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Optimum site selection for blacklight insect traps as predicted by relating tobacco hornworm collections to factors describing trap surroundings

John L. Goodenough

To the Graduate Council:

I am submitting herewith a dissertation written by John L. Goodenough entitled "Optimum site selection for blacklight insect traps as predicted by relating tobacco hornworm collections to factors describing trap surroundings." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Biomedical Engineering.

J.J. McDow, Major Professor

We have read this dissertation and recommend its acceptance:

R.B. Stone Jr, S.E. Bennett, R.E. Bodenheimer, Z.A. Henry

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 24, 1973

To the Graduate Council:

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John J. McDow
Major Professor

We have read this dissertation
and recommend its acceptance:

Robert E. Bodenheimer

Stedman E. Bennett

Zachary A. Henry

Russell B. Stone

Accepted for the Council:

Hilton A. Smith
Vice Chancellor for
Graduate Studies and Research

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OPTIMUM SITE SELECTION FOR BLACKLIGHT INSECT TRAPS AS PREDICTED BY RELATING TOBACCO HORNWORM COLLECTIONS TO FACTORS DESCRIBING TRAP SURROUNDINGS

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

John L. Goodenough

June 1973

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ABSTRACT

Seventy parameters describing surroundings of 51 blacklight insect trap locations on St. Croix, U. S. Virgin Islands were related to insect categories of male, mated female, virgin female, total tobacco hornworm (*Manduca sexta*), and the white belly (*M. sexta harterti*). Data were obtained from an on-site survey pertaining to slope of land at trap site, deviation of slopes from prevailing wind, roadways, incident light, slope to obstruction, and distance from traps to obstructions. Obtained from descriptive data of locations were trap density, distance from shorelines, elevation above sea level, slope of land in vicinity of traps, deviation of slope in vicinity of traps from prevailing wind, land-use category, vegetation type, geology type, groundwater potential yield, groundwater chloride, soil limitations to agriculture or development, soil association, and soil capability class.

Significance of relationships between insect collections and criteria was determined by analysis of variance for 14 discrete factors, and by correlation and multiple regression analyses for the continuous factors. Criteria significantly related to collections five or more times were type of obstruction, slope to obstruction, distance to obstruction, distance to shoreline, soil limitations to agriculture and development, slope of trap site, slope of trap vicinity, and deviation of slope in vicinity of traps from prevailing wind.

Significant one to four times were vegetation type, geology type, soil association, distance to roadway, related traffic flow on

roadway, weighted obstruction, percent obstruction, land-use category scaled according to estimated ability to support an insect population, slope deviation at site from prevailing wind, groundwater potential yield, soil capability class, relative ultraviolet radiation of incident light, relative intensity of incident light, elevation of trap site, and trap density.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

TABLE PAGE

LIST OF FIGURES

CHAPTER I

STATEMENT OF THE PROBLEM

Light traps have been used for many years to collect insects for survey purposes (Frost, 1952; Prod. Res. Rep. #100, 1968), for insect detection (Glick, et al., 1956), to reduce insect populations (Lawson, et al., 1963; Barrett, et al., 1971; Cantelo and Smith, 1971; Stanley, et al., 1971; and Tedders, et al., 1972), to investigate control possibilities and to obtain museum specimens (Frost, 1952).

The cost of a light trap program is determined mainly by the number of traps used. If the same number of a target species caught in traps placed in a grid pattern (often seen in literature as an attempt to place a certain number of traps per square mile, mi.) can be caught by fewer traps placed in relatively high collecting sites, substantial savings in initial investment and operating costs would result. Looking at it another way, the same number of traps more strategically placed would be more effective. To obtain maximum benefit from the traps we need to know how to select the high-collecting sites.

Since insects do not disperse equally across an area (Robinson and Robinson, 1950), and light traps apparently attract from relatively short distances (Graham, et al., 1961; Prod. Res. Rep. #100, 1968; Stewart, et al., 1969, and Stanley, et al., 1970), traps must be placed at locations in which the insects are flying in order to maximize collections.

Host vegetation and weather are, doubtless, among the many factors which influence insect behavior. However, although much work has been done relating importance of trap placement to collections, merely placing traps near host plants has not insured economic control of the plants' insect pests. Many factors in addition to proximity of host vegetation may be influential in insect activity.

In this study, 21 factors describing 51 blacklight (BL) trap sites were evaluated as to their possible influence on trap collections. A fundamental assumption is that factors found to influence collections could be used to develop guidelines for trap placement; those found not to influence collections might be considered unworthy of further consideration.

The potential use of guidelines for BL-trap placement has widespread applications. Research workers operate thousands of traps throughout many parts of the world and farmers use many in attempting to control economic pests and decrease amounts of pesticides used. The traps are being used both as the sole deterrent and in programs wherein they are integrated with various biological control measures. Common goals of such programs are to reduce the use of toxic materials because of problems of contamination and resistance of insects to toxicants.

The resources required to complete this study were provided by the Agricultural Research Service, United States Department of Agriculture, St. Croix, U. S. Virgin Islands, and Knoxville, Tennessee, and The University of Tennessee, Knoxville, Tennessee. The initial computer analyses were performed at Virginia Polytechnic Institute

and State University, Blacksburg. Successive statistical analyses were performed via the Statistical Analysis System (SAS) at the University of Tennessee Computing Center, The University of Tennessee, Knoxville.

I. OBJECTIVES

The objectives of this study were:

1. To determine topographic, geologic, and orientation criteria that affect blacklight trap collections of the tobacco hornworm (Manduca sexta).
2. To determine factors which would aid in selecting locations for trap placement that would maximize catch.

CHAPTER II

REVIEW OF LITERATURE

Although there are more than 1000 references describing uses of BL traps (Heinton, 1970), relatively few report work on the factors describing trap placement that are included in this study. Three articles dealt with a general "location" effect. H. S. Robinson (1952) noted that catches vary substantially between two locations as little as 50 yards apart ". . . even where the alternative sites are visible one from the other." (He was using 80-150 watt lamps.) Hendricks (1968) found that differences in collection due to baiting BL traps with virgin female tobacco budworms were not apparent until data were adjusted to compensate for trap location and effect of wind. He used cabbage looper catch to establish an index to adjust tobacco budworm catch.

While developing a technique for measuring trapping efficiency of BL insect traps, Hartstack and Hollingsworth (1968) found that large numbers of bollworm and cabbage looper moths attracted to traps landed on the ground around the traps. They reported that some continued to the traps and were caught, and that some may have landed several times. The trapping efficiency and number of landings varied with species of insects. Presumably some condition around the traps affected the number and distance of landings around traps. Robinson and Robinson (1950) reported "Traps with a light that illuminates nearby objects collect fewer insects than traps with no such objects present."

Stewart, et al. (1969) reported that interferences by artificial lights may have caused the failure of a similar study on range of attractiveness of BL lamps by J. D. Hoffman and J. J. Lam, Jr. (Unpublished data) at Oxford, N. C. in 1966.

Several authors have reported on the attractive distance of light traps. Works by Robinson and Robinson (1950), Newman (1952), H. S. Robinson (1952), Laithwaite (1960), and Mazhim-Porshnyakov (1960) contain mainly qualitative remarks and observations on insect flight and attractivity to light traps. More recently, several reports cite quantitative data on attractive distances. In 1961, Graham, et al. found that the pink bollworm responded to radiation of a trap equipped with three 2-watt argon glow lamps (peak radiation of 3654 millimicrons; near UV) up to 140 feet (ft.) from the light source. The apparatus used reduced light intensity by 1/2. Therefore, they reported, the moths responded to an intensity equivalent to that produced by the trap at an unobstructed distance of approximately 200 ft. They contended that response at distance beyond 140 ft. was not determined because of inadequate facilities.

The range of attractiveness of BL lamps was reported to be less than 50 ft. for granulate cutworm, but extended to 50 ft. with less attraction at 100 ft. for cabbage looper, corn earworm, beet armyworm, and yellow-striped armyworm (Prod. Res. Bull.#100, 1968). For cabbage looper the field of attractiveness dropped off rapidly between 50 and 100 ft., but beet armyworm may be attracted to light at a somewhat greater distance. Stewart, et al. (1969) found that 96 percent of a group of tobacco hornworm moths that had gone to the ground within

1.2 meters (m) of a ground-level lamp moved toward the lamp after a period of rest. "Indeed, judged by their unswerving orientation toward the lamp, most moths seemed to be irresistibly attracted at that short distance." However, ". . . the uncaged M. sexta moths rested quietly for at least 1/2 hour when they were only a short distance from the ground-level lamp. Presumably radiant energy does not stimulate flight, even at close range." In tests with moths placed in two rows of cages that had ends oriented toward and away from the lamp and covered with 16 mesh black-painted wire (62.5% of BL illumination passed through) there was movement toward the lamp (positive response) by 48% of the tobacco budworms with cages at 4.6 m. There was a steady decline in response beyond 20.6 m. with increasing distance from the lamp. The extreme limit of response was 120-135 m. Positive response was made by 75% of caged tobacco budworms at 6.1 m. with a steady and rather quick decline with increasing distance. The extreme limit of response was postulated to be 60-90 m.

Stanley, et al. (1970) reported field response of tobacco hornworm moths to 15-watt BL lamps up to a distance of about 180 m.

Trap densities required to effectively utilize BL traps in insect survey and control programs reportedly range from 3/mi.^{2} (per square mile) to many more. In 1950 Robinson and Robinson estimated 60 traps/mi.^{2} were needed to effectively sample an area. Lawson, et al. (1963) found that three traps/mi.^{2} over an area of 12 mi. in diameter reduced the male and female tobacco hornworm populations by 76 and 55%, respectively, in the center area compared to check traps outside the area. McFadden and Lam (1968) reported that trap spacings of 1 and 2 mi. did not affect collections of tobacco hornworm when two groups of traps in different locations were used.

Hartstack, et al. (1971) predicted trap spacings necessary for average probability of being caught to approach unity, trap spacings of approximately 100 ft. would be needed. Spacings of 600 ft. and greater provided probability of being caught of 0.2 or less. They stated that " . . . control of phototactic insects with light traps is possible if trap spacings are much closer than those used in previous control experiments." Another method based on mathematical analysis was developed by Wolf, et al. (1971) for estimating trap density required to reduce a population of an insect by a given amount. Three parameters of an individual trap for a particular area must be known: trapping area; trap performance; and trap-density function. Trap performance was defined as the number of insects within the trapping area which are caught, divided by the total number of insects within the trapping area. The trap-density function was a correction factor which accounted for the degree of overlap in trapping patterns. A dimensionless number, which reflected the degree of overlap, was equal to the product of trapping area and trap density.

To determine effect of trap height, Glick, et al. (1956) placed seven traps (one per pole), varying from 2 to 14 ft. above the ground at 2 ft. intervals and 17 ft. apart, at the edge of a cotton field. Traps were placed at random at the various heights each night for approximately 5 weeks. The number of pink bollworms collected decreased rapidly with height. Of the total, 39% were collected at 2 ft., 71% at the three lowest levels, and only 6% at 14 ft. This varies, however, with species. Barrett, et al. (1971) obtained greater collections of striped and spotted cucumber beetles at 12 ft. with traps on separate poles than at 4 ft., either on separate poles or mounted below the 12-ft. traps. Cantelo and Smith (1971) found that collections of male tobacco hornworms increased with height of bait, when virgin female bait was placed at heights of 1, 5, and 10 ft., and when one trap was baited, collections of males in other unbaited traps to the leaward increased.

Experiments to determine the most effective wavelength for attracting insects have shown the near-ultraviolet (near UV, 300 to 390 millimicron, mμ) region to be the most efficient for attracting most moths (Glick and Hollingsworth, 1955; Earp, et al., 1965; and Stanley, et al., 1970). Robinson in 1952 noted differences in collections due to surrounding light conditions. Other researchers noted reduction in illumination intensities due to their test apparatus, but did not determine what, if any, the affect of the reduced intensity had on collections (Graham, et al.,1961 and Stewart, et al., 1969). Graham, et al. (1961) postulated that the reduced intensity reduced the effective trapping area of the test trap by a proportionate amount. Barrett, et al. (1972) compared the effect of various lamp UV emissions on 23 collection categories. The general expression was $CI = 4P^{0.4}$, where P is milliwatt lamp emission in the near-UV region and CI is a catch index based on both the number of individuals captured and the square root of frequency of capture expressed on a percentage basis:

$$CI = \text{Number} \sqrt{(\text{nights captured}/\text{nights possible to capture})100}.$$

Harwood continuously lighted a corn field in Indiana to determine if the ambient lighting would inhibit insect activity. There was not a significant increase in yield in one year's trial (personal correspondence). Dufay (1964) stated that only sufficient intensity is required to exceed a threshhold level in the insect's eye. Increased intensity above the threshhold does not incite increased response.

If light incident to the trapping area interferes with the BL lamps attractive potential, incident UV radiation of sufficient intensity would result in a significant decrease in collections. Barrett, et al. (1971b) found that although the striped cucumber beetle and spotted cucumber beetle, considered diurnal insects, were strongly attracted by the BL lamps at night, neither species was captured in BL traps during daylight hours.

Although the effects of weather on BL trap collections are purposely not evaluated in this study, many authors have shown insects to be responsive to weather changes, and an indication of the weather conditions studied, and some comments relative to this study have been included. Stirrett (1938) reported on weather factors affecting the European corn borer. Glick (1939) reported that moonlight increases insect activity in general, although Lepidoptera appear more active on dark nights. Included was a large section on meteorlogical conditions. Glick, et al. (1956) found that 86% apparently flew into the prevailing wind. However, when wind was 6 mph or greater, few moths were collected. Greatest numbers were taken when wind was less than 3 mph.

Collections in BL traps during moonlight periods usually decrease beginning a few days before full moon and increase immediately after full moon (Prod. Res. Rep.#100, 1968). The greatest decrease was just before full moon. Moonlight competing with lamplight was attributed to the decrease. Rainfall showed no correlation with collections. Hendricks (1968) adjusted collections for effects of wind, and Hartstack, et al. (1968) illustrated uneven distribution of insects in pans on ground around traps. Since these traps were in open fields, the irregular distribution may have been caused by wind.

In 1961, Cook summarized effects of environment on photosensitivity of insects. Temperature differences of 1 or 2 F will cause sudden fluctuations in insect activity. Usually there is a positive correlation between flight and temperature and usually larger flights occur on relatively warm nights. No general effects of humidity were reported; optimum may vary with the trapping area. On effects of wind, he reported that Stirrett found flight of European corn borer not affected by velocity to 17 mph. However, captures were reduced to nearly zero by 10 mph winds. In general, Cook (1961) reported wind does not influence moth flight greatly if other conditions are favorable, but practically inhibits their coming to lights. He reported atmospheric pressure had little affect on flight and photosensitivity, and that there were no definite data on effects of rainstorms. Effects of electric state of atmosphere were difficult to isolate, but heavy catches often precede storms. Clouds help cut moonlight and hold earth's heat, and may influence trap collections through these factors, since full moon usually greatly reduces light trap catches. He found little influence recorded due to fog or mist, and dew and guttation were reported by Stirrett to have no relation to moth flight.

CHAPTER III

EXPERIMENTAL PROCEDURES

There were three main divisions in this study: obtaining factors from an on-site survey, obtaining factors from descriptive data of locations, and analysis of data.

I. ON-SITE SURVEY

The on-site survey portion of this study was made during November and December 1969 on the island of St. Croix, United States Virgin Islands, located about 40 mi. east of Puerto Rico and 1,100 mi. southeast of Miami, Florida. St. Croix is about 22 mi. long and 84 mi.^{2} in area (Zube, et al., 1968). The traps were at an average density of 3/mi.^{2} and were similar to those described by Lawson, et al. (1963). Collections were made from July 1966 to January 1969, exclusive of October and November of 1968.

Many authors (among them are H. S. Robinson, 1952; Glick, et al., 1956; Lawson, et al., 1963; Hendricks, 1968; McFadden and Lam, 1968; Prod. Res. Rep. #100, 1968; and Cantelo and Smith, 1971) report unequal numbers of male and female insects collected in BL traps. This led to the evaluation of the tobacco hornworm collection separately by the categories male, mated female, virgin female, and the total (aggregate of male + mated female + virgin female) tobacco hornworm collection. The total _M. rustica harterti_ (common name on St. Croix was "white belly") collection is included as the fifth collection category.

There is wide variation in rainfall across St. Croix and correspondingly in the amounts and types of vegetation (rainfall varies from about 25 inches a year over easterly portions to an excess of 55 inches a year over some of the northwest portions--(Bowden, 1968), elevation, geology, and land use. Prevailing winds blow generally from an easterly direction, varying from north northeast to south southeast (Zube, et al., 1968). Factors; such as weather, amount of vegetation, buildings, lighting, etc., have been changing constantly since the project was initiated. Elevations, geology, distance to shorelines, directions and magnitude of slopes, and proximity of established buildings and some other obstructions have remained more constant.

At the 51 BL-trap sites, in Figure 1, a survey was made of the following factors: type of, distance to, and angle subtended by obstructions within approximately 400 ft. of each trap; slope of site; distance to and relative traffic flow on roadways; and type and relative intensity of incident light. An attempt was made to note any unusual features at each site.

Percent slope of site (ground surface near the trap) and percent slope to obstruction (measured from a point approximately at the center of each lamp) were measured with a hand level. Examples of sites with steep slope and high obstruction are shown in Figure 2, parts A and B, respectively. Percent slope to obstruction was measured at each 30° (horizontal) interval around traps and at 10° intervals where there occurred abrupt changes in obstruction. Profiles of the obstruction around each trap were plotted, converting percent slope to degrees. The areas under these plots were measured with a planimeter and percent

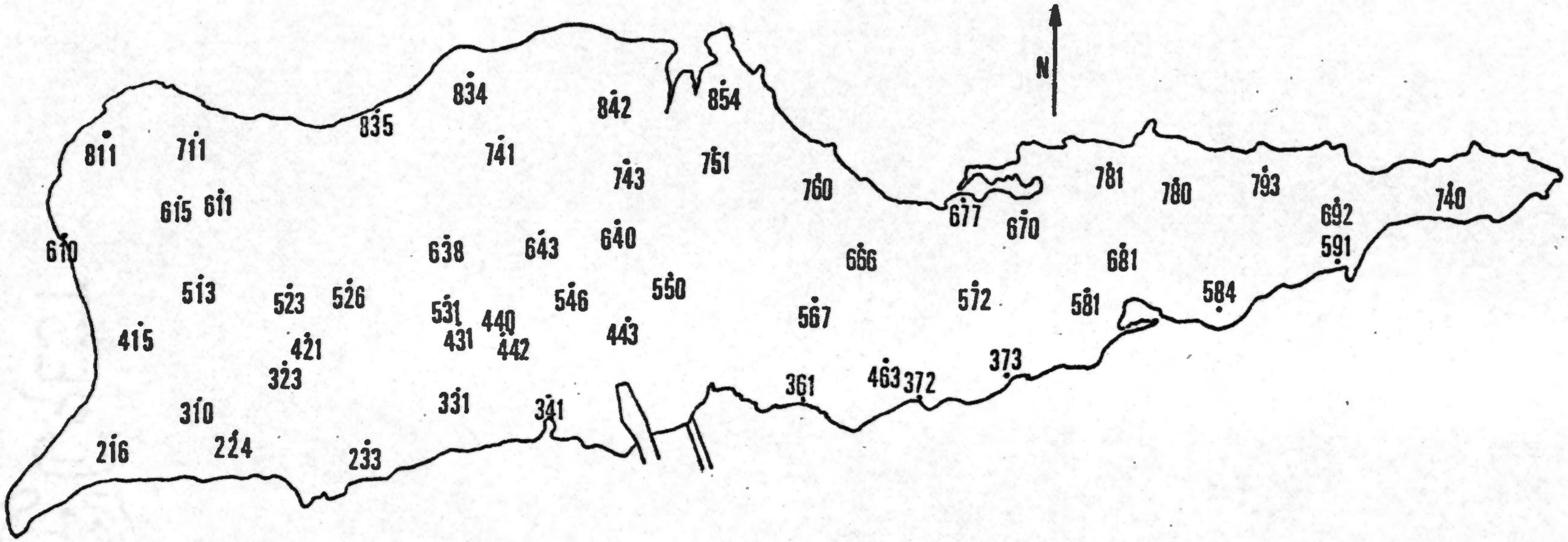
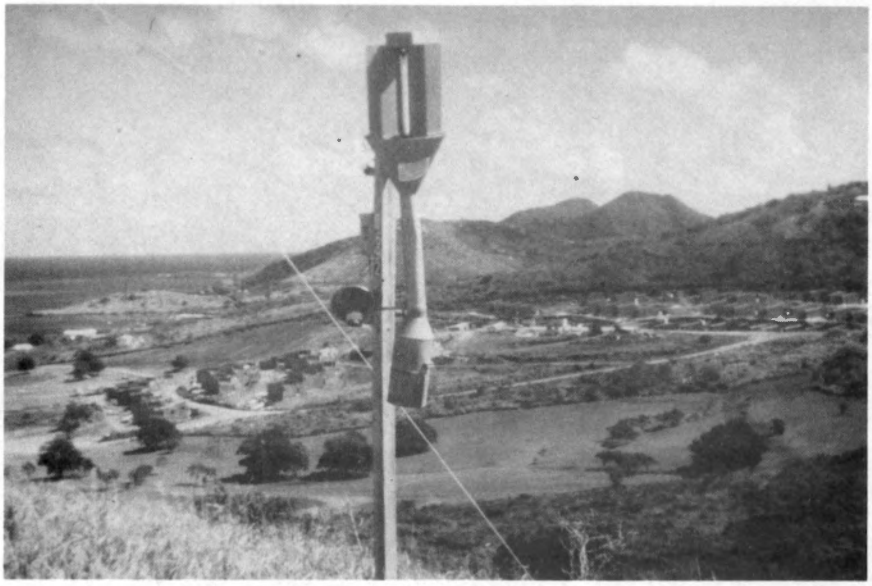


Figure 1. Location of 51 Blacklight Trap Locations, St. Croix, U. S. Virgin Islands

A. Trap 743, surrounded by large amounts of vegetative obstruction.



B. Trap 692, located on steep hillside sloping easterly.

Figure 2. Two representative blacklight insect trap sites, St. Croix, U. S. Virgin Islands.

obstruction around each trap was calculated using 90° as 100 percent obstruction (vertically). For purposes of determining percent obstruction in a particular direction, north was taken as the 90° sector from northeast to northwest, and similarly for west, south, and east. The percent obstruction for 360° around each trap was found in the same manner as for each direction (i.e., not just the mean of the four directions). Figures 3 and 4, respectively, are plots resulting from relatively low and high amounts of obstruction.

