1	381095	674.29	1.67066	14.47	17.0276	79.0	2932.00
26	63	15.8	320525	681.69	1.44182	4.00	14.8698	78.7	3369.36
26	64	20.1	569524	661.53	1.40230	17.95	11.3709	77.7	3750.1
26	65	21.4	606992	522.54	1.53915	4.22	11.9121	76.5	3960.1
26	66	26.6	554024	330.85	1.57368	7.85	13.7903	78.3	4250.0
26	67	27.2	395675	439.68	1.54531	6.41	11.6296	75.7	4896.6
26	68	13.4	354862	443.58	1.43162	16.32	12.4947	77.9	5306.9
26	69	19.3	296536	452.31	1.52436	8.81	12.1412	79.2	5595.4
26	70	9.9	324106	387.86	1.82756	0.00	10.6622	81.0	5778.6
26	71	36.2	657021	526.91	1.86235	10.19	10.3780	78.2	6083.3
28	59	304.7	87757	0.00	0.42207	10.82	22.0000	78.7	0.0
28	60	131.4	109576	0.00	0.41418	9.01	27.0000	77.9	0.0
28	61	124.6	75644	0.00	0.49730	4.20	17.0000	76.3	0.0
28	62	209.2	70934	0.00	0.37839	4.46	20.0000	78.8	0.0
28	63	441.3	66909	0.00	0.60455	24.89	15.0000	76.2	0.0
28	64	185.7	61915	0.00	2.04381	21.41	16.0000	74.7	0.0
28	65	121.2	154764	0.00	2.08751	8.39	17.0000	74.6	0.0
28	66	80.4	242570	0.00	2.25213	4.09	16.0000	74.3	0.0
28	67	92.0	217261	0.00	4.46563	18.19	23.0000	73.5	0.0
28	68	83.8	239419	153.12	3.74677	4.84	14.0813	75.9	153.1
28	69	241.9	225261	158.07	3.22090	7.54	14.2044	75.8	280.6
28	70	88.0	202618	276.02	2.86542	15.69	15.9963	76.5	500.5
28	71	91.0	159419	267.30	2.75124	4.20	14.6586	76.2	667.7

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
29	59	36.9	511863	332.80	0.48022	23.36	20.5357	77.7	332.8
29	60	59.7	90000	539.08	0.49058	10.03	18.2858	76.3	844.1
29	61	38.7	94551	685.26	0.57458	5.00	10.6228	75.5	1459.1
29	62	39.2	183990	601.07	0.51584	7.83	11.6335	76.7	1938.5
29	63	19.7	153836	763.69	0.55914	10.32	10.8210	75.7	2540.7
29	64	35.7	176360	754.70	0.60793	29.52	9.9650	76.0	3083.7
29	65	9.7	127549	886.81	0.63754	0.00	4.8887	75.6	3713.5
29	66	17.9	177762	830.27	0.63978	3.93	2.7565	75.1	4234.3
29	67	13.3	277133	1170.90	0.57015	2.10	0.0190	74.5	5052.3
29	68	24.5	189758	969.29	0.67225	0.00	0.0160	76.8	5600.6
29	69	19.1	286063	690.42	0.64734	23.07	0.0700	76.2	5824.3
29	70	6.5	160085	1000.65	0.75595	11.37	0.0220	77.3	6339.6
29	71	11.2	373682	896.84	0.82641	19.27	0.0230	77.3	6708.1
31	59	26.7	444830	4433.2	0.00000	7.19	9.1134	71.2	24433.2
31	60	9.7	327797	1609.2	0.00000	11.12	11.4171	68.6	22988.2
31	61	5.0	144588	1364.0	0.00000	3.48	14.5564	69.7	21478.7
31	62	8.1	163687	1812.9	0.00000	1.39	9.8786	68.6	20606.8
31	63	7.8	211442	5774.9	0.00000	1.48	9.8988	67.8	23805.8
31	64	12.8	287005	3085.6	0.00000	4.17	6.5835	68.3	23915.7
31	65	7.7	289034	6192.6	0.00000	1.21	8.5762	74.5	27118.9
31	66	5.3	193275	8741.0	0.00000	7.09	9.1144	68.3	32470.0
31	67	16.2	246918	5279.3	0.00000	15.61	8.8180	67.0	33690.6
31	68	7.5	211005	4375.1	0.00000	0.00	8.2619	69.1	33854.4
31	69	19.8	239357	3012.4	0.00000	9.38	8.0068	68.9	32634.9
31	70	6.6	73459	2631.5	0.00000	2.49	7.2081	69.9	31187.1
31	71	7.8	133050	2259.3	0.00000	12.39	10.4019	68.4	29548.0
32	59	73.6	573109	2449.4	2.22255	8.88	6.3518	70.7	18449.4
32	60	77.3	762428	1667.7	2.48927	11.64	7.5379	68.9	17811.0
32	61	69.9	718601	2463.6	2.46109	2.86	8.2839	69.0	18048.2
32	62	77.9	613933	3206.2	2.37936	0.00	5.2819	68.7	18998.3
32	63	62.7	704516	5120.3	2.56641	0.00	4.8076	68.2	21743.9
32	64	349.1	420360	6679.7	2.38516	0.00	1.9670	68.6	25705.6
32	65	154.3	652167	8238.7	3.00799	5.31	0.6344	69.5	30731.1
32	66	109.5	294029	8332.5	3.21323	5.10	0.0160	68.5	35222.3
32	67	172.6	521840	4016.5	3.16211	16.45	0.0160	65.2	34835.9
32	68	60.3	411211	7215.8	3.80639	0.00	0.0140	70.1	37697.3
32	69	53.2	309733	6288.3	3.52367	2.30	0.0160	67.1	39273.4
32	70	39.3	197113	1716.7	3.51610	2.24	0.0180	66.8	36081.0
32	71	43.5	309691	1256.2	3.68716	7.87	0.0150	68.1	32827.0