Additional estimates of obstruction were obtained from the field data: measured percent slope and estimated distance to obstructions. Data were averaged in each 90° sector described above to determine average slope to obstruction that were north, west, south, and east of each trap. Zeros and negative values of percent slope were included in these averages--negative values resulted when the average obstruction was below lamp level. Average values for distance to obstruction were obtained similarly. Average "type" of obstruction in each direction was determined by considering the type occurring most frequently, the type associated with greatest slope, and the type closest to traps. Types of obstruction that occurred were trees, buildings, grass or ground, rocks, cacti, highways or roadways, seashore, windmills, and brush. Seashore is not actually an obstruction, but is listed as such when no other type occurred between the lamp and seashore.

To determine if one value of obstruction and distance to obstruction in each direction could be selected that would describe the effect of obstruction as well as either of the methods presented above, a

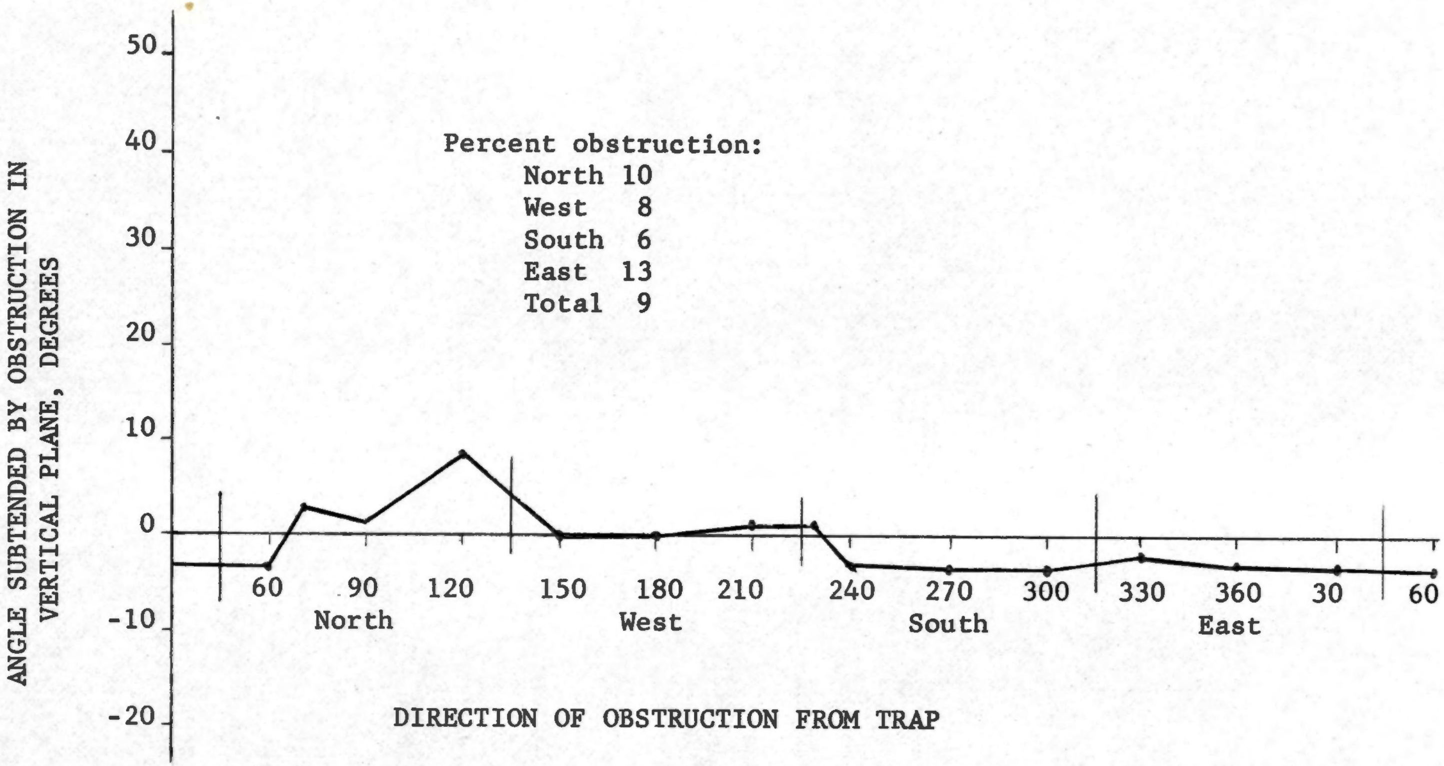


Figure 3. Obstruction surrounding BL survey trap 531 as obtained from on-site survey; an example of minimal obstruction.

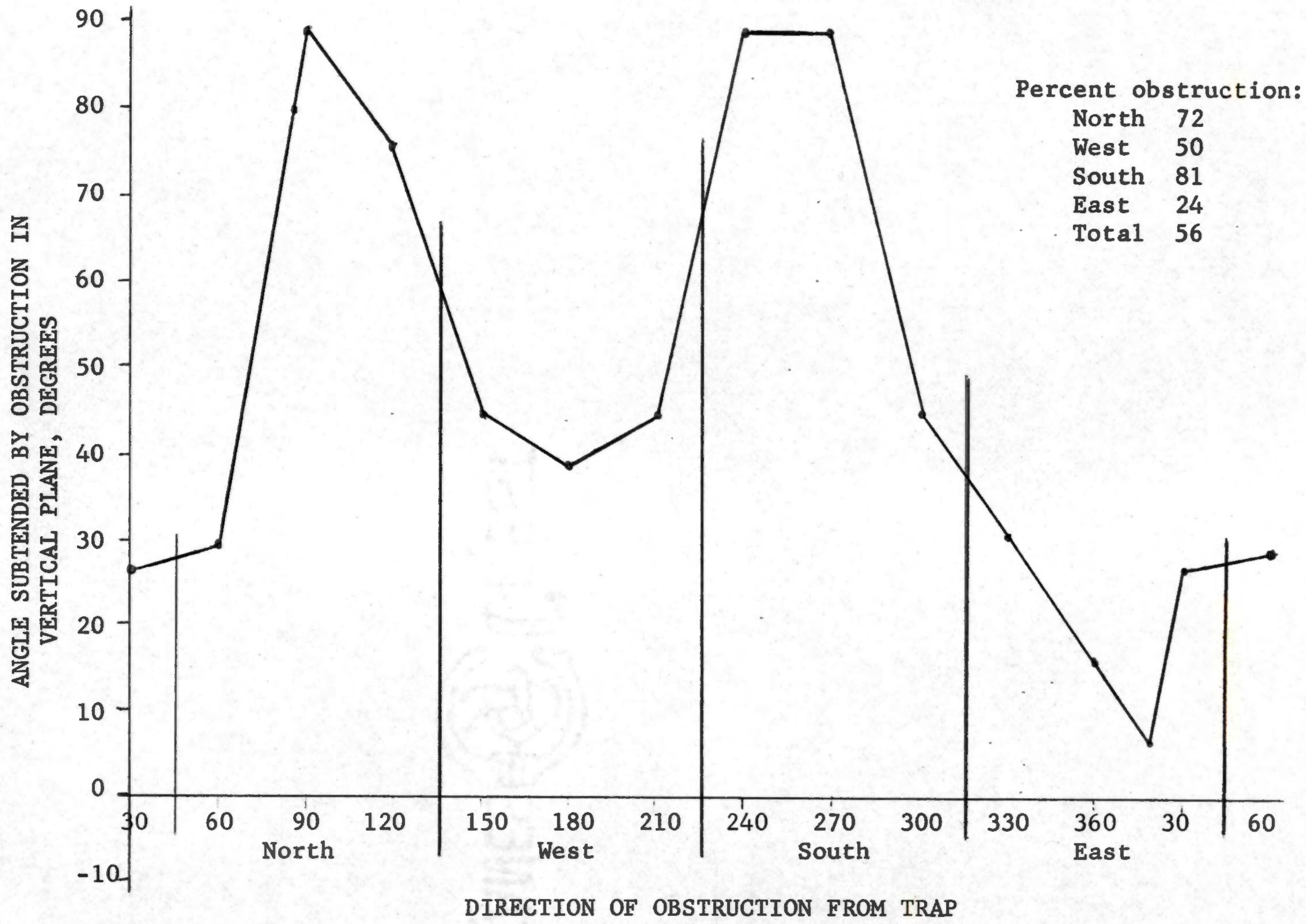


Figure 4. Obstruction surrounding BL survey trap 743 as obtained from on-site survey; an example of maximal obstruction.

"selected" percent slope to obstruction and selected distance to obstruction were chosen (again to the north, west, south, and east 90° sectors as described above) by finding the combination of slope and distance to that obstruction which would give the highest positive value from the calculation: (percent slope)/(distance). Types of obstruction corresponding to these "selected values" of slope and distance to obstruction were listed for north, west, south, and east, respectively. Using only one value would be much simpler and more convenient, especially in the field, than using several values involving computation.

Values to represent effects 360° around each trap were calculated as means of the directional values described above (mean slope to average obstruction, mean distance to average obstruction, mean slope to selected obstruction, and mean distance to selected obstruction).

Finally, weighted values in each direction were calculated from each combination of slope and distance to obstruction: $\frac{1}{n}\sum_{i=1}^{n}\left[(\text{percent slope})_i/(\text{distance})_i\right]$. A mean value was again calculated as the average of the weights in each direction.

Relative traffic flow on adjacent roadway was coded from field data as: 1, heavy; 2, moderate; 3, light; 4, practically none; and 5, trap not within 100 ft. of roadway. Distance to roadways was estimated on site. Incident light sources were categorized from types observed in the field on the basis of relative UV output with 1 corresponding to the highest amount: 1, mercury vapor; 2, incandescent; and 3, no apparent light sources near traps. Estimates of the intensity of incident light sources were made as being inversely proportional to the square of the distance between sources and traps: 1, bright; 2, moderate; 3, low; and 4, nil.

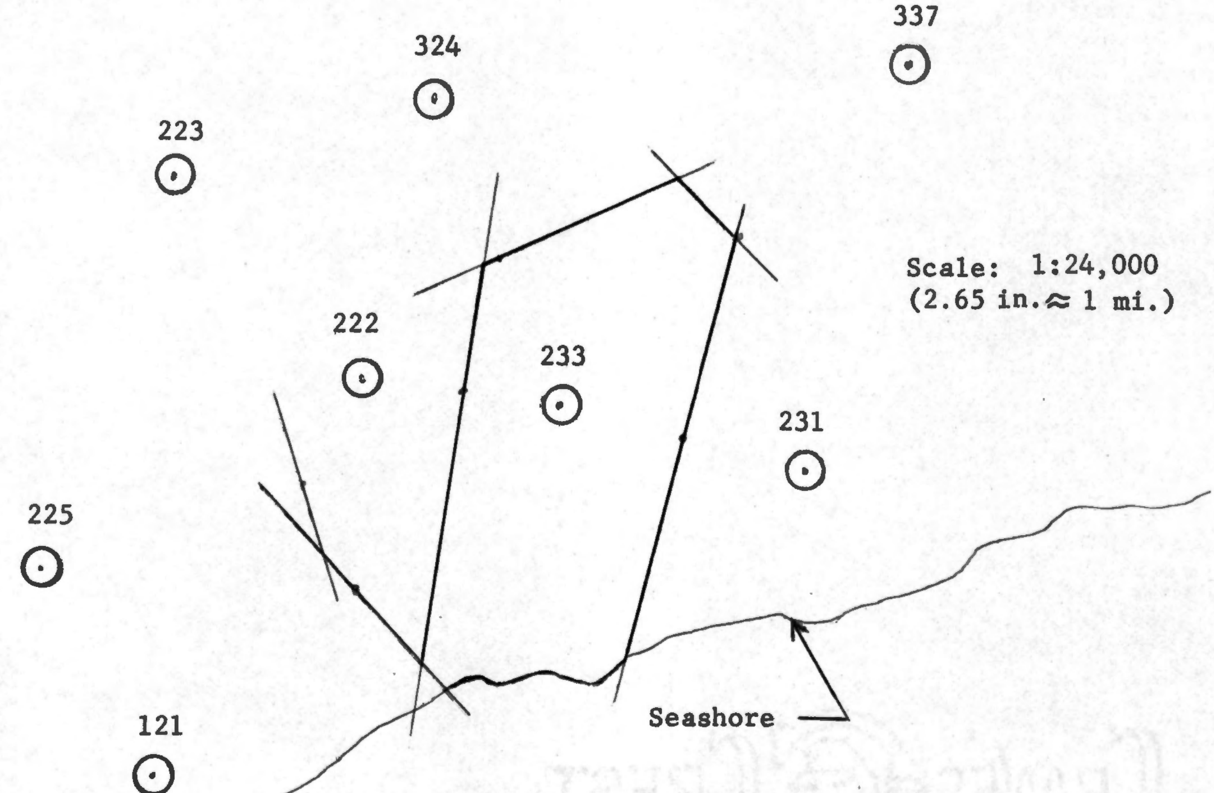
A compass was used to determine the directions of slopes at sites and directions to obstructions, using true north as 8^{o} east of magnetic north (U. S. Geological Survey, 1958). The direction of slopes at sites were coded to degrees deviation from prevailing east wind as shown in Table I. Computer names and descriptions of each field variable are summarized in Appendix B. Transformations used in statistical analyses are listed directly below the respective variables. Variables are included (but not used as factors) to number observations 1 to 51 and to list traps as they actually were numbered in the field.

II. FACTORS OBTAINED FROM DESCRIPTIVE DATA OF TRAP LOCATIONS

Information was obtained on trap density, distance to north, west, south, southeast, and northeast shorelines (the latter two were measured 30^{o} south and 30^{o} north of east, respectively, instead of directly east because the east end of the island is pointed), and elevation of trap sites from a USGS map (U. S. Geological Survey, 1958). Trap density of each trap was found graphically by constructing perpendiculars at the mid-point of a line between survey traps and each surrounding trap as shown in Figure 5. The area of the resulting inscribed polygon was measured with a planimeter; the reciprocal is trap density (drawing scale 1:24,000). Percent slope and direction of slope in vicinity of traps were found using contour intervals within 500 feet of traps. Deviation of slopes in vicinity of traps from

TABLE I. SLOPE DIRECTION AT BLACKLIGHT-TRAP SITES AS CODED TO DEVIATION FROM PREVAILING WIND

Slope direction	Field survey code	Degrees deviation
Northeast	1	45
North	2	90
Northwest	3	135
West	4	180
Southwest	5	135
South	6	90
Southeast	7	45
East	8	0



Procedure (shown for trap 233):

1. Find mid-points of line between survey trap and each surrounding trap.
2. Construct perpendiculars at these points.
3. Measure area of smallest polygon circumscribed around survey trap. This area contains all points closer to this trap than any other trap.
4. The reciprocal of this area is trap density (traps/mi.^{2}).

Figure 5. Method of determining trap density.

prevailing east wind was coded from percent slope in vicinity of traps in the same manner as was described above for direction of slope at trap site (Table I, page 20).

Land-use category, vegetation type, and geology type were taken from The Islands (Zube, et al., 1968). Land-use category was scaled according to estimated ability to support an insect population, Table II, with higher values for those land-use categories that were estimated capable of supporting a large population. Vegetation type was scaled according to relative attractiveness to insects, Table III. (Scale values were 1 to 10, with 10 corresponding to highest attractiveness.) The various categories of geology type are listed in Table IV.

Potential groundwater yield in gpm, and ppm chloride were estimated by comparing trap locations with data presented by Zube, et al. (1968), Table V. Soil limitations for agriculture or development were coded according to potential for attraction to insects, Table VI. In this coding it was assumed that land with slight and moderate limitations to agriculture and land with slight and moderate limitations for development are not significantly different in their potential for attracting insects. An average value was used for traps placed on borders of adjacent soils. Data for each of the factors land-use category, vegetation type, geology type, potential groundwater yield, chloride content, and soil limitations to agriculture or development were obtained by overlaying a map similar to Figure 1, page 13, upon the maps by Zube, et al. (1968) corresponding to each factor. Respective factor values corresponding to each trap location were recorded and coded as described above.

TABLE II. DESCRIPTION AND SCALING OF LAND-USE CATEGORY[a]

Land-use category	Scaled land-use category	Description
1	5	Wooded slopes
2	6	Pastureland
3[c]	8	Transition farmland
4	4	Residential: less than 2 families per acre
5[d]	3	Residential: 2 families or more per acre
6[d]	3[e]	Retail commercial
7[d]	5[e]	Resort commercial
8[d]	2	Industrial
9	2	Undeveloped beaches
10	2	Public parks and beaches
11[d]	3[e]	Publicly-owned land
12	1	Urban centers
13	0	Marinas

[a]Reference: Zube, et al. (1968).

[b]Estimated ability to support an insect population (scaled on basis 0-10, 10 = highest ability).

[c]Formerly sugar cane fields.

[d]Outside of urban centers.

[e]Scale may vary due to location.

TABLE III. DESCRIPTION AND SCALING OF VEGETATION TYPE[a]

Vegetation type	Scaled Vegetation type[b]	Description
1	5	Moist forest
2	6	Rain forest
3	3	Dry forest-dry forest with cactus
4	2	Cactus-shrub-woodland
5	1	Wind-flattened shrub
6	3	Croton acacia
7	2	Mangrove
8	1	Beach
9	8	Pastureland
10	10	Farmland
11	3	Urban

[a]Reference: Zube, et al. (1968).

[b]Scaled according to relative attractiveness to insects (range 1-10, with 10 the highest attractiveness).

TABLE IV. GEOLOGY TYPES[a]

Type number	Name
1	Alluvium
2	Tutu formation of Donnelly
3	Outer brass limestone of Donnelly
4	Louisenhoj formation of Donnelly
5	Water island formation of Donnelly
6	Kingshill marl
7	Jealousy formation
8	Intrusives
9	Mount Eagle volcanics

[a]Reference: Zube, et al. (1968).

TABLE V. POTENTIAL GROUNDWATER YIELD AND CHLORIDE CONTENT[a]

Potential groundwater yield, gpm			
Reference value, gpm	Scaled value	Description	Chloride, ppm
---	0	Little water or salt water	0-1400
---	0	Salt water	0-1400
1-2	1.5	No chloride, * indicates less than 300 ppm chloride	---[b]
1-5	3	Less than 500 ppm chloride	250
1-5	3	Possibly 10; less than 200 to more than 5,000 ppm chloride	---[b]
5-10	7.5	Less than 300 ppm chloride	150
5-10	7.5	Possibly 100 in larger valleys; less than 700 to more than 1,000 ppm chloride	350-1000
5-15	10	Less than 200 ppm chloride	---

[a]Reference: Zube, et al. (1968); original data obtained from "Water Resources of the Virgin Islands, A Preliminary Appraisal, 1963, by Ward, P. E. and Jordan, D. G."

[b]This category was not present at any trap site.

TABLE VI. SOILS POSSESSING LIMITATIONS TO AGRICULTURE OR DEVELOPMENT CODED TO POTENTIAL FOR ATTRACTION TO INSECTS

Coded value[a]	Description[b]
3	Slight limitations for agriculture
2	Moderate limitations for agriculture
3	Slight limitations for development
2	Moderate limitations for development
1	Severe limitations for development

[a]Assumption: slight and moderate limitations to agriculture or development are not significantly different with respect to potential for attraction. Traps falling on borders were scaled by averaging values, e.g. a trap on borders of 1 and 2 would be scaled 1.5.