Appendix Table 2, Part 1 - Continued

LOC	YR	Y_1	Y_2	Y_3	Y_4	X_1	X_2	X_3	X_4
33	59	13.5	118753	577.4	0.17478	6.14	14.0099	69.8	5577.4
33	60	14.5	191508	445.0	0.22845	14.98	18.7396	66.4	5325.2
33	61	14.4	160914	325.2	0.27922	5.15	18.8202	68.0	4984.7
33	62	7.0	192286	393.9	0.21428	2.18	15.0995	65.7	4755.6
33	63	10.9	144529	445.9	0.24259	0.00	13.2367	66.4	4607.1
33	64	15.8	94224	715.7	0.18289	5.45	11.3259	67.4	4746.9
33	65	6.4	149226	660.0	0.17191	2.78	14.1455	67.0	4813.5
33	66	10.0	148977	513.3	0.19696	7.40	15.1053	66.8	4725.1
33	67	12.6	132969	552.8	0.18137	4.46	23.6132	65.7	4687.3
33	68	11.9	96800	380.2	0.19621	7.54	15.1514	66.2	4481.5
33	69	7.8	155972	471.0	0.17286	5.90	18.9604	66.9	4392.3
33	70	3.7	92881	414.7	0.20707	2.19	10.4457	67.2	4258.0
33	71	11.8	41547	377.8	0.20410	11.73	18.0773	66.5	4103.5
34	59	173.8	903567	4835.0	0.78075	7.65	2.7547	69.8	24835.0
34	60	19.7	969077	5249.1	0.75501	7.84	1.9129	66.0	26979.6
34	61	7.6	1036122	5325.8	0.74487	4.31	0.6758	68.3	28932.9
34	62	5.8	537927	5050.8	0.92220	5.88	0.0150	65.7	30367.1
34	63	7.4	639506	6156.8	0.77412	0.00	0.0130	65.7	32728.1
34	64	12.6	640753	3127.4	0.90187	4.90	0.0140	66.5	31764.5
34	65	8.0	427603	7582.8	0.69852	2.65	0.0150	65.5	35376.7
34	66	10.7	529936	4815.9	0.80785	7.75	0.0190	64.3	35770.5
34	67	13.5	558936	12147.4	0.82953	4.37	0.0170	64.2	43446.6
34	68	10.6	552805	11853.3	0.69395	9.51	0.0160	66.0	49869.0
34	69	12.7	450499	11219.9	0.76221	6.65	0.0190	67.0	54855.2
34	70	42.2	472082	16655.0	0.92851	2.02	0.01700	68.1	64653.3
34	71	37.8	456021	8774.4	0.81883	11.48	0.01600	67.1	65346.0
35	59	11.9	140437	20.7	1.23008	14.52	4.09543	74.5	470.7
35	60	12.4	166478	25.5	0.92221	8.30	5.15204	73.6	437.3
35	61	12.4	147749	32.4	0.95258	11.86	7.08971	73.2	415.1
35	62	18.9	186089	7.8	1.02063	9.24	7.63585	73.5	370.9
35	63	9.3	189977	28.3	0.94356	12.60	6.59128	72.4	352.8
35	64	17.2	153569	16.3	1.17826	18.22	8.24967	72.4	325.0
35	65	19.5	402721	56.5	1.26844	0.00	6.04643	71.5	340.9
35	66	17.4	401898	63.1	1.28041	3.70	6.36428	69.5	361.3
35	67	7.9	381721	58.9	1.18627	8.97	5.62348	67.8	375.1
35	68	11.4	247457	47.7	1.04069	2.31	5.22841	74.4	375.9
35	69	9.8	183867	24.9	1.01279	5.18	5.74465	73.7	353.8
35	70	5.8	398943	128.8	1.15486	5.06	4.31017	74.0	438.4
35	71	6.9	316054	41.9	1.38775	10.66	6.40059	73.9	425.4

Appendix Table 2: Individual Mosquito Data, Part 2

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
1	59	53.012	4862.87	1.55659	.0075198	1.54078	70082
1	60	86.762	5169.65	1.61960	.0042982	1.56621	114700
1	61	97.050	5504.76	1.21837	.0035698	1.59389	128300
1	62	107.337	5799.58	0.71424	.0029810	1.61827	141900
1	63	117.852	5971.43	0.69061	.0038511	1.61688	155800
1	64	128.139	6110.88	0.87355	.0045809	1.61241	169400
1	65	138.275	6307.45	0.79312	.0052790	1.68861	182800
1	66	151.815	6962.93	0.48370	.0051669	1.68045	200700
1	67	167.776	6980.00	0.54941	.0040667	1.73218	221800
1	68	173.979	7411.71	0.59947	.0040652	1.79059	230000
1	69	177.307	7769.01	0.52619	.0039633	1.80350	234400
1	70	173.983	7134.96	0.69413	.0047651	1.71378	230006
1	71	178.082	6789.75	0.67112	.0036105	1.67835	235424
2	59	195.386	3586.50	0.14106	.0167958	1.47165	234463
2	60	283.583	3689.15	0.16891	.0130885	1.50961	340300
2	61	305.583	3810.58	0.13770	.0135533	1.55132	366700
2	62	326.917	3905.06	0.12511	.0139842	1.58592	392300
2	63	347.167	4105.82	0.13076	.0141167	1.61330	416600
2	64	368.167	4284.05	0.10325	.0142055	1.63564	441800
2	65	389.333	4265.01	0.10921	.0151027	1.64125	467200
2	66	414.667	4288.58	0.08673	.0156531	1.63839	497600
2	67	438.917	4504.00	0.07627	.0139909	1.70023	526700
2	68	474.083	4768.78	0.08102	.0138777	1.74848	568900
2	69	496.333	4950.23	0.08081	.0138969	1.75238	595600
2	70	516.750	5315.22	0.10850	.0135688	1.82111	620100
2	71	560.672	5363.07	0.10547	.0115368	1.84824	672806
3	59	14.401	3132.91	2.32809	.0023638	1.16820	10153
3	60	18.582	3328.77	1.97379	.0033588	1.20417	13100
3	61	20.851	3542.86	2.10654	.0043537	1.24061	14700
3	62	23.830	3732.07	1.95047	.0050000	1.27213	16800
3	63	26.383	3751.32	1.90419	.0044086	1.27358	18600
3	64	28.936	3751.85	2.32054	.0038725	1.27261	20400
3	65	30.922	3782.61	1.49235	.0036239	1.30417	21800
3	66	32.624	3724.45	1.23029	.0038261	1.19841	23000
3	67	33.475	3894.00	1.06945	.0031780	1.24791	23600
3	68	35.887	3994.15	1.28526	.0066798	1.21981	25300
3	69	37.163	4268.54	1.99674	.0045420	1.27250	26200
3	70	39.091	4156.70	1.88341	.0051526	1.17551	27559
3	71	43.687	4517.67	1.22673	.0065262	1.76608	30799
4	59	12.925	2537.97	3.58775	.0097850	1.04488	8789
4	60	13.824	2640.67	4.52481	.0101064	1.05598	9400
4	61	15.147	2758.73	4.97950	.0100971	1.07028	10300
4	62	16.765	2856.54	4.31684	.0099123	1.08214	11400
4	63	18.382	3049.74	3.32825	.0116800	1.10127	12500
4	64	19.853	3227.03	3.24291	.0131852	1.11809	13500
4	65	21.471	3000.00	2.65386	.0145205	1.11629	14600
4	66	24.265	3038.08	2.05860	.0135758	1.18381	16500
4	67	24.559	3765.00	2.28479	.0082635	1.21371	16700
4	68	25.588	3679.02	2.18424	.0095977	1.11776	17400
4	69	27.206	3749.30	2.19525	.0096757	1.10364	18500
4	70	28.229	3914.86	2.48193	.0099500	1.19082	19196
4	71	32.653	5034.45	2.22563	.0083769	1.12450	22204