[b]Reference: Zube, et al. (1968).

Additional factors describing soils were taken from Soil Survey Maps (Soil Survey of Virgin Islands of the United States, 1970). Since similar maps are available for many areas throughout the U. S., the required data would be available for application of the technique in many of these areas. The basis for establishing relationships with these data were the possible effect that relative inherent vegetative productivity of soils and the relative size of each soil deposit adjacent to traps may have on insect collections. The General Soil Map was used to locate the soil association present at each trap site. Soil types at each trap site were determined from soil maps. The soil capability class for each soil type was found for each respective soil type (the larger the soil capability class number, the greater the limitation for use: class numbers range from I to VIII). Finally, soil types were used to locate the percent of soil association in the dominant soil series. Soil capability class was multiplied by this percent to obtain a weighted value that reflects the relative amount of soil present having the particular limitation for use that typifies the particular soil capability class.

All factors in the literature survey, their computer names and transformations, are summarized in Appendix C.

III. STATISTICAL ANALYSIS

The bulk of the statistical analysis was multiple regression. Prior to regression analyses, dependent variables were ranked according to trap collections to see if they fell into distinct groups. If they did, application of discriminate factor analysis might be appropriate. Ranked male data (not included) were used to aid in this determination. Plots of dependent variables versus many of the independent variables were made to aid in selecting appropriate transformations for regression analyses.

Normality of deviations from regression lines was checked by plotting frequency versus deviations from simple regression equations of y, square root (SQ)y, natural logarithm (LN)y, and SQ(y + 1) on x with y = male and x = elevation. This was also done for multiple regression equations of all collection categories uncoded, coded SQ(y_i), and coded LN(y_i + 1) as dependent variables and the aggregate of average slope and distance to northerly, westerly, southerly, and easterly obstruction, and weighted northerly, westerly, southerly, and easterly obstruction as independent variables.

Significance of 14 factors: average and selected obstruction types to the north, west, south, and east, slope direction at site and in vicinity of traps, geology type, land-use category, vegetation type, and soil association, on insect collections was determined by analysis of variance. All continuous-data factors were ranked according to simple correlation with dependent variables. Multiple regression equations were calculated to compare models based on (1) all factors, (2) factors obtained from the published data of locations, (3) factors that may be evaluated on-site, (4) factors that may be obtained from the on-site survey, (5) factors that are most economical to measure, and (6) factors that may be obtained by untrained personnel. These calculations were made using the stepwise technique, maximum R^2 improvement option of the Statistical Analysis System (SAS) (Service, 1972). The number of terms allowed in each model was determined by the respective objective and one additional restriction: no terms were added when the first additional term did not increase R^2 of the total equation by at least 0.5%.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF THE DATA

I. BLACKLIGHT TRAP INSECT COLLECTIONS

Blacklight trap insect collections are listed in Table VII for the five collection categories: male, mated female, virgin female, total tobacco hornworm, and white belly (individual trap collections are shown in Appendix B). Mean collections are the average from 51 traps, and each of the 51 trap-values was the average of about 375 collections over a three-year period. Most of the mean total tobacco hornworm collection of 1.4 was male (61%), whereas 36% was mated female and only 3% was virgin female. White belly collection averaged 5.6 times as many as total tobacco hornworm. The ratio maximum/minimum is probably the most significant statistic in Table VII for this study: differences in trap collections at the highest collecting site compared to the lowest varied from a factor of 12 for mated female to 59 for virgin female tobacco hornworm. Since the individual trap collections are averages of about 375 collections, and the same model traps were installed at all locations, a great deal of the difference among collections may be ascribed to differences among the various sites.

An initial ranking of the collection data was made as an aid in determining appropriate statistical procedures. Individual trap collections in each category were ranked from highest to lowest. Generally the collections made a fairly continuous set, indicating that correlation

TABLE VII. DISPERSION OF INSECT COLLECTIONS IN 51 BLACKLIGHT TRAPS

Species of sphingid moth[a]	Mean collection[b]	Range[c]	Standard deviation	Maximum/ minimum
Tobacco hornworm[d], male	0.86	0.075-3.5	0.81	47
Tobacco hornworm[d], mated female	0.51	0.12-1.5	0.30	12
Tobacco hornworm[d], virgin female	0.038	0.0027-0.16	0.029	59
Tobacco hornworm[d], total	1.4	0.21-4.8	1.1	23
White belly[e]	7.8	1.3-55	8.6	42

[a]Lepidoptera: Sphingidae.

[b]Average of 51 traps (about 375 collections each).

[c]Individual trap averages of about 375 collections each, over a 29 month period.

[d]Scientific name: *Manduca sexta*.

[e]Scientific name: *M. rustica harterti*.

and regression analyses would be more appropriate than discriminant factor analysis. However, there were many more low-collecting sites than high for each collection category. Because of this and the large variation among collections, the SQ and LN transformations were investigated for use in multiple regression analyses so that the deviations between actual and predicted collections more closely approximated a normal distribution (Snedecor and Cochran, pp. 325-30). To choose the best codings, the plots of frequency versus deviation for average obstruction were used to choose the dependent-variable coding which most nearly normalized the distribution of deviations from the regression line for each collection category. On this basis, the following codings were chosen for stepwise regression analyses: for male, LN $(y_i + 1)$; for mated female, LN$(y_i + 1)$; for virgin female, SQ(y_i); for total tobacco hornworm, LN$(y_i + 1)$; and for white belly, SQ$(y_i + 1)$.

II. ON-SITE SURVEY

A complete listing of on-site data for each trap is shown in Appendix B. Means, ranges, and standard deviations of the parameters in Table VIII show that most trap sites sloped less than 25% had slopes oriented such that prevailing winds blew across the slopes more often than up or down, were within 200 ft. of roadways, had relatively little traffic on adjacent roadways, had incident light sources that were usually low in UV output and of low intensity, had percent obstruction in any direction less than 43, had total percent obstruction less than 34, had average slope and distance to obstruction in any direction less than 67% and 300 ft., respectively, and had selected slope and distance

TABLE VIII. DISPERSION OF ON-SITE DATA OF 51 BLACKLIGHT TRAPS WHICH WERE CORRELATED WITH INSECT COLLECTIONS

Factor	Mean	Range	Standard deviation
Slope of trap site, percent	12	0-70	13
Deviation of slope at trap site from prevailing wind	84	0-180	55
Distance to roadway, ft.	110	4-400	150
Relative traffic flow on adjacent roadway	3.6	1-5	1.2
Relative UV output of incident light	2.1	1-3	0.40
Relative intensity of incident light	3.3	2-4	0.70
Percent northerly obstruction	14	-15-86	22
Percent westerly obstruction	17	- 8-99	26
Percent southerly obstruction	14	- 9-99	25
Percent easterly obstruction	12	-18-89	19
Percent total obstruction	14	- 4-78	20
Average slope to northerly obstruction, percent	19	-23-180	37
Average slope to westerly obstruction, percent	26	-12-200	41
Average slope to southerly obstruction, percent	26	-15-200	48
Average slope to easterly obstruction, percent	19	-30-130	31
Mean average slope to obstruction, percent	22	- 7-127	30
Average distance to northerly obstruction, ft.	120	9-570	110
Average distance to westerly obstruction, ft.	130	3-567	110
Average distance to southerly obstruction, ft.	150	4-640	130
Average distance to easterly obstruction, ft.	150	7-800	150
Mean average distance to obstruction, ft.	140	18-458	97
Selected slope to northerly obstruction, percent	36	-30-200	50
Selected slope to westerly obstruction, percent	43	-25-200	56
Selected slope to southerly obstruction, percent	40	-25-200	58
Selected slope to easterly obstruction, percent	36	-45-200	49
Mean selected slope to obstruction, percent	38	- 8-158	41
Selected distance to northerly obstruction, ft.	66	3-350	65
Selected distance to westerly obstruction, ft.	69	2-500	95

TABLE VIII (continued)

Factor	Mean	Range	Standard deviation
Selected distance to southerly obstruction, ft.	84	4-500	110
Selected distance to easterly obstruction, ft.	82	3-700	112
Mean selected distance to obstruction, ft.	75	8-313	64
Weighted northerly obstruction	1.4	-1-36	13
Weighted southerly obstruction	3.1	0-50	9.9
Weighted easterly obstruction	1.6	-1-33	5.2
Mean weighted obstruction	2.4	0-30	5.9
(Relative UV output of incident light)*[a] (Relative intensity of incident light)	7.1	2-12	2.5
(Relative UV output of incident light)* (Relative intensity of incident light)^2	25	4-48	13.
(Distance to roadway)*(Relative traffic flow on adjacent roadway)	510	8-2000	750
(Distance to roadway)^2*(Relative traffic flow on adjacent roadway)	$17x10^4$	$48-80x10^4$	$31x10^4$

[a]* signifies multiplication.

to obstruction in any direction less than 99% and 194 ft., respectively. Mean average slope and distance to obstruction were usually less than 52% and 237 ft., respectively, and mean selected slope and distance to obstruction were usually less than 79% and 139 ft., respectively. Weighted obstruction in any direction was usually less than 13 and mean weighted obstruction was usually less than 8.3.

III. FACTORS OBTAINED FROM DESCRIPTIVE DATA OF LOCATIONS

A considerable number of location parameters were obtained from descriptive data of locations. A complete listing for each trap site is included in Appendix B. Mean, range, and standard deviation of each factor used in correlation with BL trap collections is shown in Table IX. This table shows that traps usually were placed at a density of 1.5 to 5.9 per $mi.^2$, were within 3.5 mi. of some shoreline, and were less than 300 ft. above sea level. Slope of land in vicinity of traps was usually less than 18%, and slopes were oriented such that prevailing wind blew across the slopes more often than up or down. Land-use category scaled according to estimated ability to support an insect population was usually rated less than 7 (on a scale of 10 maximum), and vegetation types scaled according to relative attractiveness to insects usually rated less than 10 (farmland vegetation was rated the maximum of 10). Groundwater potential yield and chloride content were usually less than 7.9 gpm and 790 ppm, respectively. Soil limitations to agriculture or development were usually moderate. Soil capability class was usually 3 to 7 (class ratings vary from 1: little or no

TABLE IX. DISPERSION OF FACTORS OF 51 BLACKLIGHT INSECT TRAP LOCATIONS OBTAINED FROM DESCRIPTIVE DATA

Factor	Mean	Range	Standard deviation
Trap density, no./mi.^{2}	3.7	1-12	2.2
Distance to north shoreline, mi.	2.0	0-5	1.5
Distance to west shoreline, mi.	7.4	0-19	5.6
Distance to south shoreline, mi.	2.3	0-5	1.5
Distance to southeast shoreline, mi.	3.8	0-9	2.6
Distance to northeast shoreline, mi.	3.9	0-11	2.9
Elevation above sea level, ft.	160	5-680	150
Deviation of slope in vicinity of trap from prevailing wind	84	0-180	51
Land-use category scaled according to estimated ability to support an insect population (10 = maximum).	5.8	3-8	1.5
Vegetation type scaled according to relative attractiveness to insects (farmland vegetation rated a maximum of 10).	7.1	1-10	3.1
Groundwater potential yield, gpm	4.6	0-8	3.3
Groundwater chloride, ppm	430	50-1400	360
Soil limitations to agriculture or development (1 = severe; 2 = moderate; 3 = slight).	2.0	1-3	0.76
Soil capability class	5.0	2-7	1.7
Weighted value: (soil capability class)* (percent of soil association in dominant soil association)/100.	2.2	0-6	2.0

limitation that restrict their use, to 8: that have limitations that ". . . restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes" Soil Survey of Virgin Islands of the United States, page 32), and the weighted value of [(soil capability class)(percent of soil association in dominant soil series)/100] was usually less than 4, indicating that fewer traps were located on land with more severe limitations to use.

IV. RESULTS OF STATISTICAL ANALYSES

Statistical analyses were calculated in three main parts: analysis of variance, correlation, and multiple regression. Significance of average and selected types of obstruction to the north, west, south, and east of traps, direction of slope at trap site and in vicinity of traps, land-use category, vegetation type, geology type, soil association, and weighted soil association was determined by analysis of variance for each of the five insect-collection categories. Since there are unequal numbers of observations in each class or level for these criteria (a complete data listing is included in Appendix B), analyses were calculated using the SAS procedure for regression, which performs a correct analysis of variance calculation in this case. If any analysis showed that certain level(s) contained only one observation, this level(s) was deleted and a second analysis calculated based on the new data set created after the deletion(s). The significance of F-tests from these calculations is shown in Table X for each criteria. The criteria showing significant differences among mean collections were

TABLE X. SIGNIFICANCE LEVELS FROM ANALYSIS OF VARIANCE TESTS OF TRAP LOCATION CRITERIA ON THE COLLECTION OF TOBACCO HORNWORM AND WHITE BELLY[a]

			Collection category[c]				
Criteria[b]	Number of observations	Number of levels	Male	Mated female	Virgin female	Total	White belly
OBTNA	50	4	31	14	19	20	39
OBTNS	49	4	14	10	2	9	58
OBTWA	51	4	66	82	58	74	22
OBTWS	50	4	32	18	29	26	3
OBTSA	49	3	69	96	50	79	22
OBTSS	49	3	67	92	61	76	5
OBTEA	50	4	8	8	5	5	58
OBTES	50	4	39	31	8	31	86
NSLDSI	49	7	37	8	6	26	33
NSLDVI	49	7	32	2	0	18	15
LANDU	48	5	8	35	75	12	0
VEGTY	49	7	24	31	65	24	2

TABLE X (continued)

Criteria[b]	Number of observations	Number of levels	Collection category[c] Male	Mated female	Virgin female	Total	White belly
GEOL	49	3	23	58	73	27	3
SOILAS	50	5	51	33	41	55	0

[a]The significance level listed is for calculations after any single-observation levels were deleted. For example, for the criteria OBTNA on the male collection, initially there were five levels (B, C, G, S, and T), in which the number of observations in each were 6, 1, 4, 4, and 36, respectively. Level C (N = 1) was deleted and analysis of variance calculated on the remaining four levels (B, G, S, and T). The F-test was not significant (31% level).

[b]OBTNA and OBTNS, OBTWA and OBTWS, OBTSA and OBTSS, and OBTEA and OBTES are average and selected types of obstruction to the north, west, south, and east of traps, respectively; NSLDSI and NSLDVI are direction of slope at trap site and in vicinity of traps, respectively, (Table I, page 20); LANDU is land-use category (Table II, page 23); VEGTY is vegetation type (Table III, page 24); GEOL is geology type (Table IV, page 25); SOILAS is soil association. (A complete listing of computer names is given in Appendix A.)

[c]The first four collection categories are tobacco hornworm, *Manduca sexta*, and the fifth is *M. rustica harterti*. All collections were coded to $\sqrt{y_i}$ for these calculations.

(looking only at those significant at the 10% level, $p < 0.10$, and citing the entry with the highest mean): for male, average type of easterly obstruction (tree) and land-use category (wooded slopes).

Mated female collections were significantly affected by selected type of northerly obstruction (tree), average type of easterly obstruction (tree), and direction of slope at site in vicinity (northwest).

Collection of virgin female was significantly affected by selected type of northerly and easterly obstruction (tree), average type of easterly obstruction (tree), and slope direction at site and in vicinity of traps (northwest). None of the soil-based parameters significantly affected virgin female collections.

Total tobacco hornworm collection was significantly affected by selected type of northerly obstruction (tree) and average type of easterly obstruction (tree).

The collection of white belly was significantly affected by selected type of easterly and southerly obstruction (grass or ground), land-use category (wooded slopes), geology type (Mount Eagle volcanics), vegetation type (cactus-shrub-woodland), and soil association (Cramer-Isaac).

The only parameters not significantly affecting any of the collection categories were average type of northerly, westerly, and southerly obstruction.

Each parameter listed in Table VIII, pages 34 and 35, and Table IX, page 37, and these parameters coded SQ and LN (For complete listing of names and codings, see Appendix A) were correlated to each collection category. A ranked summary of those correlations having probability of a greater $|r| < 0.25$ (r, the simple correlation coefficient) is shown in Appendix C. For male, the criteria significantly related were: average slope to westerly obstruction (coded LN), distance to roadways (coded SQ and LN), soil limitations to agriculture or development (uncoded and coded SQ and LN), and average distance to westerly obstruction (coded LN).

Mated tobacco hornworm collection was significantly correlated to selected slope to northerly (coded SQ and LN), westerly (coded LN), and southerly (coded LN) obstruction, average slope to northerly (uncoded and coded SQ and LN), westerly (coded LN), and southerly (coded LN) obstruction, weighted northerly (uncoded and coded SQ and LN) and westerly obstruction, and average distance to northerly (uncoded and coded SQ and LN) obstruction.

Significantly correlated with virgin female collections were soil limitations to agriculture or development (uncoded and coded SQ and LN), average distance to northerly (uncoded and coded SQ) and westerly (coded SQ and LN) obstruction, elevation of trap site (uncoded and coded SQ), relative UV output of incident light (uncoded and coded SQ and LN), (relative UV output of incident light)(relative intensity of incident light), $\left[(\text{relative UV output of incident light})(\text{incident light type})^2\right]$, and deviation of slope in vicinity of trap (coded to SQ).

Total tobacco hornworm collections were significantly correlated to average slope to westerly (coded LN) and southerly (coded LN) obstruction, distance to roadway (coded LN), selected slope to southerly obstruction (coded LN), soil limitations to agriculture or development (uncoded and coded SQ and LN), and to average distance to westerly obstruction (coded LN).

White belly collection was significantly correlated to the most criteria (27): average slope to southerly obstruction (coded SQ and LN), selected slope to westerly (coded SQ and LN) and southerly (coded LN) obstruction, average distance to westerly (uncoded and coded SQ) and southerly (uncoded and coded SQ) obstruction, and selected distance to north shoreline (uncoded and coded SQ and LN), to west shoreline (uncoded and coded SQ), to south shoreline (coded LN), to southeast shoreline (coded LN), and to northeast shoreline (uncoded and coded SQ and LN), percent obstruction to the south (coded LN), mean selected distance to obstruction, groundwater chloride, weighted obstruction to the north, and soil limitations for agriculture or development (uncoded and coded SQ and LN).

The percent, average, and selected procedures of computing obstruction were compared via the SAS multiple regression, maximum R^2 improvement technique. Models were constructed using each collection category coded to SQ(y_i) as the dependent variable and criteria obtained from each of the three methods uncoded and in combination with these coded to SQ(x_i) and to LN(x_i) as the independent variables. Comparing R^2 of these models showed the average method of calculating percent obstruction superior for describing the variation in every collection category. Values are summarized in Table XXXIX, Appendix D for uncoded and coded models with 5, 10, and a maximum number of criteria in the model as determined by the step at which the next additional variable did not increase R^2 of the total equation by at least 0.5%. For male, values of R^2 were 8, 25, and 3 for the percent, average, and selected methods, respectively, with 3, 9, and 1 independent variables in the uncoded model, with maximum equation size as determined above. With coded model, R^2 increased to 33, 66, and 46 for percent, average, and selected, respectively, with 9, 16, and 13 criteria included in the respective models. The average method also gave higher R^2 for the remaining collections; it was 25, 18, 24, and 33 with the uncoded model for mated female, virgin female, total tobacco hornworm, and white belly, respectively. With coded model these values were increased to 65, 78, 68, and 80, respectively.

The SAS stepwise regression procedure, maximum R^2 improvement technique, was used to compare several combinations of factors. Models were constructed to compare: (1) all factors, using average obstruction parameters; (2) factors measurable on-site; (3) factors measurable from the on-site survey; (4) factors obtained from descriptive data of locations; (5) factors economical to measure; and (6) factors measurable by untrained personnel. A complete list of independent variables in each model is included as Tables XL to XLV, Appendix D. The effectiveness of each model in describing the variability in the five collection categories (dependent variables) is summarized in Table XI for male, Table XII for mated female, Table XIII for virgin female, Table XIV for total tobacco hornworm, and Table XV for white belly. For male, criteria economical to measure accounted for the most variability in collection data (98%) but all criteria (model 1) and criteria measurable from the on-site survey accounted for nearly as much (both 90%). However, fewer criteria were used in model 1 than

TABLE XI. COMPARISON OF THE EFFECTIVENESS OF SIX COMBINATIONS OF CRITERIA IN ACCOUNTING FOR THE VARIATIONS AMONG MALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT INSECT TRAPS AT DIFFERENT LOCATIONS

	R^2 for each model size as listed					Maximum size[b]		
Model[a]	Best 5	Best 10	Best 15	Best 20	Best 25	R^2	Number of variables	Total[c]
1	44	66	76	86	91	90	23	115
2	19	21	--	--	--	20	7	16
3	43	60	70	77	87	90	28	67
4	38	52	69	73	75	72	17	48
5	38	56	67	82	88	98	32	82
6	19	29	32	32	--	31	13	23

[a]Models are listed on page 44.