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
5	59	112.525	3166.67	1.98842	.0265126	1.11104	13503
5	60	135.000	3271.87	3.69778	.0234568	1.12330	16200
5	61	150.833	3395.77	2.86381	.0221547	1.13730	18100
5	62	166.667	3494.73	2.35671	.0211500	1.14798	20000
5	63	182.500	3630.69	2.11078	.0194521	1.15851	21900
5	64	198.333	3748.68	2.64823	.0180252	1.16650	23800
5	65	214.167	3716.36	3.12571	.0278988	1.10062	25700
5	66	232.500	3720.44	2.66691	.0226523	1.12557	27900
5	67	250.833	4032.00	2.91309	.0247176	1.14292	30100
5	68	272.500	4172.68	2.50286	.0244037	1.18995	32700
5	69	291.667	4520.19	3.07951	.0262286	1.16968	35000
5	70	317.000	4784.42	3.58924	.0246320	1.20687	38040
5	71	344.067	4815.37	3.70352	.0213621	1.20647	41288
7	59	534.995	3760.55	0.07455	.0046564	1.37688	453141
7	60	540.968	3922.02	0.08781	.0044064	1.40907	458200
7	61	552.066	4105.82	0.09311	.0041210	1.44701	467600
7	62	567.769	4259.49	0.06892	.0038158	1.47601	480900
7	63	581.228	4456.08	0.08295	.0037294	1.51456	492300
7	64	592.208	4629.36	0.10719	.0036603	1.54553	501600
7	65	600.826	4539.34	0.14272	.0039536	1.53436	508900
7	66	607.438	4640.28	0.14703	.0041458	1.56164	514500
7	67	615.939	4954.00	0.14694	.0041921	1.62415	521700
7	68	623.849	5031.22	0.13883	.0050341	1.63635	528400
7	69	623.967	5168.08	0.18099	.0041760	1.65161	528500
7	70	624.398	5252.72	0.26899	.0047574	1.64091	528865
7	71	634.785	5507.07	0.28741	.0050087	1.68955	537663
8	59	250.239	3876.58	0.24064	.0022505	1.48824	164407
8	60	266.210	4025.29	0.24263	.0022699	1.52350	174900
8	61	273.059	4195.77	0.19606	.0023634	1.56154	179400
8	62	278.691	4336.50	0.21584	.0024631	1.59339	183100
8	63	283.866	4508.99	0.17303	.0023753	1.61803	186500
8	64	290.715	4656.81	0.16637	.0022723	1.64112	191000
8	65	295.890	4687.37	0.24435	.0023045	1.62888	194400
8	66	300.304	4566.13	0.22226	.0023568	1.64633	197300
8	67	299.087	5051.00	0.16383	.0022188	1.67024	196500
8	68	301.826	4900.49	0.16827	.0024861	1.71231	198300
8	69	310.959	4973.71	0.14575	.0028488	1.71718	204300
8	70	312.533	5205.62	0.30288	.0028734	1.81208	205334
8	71	320.685	5221.73	0.12622	.0025013	1.74977	210690
10	59	7.793	1824.89	3.29560	.0104474	1.01596	4403
10	60	11.681	1877.77	2.47219	.0066667	1.04229	6600
10	61	12.035	1940.74	2.34532	.0060294	1.06812	6800
10	62	12.389	1990.51	2.72257	.0054286	1.09037	7000
10	63	12.566	2226.46	2.92749	.0047887	1.06812	7100
10	64	12.920	2451.95	2.82540	.0039726	1.04284	7300
10	65	12.920	2404.76	3.81912	.0041096	0.93554	7300
10	66	13.097	2220.44	3.02565	.0027027	1.01278	7400
10	67	12.743	2174.00	3.15178	.0027778	1.04225	7200
10	68	12.566	2535.61	2.75804	.0028169	1.08681	7100
10	69	12.566	2450.70	2.23381	.0039437	1.06498	7100
10	70	12.504	2519.02	2.36658	.0028309	1.07784	7065
10	71	12.697	2485.87	2.37192	.0027878	1.13370	7174

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
11	59	359.845	3584.39	0.21019	.0029874	1.21014	374239
11	60	384.904	3774.50	0.21267	.0029728	1.22673	400300
11	61	395.481	3985.19	0.23137	.0030708	1.24466	411300
11	62	404.135	4167.72	0.20973	.0031763	1.25942	420300
11	63	412.692	4329.10	0.19069	.0030219	1.27091	429200
11	64	423.558	4467.79	0.17559	.0028558	1.28027	440500
11	65	431.923	4485.51	0.17793	.0031656	1.28928	449200
11	66	440.577	4530.06	0.26232	.0031929	1.29597	458200
11	67	446.827	4773.00	0.25330	.0031805	1.31930	464700
11	68	457.212	4948.29	0.12731	.0037329	1.32572	475500
11	69	469.519	5069.48	0.14309	.0033975	1.32630	488300
11	70	471.409	5198.37	0.15808	.0035103	1.34144	490265
11	71	494.321	5314.49	0.14914	.0038787	1.33930	514094
12	59	80.800	3349.16	4.74715	.0114851	1.49733	20200
12	60	92.520	3519.49	4.17551	.0096844	1.47836	23130
12	61	97.560	3708.99	4.06967	.0088971	1.46268	24390
12	62	101.880	3872.36	2.96266	.0082057	1.44175	25470
12	63	105.840	3950.26	3.09506	.0076342	1.45956	26460
12	64	110.160	4008.45	2.25913	.0070443	1.47365	27540
12	65	113.760	4087.99	3.21431	.0057665	1.46329	28440
12	66	117.360	3958.92	3.14470	.0061350	1.48283	29340
12	67	120.240	4607.00	2.28297	.0070858	1.63452	30060
12	68	123.840	4776.59	2.92929	.0052649	1.64638	30960
12	69	127.080	4772.77	2.08100	.0066100	1.64921	31770
12	70	129.572	4649.46	1.83486	.0064211	1.53436	32393
12	71	136.204	4713.78	1.90166	.0060204	1.60357	34051
13	59	48.597	3222.57	2.41749	.0119065	1.15761	47285
13	60	57.451	3369.86	2.40047	.0195170	1.17578	55900
13	61	62.487	3535.45	1.98166	.0266447	1.19526	60800
13	62	67.729	3675.11	2.75843	.0325948	1.21143	65900
13	63	72.662	3881.48	2.93906	.0201414	1.23563	70700
13	64	77.801	4028.51	2.76189	.0092470	1.25689	75700
13	65	82.939	3931.68	2.78759	.0105081	1.24130	80700
13	66	86.845	3975.95	2.23531	.0104024	1.26677	84500
13	67	91.367	4255.00	2.02868	.0096400	1.27327	88900
13	68	95.683	4444.88	2.50628	.0099570	1.34709	93100
13	69	103.803	4830.05	1.94171	.0100000	1.31560	101000
13	70	108.136	4974.64	1.68352	.0110630	1.30257	105216
13	71	118.452	4980.57	1.87339	.0097958	1.32412	115254
14	59	9.421	2719.41	1.10906	.0044269	1.06079	10391
14	60	9.429	2876.71	1.39196	.0059615	1.08654	10400
14	61	9.701	3049.74	1.47283	.0071963	1.11287	10700
14	62	9.882	3200.42	1.34537	.0085321	1.13546	10900
14	63	10.063	3258.20	1.50812	.0078378	1.10197	11100
14	64	10.335	3298.84	1.44027	.0071053	1.06115	11400
14	65	10.517	3386.13	1.61252	.0065517	1.12608	11600
14	66	10.789	3573.15	1.38375	.0048739	1.14891	11900
14	67	10.607	3954.00	1.50763	.0052991	1.28699	11700
14	68	10.607	4104.39	1.62979	.0055556	1.28056	11700
14	69	11.514	4244.13	1.69539	.0034646	1.31230	12700
14	70	11.565	4173.01	1.34321	.0032142	1.31373	12756
14	71	12.025	4603.36	1.23116	.0021864	1.39728	13264

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
15	59	78.961	3220.46	0.52957	.0034350	1.11860	62300
15	60	88.847	3346.68	0.43707	.0031812	1.12330	70100
15	61	92.269	3491.01	0.24674	.0031868	1.12784	72800
15	62	95.691	3610.76	0.54141	.0031921	1.13311	75500
15	63	100.253	3773.54	0.44306	.0035525	1.15199	79100
15	64	104.943	3916.58	0.46515	.0038768	1.16858	82800
15	65	106.717	3750.52	0.41999	.0045487	1.14610	84200
15	66	107.985	3921.84	0.51167	.0050469	1.17287	85200
15	67	111.027	4196.00	0.37768	.0043607	1.19017	87600
15	68	115.082	4202.93	0.41155	.0045815	1.18729	90800
15	69	121.293	4537.09	0.43371	.0037409	1.20079	95700
15	70	123.086	4530.80	0.55260	.0039026	1.19745	97115
15	71	129.324	4754.42	0.39214	.0038515	1.21464	102037
16	59	26.059	3270.04	1.26890	.0085658	1.21775	14593
16	60	30.893	3373.02	1.47349	.0076879	1.23409	17300
16	61	33.214	3494.18	1.67229	.0076344	1.25180	18600
16	62	35.714	3590.72	1.41886	.0075000	1.26804	20000
16	63	38.036	3892.06	1.17513	.0081690	1.28272	21300
16	64	40.536	4173.18	1.29490	.0087225	1.29673	22700
16	65	43.036	3942.03	1.32000	.0092946	1.28605	24100
16	66	45.000	4018.04	0.70345	.0073413	1.31115	25200
16	67	45.000	4386.00	0.90223	.0076190	1.36716	25200
16	68	46.607	4409.76	0.97841	.0158621	1.22780	26100
16	69	48.571	4941.78	1.23969	.0064706	1.37332	27200
16	70	50.063	5016.30	1.31889	.0105939	1.38333	28035
16	71	53.641	5965.55	1.64923	.0081894	1.54556	30039
17	59	0.838	2959.92	1.17336	.0139188	1.16392	45047
17	60	0.897	3021.07	1.32039	.0166183	1.13831	48200
17	61	0.912	3087.83	1.49675	.0199184	1.11183	49000
17	62	0.929	3154.01	0.95127	.0230461	1.08263	49900
17	63	0.940	3263.49	1.39297	.0226139	1.08513	50500
17	64	0.951	3354.80	1.67667	.0221722	1.08809	51100
17	65	0.957	3446.17	1.84207	.0272568	1.16974	51400
17	66	0.966	3503.01	1.29815	.0242967	1.16396	51900
17	67	0.964	3658.00	1.34614	.0276448	1.21901	51800
17	68	0.972	3789.27	1.40946	.0292720	1.19687	52200
17	69	0.973	3698.59	1.65666	.0285277	1.14744	52300
17	70	0.979	4024.46	2.44289	.0242460	1.22236	52586
17	71	1.00	4102.47	1.71500	.0243744	1.21855	53991
18	59	237.14	4068.57	3.91643	.0121687	1.54769	8300
18	60	247.14	4226.55	3.50780	.0108671	1.55851	8650
18	61	252.86	4407.41	3.51897	.0098305	1.57303	8850
18	62	260.00	4556.96	2.66495	.0087912	1.58494	9100
18	63	265.71	4739.68	3.04864	.0119355	1.62631	9300
18	64	268.57	4897.57	4.89238	.0151064	1.66268	9400
18	65	271.43	4747.41	3.31928	.0137895	1.63424	9500
18	66	272.86	4913.83	3.31280	.0131937	1.66925	9550
18	67	272.86	5056.00	4.35707	.0140314	1.67777	9550
18	68	278.57	5241.95	3.87622	.0125128	1.15800	9750
18	69	294.29	5042.25	2.71516	.0156311	1.72631	10300
18	70	294.66	5832.43	2.93802	.0139630	1.73772	10313
18	71	304.06	5932.86	3.03211	.0161624	1.78310	10642