[b]The step at which the next variable added did not increase R^2 of the total equation by 0.5%.

[c]Total number of independent variables available for inclusion in the equation.

TABLE XII. COMPARISON OF THE EFFECTIVENESS OF SIX COMBINATIONS OF CRITERIA IN ACCOUNTING FOR THE VARIATIONS AMONG MATED FEMALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT INSECT TRAPS AT DIFFERENT LOCATIONS

	R^2 for each model size as listed					Maximum size[b]		
Model[a]	Best 5	Best 10	Best 15	Best 20	Best 25	R^2	Number of variables	Total[c]
1	49	69	81	86	93	98	30	115
2	17	20	--	--	--	20	9	16
3	49	66	72	83	91	89	23	67
4	26	42	53	67	77	79	27	48
5	44	60	74	81	90	89	23	82
6	17	25	28	28	--	25	10	23

[a]Models are listed on page 44.

[b]The step at which the next variable added did not increase R^2 of the total equation by 0.5%.

[c]Total number of independent variables available for inclusion in the equation.

TABLE XIII. COMPARISON OF THE EFFECTIVENESS OF SIX COMBINATIONS OF CRITERIA IN ACCOUNTING FOR THE VARIATION AMONG VIRGIN FEMALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT INSECT TRAPS AT DIFFERENT LOCATIONS

	R^2 for each model size as listed					Maximum size[b]		
Model[a]	Best 5	Best 10	Best 15	Best 20	Best 25	R^2	Number of variables	Total[c]
1	40	66	78	87	94	95	27	115
2	10	13	--	--	--	12	7	16
3	38	50	58	61	71	59	16	67
4	30	52	63	70	81	65	18	48
5	29	57	72	78	84	98	33	82
6	21	34	39	41	--	38	13	23

[a]Models are listed on page 44.

[b]The step at which the next variable added did not increase R^2 of the total equation by 0.5%.

[c]Total number of independent variables available for inclusion in the equation.

TABLE XIV. COMPARISON OF THE EFFECTIVENESS OF SIX COMBINATIONS OF CRITERIA ACCOUNTING FOR THE VARIATION AMONG TOTAL TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT INSECT TRAPS AT DIFFERENT LOCATIONS

	R^2 for each model size as listed					Maximum size[b]		
Model[a]	Best 5	Best 10	Best 15	Best 20	Best 25	R^2	Number of variables	Total[c]
1	38	66	76	85	93	98	29	115
2	12	16	--	--	--	15	8	16
3	26	46	58	71	82	70	19	67
4	27	47	63	78	84	86	27	48
5	34	50	65	71	79	87	29	82
6	24	34	39	39	--	39	15	23

[a]Models are listed on page 44.

[b]The step at which the next variable added did not increase R^2 of the total equation by 0.5%.

[c]Total number of independent variables available for inclusion in the equation.

TABLE XV. COMPARISON OF THE EFFECTIVENESS OF SIX COMBINATIONS OF CRITERIA IN ACCOUNTING FOR THE VARIATION AMONG WHITE BELLY COLLECTIONS IN 51 BLACKLIGHT INSECT TRAPS AT DIFFERENT LOCATIONS

Model[a]	R^2 for each model size as listed					Maximum size[b]		
	Best 5	Best 10	Best 15	Best 20	Best 25	R^2	Number of variables	Total[c]
1	70	83	90	96	98	96	20	115
2	31	36	--	--	--	36	9	16
3	65	79	86	90	93	86	17	67
4	51	67	73	87	89	86	19	48
5	62	75	83	91	98	96	21	82
6	42	53	58	59	--	50	8	23

[a]Models are listed on page 44.

[b]The step at which the next variable added did not increase R^2 of the total equation by 0.5%.

[c]Total number of independent variables available for inclusion in the equation.

either 3 or 5 (23 versus 28 and 32, respectively). Those criteria that may be evaluated in the field and that may be evaluated by untrained personnel were unsatisfactory in describing variability in the male collection data (R^2 of 0.20 and 0.31, respectively).

Variability in mated female collection was best accounted for by model 1 (98% with 30 criteria included), next by models 3 and 5 (89% with 23 criteria included), and then model 4 (79% with 27 criteria included). Models 2 and 6 again did a poor job with 20 and 25%, respectively.

For virgin female collection, model 5 accounting for 98% and 33 criteria and model 1 95% and 27 criteria, were the only models with high R^2. Models 4 and 3 accounted for 65 and 59% with 18 and 16 criteria, respectively. Model 6 was next with 38% with 13 criteria, and model 2 again had the lowest R^2, only 0.12 with 7 variables.

For total tobacco hornworm collection, model 1 had the highest R^2 of 0.98 with 29 criteria, followed by models 5 and 4 (0.87 and 0.86 with 29 and 27 criteria, respectively), model 3 with R^2 of 0.70 with 19 criteria, and again models 6 and 2 had the lowest R^2 of 0.39 and 0.15, respectively.

For white belly, models 1 and 5 had the highest R^2 of 0.96 with 20 and 21 criteria, respectively, and models 3 and 4 were next, both with 0.86 and 17 and 19 criteria, respectively. Models 6 and 2 again had the lowest R^2, but at 0.50 and 0.36 with 8 and 9 criteria, respectively, they accounted for considerably more of the variability in white belly collections than in any of the tobacco hornworm collection categories.

In summary of these comparisons at the "maximum" model size, having all the factors available for inclusion in the regression equations (model 1) gave consistently high R^2 (0.90, 0.98, 0.95, 0.98, and 0.96 for male, mated female, virgin female, total tobacco hornworm, and white belly, respectively). However, with 82 factors available compared to 115 for model 1 (and supposedly less expensive to evaluate), the criteria deemed economical to measure accounted for more variability in male and virgin female and an equal amount in white belly collections (98, 89, 98, 87, and 96%, respectively, for male, mated female, virgin female, total tobacco hornworm, and white belly, respectively). Those factors that may be evaluated from an on-site survey accounted for a large portion of the variability in male, mated female and white belly, but a lower portion for virgin female and total tobacco hornworm (90, 89, 86, 59, and 70%, respectively). Criteria that may be obtained from descriptive data of locations with 48 factors available for inclusion accounted for a fair portion of the variability in male and virgin female, somewhat more for mated female, and a very good portion of total tobacco hornworm and white belly (72, 65, 79, 86, and 86%, respectively). The criteria that may be evaluated by untrained personnel and that may be evaluated in the field accounted for a disappointingly low amount of variability: the first accounted for 31, 25, 38, 39, and 50% for male, mated female, virgin female, total tobacco hornworm and white belly, respectively, and the latter 20, 20, 12, 15, and 36%, respectively.

From a practical standpoint, equations with such a large number of independent variables may be difficult to use. However, looking at the results of male tobacco hornworm collections versus all factors, Table XVI, the regression coefficients (b values) indicate that collections increased with certain factors and decreased with others. (Standard partial regression coefficients, Snedecor and Cochran, page 398, herein referred to as standard b values, which represent the predicted change in the dependent variable for a unit change in the particular independent variable, may be used to compare the relative effect a change in their magnitude has on the dependent variable.) The effect of criteria entered only once can readily be interpreted.

Several criteria are entered in the equation more than once due to the coded values. Care must be taken to consider the aggregate effect of all entries for each criterion. For example, soil limitations to agriculture or development (SOILZ) showed a decrease in collection per unit change (standard b value) of 4.70. (A higher scaled value implies less severe limitations, Table VI, page 27.) This is not as would be expected when traps are placed on soils having less severe limitations. (However, this may indicate that more insects were collected in the less developed areas.) When both components included in the equation are considered to estimate the change in male collection due to this criterion (assuming for this consideration that other criteria remain constant) the contribution due to this criterion remained positive, increased as soil limitations changed from 1 to 2, and decreased as soil limitations changed from 2 to 3. (Values were 3.33, 3.43, and 2.99 for soil limitations of 1, 2, and 3, respectively.) Thus, according to these data, male collection would tend to first increase, then decrease as soil limitations become less severe. This total contribution of

TABLE XVI. RESULTS OF MULTIPLE REGRESSION OF MALE TOBACCO HORNWORM COLLECTION ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS AT 51 LOCATIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				30.6			
LNOBDWA	1	0.4466	0.0003	-1.074	0.0001	0.1393	-3.10
SOILZ	1	0.3556	0.0008	-2.187	0.0004	0.5135	-4.70
LNOBWW	1	0.2673	0.0024	-0.432	0.0001	0.0773	-1.05
SQOBDWA	1	0.5920	0.0001	0.151	0.0001	0.0243	1.97
OBWE	1	0.2043	0.0061	0.046	0.0011	0.0121	0.67
OBSSA	1	0.2878	0.0018	-0.014	0.0001	0.0024	-1.94
OBWS	1	0.3788	0.0006	0.039	0.0013	0.0106	1.09
GWPYI	1	0.2416	0.0034	0.240	0.0001	0.0420	2.21
SQGWPYI	1	0.3113	0.0013	-0.640	0.0001	0.1195	-2.08
SQELEV	1	0.1730	0.0103	-0.028	0.0011	0.0073	-0.43
LNSLDSI	1	0.1074	0.0374	0.043	0.0091	0.0152	0.21
LNOBWN	1	0.1033	0.0410	-1.146	0.0001	0.2007	-1.92
OBSNA	1	0.2304	0.0040	0.014	0.0003	0.0031	1.46
SQSOILZ	1	0.2314	0.0040	5.522	0.0008	1.4090	4.42
LNSOICAP	1	0.2248	0.0044	15.155	0.0795	8.4136	16.36
SOICAP	1	0.1723	0.0105	4.716	0.0286	2.0627	22.13
LIGHT2	1	0.1817	0.0089	0.007	0.0214	2.88×10^{-3}	0.25
SQSOICAP	1	0.1920	0.0074	-34.816	0.0455	16.8108	-38.67
ROAD1	1	0.1440	0.0177	-8.7×10^{-4}	0.0003	1.9×10^{-4}	-1.86
ROAD2	1	0.2703	0.0023	1.9×10^{-6}	0.0006	4.7×10^{-7}	1.67
VEGSC	1	0.2823	0.0019	0.043	0.0010	0.0112	0.38
SQSLPSI	1	0.1087	0.0364	0.067	0.0062	0.0225	0.30
SQOSTOTA	1	0.1358	0.0207	0.095	0.0207	0.0390	0.66

TABLE XVI (continued)

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique.

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	23	5.6428	0.2453	0.0001	0.90
Error	27	0.6199	0.02296		
Corrected total	50	6.2628			

this component is partially inconsistent with the assumption that collections should increase when traps are placed on soils having less-severe limitations.

The effect of groundwater potential yield (GWPYI) was also inconsistent. The aggregate effect estimated from b values was to decrease collections, although less at higher values of groundwater yield. (The portion of male collection due to this variable was estimated to be -0.43, -0.32, -0.13, and 0.11 for rates of 2, 4, 6, and 8 gpm, respectively.) It would appear that available groundwater would be beneficial to insect host plants, and thus collections would be expected to increase with increasing potential groundwater yield. Collections were estimated to decrease as average distance to westerly obstruction (OBDWA) increased, as would be expected if obstructions reduced the attractive potential of BL lamps. (Estimated contributions were -0.92, -2.54, -3.44, and -3.30 for distances of 3, 20, 100, and 500 ft., respectively.) Collections decreased with an increase in weighted northerly (OBWN) and westerly (OBWW) obstruction, but increased with weighted southerly (OBWS) and easterly (OBWE) obstruction. Insects tend to land on illuminated objects near traps and may later fly and be captured. This would tend to increase collections with certain obstructions near traps. As predicted by b values, very little change occurs due to soil capability class (SOICAP). Contributions were -29.2, -29.8, and -29.5 for soil capability values of 2, 5, and 7, respectively.

Some reasons for discrepancies between predicted and expected results could be: too many independent variables in the equation (these were all significant, however, at $p < 0.0001$), differences in insect population levels at the different trap locations (a basic assumption in this study is that BL traps collect a relatively constant percentage of insects regardless of the population), an error due to using average insect collections over a long time period as compared to using collections over definite peak periods, errors in measuring the independent variables, the change of some independent variables with time, while others remain relatively constant, and the fact that the criteria described herein are only a portion of the many factors that affect insect behavior in the vicinity of BL traps. In order to obtain a better estimate of factors surrounding high collecting sites as compared to low collecting sites, stepwise regression, maximum R^2 improvement technique, was rerun for each dependent variable, first after deleting the low collecting traps, then after deleting the high. Results follow at the step at which one additional independent variable did not increase R^2 of the entire equation by at least 1%.

For tobacco hornworm data, subsets were formed by deleting collections ≥ 0.42 and then deleting collections ≤ 1.0, leaving the smallest 18 collections and the largest 16, respectively. Statistics describing the equation for the 18 smallest male collections (Table XVII) indicate that the 10 factors affecting these collections most significantly were distance from north shoreline (SHORN), weighted westerly obstruction (OBWN), soil limitations to agriculture or development (SOILZ), land-use category scaled according to estimated ability to support an insect population (LANSC), deviation of slope at site from prevailing wind (SLDSI), groundwater potential yield

TABLE XVII. RESULTS OF MULTIPLE REGRESSION OF MALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 18 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				-0.5092			
SHORN	1	0.03144	0.0001	0.0366	0.0001	0.00291	0.593
OBWW	1	0.02191	0.0001	0.0504	0.0001	0.00450	0.631
SQSOILZ	1	0.01763	0.0001	0.6119	0.0215	0.20891	2.099
LANSC	1	0.02564	0.0001	0.0449	0.0001	0.00313	0.901
SQSLDSI	1	0.01232	0.0003	0.0087	0.0004	0.00118	0.391
LNGWPYI	1	0.00224	0.0121	-0.0413	0.0004	0.00570	-0.439
LNOBDSA	1	0.00327	0.0052	0.0248	0.0022	0.00507	0.282
SOILZ	1	0.00355	0.0043	-0.2854	0.0086	0.07879	-2.649
OBDWA	1	0.00197	0.0160	2.63×10^{-4}	0.0035	5.98×10^{-5}	-0.279
ROAD2	1	0.00376	0.0038	6.0×10^{-8}	0.0038	1.0×10^{-8}	0.248

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on male collections < 0.42 (MALE, Table XXV, Appendix B).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	10	0.1237	0.01237	0.0001	0.99
Error	7	0.0014	0.00020		
Corrected total	17	0.1251			

(GWPYI), average distance to southerly and westerly obstruction (OBDSA and OBDWA, respectively), and the calculation: (distance to roadway)^2 (type of roadway); ROAD2. The criteria soil limitations to agriculture or development was entered twice, uncoded and coded SQ. The aggregate effect of this factor on the 18 smallest male collections at values of 1, 2, and 3 was 0.327, 0.295, and 0.205, respectively, a decrease with decreasing soil limitations.

For the model with only the largest 16 male collections (Table XVIII), male collection decreased with increasing soil capability class (SOICAP) (i.e. decrease in collection on poorer soil) and average slope to westerly obstruction (OBSWA), remained nearly constant for soil limitations to agriculture or development (SOILZ) (the aggregate contributions to these collections were -216, -216, and -217, respectively, for SOILZ = 1, 2, and 3), and increased for mean of the four average slopes to obstruction (OSTOTA), relative UV output of incident light, and increased very slightly with average distance to westerly obstruction and slope at site.

Criteria deemed important at the largest male-collecting sites, but not included at the lowest collecting sites were soil capability class (SOICAP), relative UV output of incident light (ILITY) and slope of site. Also not included were average slope to westerly obstruction (OBSWA) and mean of the four average slopes to obstruction. However, although not identical, the criterion weighted westerly obstruction that was included in the model of smaller collections was obtained in a similar manner to the data for these.

TABLE XVIII. RESULTS OF MULTIPLE REGRESSIONS OF MALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 16 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				215.2966			
LNSOICAP	1	0.20875	0.0005	-0.9512	0.0001	0.06915	-1.356
LNOBSWA	1	0.20813	0.0005	-0.4149	0.0001	0.03006	-1.981
SOILZ	1	0.16454	0.0008	46.6658	0.0028	9.19021	124.264
LNSOILZ	1	0.21478	0.0005	89.9953	0.0022	16.81272	141.987
LNOSTOTA	1	0.06540	0.0053	0.4734	0.0002	0.04604	1.661
SQILITY	1	0.14657	0.0010	2.1309	0.0003	0.23458	1.071
SQSOILZ	1	0.07185	0.0044	-262.8927	0.0025	50.29768	-265.863
OBDWA	1	0.06285	0.0058	6.88×10^{-4}	0.0044	1.5×10^{-4}	0.324
SLPSI	1	0.03510	0.0188	3.47×10^{-3}	0.0188	1.09×10^{-3}	0.210

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on male collections > 1.0 (MALE, Table XXV, Appendix B).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	9	1.1780	0.13089	0.0005	0.98
Error	6	0.0208	0.00346		
Corrected total	15	1.1987			

Five criteria included in the calculation for the smallest collecting traps were not included in the model for the largest: distance to north shoreline (SHORN), land-use category scaled according to estimated ability to support an insect population (LANSC), deviation of slope at site (SLDSI), groundwater potential yield (GWPYI), and the generated factor (distance to roadway)^2(relative traffic flow on adjacent roadway); ROAD2. Criteria included in this model that had criteria in the other model that were obtained similarly were weighted westerly obstruction (OBWW) and average distance to southerly obstruction (OBDSA).

Criteria entered in both models were soil limitations to agriculture or development (SOILZ), uncoded and coded SQ, and average distance to westerly obstruction. The slopes of the three factors entered in both models were opposite in each case. However, the b values for average distance to westerly obstruction were both very small and therefore had very little effect on estimated collection. The aggregate effect of soil limitations to agriculture or development (described above) was small but positive for the smallest collections, but large and negative for the largest collections. Results of multiple regression calculations of the largest and smallest mated female, virgin female, total tobacco hornworm, and white belly collections are included as Tables XLVI to XLIX, Appendix D.

Multiple regression equations calculated by the maximum R^2 improvement technique have been shown to be important in that they show that the measured factors do account for a large portion of variability in collection data. For the groups of smallest collections and largest collections, this is done with only 8 to 10 independent variables in the equations. As noted above, however, inconsistencies may be found when practical application of the resulting equations is to be made.

Additional calculations run using the SAS multiple regression stepwise technique may give additional insight into use of these factors for practical application. Calculations made with all factors (model 1) and with only the largest and the smallest collections showed the stepwise technique retained considerably fewer criteria for most collection categories than the maximum R^2 improvement technique (even though F-tests of the sequential and partial mean squares and t-tests of the b values from the maximum R^2 improvement technique were highly significant). The stepwise technique as used herein included criteria significant at the 50% level, but retains only those significant at the 10% level.

For male, with all 51 collections, five factors were deemed significant (Table XIX). Collections were predicted to decrease with distance to roadway (DROAD), increase with relative UV output of incident light (ILIIN) decrease with average slope to westerly obstruction (aggregate affect of LNOBSWA and SQOBSWA) and increase with groundwater potential yield (GWPYI). When looking at only the smallest 18 collections (Table XX), male collections were predicted to decrease with decreasing soil limitations to agriculture or development (SOILZ), and from the aggregate effect of distance to northeast shoreline, to be low near the shoreline and increase with distance up to 5 to 7 mi., and then decrease at longer distances.

TABLE XIX. RESULTS OF STEPWISE MULTIPLE REGRESSION OF MALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS AT 51 LOCATIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				0.2136			
LNDROAD	1	0.46289	0.0179	-0.1031	0.0018	0.03046	-0.429
LNILIIN	1	0.93021	0.0016	0.9328	0.0011	0.25989	0.454
LNOBSWA	1	0.33441	0.0417	-0.4323	0.0015	0.12480	-1.170
SQOBSWA	1	0.74013	0.0038	0.1232	0.0072	0.04373	0.957
GWPYI	1	0.28441	0.0595	0.0246	0.0595	0.01290	0.227

[a]Computer names are defined in Appendix A. Calculations were made via SAS, stepwise regression technique, with $p < 0.10$ level for retention of independent variables.

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	5	2.7520	0.55041	0.0002	0.44
Error	45	3.5107	0.07802	.	
Corrected total	50	6.2628			

TABLE XX. RESULTS OF STEPWISE MULTIPLE REGRESSION OF MALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 18 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				0.0950			
LNSHORNE	1	0.04516	0.0018	0.2980	0.0014	0.07277	2.145
SHORNE	1	0.02228	0.0146	-0.0476	0.0077	0.01532	-1.632
SOILZ	1	0.01683	0.0293	-0.0400	0.0293	0.01667	-0.372

[a]Computer names are defined in Appendix A. Calculations were made via SAS, stepwise regression technique, with $p < 0.10$ level for retention of independent variables.