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
19	59	79.73	3721.52	0.30770	.0179960	1.45843	205546
19	60	89.72	3929.40	0.34522	.0165499	1.50881	231300
19	61	94.65	4158.73	0.30210	.0162131	1.56050	244000
19	62	99.57	4359.70	0.28674	.0159135	1.60772	256700
19	63	104.46	4546.03	0.20874	.0153063	1.63862	269300
19	64	109.46	4708.55	0.18080	.0147378	1.66516	282200
19	65	114.39	4650.10	0.24229	.0166056	1.64870	294900
19	66	118.70	4680.36	0.21532	.0149150	1.67238	306000
19	67	121.30	4880.00	0.14048	.0141861	1.64676	312700
19	68	125.45	5086.83	0.14511	.0114100	1.69982	323400
19	69	132.27	5383.10	0.16226	.0114076	1.75319	341000
19	70	135.37	5711.96	0.19925	.0107939	1.78538	348993
19	71	144.32	5838.34	0.22182	.0136057	1.85613	372049
21	59	1124.91	3541.14	0.32243	.0101675	1.36251	323973
21	60	1313.89	3650.16	0.33018	.0088372	1.40155	378400
21	61	1364.58	3779.89	0.28030	.0086387	1.44226	393000
21	62	1415.63	3881.86	0.38811	.0084498	1.47975	407700
21	63	1465.63	4045.50	0.23488	.0087349	1.51728	422100
21	64	1515.28	4189.02	0.17150	.0090032	1.55277	436400
21	65	1563.19	4064.18	0.20633	.0097823	1.53024	450200
21	66	1603.47	4063.13	0.18117	.0095539	1.50944	461800
21	67	1646.88	4294.00	0.12279	.0105208	1.54563	474300
21	68	1727.08	4473.17	0.18165	.0108967	1.56995	497400
21	69	1788.19	4615.02	0.16465	.0116078	1.56208	515000
21	70	1813.64	4683.88	0.22295	.0106427	1.58189	522329
21	71	1923.35	4787.10	0.21679	.0113535	1.58514	553926
22	59	706.36	2589.66	1.51632	.0472280	1.50034	17659
22	60	722.40	2881.98	0.54481	.0444075	1.45535	18060
22	61	727.200	3190.48	2.09700	.0424092	1.41142	18180
22	62	366.000	3475.74	2.66783	.0403825	1.35251	18300
22	63	367.200	3568.25	2.68961	.0418301	1.46290	18360
22	64	368.400	3643.08	2.70425	.0432139	1.55966	18420
22	65	368.400	3427.54	2.64687	.0448426	1.63616	18420
22	66	369.600	3537.07	2.74514	.0436688	1.69023	18480
22	67	366.000	3706.00	2.64858	.0450820	1.75815	18300
22	68	366.000	4068.29	1.76054	.0398907	1.70199	18300
22	69	367.200	4602.82	1.83896	.0397059	1.75517	18360
22	70	372.420	4151.27	2.58669	.0446270	1.80477	18621
22	71	391.740	4169.61	2.60093	.0403839	1.69498	19587
23	59	112.647	3012.66	1.26349	.0014500	1.70237	33794
23	60	125.717	3265.54	2.06359	.0015113	1.25676	37715
23	61	130.467	3536.51	1.41108	.0016607	1.30986	39140
23	62	135.217	3781.65	1.11566	.0017996	1.35854	40565
23	63	140.283	3873.02	1.06617	.0030177	1.37393	42085
23	64	144.717	3945.09	1.32916	.0041460	1.38640	43415
23	65	149.467	3960.66	1.30642	.0045718	1.35141	44840
23	66	151.683	3830.66	1.38473	.0041094	1.38357	45505
23	67	151.367	4070.00	2.18291	.0045805	1.41185	45410
23	68	152.633	4284.88	1.09782	.0056563	1.45420	45790
23	69	159.333	4413.15	0.76213	.0051255	1.60103	47800
23	70	160.980	4615.04	1.01582	.0028161	1.46348	48294
23	71	166.137	4868.37	1.00113	.0022672	1.45344	49841

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
24	59	26.936	3609.70	0.52544	.0007195	1.16697	27798
24	60	28.876	3602.74	0.66562	.0006711	1.20460	29800
24	61	29.845	3614.81	0.64461	.0006494	1.24174	30800
24	62	30.814	3599.16	0.45167	.0006289	1.27391	31800
24	63	31.783	4178.84	0.58295	.0006098	1.28275	32800
24	64	32.558	4737.06	0.73515	.0005952	1.28940	33600
24	65	32.946	5518.63	0.51649	.0008824	1.30502	34000
24	66	33.333	5022.04	0.60443	.0014244	1.26309	34400
24	67	33.721	5315.00	0.71957	.0020402	1.28226	34800
24	68	34.884	5557.07	0.71450	.0023889	1.32810	36000
24	69	36.337	5614.08	0.77112	.0026400	1.33580	37500
24	70	36.571	5718.30	0.74309	.0025437	1.35763	37741
24	71	37.508	5707.60	0.64108	.0038752	1.38408	38708
25	59	109.346	3420.89	0.58463	.0139832	1.32694	64077
25	60	132.935	3566.91	0.71692	.0119255	1.36884	77900
25	61	139.420	3732.28	0.79669	.0117870	1.41118	81700
25	62	146.075	3871.31	0.65490	.0116355	1.44783	85600
25	63	152.730	4065.61	0.68450	.0122570	1.45537	89500
25	64	159.215	4240.76	0.75469	.0128296	1.46010	93300
25	65	165.870	4066.25	0.78839	.0133745	1.41225	97200
25	66	170.648	4057.11	0.73083	.0139200	1.41157	100000
25	67	176.621	4281.00	1.02943	.0147923	1.42411	103500
25	68	186.177	4432.20	0.70236	.0153437	1.43032	109100
25	69	200.341	4632.86	0.56112	.0135775	1.46222	117400
25	70	205.483	4704.71	0.42985	.0128558	1.45521	120413
25	71	217.930	4690.81	0.37062	.0133665	1.43716	127707
26	59	160.962	3034.81	0.88653	.0161100	1.31426	93358
26	60	174.759	3184.40	1.00984	.0155189	1.37027	101360
26	61	182.483	3351.32	0.80702	.0155140	1.42789	105840
26	62	190.207	3494.73	1.07268	.0155094	1.47822	110320
26	63	197.655	3802.12	0.78607	.0160328	1.62218	114640
26	64	205.655	4089.76	0.86710	.0164738	1.74772	119280
26	65	213.793	4098.34	0.73284	.0165161	1.73011	124000
26	66	223.862	4107.21	0.77676	.0179375	1.74700	129840
26	67	223.586	4354.00	0.72690	.0188387	1.82415	129680
26	68	225.931	4448.78	0.72777	.0190171	1.85703	131040
26	69	230.621	4553.05	0.72512	.0155652	1.81303	133760
26	70	233.759	4568.84	0.93444	.0191400	1.79594	135580
26	71	242.572	4553.00	0.73202	.0192904	1.77054	140692
28	59	11.029	2652.95	0.57629	.0017221	1.03291	11614
28	60	11.111	2773.45	0.66674	.0017094	1.04375	11700
28	61	11.111	2908.99	0.78488	.0017094	1.05322	11700
28	62	11.111	3022.15	0.76472	.0017094	1.06292	11700
28	63	11.111	3208.47	1.06200	.0017094	1.09198	11700
28	64	11.111	3378.04	1.81888	.0017094	1.11772	11700
28	65	11.040	3788.82	1.91534	.0017204	1.11820	11625
28	66	10.969	3443.89	1.86178	.0017316	1.11442	11550
28	67	10.897	3163.00	1.28401	.0017429	1.13126	11475
28	68	11.111	3409.76	1.79415	.0100855	1.22437	11700
28	69	11.325	3515.49	1.77030	.0109853	1.20914	11925
28	70	11.458	3597.83	1.95488	.0016577	1.19490	12065
28	71	11.595	4021.20	2.00543	.0075348	1.20608	12210

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
29	59	448.526	3703.59	0.00000	.0035339	1.47768	197800
29	60	426.982	3853.53	0.00000	.0033617	1.51564	188299
29	61	404.082	4024.34	0.00000	.0031874	1.55669	178200
29	62	434.014	4166.67	0.00000	.0026228	1.59111	191400
29	63	404.082	4288.89	0.00000	.0030135	1.61344	178200
29	64	415.873	4389.65	0.00000	.0031189	1.63127	183400
29	65	426.304	4282.61	0.00000	.0029468	1.61194	188000
29	66	416.553	4502.00	0.00000	.0023244	1.67200	183700
29	67	400.680	4783.00	0.00000	.0025693	1.70294	176700
29	68	408.163	4880.00	0.00000	.0030889	1.72217	180000
29	69	415.193	4885.45	0.00000	.0040360	1.71160	183100
29	70	425.776	4915.76	0.00000	.0052725	1.71047	187767
29	71	406.803	5099.82	0.00000	.0042754	1.76088	179400
31	59	86.041	5145.57	3.73988	.0009409	1.26914	132848
31	60	89.926	5346.68	1.53873	.0009291	1.33384	138846
31	61	91.438	5576.72	1.51969	.0009350	1.39810	141180
31	62	92.949	5765.82	1.91597	.0009476	1.45459	143514
31	63	94.461	5875.13	1.99690	.0009599	1.48930	145848
31	64	95.973	5958.82	1.93332	.0009650	1.51963	148182
31	65	97.484	5929.61	1.94156	.0011427	1.53679	150516
31	66	98.996	6124.25	1.85520	.0014066	1.51713	152850
31	67	100.508	6310.00	1.81037	.0012437	1.51846	155184
31	68	102.019	6552.20	1.65733	.0012443	1.55910	157518
31	69	103.531	6565.26	1.82093	.0014013	1.57197	159852
31	70	105.042	6680.25	1.87655	.0019299	1.58676	162185
31	71	108.873	6989.40	1.99391	.0020940	1.60515	168100
32	59	176.255	3339.66	0.00000	.0022949	1.22978	47060
32	60	181.854	3460.48	0.00000	.0023684	1.25455	48555
32	61	185.974	3600.00	0.00000	.0024771	1.28741	49655
32	62	190.094	3713.08	2.03676	.0025613	1.31537	50755
32	63	194.213	3984.13	0.40814	.0031048	1.30828	51855
32	64	198.333	4234.42	0.90300	.0036068	1.30124	52955
32	65	202.453	4092.13	0.00000	.0039034	1.29946	54055
32	66	206.573	4170.34	0.59770	.0041701	1.36456	55155
32	67	210.693	4376.00	0.21424	.0043018	1.37906	56255
32	68	214.813	4624.39	0.13588	.0040973	1.40275	57355
32	69	218.933	4703.29	0.64252	.0038833	1.40952	58455
32	70	223.049	4700.18	0.55059	.0040132	1.41176	59554
32	71	227.172	4914.31	0.00000	.0039403	1.43034	60655
33	59	668.521	3829.11	0.00000	.0017190	1.33167	318216
33	60	702.523	4013.70	0.00000	.0017494	1.35012	334401
33	61	728.779	4220.11	0.00000	.0017930	1.37105	346899
33	62	755.036	4394.51	0.00000	.0018364	1.39014	359397
33	63	781.292	4606.35	0.00000	.0015515	1.43473	371895
33	64	807.548	4794.09	0.00000	.0012851	1.47447	384393
33	65	833.805	4760.87	0.00000	.0016528	1.46747	396891
33	66	860.061	4851.70	0.00000	.0016977	1.49120	409389
33	67	886.317	5173.00	0.00000	.0024651	1.56827	421887
33	68	912.574	5347.32	0.00000	.0019890	1.61548	434385
33	69	938.830	5345.54	0.00000	.0025309	1.60025	446883
33	70	965.086	5461.05	0.00000	.0027755	1.61512	459381
33	71	991.342	5549.47	0.00000	.0030749	1.62150	471879