Source	DF	Sum of squares	Mean squares	Prob > F	R^2
Regression	3	0.08427	0.02809	0.0013	0.67
Error	14	0.04084	0.00292		
Corrected total	17	0.12512			

The only criterion entered in the equation with the largest 16 collections (Table XXI) was for decreasing collection with increasing distance to roadway. Because information is obtained on only a very few criteria, calculations as illustrated in Tables XIX, page 60, XX, and XXI, may be of more limited use in this study than with the maximum R^2 improvement technique as shown in Tables XVII, page 55, and XVIII, page 57.

V. APPLICATION OF OBTAINED RELATIONSHIPS FOR ST. CROIX, U. S. VIRGIN ISLANDS

To make suggestions for blacklight trap placement that should augment the following insect collections, significant criteria found via analysis of variance, correlation, or multiple regression (maximum R^2 improvement technique on largest collections) were summarized for each collection category.

For male tobacco hornworm, blacklight traps should be placed:

1. West of trees;
2. With little or no obstruction to the west;
3. Near roadways;
4. On soils having few limitations that restrict their agricultural use; and
5. Where there is little UV radiation in incident light.

For mated female tobacco hornworm, blacklight traps should be placed:

1. If near trees, west or south of trees;
2. With little or no obstruction to the west or south;
3. If on slopes, the slopes should face northwest;
4. Where there is little UV radiation in incident light;
5. Where there is little chloride in groundwater; and
6. Close to north or west shorelines.

TABLE XXI. RESULTS OF STEPWISE MULTIPLE REGRESSION OF MALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED FACTORS DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 16 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				1.3054			
LNDROAD	1	0.28918	0.0510	-0.0888	0.0510	0.4211	-0.491

[a]Computer names are defined in Appendix A. Calculations were made via SAS, stepwise regression technique, with $p < 0.10$ level for retention of independent variables.

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	1	0.2891	0.28918	0.0510	0.24
Error	14	0.9096	0.06497		
Corrected total	15	1.1987			

In addition, the per-trap average of this collection decreased as trap density increased.

For virgin female tobacco hornworm, blacklight traps should be placed:

1. If near trees, west or south of trees;
2. With little or no obstruction to the north or west;
3. On soils less suited to agriculture or development;
4. On slopes facing away from prevailing winds;
5. Away from busy roadways; and
6. Where there is low incident UV radiation and incident light.

For total tobacco hornworm collection, blacklight traps should be placed:

1. If near trees, west or south of trees;
2. With little or no obstruction to the north or west;
3. On soils having few limitations for agricultural use;
4. Near roadways;
5. Near the west shoreline;
6. On moderate to steeply sloping sites that face away from prevailing wind; and
7. At low elevation.

In addition, the per-trap average of this collection increased as trap density increased.

For white belly, blacklight traps should be placed:

1. Where there is little or no obstruction in any direction;
2. In areas close to host plants;
3. On slopes facing away from prevailing wind; and
4. At low elevation.

Two general differences were noted between tobacco hornworm and white belly. The tobacco hornworm collections were generally highest when there were trees north or east of traps, and white belly collections were highest where there was low obstruction in all directions. This may have been due to species differences or to population differences. Collections of white belly were several times greater than those of tobacco hornworm. It may be that certain factors, such as obstruction, do not significantly influence collections at low population levels, but would if population levels were sufficiently high.

CHAPTER V

SUMMARY AND CONCLUSIONS

Factors describing 51 blacklight insect trap locations on St. Croix, U. S. Virgin Islands, were related to five insect collection categories. Data were obtained from an on-site survey of trap locations describing the following: slope of land at trap site, deviation of slope at trap site from prevailing winds, distance to and relative traffic flow on adjacent roadway, relative UV output and relative intensity of incident light, percent northerly, westerly, southerly, easterly, and total obstruction to lamp radiation, slope and distance to obstructions in each direction by "average" and "selected" methods, and weighted values of obstruction to each direction.

Data were obtained from descriptive data of locations for: trap density, distance of trap from north, west, south, southeast, and northeast shorelines, elevation above sea level, slope of land in vicinity of trap, deviation of slope in vicinity of trap from prevailing wind, land-use category (also scaled according to estimated ability to support an insect population), vegetation type (also scaled according to relative attractiveness to insects), geology type, groundwater potential yield, groundwater chloride, soil limitations to agriculture or development, soil association, and soil capability class.

Factors obtained from the continuous data and codings by square root and logarithmic transformations were related to male, mated female, virgin female, total tobacco hornworm, and white belly collections via simple correlation and multiple regression calculations. The significance of 14 discrete factors was determined by analysis of variance calculations: average and selected types of obstruction to north, west, south, and east of traps, direction of slope at trap site and in vicinity of traps, land-use category, vegetation type, geology type, and soil association. The measure (class) corresponding to the highest mean in each class for each criteria showing a significant difference(s) ($p < 0.10$) among means was: for male, trees east of traps, and land-use category; for mated female, northerly and easterly trees, and trap sites and vicinities around traps that sloped to the northwest (these deviated 135° from prevailing winds); for virgin female, northerly and easterly trees, trap sites and vicinities around traps that sloped to the northwest; and for total tobacco hornworm, trees to the north and east; and for white belly, grass or ground to the west and south, land-use category, vegetation type, geology type, and soil association.

Correlations showed the following criteria significantly related ($p < 0.05$) to male: slope to westerly obstruction and distance to roadway; to mated female: slope to westerly and southerly obstruction, and weighted northerly obstruction; to virgin female: soil limitations to agriculture or development, distance to westerly and northerly obstruction; to total tobacco hornworm: slope to westerly obstruction and distance to roadway; and to white belly: slope and distance to westerly and southerly obstruction, distance to north, west, and northeast shorelines, percent southerly obstruction, and mean distance to obstruction.

Multiple R^2 was calculated to compare the efficiency of the percent, average, and selected methods of obtaining obstruction in accounting for variability in insect collection data. The average method was most efficient for each collection category.

Also compared via multiple regression calculations were the efficiency of several models constructed to compare: (1) all factors using the data of obstruction obtained by the average method; (2) factors measurable on-site; (3) factors measurable from the on-site survey; (4) factors obtained from descriptive data of locations; (5) factors economical to measure; and (6) factors measurable by untrained personnel. Models accounting for the most variability in data were: for male and virgin female, criteria economical to measure, both 98%; for mated female and total tobacco hornworm, all criteria, both 98%, and for white belly, all criteria and criteria economical to measure, both 96%. Models of all criteria and criteria economical to measure consistently described collections to a high degree (R^2 = 0.87 to 0.98), models of criteria measurable from an on-site survey and obtainable from descriptive data of locations gave intermediate values (R^2 = 0.59 to 0.90), and criteria measurable on-site and by untrained personnel were inadequate in describing collections (R^2 = 0.12 to 0.50).

When initially attempting to apply the multiple regression equations to site selection, discrepancies were found between predicted effects of some factors and trends observed in practice. Also, with 20 to 30 criteria in the equations, interpretation was difficult. To obtain a more accurate estimate of conditions surrounding the largest and smallest collecting sites, multiple regression calculations were rerun with approximately 17 of the smallest collections and 16 of the largest collections for each collection category. Results with the smallest male collections showed that $R^2 = 0.99$ with 10 factors in the equation, and with the largest collections $R^2 = 0.98$ with 9 factors. Similarly, R^2 with smallest and largest mated female collections were 0.99 and 1.00, respectively, with 8 factors in both equations; for virgin female R^2 was 0.99 and 1.00 with 7 and 8, respectively; for total tobacco hornworm R^2 was 0.99 for both with 8 and 10, respectively, and for white belly R^2 was 0.99 and 1.00 with 10 and 5 factors, respectively.

By considering significant relationships from analysis of variance calculations, correlation analysis, and multiple regression calculations, male tobacco hornworm collection in blacklight traps may be augmented by locating traps on the west side of trees, at sites that are open to the west, near roadways, near soils that have few limitations that restrict their agricultural use, and at sites of low relative UV output of incident light.

For mated female, traps should be placed west or south of trees (if placed near trees), with little or no obstruction to the west or south, on slopes facing northwest (if on sloping land), where there is little UV radiation in incident light, where there is little chloride in groundwater, and nearer north or west shorelines.

For virgin female, traps should be placed west or south of trees (if near trees), where there is little or no obstruction to the north or west, on soils less suited to agriculture or development, on slopes that face away from prevailing winds, away from busy roadways, where there is low intensity of incident UV radiation, and low intensity of incident light.

For total tobacco hornworm, traps should be placed west or south of trees (if near trees), with little or no obstruction to the north or west, on soils having few limitations for agricultural use, near roadways, nearer the west shoreline, on moderate to steeply sloping sites that face away from prevailing wind, and at low elevation.

For white belly, traps should be placed where there is little or no obstruction in any direction, close to host plants, on slopes facing away from prevailing wind, and at low elevation.

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APPENDIXES

APPENDIX A

TABLE XXII. ABBREVIATIONS AND SYMBOLS

BL	Blacklight
UV	Ultraviolet
SAS	Statistical Analysis System
LN	Natural logarithm
SQ	Square root
r	Simple correlation coefficient
R^2	Multiple coefficient of determination

TABLE XXIII. SUMMARY OF COMPUTER NAMES AND DESCRIPTIONS OF VARIABLES OBTAINED FROM ON-SITE SURVEY

Computer name	Description[a]
SLPSI	Slope of trap site, percent
SQSLPSI	$\sqrt{SLPSI}$
LNSLPSI	ln(SLPSI + 1)
NSLDSI	Direction of slope at trap site (Table I, page 20)
SLDSI	Deviation of slope at trap site from prevailing wind (Table I, page 20)
SQSLDSI	$\sqrt{SLDSI}$
LNSLDSI	ln(SLDSI + 1)
DROAD	Distance to roadway, ft.
SQDROAD	$\sqrt{DROAD}$
LNDROAD	ln(DROAD)
TROAD	Relative traffic flow on adjacent roadway
SQTROAD	$\sqrt{TROAD}$
LNTROAD	ln(TROAD)
ILITY	Relative UV output of incident light
SQILITY	$\sqrt{ILITY}$
LNILITY	ln(ILITY)
ILIIN	Relative intensity of incident light
SQILIIN	$\sqrt{ILIIN}$
LNILIIN	ln(ILIIN + 1)
OBPN	Percent northerly obstruction
SQOBPN	$\sqrt{OBPN + 20}$
LNOBPN	ln(OBPN + 20)
OBPW	Percent westerly obstruction
SQOBPW	$\sqrt{OBPW + 20}$
LNOBPW	ln(OBPW + 20)
OBPS	Percent southerly obstruction
SQOBPS	$\sqrt{OBPS + 20}$
LNOBPS	ln(OBPS + 20)
OBPE	Percent easterly obstruction
SQOBPE	$\sqrt{OBPE + 20}$
LNOBPE	ln(OBPE + 20)

TABLE XXIII (continued)

Computer name	Description[a]
OBPTOT	Percent total obstruction
SQOBPTOT	$\sqrt{OBPTOT + 20}$
LNOBPTOT	ln(OBPTOT + 20)
OBSNA	Average slope to northerly obstruction, percent
SQOBSNA	$\sqrt{OBSNA + 23}$
LNOBSNA	ln(OBSNA + 24)
OBSWA	Average slope to westerly obstruction, percent
SQOBSWA	$\sqrt{OBSWA + 12}$
LNOBSWA	ln(OBSWA + 13)
OBSSA	Average slope to southerly obstruction, percent
SQOBSSA	$\sqrt{OBSSA + 15}$
LNOBSSA	ln(OBSSA + 16)
OBSEA	Average slope to easterly obstruction, percent
SQOBSEA	$\sqrt{OBSEA + 30}$
LNOBSEA	ln(OBSEA + 31)
OBDNA	Average distance to northerly obstruction, ft.
SQOBDNA	$\sqrt{OBDNA}$
LNOBDNA	ln(OBDNA)
OBDWA	Average distance to westerly obstruction, ft.
SQOBDWA	$\sqrt{OBDWA}$
LNOBDWA	ln(OBDWA)
OBDSA	Average distance to southerly obstruction, ft.
SQOBDSA	$\sqrt{OBDSA}$
LNOBDSA	ln(OBDSA)
OBDEA	Average distance to easterly obstruction, ft.
SQOBDEA	$\sqrt{OBDEA}$
LNOBDEA	ln(OBDEA)
OBTNA	Average type of northerly obstruction
OBTWA	Average type of westerly obstruction
OBTSA	Average type of southerly obstruction
OBTEA	Average type of easterly obstruction

TABLE XXIII (continued)

Computer name	Description[a]
OBSNS	Selected slope to northerly obstruction, percent
SQOBSNS	$\sqrt{OBSNS + 30}$
LNOBSNS	ln(OBSNS + 31)
OBSWS	Selected slope to westerly obstruction, percent
SQOBSWS	$\sqrt{OBSWS + 25}$
LNOBSWS	ln(OBSWS + 26)
OBSSS	Selected slope to southerly obstruction, percent
SQOBSSS	$\sqrt{OBSSS + 25}$
LNOBSSS	ln(OBSSS + 26)
OBSES	Selected slope to easterly obstruction, percent
SQOBSES	$\sqrt{OBSES + 45}$
LNOBSES	ln(OBSES + 46)
OBDNS	Selected distance to northerly obstruction, ft.
SQOBDNS	$\sqrt{OBDNS}$
LNOBDNS	ln(OBDNS)
OBDWS	Selected distance to westerly obstruction, ft.
SQOBDWS	$\sqrt{OBDWS}$
LNOBDWS	ln(OBDWS)
OBDSS	Selected distance to southerly obstruction, ft.
SQOBDSS	$\sqrt{OBDSS}$
LNOBDSS	ln(OBDSS)
OBDES	Selected distance to easterly obstruction, ft.
SQOBDES	$\sqrt{OBDES}$
LNOBDES	ln(OBDES)
OBTNS	Selected type of northerly obstruction
OBTWS	Selected type of westerly obstruction
OBTSS	Selected type of southerly obstruction
OBTES	Selected type of easterly obstruction
OSTOTS	Mean of the 4 average slopes to obstruction: (OBSNA + OBSWA + OBSSA + OBSEA)/4, percent
SQOSTOTA	$\sqrt{OSTOTA + 6.5}$
LNOSTOTA	ln(OSTOTA + 7.5)

TABLE XXIII (continued)

Computer name	Description[a]
OSTOTA	Mean of the 4 average distances to obstruction: (OBDNA + OBDWA + OBDSA + OBDEA)/4, ft.
SQODTOTA	$\sqrt{\text{ODTOTA}}$
LNODTOTA	ln(ODTOTA)
OSTOTS	Mean of the 4 selected slopes to obstruction: (OBSNS + OBSWS + OBSSS + OBSES)/4, percent
SQOSTOTS	$\sqrt{\text{OSTOTS} + 8}$
LNOSTOTS	ln(OSTOTS + 9)
ODTOTS	Mean of the 4 selected distances to obstruction: (OBDNS + OBDWS + OBDSS + OBDES)/4, ft.
SQODTOTS	$\sqrt{\text{ODTOTS}}$
LNODTOTS	ln(ODTOTS)
OBWN	Weighted northerly obstruction
SQOBWN	$\sqrt{\text{OBWN} + 0.7}$
LNOBWN	ln(OBWN + 1.7)
OBWW	Weighted westerly obstruction
SQOBWW	$\sqrt{\text{OBWW} + 0.5}$
LNOBWW	ln(OBWW + 1.5)
OBWS	Weighted southerly obstruction
SQOBWS	$\sqrt{\text{OBWS} + 0.2}$
LNOBWS	ln(OBWS + 1.2)
OBWE	Weighted easterly obstruction
SQOBWE	$\sqrt{\text{OBWE} + 1.2}$
LNOBWE	ln(OBWE + 2.2)
OBWTOT	Mean of the 4 weighted obstructions: (OBWN + OBWW + OBWS + OBWE)/4
SQOBWTOT	$\sqrt{\text{OBWTOT} + 0.2}$
LNOBWTOT	ln(OBWTOT + 1.2)
INDEX	Numbers observations 1 to 51
TRAPNO	Trap numbers as used in the field

TABLE XXIII (continued)

Computer name	Description[a]
LIGHT1	(ILITY)(ILIIN)
LIGHT2	(ILITY)($ILIIN^2$)
ROAD1	(DROAD)(TROAD)
ROAD2	($DROAD^2$)(TROAD)

[a]Variables are coded in the form $\sqrt{(x_i + k)}$ and $\ln(x_i + k)$, where x_i denotes the criteria at each trap site, and k, if present, is the amount added to avoid negative numbers in the coded value.

TABLE XXIV. SUMMARY OF COMPUTER NAMES AND DESCRIPTIONS OF VARIABLES OBTAINED FROM DESCRIPTIVE DATA OF TRAP LOCATIONS

Computer name	Description
TDEN	Trap density, no./mi^2 (Figure 5, page 21)
SQTDEN	$\sqrt{TDEN}$
LNTDEN	ln(TDEN + 1)
SHORN	Distance to north shoreline, mi.
SQSHORN	$\sqrt{SHORN}$
LNSHORN	ln(SHORN + 1)
SHORW	Distance to west shoreline, mi.
SQSHORW	$\sqrt{SHORW}$
LNSHORW	ln(SHORW + 1)
SHORS	Distance to south shoreline, mi.
SQSHORS	$\sqrt{SHORS}$
LNSHORS	ln(SHORS + 1)
SHORSE	Distance to southeast shoreline, mi.
SQSHORSE	$\sqrt{SHORSE}$
LNSHORSE	ln(SHORSE + 1)
SHORNE	Distance to northeast shoreline, mi.
SQSHORNE	$\sqrt{SHORNE}$
LNSHORNE	ln(SHORNE + 1)
ELEV	Elevation above sea level, ft.
SQELEV	$\sqrt{ELEV}$
LNELEV	ln(ELEV)
SLPVI	Slope of land in vicinity of trap, percent
SQSLPVI	$\sqrt{SLPVI}$
LNSLPVI	ln(SLPVI + 1)
NSLDVI	Direction of slope in vicinity of trap (Table I, page 20)
SLDVI	Deviation of slope in vicinity of trap from prevailing wind (Table 1, page 20)
SQSLDVI	$\sqrt{SLDVI}$
LNSLDVI	ln(SLDVI + 1)

TABLE XXIV (continued)

Computer name	Description
LANDU	Land-use category (Table II, page 23)
LANSC	LANDU scaled according to estimated ability to support an insect population
SQLANSC	$\sqrt{LANSC}$
LNLANSC	ln(LANSC)
VEGTY	Vegetation type (Table III, page 24)
VEGSC	VEGTY scaled according to relative attractiveness to insects
SQVEGSC	$\sqrt{VEGSC}$
LNVEGSC	ln(VEGSC)
GEOL	Geology type (Table IV, page 25)
GWPYI	Groundwater potential yield, gpm (Table V, page 26)
SQGWPYI	$\sqrt{GWPYI}$
LNGWPYI	ln(GWPYI + 1)
GWCL	Groundwater chloride, ppm (Table V, page 26)
SQGWCL	$\sqrt{GWCL}$
LNGWCL	ln(GWCL)
SOILZ	Soil limitations to agriculture or development coded as shown in Table VI, page 27)
SQSOILZ	$\sqrt{SOILZ}$
LNSOILZ	ln(SOILZ)
SOILAS	Soil association (Reference: Soil Survey of Virgin Islands of the United States, 1970)
SOIPDS	Percent of soil association in dominant soil series
SOICAP	Soil capability class
SQSOICAP	$\sqrt{SOICAP}$
LNSOICAP	ln(SOICAP)
SOICAPW	Weighted value: [(SOICAP)(SOIPDS)] /100
SOICAPWS	[(SQSOICAP)(SQIPDS)] /100
SOICAPWN	[(LNSOICAP)(SOIPDS)] /100

APPENDIX B

LIST OF DATA

TABLE XXV. INSECT COLLECTIONS IN 51 BLACKLIGHT TRAPS[a]

OBS	TRAPNO	MALE	MATED	VIRG	TOTAL	RUST
1	216	0.360	0.293	.0240	0.6770	3.24
2	224	0.693	0.693	.0400	1.4260	3.60
3	233	0.364	0.342	.0160	0.7220	1.76
4	310	0.214	0.231	.0107	0.4557	2.52
5	323	0.469	0.456	.0267	0.9517	5.29
6	331	3.062	0.818	.0374	3.9174	2.94
7	341	0.789	0.439	.0406	1.2686	2.35
8	361	1.254	0.933	.0963	2.2833	13.14
9	372	2.787	0.934	.0665	3.7875	18.07
10	415	0.525	0.320	.0133	0.8583	4.28
11	421	0.557	0.483	.0267	1.0667	4.08
12	431	0.350	0.422	.0214	0.7934	2.78
13	440	0.374	0.249	.0241	0.6471	1.34
14	443	0.375	0.534	.0536	0.9626	5.53
15	463	0.371	0.258	.0188	0.6478	6.09
16	513	1.311	0.773	.0428	2.1268	7.72
17	523	0.337	0.372	.0134	0.7224	1.97
18	526	0.459	0.448	.0292	0.9362	4.03
19	531	0.400	0.384	.0267	0.8107	3.31
20	546	1.760	1.027	.0693	2.8563	10.04
21	550	0.390	0.358	.0454	0.7934	3.17
22	567	0.816	0.332	.0401	1.1881	3.73
23	572	0.416	0.271	.0371	0.7241	6.69
24	581	0.184	0.184	.0027	0.3707	3.24
25	584	0.735	0.463	.0241	1.2221	10.76
26	591	3.166	0.780	.0408	3.9868	17.96
27	610	1.048	0.464	.0187	1.5307	15.24
28	611	0.678	0.314	.0239	1.0159	5.62
29	615	0.387	0.413	.1627	0.9627	2.15
30	633	0.571	0.427	.0133	1.0113	3.55
31	640	1.059	0.699	.0853	1.8433	6.62
32	643	0.201	0.193	.0295	0.4235	2.57
33	666	0.525	0.458	.0697	1.0527	5.28
34	670	0.591	0.468	.0535	1.1125	15.54
35	677	0.231	0.290	.0241	0.5451	5.98
36	681	1.088	0.491	.0106	1.5896	16.82
37	692	0.449	0.258	.0081	0.7151	5.16
38	711	0.722	0.390	.0241	1.1361	8.16
39	741	1.496	0.397	.0213	1.9143	8.39
40	743	1.112	0.579	.0347	1.7257	3.18
41	751	0.221	0.234	.0243	0.4793	2.39
42	760	0.075	0.123	.0161	0.2141	1.93
43	780	1.037	1.098	.0292	2.1642	15.51
44	781	0.107	0.123	.0134	0.2434	2.40
45	790	2.139	1.528	.0693	3.7363	54.99
46	793	1.389	0.587	.0241	2.0001	13.80
47	811	0.668	0.449	.0321	1.1491	5.84
48	834	0.511	0.615	.0588	1.1848	5.74
49	835	1.933	1.187	.0613	3.1813	25.92
50	842	3.523	1.200	.1120	4.8350	11.33
51	854	0.578	0.305	.0162	0.8992	4.05

[a]Collection categories are defined in Appendix A.

TABLE XXVI. ON-SITE DATA OF SLOPES, ROADWAYS, AND INCIDENT LIGHT NEAR BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	SLPSI	NSLDSI	SLDSI	DROAD	TROAD	ILITY	ILIIN
1	216	3	5	135	15	4	2	4
2	224	2	4	180	6	3	2	3
3	233	1	4	180	250	5	1	2
4	310	5	6	90	175	5	2	4
5	323	1	5	135	8	1	2	2
6	331	6	6	90	15	3	2	3
7	341	4	7	45	75	2	2	3
8	361	7	3	135	6	4	3	4
9	372	5	5	135	25	4	3	4
10	415	4	5	135	6	3	2	3
11	421	5	1	45	35	4	2	3
12	431	5	7	45	10	1	2	2
13	440	10	1	45	6	4	2	3
14	443	2	8	0	15	2	2	2
15	463	11	4	180	400	5	3	4
16	513	70	8	0	400	5	3	4
17	523	5	3	135	400	5	3	4
18	526	20	8	0	100	4	2	3
19	531	3	6	90	100	4	2	3
20	546	0	3	135	400	5	2	4
21	550	7	6	90	75	3	2	3
22	567	5	1	45	20	2	2	3
23	572	40	1	45	20	4	2	4
24	581	14	6	90	50	4	2	4
25	584	20	8	0	20	3	2	4
26	591	10	6	90	4	3	2	4
27	610	10	5	135	125	5	2	3
28	611	25	6	90	60	4	2	4
29	615	17	2	90	400	5	3	4
30	633	7	1	45	400	5	2	3
31	640	25	3	135	30	4	2	3
32	643	2	8	0	10	1	2	2
33	666	20	1	45	300	5	2	4
34	670	10	4	180	15	4	2	3
35	677	45	1	45	30	3	2	3
36	681	4	1	45	400	5	3	4
37	692	15	8	0	30	4	2	3
38	711	9	6	90	100	4	2	3
39	741	11	1	45	8	2	2	3
40	743	2	8	0	50	3	2	4
41	751	15	4	180	75	1	2	3
42	760	4	2	90	20	1	2	2
43	780	24	6	90	25	4	2	3
44	781	5	6	90	400	5	3	4
45	790	10	5	135	20	4	2	3
46	793	7	6	90	12	4	2	4
47	811	5	5	135	6	3	2	2
48	834	5	8	0	400	5	2	4
49	835	30	3	135	50	3	2	4
50	842	10	7	45	4	4	2	3
51	854	20	1	45	30	3	2	3

[a] Data names are defined in Appendix A.

TABLE XXVII. PERCENT OBSTRUCTION AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	OBPN	OBPW	OBPS	OBPE	OBPTOT
1	216	3	7	24	43	19
2	224	41	15	6	4	16
3	233	8	1	4	23	9
4	310	4	4	1	0	3
5	323	4	10	7	15	8
6	331	1	1	1	11	3
7	341	5	1	0	4	2
8	361	-1	8	16	5	7
9	372	13	12	5	4	8
10	415	6	13	3	9	8
11	421	19	4	15	39	19
12	431	1	19	14	17	13
13	440	-3	5	20	0	6
14	443	8	2	6	32	12
15	463	-1	-4	-2	4	-1
16	513	-3	26	6	-16	2
17	523	28	21	22	35	27
18	526	51	84	13	1	38
19	531	2	1	-3	-3	1
20	546	10	8	6	13	9
21	550	6	1	0	5	3
22	567	55	99	99	50	76
23	572	51	70	72	48	60
24	581	6	7	-2	-4	2
25	584	3	14	-1	-7	2
26	591	6	-1	-7	-2	-1
27	610	17	3	-3	13	7
28	611	47	13	19	19	25
29	615	28	31	22	19	25
30	633	-2	7	6	4	4
31	640	4	17	16	14	13
32	643	7	3	2	10	5
33	666	3	34	26	8	18
34	670	-1	13	-5	5	3
35	677	-15	10	15	-13	-1
36	681	3	0	-8	-4	-2
37	692	6	2	-7	-18	-1
38	711	40	43	23	40	40
39	741	54	71	99	89	78
40	743	72	50	81	24	56
41	751	14	7	6	4	8
42	760	-12	5	15	-5	1
43	780	8	-6	-6	7	1
44	781	-1	3	4	-1	1
45	790	8	-6	-9	15	2
46	793	0	0	6	4	0
47	811	22	15	42	21	25
48	834	-1	10	7	-1	3
49	835	86	99	45	25	64
50	842	10	-8	-1	10	3
51	854	-7	1	2	-11	-4

[a]Data names are defined in Appendix A. The "percent" method of obtaining data of obstruction is defined in Chapter III.

TABLE XXVIII. AVERAGE OBSTRUCTION AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	OBSNA	OBSWA	OBSSA	OBSEA	OBDNA	OBDWA	OBDSA	OBDEA	OBTNA	OBTWA	OBTSA	OBTEA
1	216	4.0	9.0	48	76.0	196	262	108	91	B	T	T	T
2	224	82.0	32.0	7	6.0	28	35	239	171	T	T	T	G
3	233	12.0	0.0	6	36.0	199	273	102	56	T	S	T	T
4	310	7.0	5.0	2	-0.5	196	158	238	171	T	T	T	B
5	323	5.0	18.0	10	19.0	250	104	150	95	T	T	T	T
6	331	1.0	-1.0	1	15.0	196	156	108	35	T	B	T	T
7	341	9.0	1.0	0	5.0	95	267	283	211	T	T	G	T
8	361	-3.0	12.0	27	7.0	125	54	33	77	T	T	T	T
9	372	21.0	16.0	6	7.0	74	23	158	217	T	T	T	T
10	415	16.0	14.0	3	16.0	34	115	240	161	T	T	T	T
11	421	35.0	6.0	31	73.0	93	58	44	23	T	T	T	T
12	431	2.0	29.0	30	28.0	450	214	79	127	B	T	T	T
13	440	-4.0	9.0	38	1.0	333	81	112	325	G	T	T	G
14	443	17.0	3.0	10	61.0	83	102	250	11	T	T	T	T
15	463	-2.0	-7.0	-3	9.0	205	206	238	80	T	T	G	G
16	513	-4.0	43.0	5	-16.0	24	125	81	24	T	T	T	T
17	523	48.0	33.0	32	83.0	45	117	70	44	T	T	T	T
18	526	-10.0	166.0	22	-1.0	28	14	133	47	T	T	T	T
19	531	4.0	0.7	-3	-4.0	121	242	619	400	B	G	G	G
20	546	20.0	10.0	11	21.0	75	120	100	125	T	T	T	T
21	550	10.0	4.0	1	6.0	175	170	242	162	T	B	T	T
22	567	19.0	85.0	200	33.0	88	6	5	27	T	T	T	T
23	572	3.0	78.0	92	-13.0	75	25	16	31	G	T	T	T
24	581	12.0	15.0	-3	-7.0	240	78	131	150	T	B	T	G
25	584	5.0	23.0	-2	-11.0	72	250	250	500	S	G	S	S
26	591	9.0	-4.0	-11	-3.0	192	100	217	267	C	S	S	C
27	610	23.0	2.0	-3	20.0	81	160	217	111	T	T	T	T
28	611	97.0	20.0	33	30.0	33	77	57	53	T	T	T	T
29	615	47.0	55.0	35	29.0	53	75	208	200	T	T	T	T
30	633	0.3	11.0	10	10.0	108	217	174	107	G	G	T	T
31	640	9.0	33.0	27	22.0	62	27	78	89	T	T	T	T
32	643	9.0	7.0	3	28.0	54	158	27	79	T	T	G	T
33	666	6.0	60.0	45	20.0	75	25	70	175	T	T	T	T
34	670	-3.0	24.0	-9	9.0	72	54	60	118	S	T	T	B
35	677	-23.0	11.0	27	-22.0	30	70	76	133	S	S	B	S
36	681	-1.0	8.0	-10	1.0	98	69	100	120	T	T	U	T
37	692	10.0	3.0	-9	-30.0	567	125	267	800	G	G	T	G
38	711	71.0	90.0	40	95.0	35	28	22	7	S	T	T	S
39	741	14.0	51.0	200	130.0	35	51	4	28	T	T	T	T
40	743	145.0	93.0	167	36.0	17	13	5	37	T	T	T	T
41	751	-18.0	11.0	38	-8.0	133	96	38	80	T	T	T	S
42	760	26.0	9.0	11	5.0	80	167	150	117	B	T	T	T
43	780	15.0	-10.0	-11	12.0	76	78	225	279	T	S	S	B
44	781	-0.2	5.0	5	0.0	304	383	640	500	T	S	S	G
45	790	14.0	-8.0	-15	23.0	127	567	417	225	T	G	G	T
46	793	2.0	0.3	-6	12.0	88	100	113	88	B	S	S	T
47	811	40.0	22.0	80	36.0	250	340	244	168	T	T	T	T
48	834	-2.0	17.0	9	-5.0	133	92	126	81	T	T	T	T
49	835	180.0	200.0	80	48.0	9	3	83	37	T	T	T	T
50	842	18.0	-12.0	2	16.0	66	25	79	117	T	S	T	T
51	854	-10.0	1.0	5	-17.0	67	43	158	175	B	S	S	B

[a] Data names are defined in Appendix A. The "average" method of obtaining criteria of obstruction is described in Chapter III.

TABLE XXIX. SELECTED OBSTRUCTION AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	OBSNS	OBSWS	OBSSS	OBSES	OBDNS	OBDWS	OBDSS	OBDES	OBTNS	OBTWS	OBTSS	OBTES
1	216	15	10	140	140	75	150	10	15	T	T	T	T
2	224	180	115	30	20	15	10	20	30	T	T	T	T
3	233	30	0	15	60	20	20	10	20	T	S	T	T
4	310	9	7	5	7	75	75	200	25	B	T	T	T
5	323	8	35	25	25	150	6	75	60	B	T	T	T
6	331	5	3	2	35	30	150	75	30	T	T	T	T
7	341	10	3	0	5	15	250	50	20	T	T	T	T
8	361	3	15	30	20	100	40	30	30	T	T	T	T
9	372	40	20	15	15	20	25	25	200	T	T	T	T
10	415	45	45	7	17	25	25	100	40	T	T	T	T
11	421	80	10	60	85	30	10	15	15	T	T	T	T
12	431	3	55	75	45	300	20	40	35	B	T	T	T
13	440	-5	10	55	15	350	20	25	150	G	T	T	S
14	443	70	20	15	90	6	5	150	3	T	T	T	T
15	463	10	0	5	25	75	125	125	50	T	T	T	T
16	513	25	60	40	-25	40	50	30	75	T	T	T	T
17	523	75	35	40	180	30	50	50	40	T	T	T	T
18	526	10	200	35	20	40	5	50	30	B	T	T	T
19	531	15	2	2	-5	100	125	75	350	T	T	T	G
20	546	30	20	20	40	50	80	75	100	T	T	T	T
21	550	15	12	10	15	75	125	100	150	T	B	T	T
22	567	40	200	200	75	50	5	5	8	T	T	T	T
23	572	45	120	130	0	75	15	10	30	T	T	T	T
24	581	20	35	-3	0	125	50	75	100	B	B	B	G
25	584	10	20	10	-10	15	200	300	200	S	G	G	S
26	591	7	-2	-12	5	75	50	150	150	C	S	S	C
27	610	60	20	0	45	50	25	50	30	T	T	T	T
28	611	115	45	40	60	30	50	30	60	T	T	T	T
29	615	60	75	30	40	50	50	125	100	T	T	T	T
30	633	5	10	35	55	150	150	25	20	G	G	T	T
31	640	25	60	45	35	100	15	50	35	T	T	T	T
32	643	22	45	5	120	25	30	25	20	T	T	G	T
33	666	25	70	60	35	25	20	30	175	T	T	T	T
34	670	7	40	-10	6	30	12	50	20	S	T	T	T
35	677	-30	25	25	-45	30	30	40	100	S	S	T	S
36	681	10	35	35	25	50	50	50	50	T	W	W	T
37	692	10	15	-17	-40	100	50	400	700	B	B	G	G
38	711	110	105	35	125	12	30	8	6	S	T	T	S
39	741	30	200	200	200	35	4	4	4	T	T	T	T
40	743	200	100	200	60	15	5	5	20	T	T	T	T
41	751	-30	33	70	-10	100	30	20	65	H	T	T	B
42	760	70	10	22	20	15	75	150	60	T	T	T	T
43	780	45	-15	-25	20	40	12	200	175	T	S	S	B
44	781	-3	7	5	4	25	400	400	200	S	S	S	T
45	790	35	-25	-20	30	50	500	500	75	T	G	G	T
46	793	10	3	-5	30	125	50	15	50	B	S	S	T
47	811	50	40	110	50	100	75	40	40	T	T	T	T
48	834	0	15	20	15	100	75	30	30	T	T	T	T
49	835	200	200	200	33	3	2	6	20	T	T	T	T
50	842	15	0	12	15	40	25	75	75	T	S	T	T
51	854	-6	5	10	-10	90	50	75	75	B	S	S	B

[a]Data names are defined in Appendix A. The "selected" method of obtaining criteria of obstruction is described in Chapter III.

TABLE XXX. MEAN OF THE AVERAGE AND SELECTED CRITERIA DESCRIBING OBSTRUCTION AND THE CRITERIA WEIGHTED OBSTRUCTION AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	OSTOTA	ODTOTA	OSTOTS	ODTOTS	OBWN	OBWW	OBWS	OBWE	OBWTOT
1	216	34.250	164.25	76.25	62.50	0.0	0.0	3.3	4.1	1.850
2	224	31.750	118.25	86.25	18.75	5.0	3.2	0.4	0.2	2.200
3	233	13.500	157.50	26.25	17.50	0.4	0.0	0.4	1.7	0.625
4	310	3.375	190.75	7.00	93.75	0.1	0.0	0.0	0.0	0.025
5	323	13.000	149.75	23.25	72.75	0.0	3.3	0.1	0.2	0.900
6	331	4.000	123.75	11.25	71.25	0.1	-0.1	0.0	0.5	0.125
7	341	3.750	214.00	4.50	83.75	0.4	0.0	0.0	0.1	0.125
8	361	10.750	72.25	17.00	50.00	0.0	0.3	0.8	0.2	0.325
9	372	12.500	118.00	22.50	67.50	0.8	0.7	0.2	0.0	0.425
10	415	12.250	137.50	28.50	47.50	0.6	0.6	0.0	0.2	0.350
11	421	36.250	54.50	58.75	17.50	1.0	0.5	1.5	3.7	1.675
12	431	22.250	217.50	44.50	98.75	0.0	1.1	0.6	0.5	0.550
13	440	11.000	212.75	18.75	136.25	0.0	0.3	1.0	0.0	0.325
14	443	22.750	111.50	48.75	41.00	2.9	1.0	0.0	10.6	3.625
15	463	-0.750	182.25	10.00	93.75	0.0	0.0	0.0	0.1	0.025
16	513	7.000	63.50	25.00	48.75	-0.5	0.6	0.3	-1.2	-0.200
17	523	49.000	69.00	82.50	42.50	1.5	0.5	0.5	2.2	1.175
18	526	44.250	55.50	66.25	31.25	-0.6	32.1	0.3	0.1	7.975
19	531	-0.575	345.50	3.50	162.50	0.1	0.0	0.0	0.0	0.025
20	546	15.500	105.00	27.50	76.25	0.2	0.1	0.1	0.2	0.150
21	550	5.250	187.25	13.00	112.50	0.1	0.0	0.0	0.0	0.025
22	567	84.250	31.50	128.75	17.00	0.3	15.8	40.0	4.2	15.075
23	572	40.000	36.75	73.75	32.50	0.0	4.6	8.7	-0.7	3.150
24	581	4.250	149.75	13.00	87.50	0.1	0.4	0.0	0.0	0.125
25	584	3.750	268.00	7.50	178.75	0.2	0.1	0.0	0.0	0.075
26	591	-2.250	194.00	-0.50	106.25	0.1	0.0	-0.1	0.0	0.000
27	610	10.500	142.25	31.25	38.75	0.5	0.3	0.0	0.4	0.300
28	611	45.000	55.00	65.00	42.50	2.9	0.5	0.9	0.6	1.225
29	615	41.500	134.00	51.25	81.25	0.9	0.9	0.2	0.2	0.550
30	633	7.825	151.50	26.25	86.25	0.0	0.1	0.3	0.7	0.275
31	640	22.750	64.00	41.25	50.00	0.1	1.8	0.5	0.2	0.650
32	643	11.750	79.50	48.00	25.00	0.3	0.2	0.1	1.3	0.475
33	666	32.750	86.25	47.50	62.50	0.2	2.5	1.3	0.1	1.025
34	670	5.250	76.00	10.75	28.00	0.0	1.6	-0.2	0.1	0.375
35	677	-1.750	77.25	-6.25	50.00	-0.7	0.3	0.4	-0.2	-0.050
36	681	-0.500	96.75	26.25	50.00	0.1	0.1	-0.1	0.1	0.050
37	692	-6.500	439.75	-8.00	312.50	0.0	0.1	0.0	0.0	0.025
38	711	74.000	23.00	93.75	14.00	4.4	3.1	2.2	13.5	5.800
39	741	98.750	29.50	157.50	11.75	0.4	10.4	50.0	33.3	23.525
40	743	110.250	18.00	140.00	11.25	9.4	10.1	33.3	4.0	14.200
41	751	5.750	86.75	15.75	53.75	-0.2	0.5	1.3	-0.3	0.325
42	760	12.750	128.50	30.50	75.00	1.6	0.1	0.1	0.1	0.475
43	780	1.500	164.50	6.25	106.75	0.3	-0.4	-0.1	0.1	-0.025
44	781	2.450	456.75	3.25	256.25	0.0	0.0	0.0	0.0	0.000
45	790	3.500	334.00	5.00	281.25	0.2	0.0	0.0	0.1	0.075
46	793	2.075	97.25	9.50	60.00	0.0	0.0	-0.1	0.2	0.025
47	811	44.500	250.50	62.50	63.75	0.2	0.2	1.4	0.5	0.575
48	834	4.750	108.00	12.50	58.75	0.0	0.2	0.2	-0.1	0.075
49	835	127.000	33.00	158.25	7.75	36.1	75.0	8.6	1.3	30.250
50	842	6.000	71.75	10.50	53.75	0.3	-0.5	0.0	0.1	-0.025
51	854	-5.250	110.75	-0.25	72.50	-0.2	0.0	0.1	-0.1	-0.050

[a]Data names are defined in Appendix A. The procedure for obtaining weighted criteria of obstruction is described in Chapter III.