Appendix Table 2, Part 2 - Continued

LOC	YR	X_6	X_7	X_8	X_9	W^B	N
34	59	153.223	3709.92	0.11260	.0126259	1.37347	98369
34	60	168.600	3835.62	0.16550	.0112989	1.41834	108241
34	61	184.212	3982.01	0.19059	.0101806	1.46477	118264
34	62	199.824	4100.21	0.11676	.0092371	1.50762	128287
34	63	215.436	4265.61	0.11942	.0079531	1.52343	138310
34	64	231.048	4408.66	0.16208	.0068360	1.53823	148333
34	65	246.660	4277.43	0.06585	.0064791	1.51951	158356
34	66	262.273	4390.78	0.00000	.0071030	1.52910	168379
34	67	277.885	4633.00	0.00000	.0065078	1.56065	178402
34	68	293.497	4949.27	0.00000	.0063633	1.59222	188425
34	69	309.109	4980.28	0.00458	.0032553	1.60922	198448
34	70	324.720	4877.72	.209063	.00390944	1.59060	208470
34	71	340.333	5017.67	.199163	.00368889	1.61186	218494
35	59	262.548	3216.24	.169785	.00558824	1.19912	68000
35	60	329.027	3300.32	.199884	.00472905	1.23111	85218
35	61	372.201	3402.12	.139795	.00442946	1.26239	96400
35	62	401.158	3478.90	.161964	.00433109	1.28936	103900
35	63	430.116	3680.42	.151539	.00354578	1.30491	111400
35	64	462.548	3862.72	.145023	.00282972	1.31827	119800
35	65	490.734	3734.99	.166560	.00325728	1.31288	127100
35	66	530.888	3552.10	.129896	.00271273	1.22942	137500
35	67	568.340	3611.00	.112731	.00293478	1.23283	147200
35	68	603.089	3754.15	.120483	.00243918	1.31015	156200
35	69	650.579	3848.83	.076901	.00250445	1.28125	168500
35	70	664.502	3915.76	.086840	.00296910	1.29029	172106
35	71	693.436	4009.72	.088329	.00305122	1.16706	179600

Appendix Table 3: Amount and Cost ($) per Acre of Temporary Control Work

LOC	Year	Acres	$/Acres	LOC	Year	Acres	$/Acres
1	1969	743,889	.215993	15	1969	227,241	.106424
	1970	555,786	.247869		1970	200,839	.149314
	1971	1,427,126	.169822		1971	253,286	.239488
2	1969	176,306	.183363	16	1969	-	0
	1970	178,673	.220632		1970	144,173	.101656
	1971	277,875	.228520		1971	311,337	.072356
3	1969	467,929	.097630	17	1969	1,456,668	.147767
	1970	513,366	.144472		1970	1,264,739	.147279
	1971	753,077	.113853		1971	1,856,369	.144785
4	1969	852,851	.081680	18	1969	85,624	.068649
	1970	770,524	.095416		1970	89,641	.101483
	1971	806,403	.054230		1971	83,976	.061291
5	1969	1,196,744	.117885	19	1969	137,776	.196173
	1970	1,364,500	.119782		1970	86,083	.331262
	1971	1,799,026	.130774		1971	106,261	.280573
7	1969	698,517	.090622	21	1969	1,074,518	.079684
	1970	1,243,265	.127153		1970	1,021,287	.157155
	1971	1,235,231	.095147		1971	1,144,090	.171721
8	1969	339,443	.082409	22	1969	280,679	.085514
	1970	383,790	.088895		1970	160,825	.088817
	1971	270,938	.149041		1971	213,446	.094183
10	1969	115,637	.063794	23	1969	476,365	.088394
	1970	88,727	.076425		1970	501,211	.098926
	1971	132,606	.068436		1971	884,088	.047988
11	1969	1,307,697	.085924	24	1969	304,049	.060247
	1970	1,000,904	.108315		1970	353,584	.059052
	1971	1,050,690	.094854		1971	390,520	.055288
12	1969	243,709	.147048	25	1969	371,637	.089232
	1970	294,712	.114522		1970	375,679	.093809
	1971	430,347	.103442		1971	493,296	.086530
13	1969	917,861	.319499	26	1969	296,535	.230071
	1970	726,559	.341401		1970	327,005	.270121
	1971	2,038,853	.184274		1971	664,316	.222334
14	1969	121,212		28	1969	225,261	.071575
	1970	123,273	.068133		1970	202,730	.076160
	1971	130,209	.072099		1971	159,438	.086510

Appendix Table 4: Amount and Cost Per Acre of Permanent Control Work

LOC	Year	Acres	$/Acres	LOC	Year	Acres	$/Acres
1	1966	702.6	37.514	10	1967	61.62	45.699
	1967	387.8	31.447		1968	7.64	77.092
	1968	367.1	37.135		1969	16.55	73.351
	1969	575.1	35.385		1970	0.00	73.351
	1970	661.8	44.422		1971	0.00	73.351
	1971	617.2	42.452				
2	1966	258.2	69.333	11	1966	240.52	49.616
	1967	265.2	51.585		1967	300.82	64.978
	1968	244.4	83.015		1968	109.76	105.701
	1969	251.6	74.462		1969	47.51	76.867
	1970	249.6	94.946		1970	170.61	80.351
	1971	135.9	132.700		1971	37.61	123.540
3	1966	532.0	40.462	12	1966	50.36	98.001
	1967	71.9	42.923		1967	195.38	57.892
	1968	598.2	30.988		1968	74.20	161.363
	1969	402.2	58.043		1969	32.97	359.560
	1970	151.9	49.153		1970	35.52	228.686
	1971	337.6	38.973		1971	26.57	349.588
4	1966	242.9	54.319	13	1966	604.85	69.435
	1967	242.4	53.124		1967	527.74	139.591
	1968	158.2	86.759		1968	466.62	161.272
	1969	181.0	68.019		1969	465.34	168.037
	1970	182.4	87.238		1970	386.99	178.895
	1971	192.9	75.333		1971	475.38	95.298
5	1966	108.24	39.853	14	1966	26.71	91.914
	1967	165.90	34.298		1967	37.68	79.622
	1968	114.75	31.355		1968	31.36	84.225
	1969	11.49	151.944		1969	24.08	112.300
	1970	0.00	151.944		1970	36.90	74.910
	1971	0.00	151.944		1971	16.49	159.655
7	1966	480.94	93.585	15	1966	251.09	47.376
	1967	406.74	119.146		1967	291.21	33.337
	1968	310.64	111.733		1968	98.97	64.240
	1969	520.18	92.241		1969	165.24	67.406
	1970	341.46	111.836		1970	59.62	152.206
	1971	459.13	98.676		1971	45.27	35.143
8	1966	68.11	275.411	16	1966	80.88	45.553
	1967	89.12	288.850		1967	88.15	21.528
	1968	108.08	99.028		1968	51.15	50.686
	1969	167.19	106.664		1969	27.47	0.000
	1970	37.55	298.815		1970	175.10	32.296
	1971	27.85	380.005		1971	66.25	39.044