TABLE XXXI. DISTANCE TO SHORELINES OF BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	TDEN	SHORN	SHORS	SHORW	SHORSE	SHORNE
1	216	3.22	4.9	0.8	0.7	1.3	10.6
2	224	2.31	4.6	0.6	2.7	1.3	9.0
3	233	2.47	4.6	0.5	4.1	0.8	8.0
4	310	6.94	4.1	1.2	1.8	2.4	9.2
5	323	3.66	3.7	1.5	2.8	2.4	8.0
6	331	3.68	4.3	0.8	4.9	1.4	6.8
7	341	0.99	4.9	0.6	6.4	1.7	6.0
8	361	2.14	3.1	0.1	10.2	0.9	7.6
9	372	2.73	2.7	0.1	11.7	0.3	7.2
10	415	6.07	3.2	2.3	0.9	4.2	8.4
11	421	3.93	2.9	2.3	3.1	3.4	7.4
12	431	2.96	3.5	1.7	5.2	3.4	5.8
13	440	2.89	3.8	1.6	6.0	2.8	5.3
14	443	3.14	4.1	1.8	7.7	2.5	4.0
15	463	2.71	2.1	0.7	11.4	1.5	6.1
16	513	3.59	2.5	2.8	1.8	4.5	7.2
17	523	2.30	2.3	2.8	3.0	4.3	7.2
18	526	7.93	2.2	2.9	3.9	5.0	6.3
19	531	4.69	2.8	2.4	5.1	4.0	5.3
20	546	3.24	3.4	2.4	6.8	3.6	4.1
21	550	3.82	2.4	1.9	8.6	3.8	2.7
22	567	3.50	1.8	1.5	10.5	2.6	4.7
23	572	1.43	1.3	1.4	12.7	2.2	3.9
24	581	1.00	2.2	0.7	14.2	0.8	4.3
25	584	5.06	2.3	0.2	15.9	0.3	4.6
26	591	2.02	1.4	0.1	17.7	0.1	0.8
27	610	8.80	0.7	3.7	0.1	6.3	3.4
28	611	0.98	1.0	4.2	2.5	7.3	2.1
29	615	2.04	1.2	4.1	2.0	7.6	1.9
30	633	4.66	2.0	3.2	5.3	4.4	4.8
31	640	2.80	2.5	2.9	7.8	5.3	2.8
32	643	3.55	2.6	3.2	6.8	5.5	3.5
33	666	2.25	0.6	2.4	11.1	3.4	1.1
34	670	5.53	0.6	2.3	13.4	3.0	2.2
35	677	7.08	0.1	2.7	12.6	3.4	1.5
36	681	6.97	1.4	1.3	14.7	2.1	2.6
37	692	3.80	0.7	0.9	17.9	0.8	0.8
38	711	1.02	0.5	4.9	1.5	8.0	0.7
39	741	2.19	1.2	4.6	6.3	7.9	2.8
40	743	1.72	1.6	3.6	8.0	6.5	2.2
41	751	4.51	1.1	3.5	9.2	6.6	1.2
42	760	3.43	0.3	3.3	10.7	4.7	0.3
43	780	2.28	0.5	2.1	15.6	2.6	0.7
44	781	2.77	0.3	2.4	14.7	3.3	0.8
45	790	2.52	0.3	0.3	19.3	0.7	1.0
46	793	6.22	0.2	1.7	17.0	1.9	0.5
47	811	2.65	0.3	5.3	0.1	9.3	0.8
48	834	12.00	0.3	5.4	0.5	8.9	0.8
49	835	1.67	0.0	5.1	0.0	8.8	0.0
50	842	3.01	0.7	4.7	1.4	7.6	1.2
51	854	4.11	0.5	4.4	1.2	7.0	0.5

[a]Data names are defined in Appendix A.

TABLE XXXII. ELEVATIONS, SLOPES, LAND-USE, VEGETATION TYPE, AND GEOLOGY TYPE AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	ELEV	SLPVI	NSLDVI	SLDVI	LANDU	LANSC	VEGTY	VEGSC	GEOL
1	216	75	2	6	90	4	4	8	1	6
2	224	42	1	1	90	4	4	10	10	1
3	233	40	2	1	135	3	8	10	10	1
4	310	140	4	6	90	4	4	10	10	6
5	323	120	4	1	90	3	8	10	10	1
6	331	80	4	1	90	11	8	10	10	1
7	341	20	7	6	90	11	8	3	3	1
8	361	40	5	3	135	2	6	9	8	6
9	372	30	6	6	90	2	6	9	8	1
10	415	80	4	4	180	3	8	10	10	9
11	421	220	8	8	0	3	8	10	10	9
12	431	75	2	7	45	11	8	10	10	1
13	440	120	16	2	90	11	8	10	10	6
14	443	85	5	2	90	3	8	10	10	6
15	463	65	2	4	180	2	6	9	8	1
16	513	320	18	1	45	1	5	2	6	9
17	523	310	24	4	180	1	5	1	5	9
18	526	260	14	8	0	2	6	1	5	9
19	531	120	2	7	45	3	8	10	10	1
20	546	160	3	3	135	3	8	10	10	6
21	550	180	5	4	180	3	8	1	5	6
22	567	140	20	2	90	5	3	10	10	1
23	572	240	30	8	0	1	5	1	5	9
24	581	100	9	7	45	2	6	9	8	1
25	584	65	17	8	0	1	5	4	2	9
26	591	30	6	6	90	1	5	4	2	9
27	610	60	8	4	180	7	5	10	10	9
28	611	675	14	7	45	2	6	1	5	9
29	615	540	10	3	135	2	6	2	6	9
30	633	240	8	8	0	4	4	10	10	8
31	640	240	16	3	135	1	5	3	3	1
32	643	120	3	6	90	3	8	10	10	9
33	666	180	10	2	90	1	5	1	5	9
34	670	110	16	6	90	2	6	11	3	9
35	677	40	10	1	45	2	6	11	3	9
36	681	150	10	7	45	1	5	10	10	8
37	692	200	16	7	45	1	5	3	3	9
38	711	550	22	6	90	2	6	2	6	9
39	741	520	20	7	45	1	5	1	5	9
40	743	5	5	7	45	3	8	10	10	9
41	751	180	10	2	90	4	4	10	10	6
42	760	60	4	1	45	6	3	11	3	6
43	780	140	11	5	135	1	5	10	10	9
44	781	10	3	2	90	2	6	9	8	1
45	790	100	10	5	135	1	5	4	2	9
46	793	80	10	6	90	1	5	10	10	9
47	811	20	14	6	90	1	5	2	6	9
48	834	120	12	1	45	4	4	10	10	9
49	835	50	12	3	135	2	6	10	10	9
50	842	530	36	7	45	1	5	1	5	9
51	854	210	20	8	0	4	4	5	1	9

[a]Data names are defined in Appendix A.

TABLE XXXIII. GROUNDWATER AND SOIL CRITERIA AROUND BLACKLIGHT INSECT TRAPS AT 51 LOCATIONS[a]

OBS	TRAPNO	GWPYI	GWCL	SOILZ	SOILAS	SOIPTA	SOILASW	SOICAP	SOIPDS	SOICAPW
1	216	0.0	1250	1.0	2	22	0.44	6	10	0.60
2	224	0.0	1000	3.0	3	8	0.24	3	60	1.80
3	233	7.5	800	3.0	2	22	0.44	3	10	0.30
4	310	7.5	150	2.0	2	22	0.44	4	50	2.00
5	323	7.5	150	2.0	3	8	0.24	4	10	0.40
6	331	7.5	600	2.0	2	22	0.44	3	20	0.60
7	341	7.5	800	2.0	2	22	0.44	3	10	0.30
8	361	7.5	900	2.5	2	22	0.44	6	50	3.00
9	372	3.0	450	2.0	7	6	0.42	6	5	0.30
10	415	7.5	150	3.0	1	19	0.19	4	15	0.60
11	421	7.5	150	2.5	1	19	0.19	4	15	0.60
12	431	7.5	350	2.5	3	8	0.24	4	60	2.40
13	440	7.5	400	2.5	2	22	0.44	7	50	3.50
14	443	7.5	600	2.5	2	22	0.44	3	20	0.60
15	463	3.0	400	2.0	7	6	0.42	6	5	0.30
16	513	7.5	100	1.0	1	19	0.19	7	80	5.60
17	523	7.5	50	1.0	1	19	0.19	6	80	4.80
18	526	7.5	200	2.5	1	19	0.19	6	80	4.80
19	531	0.0	450	3.0	3	8	0.24	3	60	1.80
20	546	7.5	350	2.5	2	22	0.44	3	20	0.60
21	550	7.5	400	1.0	2	22	0.44	6	50	3.00
22	567	3.0	250	2.5	2	22	0.44	4	15	0.60
23	572	3.0	50	2.0	5	41	2.05	3	10	0.30
24	581	3.0	300	3.0	7	6	0.42	6	5	0.30
25	584	0.0	800	2.0	5	41	2.05	6	10	0.60
26	591	0.0	1250	1.0	5	41	2.05	2	10	0.20
27	610	7.5	150	1.0	1	19	0.19	6	80	4.80
28	611	7.5	100	1.0	1	19	0.19	6	80	4.80
29	615	7.5	150	1.0	1	19	0.19	6	80	4.80
30	633	7.5	200	2.0	4	2	0.08	4	5	0.20
31	640	7.5	350	2.0	2	22	0.44	6	50	3.00
32	643	0.0	500	3.0	3	8	0.24	3	60	1.80
33	666	3.0	150	1.0	1	19	0.19	2	5	0.10
34	670	3.0	200	1.0	1	19	0.19	2	5	0.10
35	677	3.0	250	1.0	1	19	0.19	6	80	4.80
36	681	3.0	200	2.0	7	6	0.42	7	5	0.35
37	692	0.0	1000	1.5	5	41	2.05	7	60	4.20
38	711	7.5	50	1.0	1	19	0.19	7	80	5.60
39	741	7.5	75	1.0	1	19	0.19	6	80	4.80
40	743	0.0	400	1.0	3	8	0.24	6	10	0.60
41	751	0.0	500	2.0	2	22	0.44	6	50	3.00
42	760	0.0	800	2.5	2	22	0.44	3	20	0.60
43	780	3.0	250	3.0	5	41	2.05	7	60	4.20
44	781	3.0	500	3.0	7	6	0.42	4	35	1.40
45	790	0.0	1250	1.0	5	41	2.05	7	60	4.20
46	793	0.0	1400	3.0	5	41	2.05	3	10	0.30
47	811	7.5	125	2.5	1	19	0.19	7	80	5.60
48	834	7.5	125	1.5	5	41	2.05	6	60	3.60
49	835	7.5	200	2.0	1	19	0.19	4	15	0.60
50	842	7.5	100	1.0	1	19	0.19	7	80	5.60
51	854	0.0	600	3.0	2	22	0.44	7	50	3.50

[a] Data names are defined in Appendix A.

APPENDIX C

SIMPLE CORRELATION COEFFICIENTS

TABLE XXXIV. SIMPLE CORRELATION COEFFICIENTS (r) BETWEEN MALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT TRAPS AND CRITERIA DESCRIBING TRAP LOCATIONS[a]

Computer name /r/ probability of a greater |r|

LNOBSWA	LNDROAD	SOILZ	SQSOILZ	LNSOILZ
-0.31	-0.30	-0.26	-0.25	-0.24
0.25	0.032	0.066	0.072	0.079
SQDROAD	LNOBDWA	LNOBSSA	LNOBSWS	LNILIIN
-0.23	-0.23	-0.22	-0.22	0.22
0.10	0.10	0.11	0.11	0.12
SQILIIN	ILIIN	SLPVI	LNSHORSE	LNOBSNA
0.21	0.21	0.19	-0.19	0.19
0.13	0.14	0.17	0.17	0.18
LNSHORS	OBDNS	SQSHORS	DROAD	GWCL
-0.19	-0.18	-0.18	-0.18	0.18
0.18	0.20	0.20	0.20	0.21
SQSLPVI	OBWN	SQOBDWA	SQOBDNS	OBDNA
0.17	0.17	-0.17	-0.17	-0.17
0.22	0.22	0.22	0.22	0.23
SQOBSNA	LNSLPVI	ROAD1		
0.17	0.16	-0.16		
0.23	0.25	0.25		

[a]Computer names are defined in Appendix A. Criteria not included were not significant at $p < 0.25$.

TABLE XXXV. SIMPLE CORRELATION COEFFICIENTS (r) BETWEEN MATED FEMALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT TRAPS AND CRITERIA DESCRIBING TRAP LOCATIONS[a]

Computer name	/r/	probability of a greater $\lvert r \rvert$
LNOBSWS	-0.36	0.0097
LNOBSSA	-0.31	0.024
OBWN	0.31	0.025
SQOBWN	0.28	0.044
LNOBSSS	-0.27	0.050
LNOBSWA	-0.26	0.066
OBDNA	-0.26	0.067
SQOBDNA	-0.26	0.068
LNOBDNA	-0.25	0.070
OBWN	0.25	0.075
SQOBSNA	0.25	0.076
OBSNA	0.24	0.080
LNOBSNA	0.24	0.087
LNOBWN	0.24	0.088
SQOBSNS	0.24	0.089
LNOBSNS	0.23	0.093
OBSNS	0.22	0.12
SQSLDVI	0.21	0.14
LNTROAD	0.21	0.14
SLDVI	0.21	0.14
LNOBDWA	-0.21	0.14
SQOBSSA	-0.20	0.15
LNOBDNS	-0.19	0.17
LNOBPS	-0.19	0.19
LNSLDVI	0.18	0.20
SQOBDNS	-0.18	0.20
SQTROAD	0.18	0.20
OBDNS	-0.18	0.21
SQOBSWS	-0.18	0.22
LNDROAD	-0.17	0.23
SQSHORNE	-0.16	0.25
LNILIIN	0.16	0.25
LNOBPN	0.16	0.25
LNOBSEA	0.16	0.25

[a]Computer names are defined in Appendix A. Criteria not included were not significant at $p < 0.25$.

TABLE XXXVI. SIMPLE CORRELATION COEFFICIENTS (r) BETWEEN VIRGIN FEMALE TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT TRAPS AND CRITERIA DESCRIBING TRAP LOCATIONS[a]

Computer name	/r/	probability of a greater |r|
SOILZ	-0.29	0.037
SQSOILZ	-0.29	0.039
LNOBDWA	-0.29	0.040
LNSOILZ	-0.28	0.041
OBDNA	-0.28	0.041
SQOBDNA	-0.26	0.058
ELEV	0.26	0.058
SQOBDWA	-0.26	0.064
ILITY	0.25	0.079
SQILITY	0.25	0.079
LIGHT1	0.24	0.080
LNILITY	0.24	0.084
SQSLDVI	0.24	0.088
LIGHT2	0.23	0.10
SQELEV	0.23	0.10
SLDVI	0.23	0.11
GWPYI	0.22	0.11
LNOBDNA	-0.22	0.12
LNOSTOTA	0.22	0.12
LNSLDVI	0.22	0.12
SQGWPYI	0.21	0.13
LNGWPYI	0.21	0.13
ODTOTA	-0.21	0.14
SHORSE	0.19	0.17
SQODTOTA	-0.19	0.18
OBDWA	-0.19	0.19
SQTDEN	-0.18	0.20
LNTDEN	-0.18	0.20
LNOBPE	0.18	0.21
ILIIN	0.18	0.21
SQILIIN	0.18	0.21
LNILIIN	0.18	0.21
SOICAPW	0.18	0.21
LNOBSEA	0.17	0.22
TDEN	-0.17	0.22
SOICAPWN	0.17	0.23
SOICAPWS	0.17	0.23
LNELEV	0.17	0.24
LNOBSNA	0.17	0.24
SLPVI	0.17	0.24
SQOSTOTA	0.17	0.24
LNTROAD	0.16	0.25

[a]Computer names are defined in Appendix A. Criteria not included were not significant at $p < 0.25$.

TABLE XXXVII. SIMPLE CORRELATION COEFFICIENTS (r) BETWEEN TOTAL TOBACCO HORNWORM COLLECTIONS IN 51 BLACKLIGHT TRAPS AND CRITERIA DESCRIBING TRAP LOCATIONS[a]

<table>
<tr><th>Computer name</th><th>/r/</th><th>probability of a greater |r|</th></tr>
<tr><td>LNOBSWA</td><td>-0.31</td><td>0.027</td></tr>
<tr><td>LNDROAD</td><td>-0.27</td><td>0.050</td></tr>
<tr><td>LNOBSWS</td><td>-0.27</td><td>0.055</td></tr>
<tr><td>LNOBSSA</td><td>-0.26</td><td>0.067</td></tr>
<tr><td>SOILZ</td><td>-0.24</td><td>0.081</td></tr>
<tr><td>SQSOILZ</td><td>-0.24</td><td>0.088</td></tr>
<tr><td>LNOBDWA</td><td>-0.24</td><td>0.090</td></tr>
<tr><td>LNSOILZ</td><td>-0.23</td><td>0.096</td></tr>
<tr><td>OBWN</td><td>0.22</td><td>0.11</td></tr>
<tr><td>LNILIIN</td><td>0.20</td><td>0.12</td></tr>
<tr><td>LNOBSNA</td><td>0.22</td><td>0.13</td></tr>
<tr><td>SQILIIN</td><td>0.21</td><td>0.13</td></tr>
<tr><td>OBDNA</td><td>-0.21</td><td>0.14</td></tr>
<tr><td>SQROAD</td><td>-0.21</td><td>0.14</td></tr>
<tr><td>ILIIN</td><td>0.21</td><td>0.13</td></tr>
<tr><td>SQOBSNA</td><td>0.20</td><td>0.15</td></tr>
<tr><td>SQOBWN</td><td>0.20</td><td>0.15</td></tr>
<tr><td>SQOBDNA</td><td>0.20</td><td>0.16</td></tr>
<tr><td>OBDNS</td><td>-0.19</td><td>0.18</td></tr>
<tr><td>LNOBDNA</td><td>-0.19</td><td>0.18</td></tr>
<tr><td>OBSNA</td><td>0.18</td><td>0.19</td></tr>
<tr><td>SQOBDNS</td><td>-0.18</td><td>0.19</td></tr>
<tr><td>LNOBSSS</td><td>-0.18</td><td>0.20</td></tr>
<tr><td>LNOBSNS</td><td>0.18</td><td>0.20</td></tr>
<tr><td>LNSHORS</td><td>-0.18</td><td>0.20</td></tr>
<tr><td>SLPVI</td><td>0.18</td><td>0.20</td></tr>
<tr><td>LNSHORSE</td><td>0.18</td><td>0.21</td></tr>
<tr><td>GWCL</td><td>0.18</td><td>0.21</td></tr>
<tr><td>OBWW</td><td>0.18</td><td>0.21</td></tr>
<tr><td>SQSHORS</td><td>-0.17</td><td>0.22</td></tr>
<tr><td>LNOBDNS</td><td>-0.17</td><td>0.24</td></tr>
<tr><td>LNTROAD</td><td>0.17</td><td>0.24</td></tr>
<tr><td>LNOBWN</td><td>0.17</td><td>0.24</td></tr>
<tr><td>SQOBDWA</td><td>-0.17</td><td>0.24</td></tr>
<tr><td>LNSLDVI</td><td>0.17</td><td>0.25</td></tr>
<tr><td>SQSLPVI</td><td>0.16</td><td>0.25</td></tr>
<tr><td>LNOBPN</td><td>0.16</td><td>0.25</td></tr>
</table>

[a] Computer names are defined in Appendix A. Criteria not included were not significant at $p < 0.25$.

TABLE XXXVIII. SIMPLE CORRELATION COEFFICIENTS (r) BETWEEN WHITE BELLY COLLECTIONS IN 51 BLACKLIGHT TRAPS AND CRITERIA DESCRIBING TRAP LOCATIONS[a]

Computer name	/r/	probability of a greater |r|
LNOBSSA	-0.51	0.0003
LNOBSWS	-0.50	0.0004
OBDSS	0.41	0.0032
SQSHORN	-0.40	0.0040
OBDWS	0.40	0.0043
LNSHORN	-0.39	0.0050
SHORW	0.38	0.0054
SHORN	-0.36	0.0087
LNOBSSS	-0.35	0.010
SQSHORNE	-0.33	0.017
LNSHORNE	-0.33	0.019
SQOBDSS	0.31	0.024
SQOBSSA	-0.31	0.026
SHORNE	-0.30	0.031
LNOBPS	-0.29	0.034
OBDWA	0.28	0.044
ODTOTS	0.28	0.047
GWCL	0.27	0.053
OBWN	0.25	0.070
SQOBDWS	0.25	0.072
SQSHORW	0.25	0.079
LNSHORSE	0.24	0.081
SQOBSWS	-0.24	0.082
SQSOILZ	-0.24	0.085
LNSOILZ	-0.24	0.086
SOILZ	-0.24	0.086
LNSHORS	-0.23	0.099
SQOBSSS	-0.22	0.11
SQSHORS	-0.22	0.11
OBWW	0.22	0.12
SQSHORSE	-0.22	0.12
LNOBSWA	-0.22	0.12
SQOBPS	-0.21	0.13
SQGWCL	0.21	0.13
SLDSI	0.21	0.13
SQODTOTS	0.21	0.14
SLDVI	0.20	0.15
SQOBWN	0.20	0.16
LNVEGSC	-0.20	0.17
SQSLDSI	0.20	0.17
SQVEGSC	-0.19	0.17
LNOBDSS	0.19	0.18
SQSLDVI	0.18	0.19
LNSHORW	0.18	0.20
GWPYI	-0.18	0.21
VEGSC	-0.18	0.21
LNTROAD	0.18	0.21
LNSLPVI	0.18	0.21
LNSLPSI	0.18	0.21
SQGWPYI	0.17	0.24
LNGWPYI	-0.17	0.24
LNILIIN	0.17	0.24
SQILIIN	0.16	0.25
SOICAP	0.16	0.25

[a]Computer names are defined in Appendix A. Criteria not included were not significant at $p < 0.25$.