Appendix Table 4 (Continued)

LOC	Year	Acres	$/Acre	LOC	Year	Acres	$/Acre
17	1966	608.83	45.873	23	1966	168.77	196.466
	1967	513.51	53.590		1967	83.49	243.404
	1968	186.33	106.266		1968	33.49	400.335
	1969	96.58	143.768		1969	5.94	145.461
	1970	123.58	184.423		1970	101.26	114.539
	1971	210.63	110.044		1971	0.00	114.539
18	1966	195.55	12.472	24	1966	47.32	161.340
	1967	131.45	26.443		1967	30.27	346.238
	1968	98.87	49.407		1968	13.52	435.042
	1969	158.95	24.746		1969	9.65	537.637
	1970	96.87	75.488		1970	13.60	274.372
	1971	162.04	23.644		1971	17.18	204.759
19	1966	357.26	45.131	25	1966	819.75	18.309
	1967	288.92	51.053		1967	682.57	21.040
	1968	452.34	31.301		1968	719.12	16.254
	1969	444.79	38.497		1969	614.89	28.254
	1970	196.51	51.874		1970	571.28	21.465
	1971	105.34	66.859		1971	171.74	28.439
21	1966	493.54	56.237	26	1966	330.85	111.267
	1967	573.84	65.872		1967	439.68	86.299
	1968	716.08	52.796		1968	443.58	125.508
	1969	717.69	58.146		1969	452.31	144.928
	1970	515.59	85.591		1970	387.86	163.312
	1971	525.42	76.535		1971	526.91	125.112
22	1966	144.88	49.416	28	1968	153.12	34.208
	1967	242.58	56.649		1969	158.07	39.420
	1968	139.89	53.631		1970	276.02	20.199
	1969	198.08	76.095		1971	267.30	21.227
	1970	177.50	111.654				
	1971	269.93	43.722				

Appendix Table 5: Comparison of Mosquito Monitoring Data: light trap counts, landing counts and complaints

Obs.	Light Traps[a]	Landing Counts[b]	Complaints[c]
	Chatham County, Georgia		
1	50.6	1.10	7.2
2	24.3	0.90	5.4
3	39.6	1.00	7.0
4	13.5	0.04	0.6
5	18.4	1.30	0.6
6	13.6	0.40	6.4
7	23.8	0.20	4.4
8	19.1	0.30	8.0
9	6.4	0.30	7.0
10	10.9	1.29	4.0
	E. Volusia, Florida		
11	31.2	5.40	
12	60.2	7.00	
13	231.6	10.60	
14	68.7	6.60	
15	86.8	5.20	
16	22.4	4.80	
17	63.9	2.90	
18	54.5	3.40	
19	61.0	4.20	
20	71.6	2.70	
21	34.1	3.40	
22	62.8	6.60	

[a] Mean no. mosquitoes per light trap night

[b] Mean no. mosquitoes landing on a person per minute

[c] Mean no. phone calls per day

Appendix Table 6: Labor's Share of Direct Field Expenditures (B_i)

Location	Labor's Share of Expenditures	Location	Labor's Share of Expenditures
Brevard	.36	Nassau	.46
Broward	.56	Palm Beach	.43
Charlotte	.36	Pinellas	.42
Citrus	.25	St. Johns	.41
Collier	.19	St. Lucie	.37
Duval	.46	Santa Rosa	.31
Escambia	.46	Sarasota	.36
Franklin	.25	Volusia	.51
Hillsborough	.29	Walton	.29
Indian River	.46	Chatham	.50
Lee	.31	Delaware	.45
Levy	.32	Cape May	.41
Manatee	.19	Monmouth	.40
Martin	.29	Ocean	.44
Monroe	.22	Virginia Beach	.25

Appendix Table 7: Wholesale Price Index (1967 = 100)

Year	Wholesale Price Index	Year	Wholesale Price Index
1959	94.8	1966	99.8
1960	94.9	1967	100.0
1961	94.5	1968	102.5
1962	94.8	1969	106.5
1963	94.5	1970	110.4
1964	94.7	1971	113.2
1965	96.6		

Appendix Table 8: Mosquito Abatement Regression Estimates for Single Equation Least Squares Model. Sample size (n) = 390

Independent Variables	Dependent Variables			
	Number Mosquitoes (Y_1)	Acres Chemical Control (Y_2)	Acres Permanent Control (Y_3)	Local Expenditure (Y_4)
Intercept	5.206	0.381	1.635	-6.977
No. Mosquitoes (Y_1)		0.036* (1.857)		0.076*** (2.619)
Acres Chemical Control (Y_2)	-0.044[a,b] (-0.546)		-0.181** (-2.422)	
Acres Chemical (Y_{2t-1})		.762*** (24.195)		
Storm Rain (X_1)	0.031 (0.700)			
Sequence Rain (X_2)	0.116*** (4.211)			
Temperature (X_3)	-0.328 (-0.130)			
Stock Permanent Control (X_4)	-0.180*** (-4.285)		0.783*** (25.484)	
Budget (X_5)		0.218*** (5.904)		
Population Density (X_6)		-0.027* (-1.702)		
Income (X_7)				1.563*** (7.208)
State Grants (X_8)				0.356*** (8.327)
Tourism (X_9)				0.344*** (9.064)
Wage Rate (W^B)				-1.827*** (-5.604)
Population (N)				-0.333*** (-7.681)
Coefficient Mult. Det., R^2	.684	.801	.652	.686
F Value Regression F	22.614	386.339	362.256	139.246

[a] The values in parenthesis are the t values

[b] A one-tailed t test was used since *a priori* information indicates the direction of the effect of each predetermined variable upon the dependent variable. The .01, .05 and .10 levels of significance are considered relevant throughout this report and are designated by ***, **, and * respectively.