APPENDIX D

MULTIPLE REGRESSION RESULTS

TABLE XXXIX. COMPARISON OF THE EFFECTIVENESS OF THE THREE METHODS OF MEASURING OBSTRUCTIONS IN DESCRIBING THE VARIATION IN INSECT COLLECTIONS IN 51 BLACKLIGHT TRAPS

		Values for uncoded model				Values for uncoded model			
		R^2		Maximum size[g]		R^2		Maximum size[g]	
Method of determination[a]	Collection[b]	Best 5[e]	Best 10[f]	R^2	Model size	Best 5[e]	Best 10[f]	R^2	Model size
Percent	Male	13	--	8	3	24	34	33	9
Average	Male	17	25	25	9	40	55	66	16
Selected	Male	5	5[h]	3	1	27	42	46	13
Percent	Mated female	20	--	20	5	19	40	52	12
Average	Mated female	21	26	25	7	47	57	65	14
Selected	Mated female	11	11[h]	11	4	42	48	53	13
Percent	Virgin female	7	--	2	1	15	36	15	5
Average	Virgin female	16	19	18	7	34	45	78	25
Selected	Virgin female	7	7[h]	7	4	15	31	41	17
Percent	Total	15	--	15	5	25	38	44	13
Average	Total	18	24	24	8	43	57	68	18
Selected	Total	6	6[h]	5	3	33	43	45	11
Percent	White belly	14	--	14	5	47	65	69	12
Average	White belly	27	33	33	8	69	78	80	12
Selected	White belly	17	17[h]	17	5	47	51	71	18

TABLE XXXIX (continued)

[a]The percent, average, and selected methods of determining obstruction to lamp radiation are described in Chapter III.

[b]All collections were coded to $\sqrt{y_i}$ for these calculations.

[c]The uncoded model contained 5, 14, and 10 factors available for inclusion in equations for percent, average, and selected methods, respectively.

[d]Coded model includes all variables in uncoded model plus these variables coded to $\sqrt{x_i}$ and $\ln x_i$ (codings are listed in Appendix B). The coded model contained 15, 42, and 30 independent variables available for inclusion in equations for percent, average, and selected methods, respectively.

[e]R^2 with 5 independent variables in the equation.

[f]R^2 with 10 independent variables in the equation.

[g]R^2 and numbers of independent variables in the equation at the step at which the next additional variable did not increase R^2 of the total equation by 0.5%.

[h]Only 8 variables are included in calculations for this value.

TABLE XL. ALL CRITERIA DESCRIBING LOCATIONS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT COLLECTION CATEGORIES[a]

SLPSI	SQSLPSI	LNSLPSI	SLDSI	SQSLDSI	LNSLDSI	DROAD	SQDROAD	LNDROAD
TROAD	SQTROAD	LNTROAD	ILITY	SQILITY	LNILITY	ILIIN	SQILIIN	LNILIIN
OBSNA	SQOBSNA	LNOBSNA	OBSWA	SQOBSWA	LNOBSWA	OBSSA	SQOBSSA	LNOBSSA
OBSEA	SQOBSEA	LNOBSEA	OSTOTA	SQOSTOTA	LNOSTOTA	OBDNA	SQOBDNA	LNOBDNA
OBDWA	SQOBDWA	LNOBDWA	OBDSA	SQOBDSA	LNOBDSA	OBDEA	SQOBDEA	LNOBDEA
ODTOTA	SQODTOTA	LNODTOTA	OBWN	SQOBWN	LNOBWN	OBWW	SQOBWW	LNOBWW
OBWS	SQOBWS	LNOBWS	OBWE	SQOBWE	LNOBWE	OBWTOT	SQOBWTOT	LNOBWTOT
LIGHT1	LIGHT2		ROAD1	ROAD2		TDEN	SQTDEN	LNTDEN
SHORN	SQSHORN	LNSHORN	SHORW	SQSHORW	LNSHORW	SHORS	SQSHORS	LNSHORS
SHORSE	SQSHORSE	LNSHORSE	SHORNE	SQSHORNE	LNSHORNE	ELEV	SQELEV	LNELEV
SLPVI	SQSLPVI	LNSLPVI	SLDVI	SQSLDVI	LNSLDVI	LANSC	SQLANSC	LNLANSC
VEGSC	SQVEGSC	LNVEGSC	GWPYI	SQGWPYI	LNGWPYI	GWCL	SQGWCL	LNGWCL
SOILZ	SQSOILZ	LNSOILZ	SOICAP	SQSOICAP	LNSOICAP	SOICAPW	SOICAPWS	SOICAPWN

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variables included in mode 1, page 44.

TABLE XLI. CRITERIA THAT MAY BE EVALUATED ON-SITE DESCRIBING SURROUNDINGS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT CATEGORIES[a]

SLPSI	SLDSI	DROAD	TROAD	ILITY	ILIIN
OBSNS	OBSWS	OBSSS	OBSES	OSTOTS	OBDNS
OBDWS	OBDSS	OBDES	ODTOTS		

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variables included in model 2, page 44.

TABLE XLII. CRITERIA THAT MAY BE EVALUATED FROM AN ON-SITE SURVEY DESCRIBING SURROUNDINGS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT COLLECTION CATEGORIES[a]

SLPSI	SQSLPSI	LNSLPSI	SLDSI	SQSLDSI	LNSLDSI	DROAD	SQDROAD	LNDROAD
TROAD	SQTROAD	LNTROAD	ILITY	SQILITY	LNILITY	ILIIN	SQILIIN	LNILIIN
OBSNA	SQOBSNA	LNOBSNA	OBSWA	SQOBSWA	LNOBSWA	OBSSA	SQOBSSA	LNOBSSA
OBSEA	SQOBSEA	LNOBSEA	OSTOTA	SQOSTOTA	LNOSTOTA	OBDNA	SQOBDNA	LNOBDNA
OBDWA	SQOBDWA	LNOBDWA	OBDSA	SQOBDSA	LNOBDSA	OBDEA	SQOBDEA	LNOBDEA
ODTOTA	SQODTOTA	LNODTOTA	OBWN	SQOBWN	LNOBWN	OBWW	SQOBWW	LNOBWW
OBWS	SQOBWS	LNOBWS	OBWE	SQOBWE	LNOBWE	OBWTOT	SQOBWTOT	LNOBWTOT
LIGHT1	LIGHT2		ROAD1	ROAD2				

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variables included in model 3, page 44.

TABLE XLIII. CRITERIA OBTAINED FROM DESCRIPTIVE DATA OF LOCATIONS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT COLLECTION CATEGORIES[a]

TDEN	SQTDEN	LNTDEN	SHORN	SQSHORN	LNSHORN	SHORW	SQSHORW	LNSHORW
SHORS	SQSHORS	LNSHORS	SHORSE	SQSHORSE	LNSHORSE	SHORNE	SQSHORNE	LNSHORNE
ELEV	SQELEV	LNELEV	SLPVI	SQSLPVI	LNSLPVI	SLDVI	SQSLDVI	LNSLDVI
LANSC	SQLANSC	LNLANSC	VEGSC	SQVEGSC	LNVEGSC	GWPYI	SQGWPYI	LNGWPYI
GWCL	SQGWCL	LNGWCL	SOILZ	SQSOILZ	LNSOILZ	SOICAP	SQSOICAP	LNSOICAP
SOICAPW	SOICAPWS	SOICAPWN						

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variable included in model 4, page 44.

TABLE XLIV. CRITERIA THAT ARE MOST ECONOMICAL TO MEASURE DESCRIBING SURROUNDINGS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT COLLECTION CATEGORIES[a]

SLPSI	SQSLPSI	LNSLPSI	SLDSI	SQSLDSI	LNSLDSI	DROAD	SQDROAD	LNDROAD
TROAD	SQTROAD	LNTROAD	ILITY	SQILITY	LNILITY	ILIIN	SQILIIN	LNILIIN
OBSNS	SQOBSNS	LNOBSNS	OBSWS	SQOBSWS	LNOBSWS	OBSSS	SQOBSSS	LNOBSSS
OBSES	SQOBSES	LNOBSES	OSTOTS	SQOSTOTS	LNOSTOTS	OBDNS	SQOBDNS	LNOBDNS
OBDWS	SQOBDWS	LNOBDWS	OBDSS	SQOBDSS	LNOBDSS	OBDES	SQOBDES	LNOBDES
ODTOTS	SQODTOTS	LNODTOTS	LIGHT1	LIGHT2		ROAD1	ROAD2	
TDEN	SQTDEN	LNTDEN	SHORN	SQSHORN	LNSHORN	SHORW	SQSHORW	LNSHORW
SHORS	SQSHORS	LNSHORS	SHORSE	SQSHORSE	LNSHORSE	SHORNE	SQSHORNE	LNSHORNE
ELEV	SQELEV	LNELEV	LANSC	SQLANSC	LNLANSC	VEGSC	SQVEGSC	LNVEGSC
SOICAP	SQSOICAP	LNSOICAP						

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variables included in model 5, page 44.

TABLE XLV. CRITERIA THAT MAY BE MEASURED BY UNTRAINED PERSONNEL DESCRIBING SURROUNDINGS OF 51 BLACKLIGHT TRAPS THAT WERE AVAILABLE FOR INCLUSION IN MULTIPLE REGRESSION EQUATIONS WITH FIVE INSECT COLLECTION CATEGORIES[a]

SLPSI	SLDSI	DROAD	TROAD	ILITY
ILIIN	OBSNS	OBSWS	OBSSS	OBSES
OBDNS	OSTOTS		OBDWS	OBDSS
OBDES	ODTOTS	TDEN	SHORN	SHORS
SHORW	SHORSE	SHORNE	ELEV	

[a]Computer names are defined in Appendix A. Separate calculations were made for each collection category. Referred to as the independent variables included in model 6, page 44.

TABLE XLVI. RESULTS OF MULTIPLE REGRESSION OF MATED FEMALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 17 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				0.5490			
LNSHORW	1	0.01042	0.0001	-0.0574	0.0001	0.00315	-0.859
SQOBDSA	1	0.00872	0.0001	-0.0130	0.0001	0.00068	-1.331
LNTROAD	1	0.01098	0.0001	0.0871	0.0001	0.00516	0.924
LNOBSEA	1	0.00279	0.0002	-0.0294	0.0001	0.00252	-0.575
SLDVI	1	0.00668	0.0001	0.0009	0.0001	0.00006	0.827
LNSHORNE	1	0.00473	0.0001	-0.0547	0.0001	0.00530	-0.725
OBWN	1	0.00166	0.0006	0.0033	0.0006	0.00055	0.232
LNELEV	1	0.00957	0.0023	-0.0132	0.0023	0.00292	-0.223

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on mated female collections < 0.35 (MATED, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	8	0.0469	0.00587	0.0001	0.99
Error	8	0.0004	0.00005		
Corrected total	15	0.0473			

TABLE XLVII. RESULTS OF MULTIPLE REGRESSION OF MATED FEMALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 16 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				1.0306			
LNSLDSI	1	0.08933	0.0001	0.0381	0.0001	0.00140	0.570
LNGWCL	1	0.04513	0.0001	-0.1195	0.0001	0.00483	-0.747
SQOBDWA	1	0.07234	0.0001	0.0221	0.0001	0.00062	0.785
SQTDEN	1	0.04069	0.0001	-0.1718	0.0001	0.00594	-0.644
SQSHORN	1	0.02209	0.0001	-0.0906	0.0001	0.00430	-0.426
SLPSI	1	0.01294	0.0001	-0.0036	0.0001	0.00020	-0.440
SQILITY	1	0.01592	0.0001	0.3454	0.0001	0.02365	0.311
LNSHORW	1	0.00522	0.0003	-0.0311	0.0003	0.00409	-0.204

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on mated female collections > 0.5 (MATED, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	8	0.3037	0.03796	0.0001	1.00
Error	7	0.0006	0.00009		
Corrected total	15	0.3043			

TABLE XLVIII. RESULTS OF MULTIPLE REGRESSION OF VIRGIN FEMALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 16 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				-0.1506			
SQSHORSE	1	0.00398	0.0001	0.0372	0.0001	0.00180	0.966
LNSLPVI	1	0.00167	0.0001	-1.1562	0.0001	0.10509	-34.335
SQSLPVI	1	0.00134	0.0001	1.2205	0.0001	0.11785	57.951
SLPVI	1	0.00124	0.0001	-0.0845	0.0001	0.00866	-24.595
SOILZ	1	0.00074	0.0002	-0.0118	0.0001	0.00142	-0.377
LNSLPSI	1	1.85×10^{-4}	0.0049	-0.0102	0.0018	0.00214	-0.267
OBSWA	1	1.95×10^{-4}	0.0042	-3.2×10^{-4}	0.0042	8.02×10^{-5}	0.188

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on virgin female collections < 0.0240 (VIRG, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	7	0.0093	1.34×10^{-3}	0.0001	0.99
Error	8	9.8×10^{-5}	1.22×10^{-5}		
Corrected total	15	9.4×10^{-3}			

TABLE XLIX. RESULTS OF MULTIPLE REGRESSION OF VIRGIN FEMALE TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 16 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				2.0498			
SOICAPWS	1	0.01052	0.0001	0.0681	0.0001	0.00365	0.992
LNOBSEA	1	0.01277	0.0001	0.4373	0.0001	0.02532	3.543
LIGHT1	1	0.00922	0.0001	0.0054	0.0008	0.00089	0.266
SQOBSEA	1	0.00578	0.0001	-0.1102	0.0001	0.00726	-2.906
SQSLDVI	1	0.00220	0.0002	-0.1109	0.0002	0.01321	-4.161
OBDWA	1	0.00073	0.0021	-0.0001	0.0002	0.00001	-0.288
LNSLDVI	1	0.00147	0.0004	0.5259	0.0003	0.06573	4.189
ROAD2	1	0.00074	0.0020	2.0×10^{-6}	0.0020	0.0×10^{-8}	0.162

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R2 improvement technique, on virgin female collections > 0.0402 (VIRG, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	8	0.0434	0.00543	0.0001	1.00
Error	7	0.0002	0.00003		
Corrected total	15	0.0436			

TABLE L. RESULTS OF MULTIPLE REGRESSION OF TOTAL TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 17 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				-8.5393			
SHORNE	1	0.34435	0.0001	-2.7001	0.0001	0.16678	-25.760
SLDVI	1	0.52234	0.0001	0.0034	0.0001	0.00032	0.571
SQSHORNE	1	0.23352	0.0001	30.2290	0.0001	2.00308	75.241
LNSHORNE	1	0.12592	0.0001	-24.7218	0.0001	1.67595	-50.864
SQSOICAP	1	0.20068	0.0001	-0.4121	0.0001	0.03925	-0.453
OBSNA	1	0.16567	0.0001	0.0089	0.0001	0.00094	0.431
GWPYI	1	0.04498	0.0016	0.0217	0.0012	0.00422	0.218
ROAD1	1	0.03811	0.0025	-0.0001	0.0025	0.00002	-0.231

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on total tobacco hornworm collections < 0.85 (TOTAL, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	8	1.6756	0.20945	0.0001	0.99
Error	8	0.0154	0.00192		
Corrected total	16	1.6910			

TABLE LI. RESULTS OF MULTIPLE REGRESSION OF TOTAL TOBACCO HORNWORM COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 18 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				4.5352			
SQSHORW	1	0.40741	0.0001	-0.1744	0.0001	0.01771	-0.500
SLPSI	1	0.62672	0.0001	-0.0205	0.0001	0.00141	-0.720
SQSLPVI	1	0.20219	0.0003	0.5592	0.0001	0.02700	1.403
LNELEV	1	0.50423	0.0001	-0.6262	0.0001	0.03264	-1.587
OBSNA	1	0.70128	0.0001	-0.0135	0.0001	0.00087	-1.500
LNSLDVI	1	0.34021	0.0001	0.2923	0.0001	0.01989	0.720
LNOBDNA	1	0.25788	0.0002	-0.6172	0.0001	0.05254	-1.081
SOICAP	1	0.37539	0.0001	-0.1346	0.0001	0.01151	-0.521
LNTDEN	1	0.26030	0.0002	3.0998	0.0030	0.72262	2.733
SQTDEN	1	0.05947	0.0055	-2.1738	0.0055	0.57281	-2.376

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on total tobacco hornworm collections > 1.2 (TOTAL, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	10	3.7400	0.37400	0.0001	0.99
Error	8	0.0330	0.00413		
Corrected total	18	3.7730			

TABLE LII. RESULTS OF MULTIPLE REGRESSION OF WHITE BELLY COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 17 LOCATIONS HAVING THE SMALLEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > |T|	Standard error b	Standard b values
MEAN				-1.0988			
LNSLPVI	1	0.11705	0.0001	-0.4920	0.0001	0.02394	-1.640
LNILIIN	1	0.14011	0.0001	1.8209	0.0001	0.08562	1.942
TROAD	1	0.12858	0.0001	-0.0738	0.0002	0.00745	-0.605
LNELEV	1	0.02566	0.0020	0.1745	0.0001	0.01295	1.070
LNTDEN	1	0.02635	0.0019	-0.2368	0.0004	0.02733	-0.439
LNSHORW	1	0.02340	0.0024	0.7667	0.0002	0.06800	2.401
SHORW	1	0.5785	0.0004	-0.0793	0.0003	0.00888	-1.661
SLPSI	1	0.02696	0.0018	-0.0196	0.0008	0.00280	-0.490
OBDSA	1	0.02699	0.0018	-0.0004	0.0010	0.00006	-0.392
LNSLDSI	1	0.01105	0.0112	0.0241	0.0112	0.00665	0.196

[a] Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on white belly collections < 3.5 (RUST, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	10	0.5840	0.05840	0.0002	0.99
Error	6	0.0050	0.00084		
Corrected total	16	0.5890			

TABLE LIII. RESULTS OF MULTIPLE REGRESSION OF WHITE BELLY COLLECTIONS ON ALL MEASURED CRITERIA DESCRIBING BLACKLIGHT TRAP SURROUNDINGS OF THE 13 LOCATIONS HAVING THE LARGEST COLLECTIONS[a]

Source	DF	Sequential sum of squares	Prob > F	b values	Prob > $\lvert T \rvert$	Standard error b	Standard b values
MEAN				7.6782			
OBDWA	1	6.9787	0.0001	0.0086	0.0001	0.00049	1.160
LNOBDWA	1	4.4692	0.0001	-0.8865	0.0001	0.06296	-1.030
LNOBSSA	1	1.6709	0.0002	-0.4709	0.0004	0.06365	0.489
LNSLDVI	1	0.7636	0.0011	0.1795	0.0019	0.03568	0.220
SQELEV	1	0.4676	0.0035	-0.0440	0.0035	0.00996	-0.186

[a]Computer names are defined in Appendix A. Calculations were made via SAS, maximum R^2 improvement technique, on white belly collections > 9.0 (RUST, Table XXV, page 85).

Source	DF	Sum of squares	Mean square	Prob > F	R^2
Regression	5	14.3500	2.8700	0.0001	1.00
Error	7	0.1671	0.0239		
Corrected total	12	14.5171			

VITA

John L. Goodenough was born May 12, 1938, at Morrison, Illinois, the son of Helen F. Goodenough (Mrs. Charles Bonynge) and the late Elmer L. Goodenough. He attended Unionville Elementary School and Morrison Community High School. He received the State Farmer Degree in FFA, and served as sophomore class secretary and senior class president. He was married in 1958 to Marilyn Conner. They have two children, Michael, 14, and Machelle, 11.

Entering the University of Illinois in 1960, he served as American Society of Agricultural Engineers Student Branch president his sophomore year. He received a Bachelor of Science with a major in Agricultural Engineering in 1965. He has been employed with the Agricultural Research Service, United States Department of Agriculture from 1965 to present. He was located in Knoxville, Tennessee, from 1965 to 1969, at St. Croix, U. S. Virgin Islands, from 1969 to 1971, and returned to Knoxville in 1971. He entered the Graduate School of the University of Tennessee the fall quarter, 1965, and received a Master of Science with a major in Agricultural Engineering in August, 1968. He expects to receive a Doctor of Philosophy with a major in Agricultural Engineering in June, 1973.

He is a member of the American Society of Agricultural Engineers, Sigma Xi, and Gamma Sigma Delta.